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Acoustics to Quantum Materials: A Centennial History of the Department of Physics, University of Arkansas

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ACOUSTICS TO QUANTUM MATERIALS


A CENTURY OF PHYSICS IN ARKANSAS
UNIVERSITY of ARKANSAS
1871
1907-2007

Acoustics to Quantum Materials

A Centennial History of the Department of Physics, University of Arkansas

Rajendra Gupta

Professor Emeritus of Physics

and

Paul C. Sharrah

Late Professor Emeritus of Physics

Department of Physics, Fulbright College of Arts and Sciences

University of Arkansas in Fayetteville

2020

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Front cover: Images representing some of the research conducted in the physics department in 2008. Top (left to right): laser spectroscopy, biophysics, and quantum optics. Bottom: quantum materials.

Back cover: Photographs of some of the early research and instructional laboratories in the Physics Department. Clockwise from top right: physics instructional laboratory, 1892; Dr. Ham in his acoustics laboratory; atomic physics and electronics instructional laboratory; control panel for an accelerator in Dr. Hughes's laboratory; Dr. Sharrah next to the electronics panel for Philips x-ray machine; and Dr. Hughes's isotope shift measurement apparatus.

This book is dedicated to all the faculty who came before us, especially the department leaders who, in spite of crushing teaching loads and poor resources, built this department to what it is today. And to all the students, past and present, because after all, they are the ones we are here for.

In Memoriam



Paul C. Sharrah (1914–1996)
A dedicated teacher, researcher, and foundational department leader. And beyond that, a beloved colleague and friend.

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Preface

The Physics Department celebrated its centennial in April 2008. The project to write a centennial history of the department began a year or so prior to that. A previous history of the department, *Physics at Arkansas*, had been written by my colleague and friend, the late Professor Emeritus Paul C. Sharrah, in 1994. My initial thought was to revise that history and to update it to include the 1994–2008 period. I also wanted to consult and cite primary sources as much as possible. Going to the primary sources was a very rewarding process as I discovered many things previously unknown to me. Among the sources I consulted were minutes of the University of Arkansas board meetings during the early 1900s, when the department was established; university catalogs from 1871 to the present; university budget reports; the special collections of the university library and museum; and of course, department reports, memoranda, and other records.

As the project moved forward, it became clear that it was impossible to include this material within the structure of Sharrah's book. The initial goal of updating and supplementing *Physics at Arkansas* was abandoned, and I decided to write a new history informed by Sharrah's work. Paul was among the early leaders who helped build this department, and much of his history is his eye-witness account from 1942 to 1994. Given the crucial role of Sharrah's writing in inspiring and informing my own, I am honored to credit him as coauthor.

The structure of this book is as follows: chapter 1 starts with 1907 when the Physics Department was formed, and the following two chapters describe the evolution of the department in its formative decades. Thereafter, the history is described topic by topic, concluding with chapter 17 describing the Centennial Celebrations in 2008. The department could not have been established in a vacuum, and therefore two prologues have been added. Prologue I describes the founding of the university in 1871, and prologue II describes the instruction of physics from 1872 to 1907, before the first full-time physics instructor was hired. An epilogue has been added to cover the important developments from 2008 to 2018, when this book was being written. I have tried to make each chapter self-contained, which has resulted in some repetitions between chapters. My apologies to those who may find this tiresome. Many important subjects could not neatly fit into the structure of the main body of the book and have been placed in appendices.

This project would not have been possible without the initial support and encouragement of Surendra Singh, the department chair when I started collecting material for this project prior to 2008. Before my retirement in 2010 Singh established a university account to fund this project, and as the project progressed slowly through the years, the fund provided me the assurance that the work would be published, at least in some limited form. I am grateful that I have enjoyed the continued support of the subsequent chairs, Julio Gea-Banacloche and William Oliver III.

While researching this project I came to better appreciate the tremendous contributions of those who made this department what it is today. I have not hesitated in giving credit to individuals by name where it is due, and with all humility, I have not made an exception for myself. The reader should realize, however, that no effort is necessarily an individual effort. In general, people build upon what others have done before them, and with the support of those around them. It should also be noted

that there are many individuals whose contributions have not been recognized either through personal ignorance, or because their contributions were not recorded within the available documents.

The department is very lucky to have inherited a vast collection of photographs taken or collected by Sharrah. He has provided the department with a very valuable resource, and these photographs are now kept in the department archives. If it is not known who took the picture, it is simply acknowledged in this book as "archived in the Physics Department."

My heartfelt thanks to all those who have contributed written material to this book, provided me with helpful information, and have taken the time to answer my questions. These include Surendra Singh, Donald Pederson, Stephen Day, William Oliver III, Claud Lacy, Rick Wise, Otto Zinke, Charles Richardson, Gay Stewart, Raymond Hughes, Michael Lieber, to name just a few. My thanks also to Surendra Singh, Reeta Vyas, and Usha Gupta for help in selecting the title of the book. In addition, many thanks to all my colleagues for providing their biographies and other information.

Many thanks to my editor, Jennifer Vos, for her meticulous editing and many helpful suggestions, and to Melissa Couch of Printing Services for her invaluable help in getting this book printed.

I am grateful to former chair Surendra Singh and current chair William Oliver III for providing the funds to make the publication of this book possible.

Last but not the least I thank my wife, Usha, for her understanding, especially when my preoccupation with this project prevented me from undertaking certain activities that she wished me to undertake.

Rajendra Gupta
Fayetteville, Arkansas
October 2020

ACOUSTICS TO QUANTUM MATERIALS

Prologue I

Beginnings of the University

"Then let me appeal to you . . . let not the light of knowledge be extinguished in your hands, but, on the contrary, build to it honorable temples and imperishable altars that it may descend like the unclouded sun, bright and glorious to your posterity."
— Archibald Yell[1]

Higher education in Arkansas had two beginnings. Before the Civil War, several academies and colleges were founded around the state, but most failed to survive the turmoil of the war. After the Civil War, efforts were undertaken to rebuild the educational system. It was during this second beginning, in 1871, that Arkansas's first university was founded. The university was first named Arkansas Industrial University (AIU) but later renamed the University of Arkansas.

Several abortive efforts were made to establish a university in the region as early as 1818 and later when Arkansas became a state in 1836, but this was the first successful attempt [Ref. 1-3].

Even though several private academies were operating, Arkansas had no public high schools. In 1870 the state's population of about 485,000 was almost entirely rural. Fayetteville had a population of 955, and there were only five cities in Arkansas with over one thousand residents.

Land-Grant Act Signed During Civil War

In 1862 President Lincoln signed federal land-grant legislation known as the Morrill Act into law to assist each state to establish at least one college. But at that time the War Between the States had torn the country asunder. The act was amended in 1866 to permit the reconstructed Southern states more time to take advantage of the land grants. The institution had to be in operation by February 12, 1872.

The post–Civil War government in Arkansas, military at first, was replaced by one dominated by "rank northerners." After several attempts, on March 27, 1871 this reconstruction government drew up and passed An Act for the Location, Organization and Maintenance of the Arkansas Industrial University with a Normal Department[1] Therein.

Classes Begin in January 1872

Later that same year, on October 16, the board of the AIU selected Washington County and Fayetteville as the site of the first university in Arkansas. The university's first building was completed in time for classes to begin on January 22, 1872 — just three weeks before the deadline set by the Morrill Act.

The involvement of the carpetbaggers, or outsiders, in the state government and university board received much criticism at the time. However, in retrospect, such concerns were probably unfounded. Examination of the early actions of the AIU

[1] Archibald Yell, the second governor of Arkansas, in his message to the legislature urging them to establish public institutions of learning, in 1839 (quoted in Ref. 1).

[1] In the language of that period, this meant preparing students for careers in teaching.

board as reflected in their minutes suggests a focused group of men making sound decisions, apparently free of political or partisan influences.

University Built on Mere Hope

When the university was founded it had many problems, not the least of which were its relative isolation due to difficult transportation issues (see below) and scarce funding. Noah P. Gates was named acting president, but the executive committee that oversaw the operation of the university was charged with finding a permanent appointee. This turned out to be a very difficult task. Reynolds and Thomas [Ref. 2, 108] state that "it was not an easy matter to secure a man of scholarship and ability who was willing to come into the woods and take control of a mere hope." Today, that "mere hope" has been transformed into a sprawling, major public institution of learning and scholarship.



Figure 1: The building on the right, completed in January of 1872, was the first classroom building at the university. The building on the left was constructed in the summer of 1872 and expanded in the summer of 1873. These were the only classroom buildings until Old Main was occupied in 1875. *Photo courtesy of the University of Arkansas Libraries, Digital Collections.*

University Hall Planned and Built

The university started in two makeshift two-story buildings hastily built in 1871 and 1872, the latter expanded in the summer of 1873, which are shown in figure 1. These buildings were located where the university library is currently. All classes were held in these buildings until 1875 [Ref. 5].

Plans to establish a permanent building started immediately, led by a building committee consisting of three members of the board of trustees. According to Robert A. Leflar [Ref. 3, 14–15], newspaper advertisements were placed in 1872 asking



Figure 2: Etching of University Hall that was published in the catalogue of 1872–73.

for architectural plans for a building in the range of $85,000–$120,000 and the "eastern slopes of the McIlroy farm, facing the northern residential section of the town" was considered to be an ideal site. Plans submitted by the firm of McKay and Helmle of Helena, Arkansas were initially accepted, but ultimately unsuccessful. The board had been impressed by the Main Building at the University of Illinois at Urbana-Champaign, which they had visited in 1871. "The vision of this majestic structure overlooking the Ozark hills and valleys was an appealing one, and when the board members were told that it could be erected at no greater cost than the drab building proposed by McKay and Helmle they changed their minds and de-

cided to try to make the vision a reality" [Ref. 1]. The original plans for the Illinois building had been destroyed in the Great Chicago Fire of 1871, but copies existed. The board agreed to pay $1,000 for the right to use them. An etching of the proposed building was published in the *First Report of the Arkansas Industrial University*, which was published in August 1873 together with the *Catalogue of 1872–73 and Circular for 1873–74* and is reproduced in figure 2.

The permanent building called University Hall (now called Old Main), built at a cost of $135,247, was completed and accepted by the university on September 8, 1875 [Ref. 2, 103]. A photograph of the cornerstone located near the east entrance of the University Hall is shown in figure 3. Only the first and second floors were completed, as that was all the space required then, and the basement and top two floors were completed later as the need for space grew.

Transportation Problems

Transportation to and from Fayetteville was difficult and slow. The three-man subcommittee of the newly established board of trustees visited Batesville and later Washington County in September 1871. The trip to Washington County was difficult but certainly must have been an interesting experience for the committee. They traveled by rail from Little Rock to the site of Morrilton, by steamboat to Van Buren, and then by stagecoach to Fayetteville. The return trip was by stagecoach to Missouri, and by rail to St. Louis and Little Rock.

Noah P. Gates, then the first president of the university, is credited with having personally initiated the search for a proper location for a railroad in Fayetteville. His final choice was essentially where the Frisco line was built.

June 8, 1881 was a big day for the students and the university, as the first Frisco train entered Fayetteville from the north. It was so important that the students were actually permitted to go to the railroad station to witness the event: "It was some time before Frisco trains could run to Van Buren and there connect with the Little Rock and Fort Smith Railroad, but the worst of Fayetteville's transportation difficulties were ended" [Ref. 3, 44].

Changing College Curricula

College curricula were changing throughout the country during the university's beginnings. During most of the nineteenth century, curriculum in American schools and colleges consisted of large bodies of subject matter such as natural philosophy, moral philosophy, and belles-lettres. Toward the end of the century, most subject matter was being divided into more

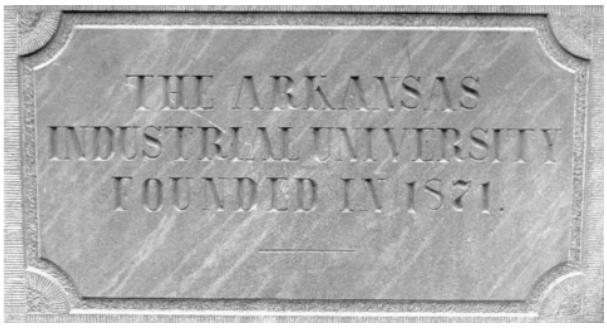


Figure 3: Cornerstone of the University Hall located at the building's southeast corner.

specialized fields. Natural philosophy proliferated into such sciences as physics, chemistry, biology, and geology. Moral philosophy subdivided into political science, economics, sociology, and anthropology. The study of belles-lettres became the study of poetry, drama, and the novel.

There was, at the same time, another influence on college curricula — America was becoming a vast agricultural and industrial nation. The public, through federal and state legislative bodies, were demanding more emphasis on agriculture and mechanics in education. The Morrill Act, the provisions of which were accepted by the state, embodied these demands

in its purposes. The university's original name, Arkansas Industrial University, also denoted the intention to emphasize the mechanic arts.

However, a faculty that was itself taught from the old curricula was slow to change. The influence of classical studies remained. Not manual, but intellectual instruction was the paramount intent of the land-grant thrust as Morrill, its author, later said. It was not intended that agricultural labor in the field be taught as a subject. A more liberal education that included the old curricula would form the basis for a theoretical and intellectual approach to agriculture and industry.

This new direction toward agriculture and industry gave a new importance to scientific study, which, of course, included physics.

There were only preparatory students that first semester ending June 28, 1872, and the preparatory department continued to function as a major activity until 1911. During these early years, the preparatory school was the source of a large portion of those who were permitted to engage in regular college-level work.

As late as 1901, there were only twenty-six accredited high schools in Arkansas providing unconditional admission to the university.

Leflar [Ref. 3] states it clearly: "The University had been started, as it had to be if it were to be established at all, as a slightly glorified high school, or public academy."

A disproportionate number of the preparatory students and college level students were from the Fayetteville area in the early years. One report tried to explain this high percentage of students from Fayetteville by pointing out that in many cases the family had indeed moved to the area so that their children could attend the new school. But there were other reasons and among them certainly was the relative remoteness of Fayetteville.

Tenuous Faculty Tenure

Another factor that held back the growth and development of the new institution was the practice of appointing teachers for only one term at a time. More than once the chairs were all vacated. Lack of funds was always a problem, and at least once the faculty was hired back the next year at a lower salary.

There were frequent disagreements between the faculty and the president, and it was several decades before the duties of the president and the board were adequately defined. One resolution passed by the board of trustees in 1882 sought to strengthen the position of the president. A second resolution passed at that same meeting upon the recommendation of General D. H. Hill, the third president of the university, sought to define the duties of the board and the faculty. This second resolution sought to establish a more professional situation for the faculty — an interesting fact considering that President Hill and a strong segment of the faculty were very much at odds at that time.

Moreover, a short-lived anti-intellectual movement held forth both in the legislature and the board of trustees in the late 1880s. "The demand was for decreased emphasis on the classics and literature at the University, and more attention to agriculture and the mechanical arts." [Ref. 3, 25]. While engineering studies prospered fairly well even from the early days, it seems that agricultural studies generally were not very popular in institutions of higher learning at that time. Local sketches of cities and factories are more often found in student publications of the time than sketches of farms and farm life. Apparently, most of the young men attending university looked upon higher education as a way to get away from the farm.

To encourage agricultural study all male students were required to work three hours per

day, and a better wage scale was set up for agriculture students. Agriculture students were paid ten cents an hour, compared to five cents for engineering students and three cents for arts and science students. Furthermore, agriculture students were given preference for living in the newly opened Buchanan Hall dormitory. Even these incentives did not increase the agriculture enrollment much [Ref. 3, 25].

Women

The university started as a coeducational institution, and indeed several women were among the first graduating class of 1876. However, a "principal faculty effort in the early days was to keep the boys and girls apart." Both boys and girls wore prescribed uniforms, and for girls "fabrics such as silks and satins" were not to be tolerated [Ref. 3].

Black Students

Although the university was technically open to black students when it was founded, it was in theory only. A fascinating account of this is given by Robert Leflar [Ref. 3], who has devoted an entire chapter to this topic.

Early Survival and Successes

It seems miraculous that the new school survived at all in view of the many problems it faced. It is clear that most of the teachers were doing a creditable job in spite of the problems. Several of the teachers went on to have interesting and successful careers elsewhere.

The first graduating class of 1875 was that of the Normal School, and their group photograph is shown in figure 4. The Normal School students had completed their courses of study and graduated, but no degrees were awarded to



Figure 4: Graduating normal class of 1875. Front row left to right: Olive Carson, Emma Bridgeford, Anna Putnam, Laura Botefuhr. Back row left to right: W. J. Waggener, Belle L. Gorton, Lizzie Davis, Charles McKinney, Eva McCart. Waggener is in Civil War Uniform with hat and sword in scabbard. ***Photo and caption courtesy of University of Arkansas, Fayetteville, Museum Collections. Caption edited for brevity.***

them [Ref. 4]. The Bachelor of Arts (Classical Studies) students studied for an additional year and received their degrees in 1876, and their names are shown in figure 5, as etched into the entrance to Old Main. [2] Two among the graduating class of 1876, Belle Gorton and William J. Waggener, had also graduated in the Normal Class of 1875.

This fledgling university, even while in its formative years and in spite of hardships and uncertainties, managed to produce leaders in a variety of fields. One exciting example from the standpoint of physics is William J. Waggener, the first graduate of the University in 1876, who went on to become the first physicist on the faculty, and the founder of, the Department of Physics at the University of Colorado, Boulder.



Figure 5: Steps to the east entrance of Old Main with names of the first graduating class of 1876. This list of nine is in conflict with Ref. 4 (see footnote 2).

[2] William Waggener, in the introduction to Ref. 4, gives the names of six students who received the AB degrees (Classical Studies) at the graduation ceremonies on June 15, 1876: Belle Gorton, Alfred Gregg, Agnes Harris, Sara Harris, Albert Johnson, and William Waggener. He was quite clear that these were the only students in the first graduating class and that the university records were incorrect. A possible resolution of this discrepancy can be found in an article from *Arkansas Alumnus* 15, no. 8 (April, 1938).

The University's First Graduate

Physicist and Founder of the University of Colorado Department of Physics

William J. Waggener, a student who received a bachelor of arts diploma in the first graduating class of 1876, went on to ultimately become the first physics professor at the University of Colorado, Boulder. Records available at Colorado indicate that during the period of 1885 to 1898, William J. Waggener was variously listed as a professor of natural sciences, natural philosophy, and physics and astronomy. He is credited with having inaugurated the university's Department of Physics. Much valuable information about him is available in *A History of the Department of Physics of the University of Colorado* by Albert Bartlett and Jack Kraushaar.[1]

The class of 1876, by a vote, had elected Waggener the class poet and class prophet. In this capacity, he wrote and read an original composition to the graduating class, the faculty, and the attending public on June 15, 1876. That long poem, after some revisions, was published in the form of a booklet [2] [Ref. 4]. In the introduction of this poem he describes the commencement ceremonies and reports that he was the first to receive his degree, as "there was no ranking of graduates," making him the first graduate of this institution. Waggener's diploma, dated June 10, 1876, is now archived in the University of Arkansas Museum Collections.[3] He served as a tutor for a year after graduation.

The early catalogs list the students in attendance at the university, along with their home-towns. Waggener was shown to have lived in Farmington, just west of Fayetteville. He was born in Lewis County, in northeast Missouri, near Monticello, on August 17, 1855.



Figure 1: William J. Waggener while he was a student at the Arkansas Industrial University. Undated. *Photo courtesy of the University of Arkansas, Fayetteville, Museum Collections.*

Waggener wrote a letter to Mrs. Marie Gates Southworth, daughter of President Gates, in 1909. Noah P. Gates was the first president of the Arkansas Industrial University (AIU). In this long letter he reflects upon his years at the AIU[4] [Ref. 5]. The following description, based on this letter, is both relevant and interesting. He had not enrolled in the University until March 1872. He points out that the only apparatus during the first year were blackboards and a set of geographical wall maps. The first apparatus for chemical laboratory work was provided in his

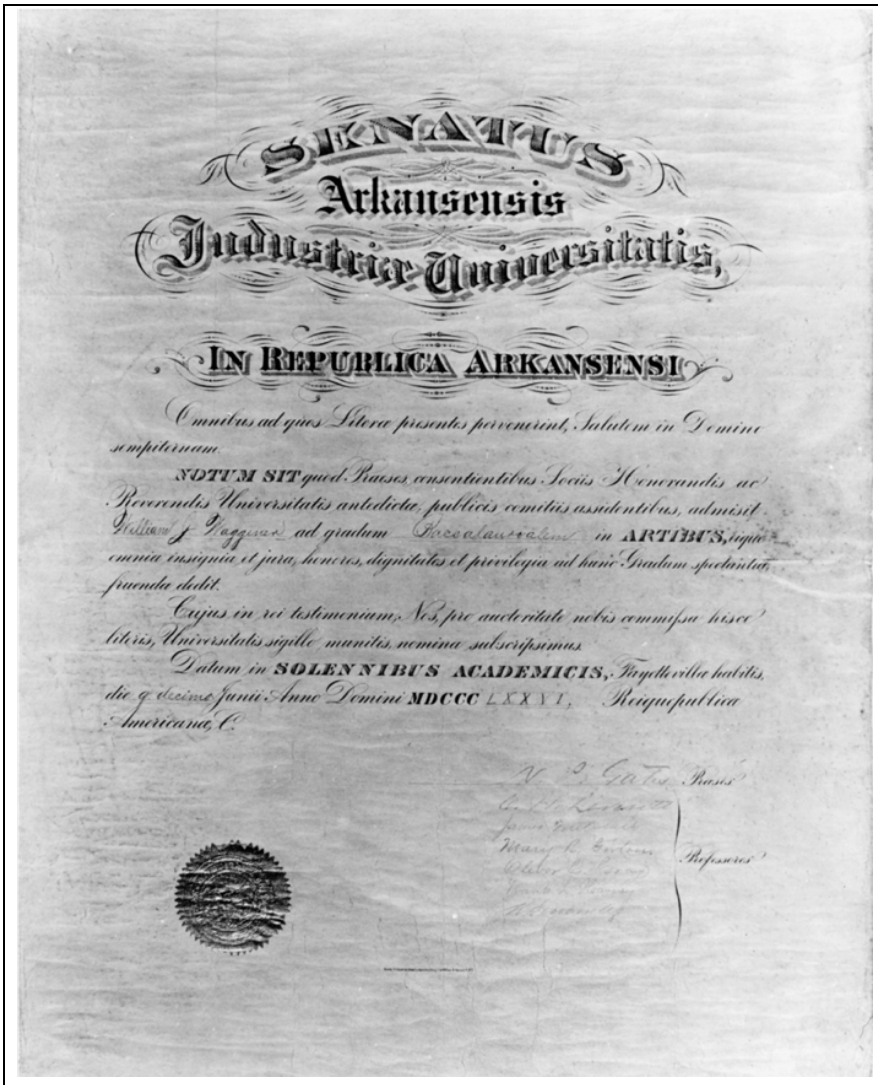

SENATUS
Arkansensis
Industriæ Universitatis,
IN REPUBLICA ARKANSENSI
Omnibus ad quos Litera presentes pervenerint, Salutem in Domino sempiternam.
NOTUM SIT quod Præses consentientibus Sociis Honorandis ac Reverendis Universitatis antedictæ publicis comitiis assidentibus, admisit William J. Waggener ad gradum Baccalaureatus in ARTIBUS, cujus omnia insignia et jura, honores, dignitates et privilegia ad hunc Gradum spectantia, fruenda dedit.
Cujus in rei testimonium, Nos, pro auctoritate nobis commissa hasce literas, Universitatis sigillo munitas, nomina subscripsimus.
Datum in SOLENNIBUS ACADEMICIS, Fayetteville habitis, die quindecimo Junii Anno Domini MDCCC LXXVI, Reipublicæ Americanæ C.

Figure 2: William J. Waggener's diploma, the first awarded by the Arkansas Industrial University. ***Photo courtesy of the University of Arkansas, Fayetteville, Museum Collections.***

third year (1873–74), when Professor Thompson came to the university to instruct the first class in chemistry. Professor Thomson also taught physics for one and a half years, and Waggener stated: "but there was at that time no physical apparatus," and, "In fact there was no regular apparatus for physics until the fifth year (1875–76) when Professor F. L. Harvey came to the Professorship of chemistry made vacant by Professor Thompson's death. He added a considerable number of physical instruments, among which I recall, the air-pump and its accessories, a Holtz electro-static machine, a galvanic battery, etc."

He goes on to say that the lack of background on the part of the students handi-capped the early university as seriously as the need for apparatus, a library, and more faculty members. The state had not recovered from the destructive effects of the Civil War, and even before the Civil War, "it was still but a new community — almost a frontier state." Because of poor transpor-tation facilities, the people of the state were little in touch with the wider world, and the public school system was poorly organized.

"Under these circum-stances," he wrote, "a body of students adequately prepared to enter a college course was not possible; nor could this preparation, either at the outset or many years there-after, be made in the state, except at the University itself: herein lay perhaps the heaviest task of the pioneer teachers at the University."

Because of these conditions, the first fractional year was devoted wholly to preparatory work. At times the entire student body was assembled for review of fundamental courses. Debates and extemporaneous discussions were held at some of the meetings. Out of these lessons "grew the first literary and debating society in the University. It was formed during the first year and started chiefly under the guidance of Miss Gorton, but with much helpful advice and kindly

criticism for President Gates also." Commenting on the student body, Waggener states that among the students were those who were the "seekers of the early fountain of knowledge" and formed the first graduating class.

Bartlett and Kraushaar have pieced together a great deal of information from available public sources about Waggener's activities after he left AIU in 1877 and have given an excellent account in their book. Noteworthy among these is that he was principal of the Del Norte Public Schools in Colorado for a brief period before he resigned in 1885.

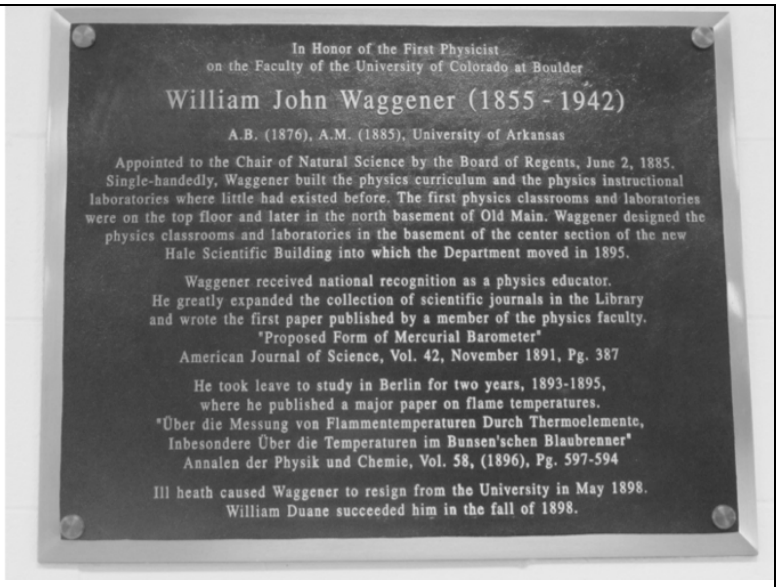
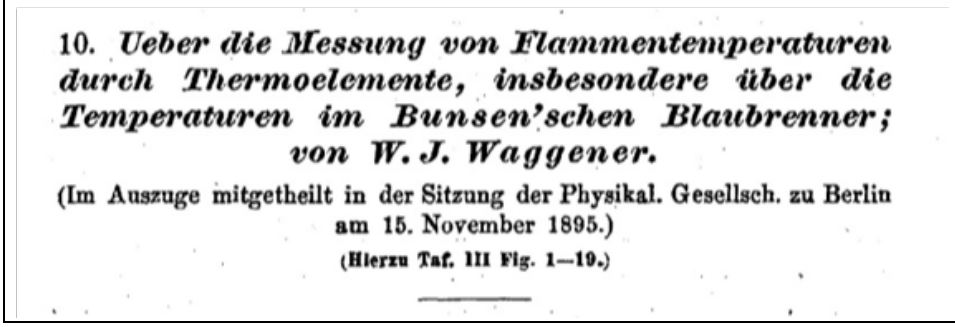


Figure 3: The plaque in honor of Professor Waggener in the lobby of Duane Physical Laboratories. *Photo courtesy of Reeta Vyas and Surendra Singh.*

Waggener returned to the university for a master's degree in 1885.[5] This is puzzling because AIU had no advanced courses in physics at that time, and Waggener was mostly in Colorado prior to the award of the degree in 1885. Perhaps the explanation is the fact that the 1885 catalog describes this degree as "honorary." One also wonders as to where he learned his advanced physics. It must have been self-taught.

In 1885, Waggener was appointed professor of physical sciences at the University of Colorado, Boulder. "The arrival of Professor Waggener in the Fall of 1885 marks the real start of physics at the University of Colorado."[6] He was to remain at the University of Colorado until 1898, when ill health forced him to resign. Bartlett and Kraushaar have chronicled Waggener's contributions to the University of Colorado in detail and state that "almost single handedly he built a Department of Physics where none had existed before. There must have been many elements of frustration in this tremendous task," and "he was vigorous in his devotion to teaching both physics and astronomy." Professor Waggener's contributions to the University of Colorado are so varied and important that Bartlett and Kraushaar have devoted 102 pages to him and his contributions. A plaque has been installed in honor of Professor Waggener in the lobby of Duane Physical Laboratories, University of Colorado, which is shown here. The department that he started can today be counted among the very best in the country, with several of the recent physics Nobel Prizes going to it.


10. ***Ueber die Messung von Flammentemperaturen durch Thermoelemente, insbesondere über die Temperaturen im Bunsen'schen Blaubrenner; von W. J. Waggener.***

(Im Auszuge mitgetheilt in der Sitzung der Physikal. Gesellsch. zu Berlin am 15. November 1895.)

(Hierzu Taf. III Fig. 1—19.)

Waggener was very interested in the development and construction of new scientific equipment, some of which was still in use in Colorado as late as 1942. These

included a tangent galvanometer, a self-evacuating barometer, a two-mirror heliostat, and a telescope.[7] In 1891 he published a paper entitled "Proposed Form of Mercurial Barometer" in the *American Journal of Science*, 42, 387–388 (1891). This is believed to be the first paper published by the faculty of the Department of Physics of the University of Colorado.[8]

In a questionnaire that Waggener filled out for the Alumni Association of the University of Arkansas in January 1938, he mentions one term of further studies at Iowa State College, Ames, and one term of special graduate studies at Clark University in Massachusetts. It is uncertain when he carried out these studies.

From 1893 to 1895, Waggener took a leave of absence to take up special studies at the Frederick Wilhelms Universitat in Berlin, Prussia. The famous teachers there from whom he had the privilege of learning or taking courses were Max Planck, professor of theoretical physics, H. von Helmholtz, famous pioneer in the natural sciences and the science of sound, and L. Fuchs, a professor of mathematics. Bartlett and Kaushaar state that "his studies in Berlin show that he knew where the great scientific work of the day was being done. His work in Berlin indicates a high degree of competence in contemporary experimental physics," and that "one suspects that one of his goals in going to study in Germany was to earn a PhD. But the doctoral degree somehow eluded him."

He published a paper entitled "Ueber die Messung von Flammentempeturen durch Thermoelemente, insbesondere uber die Tempeturen im Bunsen'schen Blaubrenner" in *Annalen der Physik* 294, 579–594 (1896).[9] His author affiliation is listed as Physikalisches Institute, Berlin.

Apparently, his work was considered important by his contemporaries. For example, he had some correspondence in 1901 with Edward L. Nichols of Cornell University, the first editor in chief of *Physical Review*, who was engaged in similar work, about this paper. It may be of interest to note that the very next article to Waggener's in this journal was by Ludwig Boltzmann. When he retired from the University of Colorado in 1898, *Silver and Gold*[10] (May 20, 1898) paid a glowing tribute to him and wrote, among other things, that "as a teacher and instructor, as a mathematician and physical scientist, Professor Waggener ranks among the first rank; as a scholar and as a man he is equaled by few."

Sometime after leaving the University of Colorado, Waggener moved to California. There he pursued his life-long interest in the invention and fabrication of scientific instruments. In his letter to Mrs. Southworth[11] he reported that he

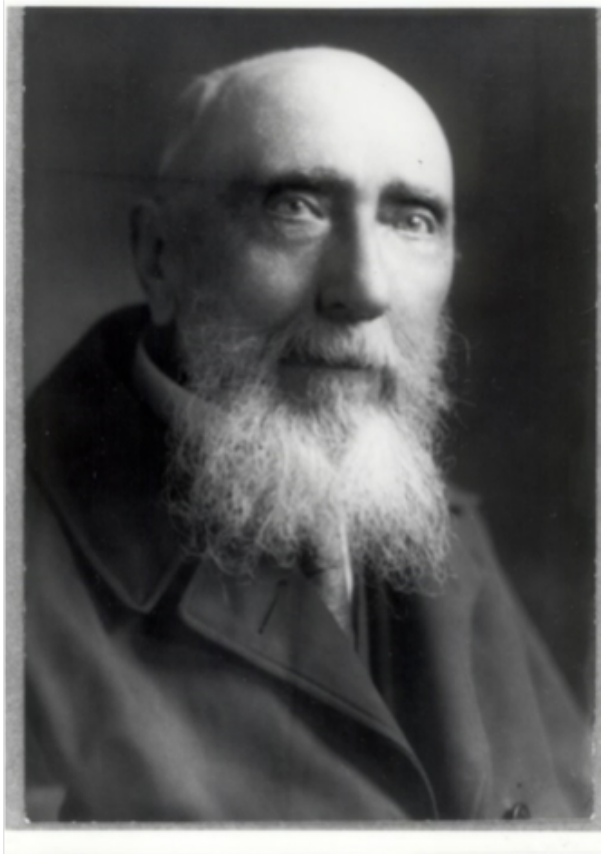


Figure 4: William Waggener. Undated, *Arkansas Alumnus*, April 1938.

built a tellurian (a model of the earth, moon and

sun system) before he entered the university in Fayetteville and that this homemade device was displayed in one of his classes in the university. As noted above, while at the University of Colorado, he developed and built physics apparatus for instruction and even published one of his inventions. His development of "contrivances" for teaching was of sufficient importance that he was requested to develop a display for the World's Columbian Exposition in 1893 in Chicago. [12] The *Arkansas Alumnus* (1938) [13] reported that since leaving the University of Colorado, "he has devoted his studies to the invention, design and construction of scientific instruments and mechanical devices for special purposes."

He died in Los Angeles on January 16, 1942 at the age of 86.

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[1] Albert A. Bartlett and Jack J. Kraushaar, *A History of the Department of Physics of the University of Colorado* (Department of Physics, University of Colorado at Boulder, 2002). A copy of this book is available in the University of Arkansas Physics Archives.

[2] Ref. 4. Special Collections, University of Arkansas (MC740). A copy of the first few pages of this booklet is available in the University of Arkansas Physics Archives.

[3] The diploma contains the names of President Noah P. Gates (philosophy), C. H. Leverett (language, English, history), James Mitchell (history, English literature), Mary C. Gorton (principal of the Preparatory Department, English, literature, mathematics), Oliver C. Gray (mathematics, civil engineering) and Frank L. Harvey (natural science, chemistry). A copy of the diploma is in the University of Arkansas Physics Archives.

[4] Ref. 5. Waggener wrote this twenty-two-page letter over a period of eight days because his ill health did not allow him to work any harder. This letter is now housed in the Special Collections department of the University of Arkansas Libraries (MC 737). A copy is available in the Physics Archives.

[5] *Arkansas Alumnus*, April 1938.

[6] Bartlett and Kraushaar *A History of the Department of Physics of the University of Colorado*.

[7] Ibid.

[8] Ibid.

[9] The English translation is: "On the Measurement of Flame Temperature by Means of Thermal Elements, in Particular, in Bunsen's Blue Burner." The paper was also presented to the Physical Society of Berlin, on November 15, 1895. One should note that the same article has been referenced in Reference 1 above as *Weidemann's Annalen der Physik und Chemie* 58, 579–594 (1896). Apparently, the two journals were merged for a while. A copy of the paper is available in the Physics Archives.

[10] A University of Colorado faculty and staff newspaper.

[11] Ref. 5.

[12] Bartlett and Kraushaar, *A History of the Department of Physics of the University of Colorado*.

[13] *Arkansas Alumnus*, April 1938.

Later Problems

A 1921 report by a committee named by the US Commissioner of Education (at the request of the Arkansas General Assembly) criticized the university in almost every aspect of its work. The faculty and the procedures used to select the faculty were about the only recipients of any complimentary statements. This candid report certainly did not make comfortable reading for, or build up the ego of, the university leaders, but in the long run it may have helped the university to move in a more constructive direction.

Certain other problems stalled progress in the earlier days. More than once there was an attempt to move the university from Fayetteville to Little Rock. At one time in 1933, a suggestion was even made to remove the faculty members who were "foreigners of the rankest kind" and the "rank northerners." [Ref. 3, 97–98]. One of these "rank foreigners" had been teaching languages at the university for quite a few years and continued for several more.

As late as the 1940s, some at the university were still saying that we could only go one way, and that way was up! It was true that while a rather successful undergraduate program had been developed, graduate teaching and research activities still had a long way to go.

Finally, in a powerful effort made in 1949 under the presidency of Lewis Webster Jones, it was determined that it was time to move ahead and develop doctoral programs within the graduate school. The departments, as a starter, were to offer a better selection of advanced undergraduate courses as deemed appropriate. The Department of Physics was approved for a doctoral program in 1959.

The development of the graduate program and other dynamic steps taken since 1949, including the honors program and the general education program, have placed the University of Arkansas in a much more visible and honorable position among the universities of the nation.

Embedded in the history of the university is the history of the Department of Physics, which is what will be explored in this book. Although physics and astronomy were taught as subjects from the very beginning of the university, the Physics Department was not formed until 1907.

Prologue II

Physics Instruction in the First Thirty-Five Years of the University

1872–1907

Physics in the Early Years

- **1871–80** First taught as part of a natural philosophy course
- **1880–85** Placed with Chemistry
- **1885** Taught by a professor of applied mathematics
- **1887** Transferred to the Department of Biology and Geology
- **1888** Transferred to the Department of Mechanic Arts and Engineering
- **1890–1904** Again placed with Chemistry
- **1904** Became part of the Department of Electrical Engineering and Physics

The first university classes began in January 1872, but the first catalog, *Catalogue for 1871–72 and Circular for 1872–73,* was not published until later that year. The title page of the catalog is shown in figure 1. We have derived information about the instruction of physics in the first thirty-five years of the university almost exclusively from the catalogs,[1] except when another source is explicitly cited. During this period, the curriculum was still being developed, and the departments and colleges were still being formed. It appears that the administration was having difficulty in placing the instruction of physics. Therefore, even though it is a bit cumbersome, we have described physics instruction year by year, where necessary, using the catalog years. These thirty-five years have been divided into five periods for organizational convenience.

A. The Early Period: 1871 to 1880

Catalogue for 1871–72

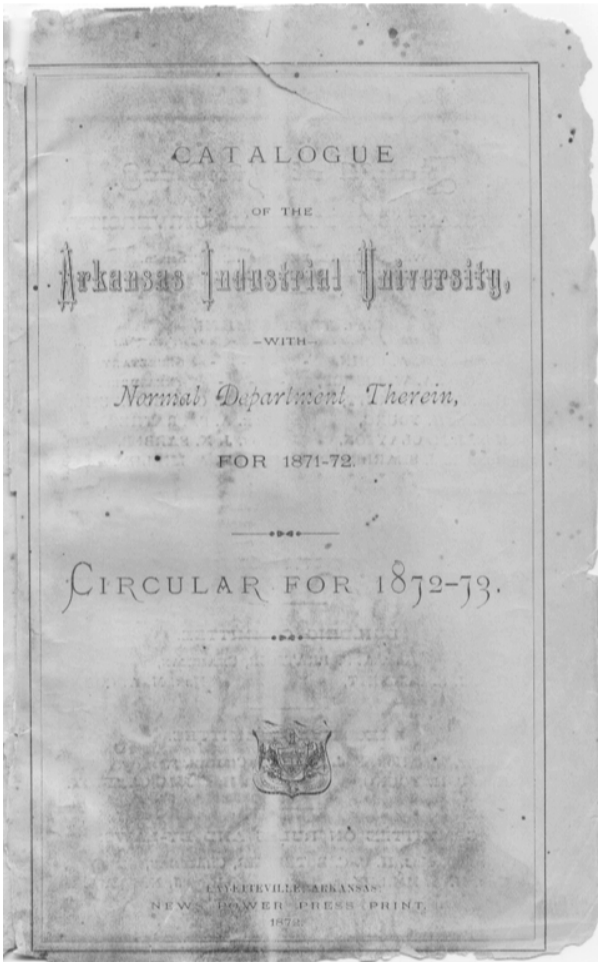
There was only one course of study, called the General Course, and the course offerings are shown in figures 2 and 3. We note that a course on natural philosophy is listed in the first and second terms of the freshman year, which presumably included physics, but it is not clear whether it included chemistry and astronomy because courses in those subjects are listed

[1] In interpreting these catalogs, we need to keep in mind that this scheme of using the term *catalogue* for the previous academic year and *circular*, *announcement*, or *calendar* for the coming year continued for this entire period. The catalogue described what happened during that academic year, including the names of the students who had graduated, and the circular described the listings of the courses to be offered the following academic year. For the sake of consistency and brevity, we only use the catalogue years here. Also note that at this time the university was on a trimester system.

separately. Physics and astronomy were frequently listed under the heading of natural philosophy in the 1800s, as physics was just being recognized as a separate subject. For historical context, note that it was in the late 1880s that the first building in the United States specifically designated for physics was constructed at Harvard. *Physical Review*, the first major physics journal in the United States, began publishing in 1893.

Catalogues for 1872–73 and 1874–75: Early Colleges Emerge

For the first time we see three different courses of study being defined, functioning as early versions of colleges: A Classical Course, a Course in Agriculture, and a Course in Engineering. The Classical Course still included a course on natural philosophy, now for only one term in the second term of the freshman year. However, there was much more study of chemistry, botany, and zoology. There was a course on astronomy, and mathematics consisted only of algebra and geometry.


CATALOGUE

OF THE

Arkansas Industrial University,

—WITH—

Normal Department Therein,

FOR 1871-72.

CIRCULAR FOR 1872-73.

FAYETTEVILLE, ARKANSAS:
NEW POWER PRESS PRINT.
1872.

Figure 1: The title page of the first catalogue of the university.

The Course in Engineering, on the other hand, did include two terms of physics in addition to the Natural Philosophy course, but this state only lasted for these two years. In addition, there were several mathematics and physics related courses: Astronomy, Theoretical Mechanics, Applied Mechanics, Theory of Mechanics, Theory of Motors, Plane and Spherical Trigonometry, Analytical Geometry, and Calculus.

Catalogues for 1875–76 and 1876–77: Colleges Defined

For the first time we see mention of the College of Engineering and College of Commerce in the 1875–76 catalogue.

The Classical Course still had one term each of Natural Philosophy and Astronomy, but engineering had now dropped physics altogether. This may have been done to make room for "real engineering" courses, such as Bridges and Roofs, Heat and Ventilation, Construction and Management of Railroads, Steam Engines, Hydraulic Motors, and so on. The only physics instruction that the engineering students received was two terms of Natural Philosophy. This continued for several years. We can presume that the same course in natural philosophy was taken both by engineering and by students of the classical course. We do not have definite information on who these courses were taught by, but perhaps the teachers were engineering or chemistry faculty. A rare insight into the instruction of physics during these early years of the university can be found in the comments of

William Waggener, the first graduate of the university (see prologue I).

The 1876–77 catalogue is almost the same, except that the classical course now required two terms of natural philosophy. A lot was in flux.

Catalogues for 1877–78 through 1879–80: Departments Formed

Now we note that Natural Philosophy was postponed until the senior year both in the Classical Course and in the Course in Engineering. Moreover, the former included two terms of Natural Philosophy while the latter included three.

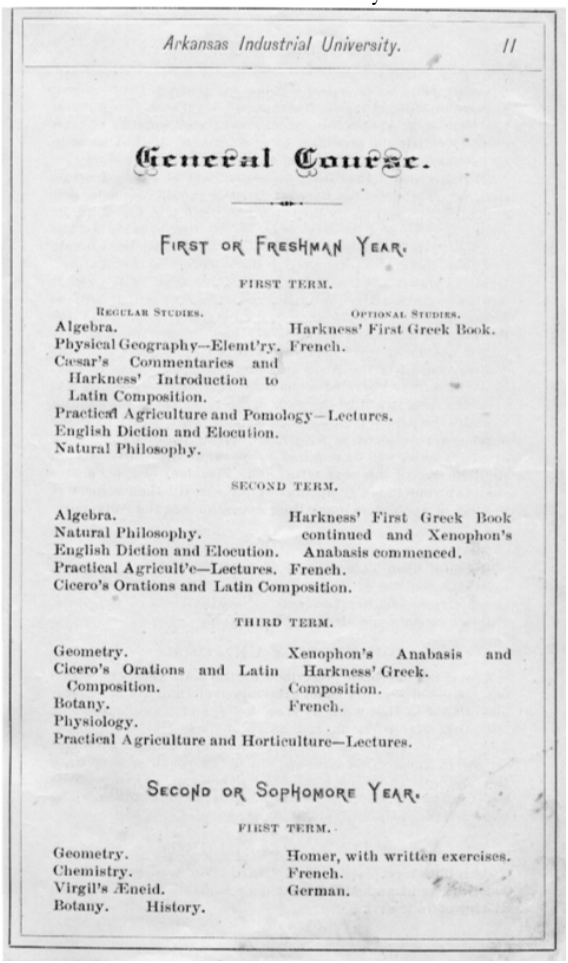
At this time departments were beginning to be formed, even though many had a faculty of one person. We see a Department of Languages, but most of the other subjects were just listed individually. For example, Pure Mathematics was listed under Professor Gray, Chemistry under Professor Harvey, and Natural Philosophy under Professor J. B. Gordon, who was the professor of mathematics and civil and mechanical engineering.

In the 1877–78 catalogue, for the first time, we find a description of the Natural Philosophy course,[2] so we reproduce it here:

> This subject embraces Physics, Mechanics and Astronomy, and is postponed to the senior year in order that the student may have the light of higher mathematics in investigating some of the problems presented.
>
> The class has three recitations per week in Physics and Mechanics, and two in Astronomy, throughout the session of nine months. Mechanics will be treated in the early part of the course along with Molar Physics. After the doctrines of motion force and energy and their applications have been discussed, the student has his attention invited to molecular physics, or the consideration of Sound, Heat, Light, Electricity and Magnetism.

Textbooks are listed: Everett's *Privat Deschauel*, Peck's *Mechanics*, Norton's *Astronomy*, and Searle's *Outline of Astronomy*. Additionally, notes were given "on points where it is deemed advisable."

It not clear whether this course description continued for the next two years or who its



Arkansas Industrial University. 11

General Course.

FIRST OR FRESHMAN YEAR.

FIRST TERM.

Regular Studies.	Optional Studies.
Algebra.	Harkness' First Greek Book.
Physical Geography—Elemt'ry.	French.
Cæsar's Commentaries and Harkness' Introduction to Latin Composition.	
Practical Agriculture and Pomology—Lectures.	
English Diction and Elocution.	
Natural Philosophy.	

SECOND TERM.

Algebra.	Harkness' First Greek Book continued and Xenophon's Anabasis commenced.
Natural Philosophy.	
English Diction and Elocution.	
Practical Agricult'e—Lectures.	French.
Cicero's Orations and Latin Composition.	

THIRD TERM.

Geometry.	Xenophon's Anabasis and Harkness' Greek.
Cicero's Orations and Latin Composition.	
Botany.	French.
Physiology.	
Practical Agriculture and Horticulture—Lectures.	

SECOND OR SOPHOMORE YEAR.

FIRST TERM.

Geometry.	Homer, with written exercises.
Chemistry.	French.
Virgil's Æneid.	German.
Botany. History.	

Figure 2: First page of the course listings in the 1871–72 catalogue.

[2] To put the instruction of physics here in perspective, Maxwell's work on electromagnetism was carried out between 1864 and 1873 (see, for example, Isaac Asimov, *Asimov's Biographical Encyclopedia of Science and Technology* (New York: Doubleday, 1982)). So, Maxwell had completed his work on what is now known as Maxwell's Equations. Of course, modern physics was yet to be established since the electron, radioactivity, and x-rays had not yet been discovered.

teachers were, because the catalogs have no information on Natural Philosophy. But it appears that the teachers were Professors F. L. Harvey and C. P. Conrad, both of chemistry [Ref. 2].

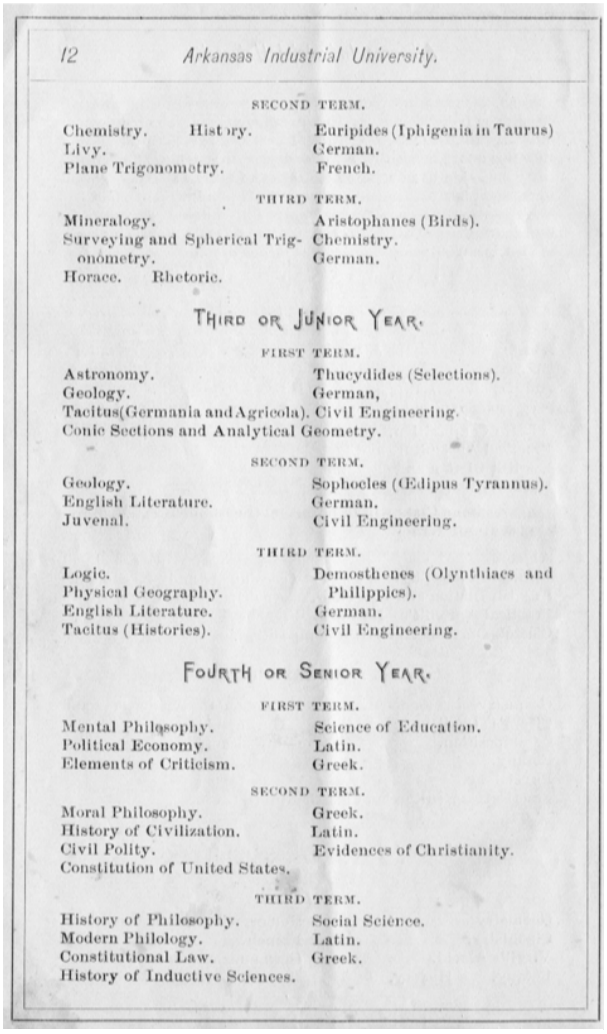
B. Physics Placed with Chemistry: 1880–1884

Catalogues from 1880–81 to 1883–84

Now, for the first time, physics and chemistry were listed together under the title Physics and Chemistry. Each had their own subtitle, and Professor Conrad was the sole instructor for both.

Under the physics subtitle we find the following description:

> PHYSICS. — The Freshman Class studies *Elementary Physics* during the first two terms. The course embraces the groundwork of future scientific study and gives correct ideas upon common phenomena in everyday life. Additional apparatus has just been purchased, and subjects will be fully illustrated. *Text Books.* — Wells, (new edition), Notes and Problems.
>
> The Senior Class studies *Advanced Physics* during two terms. *Text Books.* — Ganot's Physics; Notes and Problems. Special treatises will be recommended upon Acoustics, Optics, and Electricity.
>
> ASTRONOMY. — The Junior class studies *Descriptive Astronomy* during the third term. *Text Books.* — Newcomb & Holden.
>
> The senior class studies *Spherical and Physical Astronomy* during two terms. Recent addition of charts, photographs, etc., will add to the interest to this study. A small telescope will be bought to aid the student. *Text books.* — Norton. *Reference.* — Newcomb, Chauvenet.



12 Arkansas Industrial University.

SECOND TERM.

Chemistry. History.	Euripides (Iphigenia in Taurus)
Livy.	German.
Plane Trigonometry.	French.

THIRD TERM.

Mineralogy.	Aristophanes (Birds).
Surveying and Spherical Trigonometry.	Chemistry.
Horace. Rhetoric.	German.

THIRD OR JUNIOR YEAR.

FIRST TERM.

Astronomy.	Thucydides (Selections).
Geology.	German,
Tacitus(Germania and Agricola).	Civil Engineering.
Conic Sections and Analytical Geometry.	

SECOND TERM.

Geology.	Sophocles (Œdipus Tyrannus).
English Literature.	German.
Juvenal.	Civil Engineering.

THIRD TERM.

Logic.	Demosthenes (Olynthiacs and
Physical Geography.	Philippics).
English Literature.	German.
Tacitus (Histories).	Civil Engineering.

FOURTH OR SENIOR YEAR.

FIRST TERM.

Mental Philosophy.	Science of Education.
Political Economy.	Latin.
Elements of Criticism.	Greek.

SECOND TERM.

Moral Philosophy.	Greek.
History of Civilization.	Latin.
Civil Polity.	Evidences of Christianity.
Constitution of United States.	

THIRD TERM.

History of Philosophy.	Social Science.
Modern Philology.	Latin.
Constitutional Law.	Greek.
History of Inductive Sciences.	

Figure 3: Second page of the course listings in the 1971–72 catalogue

Some comments by Reynolds [Ref. 2] about Professor Conrad are very interesting.[3] When Adjunct Professor Conrad of Chemistry and Physics, recently from the University of Virginia, joined the university, he tried to "secure a high degree of excellence" somewhat too unrealistically and too rapidly in the 1880s. "The department had practically no apparatus for experimental work." Professor Conrad resorted entirely to the lecture method and is reported to have demanded a very high level of academic performance from his students. The above

[3] The following is based on Reynolds's description and quotations below are from his book [Ref. 2].

statement about having no apparatus seems to contradict the catalog description above. During the first year of his incumbency in the chair of physics, a senior failed, apparently an unusual occurrence. There were complaints, and it seems that about all that he accomplished was to dramatically reduce the size of the graduating class and ultimately the amount of physics that was required. The BL degree was also introduced at this time for students who were not "fit for the AB."

Some of these problems involving Professor Conrad and the faculty, students, and university president became so intense and divisive that the retiring president, General Daniel Harvey Hill, discussed the whole situation in his annual report to the board in 1884. He declared that the falling off in attendance and the internal troubles had their origin in two principles imported from the University of Virginia, namely an exceedingly high standard of scholarship required for graduation and a total indifference on the part of the professors as to the conduct of students outside the classroom. Both Professor Conrad and President Hill were forceful and determined, and this conflict was most unfortunate, even if some of the ideas about academic standards may have been justified.

The trustees asked Professor Conrad to modify the course in physics and astronomy "so as to accord with the capacity and advancement of the students in those branches." Professor Conrad substituted "simpler, easier, text-books wherever attainable" and cut down his examinations by one-half, though he still "leaned to the side of the higher standard."

C. No Place for Physics: 1884–1889

Catalogues for 1884–85 and 1885–86

For the former of these two years, physics was listed under Applied Mathematics, Physics, Astronomy, Civil Engineering and Tactics. One course each in physics and astronomy was listed and no professor for either. According to Reynolds [Ref. 2], "Upon the reorganization of the faculty and the courses of study in 1885, physics was relegated to freshmen in all courses with additional work for sophomores in the English and general science courses. It was taught by J. M. Whitham, professor of applied mathematics and commandant of cadets, who held this position for two years." The following year, the department's name changed slightly to Applied Mathematics, Physics, Astronomy, Civil and Mechanical Engineering, and Professor Whitham was explicitly listed as an instructor.

Catalogue for 1886–87

Physics was listed under the department of Geology, Biology and Physics and taught by Professor Simonds.

Three physics courses were listed. The first was a general physics course covering "heat, light, sound, electricity and magnetism, and mechanical powers." It was a year-long course taken by freshmen and "embraced recitations upon text-books, lecture, class illustrations, and experiments in Physical Laboratory." The second course was on heat; it was a one term course taken in the sophomore year and was considered "essential to the engineering and scientific courses." The third was a course on electrical engineering taught in the senior year. It is not clear why this course was listed under physics.

Catalogue for 1887–88 and 1888–89

It is not clear where physics fit in during this period, but it was listed under a separate heading, "Physics," following the section on "Engineering Studies for the Mechanical and Civil Engineering Studies." The teachers listed are Professor Whitham, who was now the "Superintendent of Mechanic Arts and Professor of Engineering," and Adjunct Professor W. E. Anderson, "Adjunct Professor of Mechanic Arts and

Instructor of Mechanical Drawing." The course description is the same as in the previous year.

D. Department of Chemistry and Physics: 1890–1904

This fourteen-year period is the first and longest of two stable periods for physics. We describe some of the details below.

Catalogue for Year Ending 1890

From 1890 to 1895 catalogues were published and named in accordance with calendar year instead of academic year — *Catalogue of Year Ending December 4, 1890, and Announcement for 1891*. Afterward these five years, the catalogues reverted back to the academic year format.

This year, physics was listed alone, but it was at the end of the section on chemistry. It was taught by Professor A. E. Menke, who was listed as "Superintendent of Agriculture, Professor of Chemistry and Minerology," and Adjunct Professor G. L. Teller, "Adjunct Professor of Chemistry and Agriculture." There was one course on physics, and its description was the same as that of the general course in the announcement for 1887–88, except that it excluded "mechanical powers."

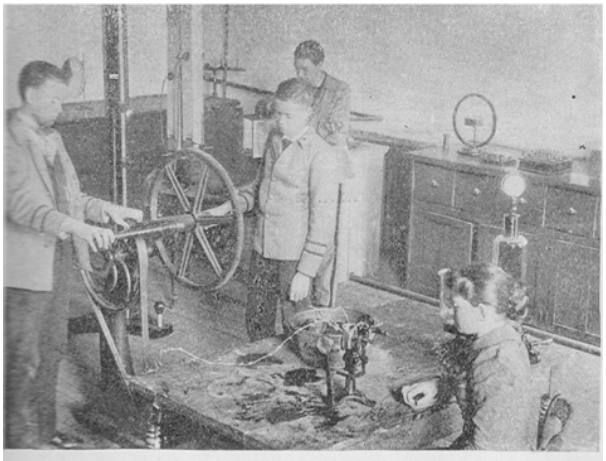


Figure 1 Figure 4: The earliest picture of a physics laboratory that is available. Reproduced here from the 1892 catalogue.

Catalogues for Years Ending 1891–1893

The department was now formally listed as the Department of Chemistry and Physics, an arrangement that lasted until 1904, and the teachers were Professor Menke and Adjunct Professor W. E. Bentley. These two teachers continued to be listed as the sole teachers in this department until 1900. The two courses listed for these years, without detailed descriptions, were General Physics and Heat. Both were year-long courses and had laboratory components. No textbooks were listed until the 1893 catalogue, when we learn that General Physics was taught from a book by Ganot and Heat from a book by Balfour Stewart.

Apparently, a new physical laboratory was established in the following year. A photograph with the following description is given in the 1892 catalog: "The new Physical Laboratory will accommodate twenty-eight students. It is fitted with a small dynamo and a supply of general apparatus for work in practical physics." The photograph of the laboratory is reproduced in figure 4.

Catalogues for year ending 1894 and 1895–96

This catalog is the same as in the previous year, except the course on heat had been eliminated in favor of a course on physical measurements taught by Professor Bentley. Four hours of laboratory was required for science students, whereas only two hours was required for the engineering students.

Catalogues for 1896–97 through 1901–02

Physics continued to be part of the Department of Chemistry and Physics, and Professors Menke and Bentley continued to be the only instructors until 1900. In 1900–01, Professor Bentley was replaced by P. H. Walker, associate professor of chemistry and physics. Now in addition to the courses on general physics and physical

measurements, a course on electricity and magnetism was added. The text for the latter was by Silvanus.

Catalogues for 1902–03 and 1903–04

This period saw a complete turnover in physics instructors. The university hired Professor of Chemistry and Physics A. M. Muckenfuss and Associate Professor of Chemistry and Physics L. H. Rose. The courses listed in the 1902–03 catalogue were Elementary Physics, Electricity and Magnetism, and General Physics, all taught by Professor Rose. In the next catalogue, the course listing had changed to Elementary Physics and Advanced General Physics, taught by Professor Rose, and Heat, Light, and Sound taught by Professor Muckenfuss.

E. Department of Electrical Engineering and Physics: 1904–1907

This is the second of two stable, though short, periods for physics.

Catalogue for 1904–05:

Physics was now transferred to the Department of Electrical Engineering. The following resolution was adopted by the university's board of trustees on July 15, 1904: "Resolved, That Physics, in the Department of Chemistry and Physics be transferred to the Department of Electrical Engineering and that the latter be known as the Department of Electrical Engineering and Physics and the former as the Department of Chemistry."

The teachers listed were: Professor W. N. Gladson, Instructor H. Schapper, and one assistant. The course offerings had jumped to seven and included Vector Analysis and Theoretical Electricity, the latter of which had prerequisites including Vector Analysis and Differential Equations, and covered Maxwell's theory. The course offerings included a significant amount of laboratory work, including a course on precision measurements that included discussions of errors and sources of errors, and least squares analysis. All of the courses, except part of General Physics, were taught by Instructor Schapper.

The catalogue describes a laboratory for physics called Physical Laboratory: "The first floor of Science Hall, with the exception of one lecture room, is devoted to physics. The laboratory for general physics is a room twenty by seventy feet, on the north side of the building. It contains tables and cases for apparatus. For advanced physics a separate room is provided and equipped with cases for apparatus, wall brackets for galvanometers, and pillars built separately from the floors to avoid vibrations. The physical lecture room is adjacent to the storeroom, where most of the apparatus is stored."

Catalogues for 1905–06 and 1906–07

Schapper had now been appointed as an adjunct professor, and he had been given one assistant. Course offerings had now increased to eight with the addition of Kinetic Theory of Gases and Thermodynamics. The course on vector analysis had been eliminated, and the subject was integrated into Theoretical Electricity. This course also included modern electron theory. Again, all the courses, with the exception of part of General Physics, were taught by Professor Schapper.

This was the last year that physics was part of the Department of Electrical Engineering before becoming an independent department.

F. Some Comments on Physics: 1872–1907

Early physics courses at the University of Arkansas were taught by various faculty, including civil engineers, mechanical engineers, electrical engineers, chemists, and even biologists, mathematicians, and geologists — but with engineering and chemistry teachers

predominating. The principal teachers of physics whose main field was chemistry were Professor Conrad (1878–1885) and Albert Ernest Menke (1890–1904), and those whose main field was engineering were J. B. Gordon, J. M. Whitham, W. N. Gladson and Heinrich Schapper. The teaching staff who taught physics as part of their load between 1872 and 1908 can be identified, and their names are listed in appendix II.

It was during the last period, 1904–1907, when physics was with electrical engineering under Professors Schapper and Gladson, that a substantial physics curriculum was developed, and this provided the foundation upon which the Physics Department was subsequently developed.

1.

Birth of the Physics Department

1907

A. Introduction

Even though the subject of physics had been taught from the very inception of the university[1], physics was first given the status of an independent department in 1907, thirty-six years after the university was founded (see prologue II). Since no full-time physics professor was hired until 1908, it had to be taught by professors of chemistry, engineering, and applied mathematics, among others. Physics was like an orphan without a permanent place to live and was being sheltered by these teachers of other disciplines. One historian of the university aptly states [Ref. 2, 253]: "In 1907 for the first time physics was advanced to the dignity of a separate department."

An examination of the minutes of various meetings of the board of trustees over a period of many years reveals no explicit resolution creating a Department of Physics, but only this simple statement about the appointment of Professor Schapper in the meeting of the board on June 11, 1907: "Heinrich Schapper, Associate professor of Physics, $1,300[2] (in charge of the Department)," as shown in figure 1. In the same board meeting, Professor W. M. Gladson was appointed professor of electrical engineering only. The year earlier, Professors Schapper and Gladson had been appointed as adjunct professor and professor, respectively, in the combined Department of Electrical Engineering and Physics. Thus the independent Physics Department was born. Apparently, Professor Schapper left the university in 1908.

Professor Giles Ripley was appointed the first full-time physics teacher in charge of the department in 1908. Professor Schapper was in charge of the department during the 1907–08 academic year only in a caretaker capacity until a permanent teacher could be hired. Professor Ripley remained head of the Physics Department until 1940 and guided the department during its formative years. He concurrently held the

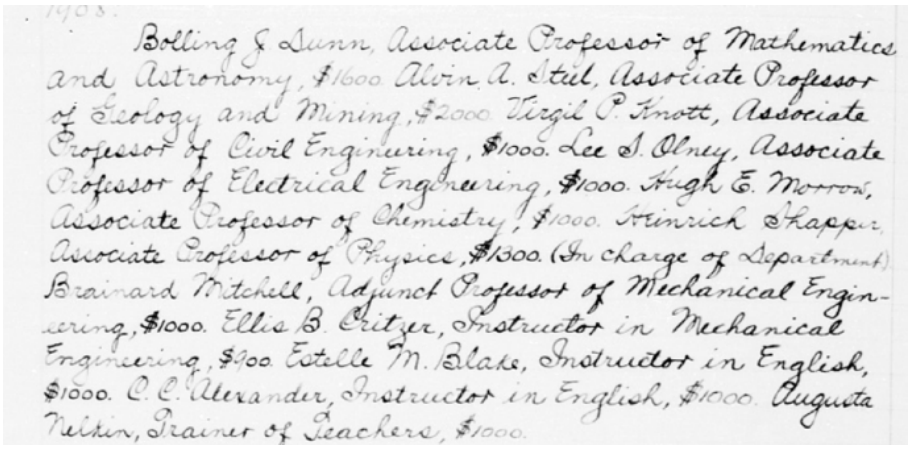

1908.
Bolling J. Sunn, Associate Professor of Mathematics and Astronomy, $1600. Alvin A. Stiel, Associate Professor of Geology and Mining, $2000. Virgil P. Knott, Associate Professor of Civil Engineering, $1000. Lee S. Olney, Associate Professor of Electrical Engineering, $1000. Hugh E. Morrow, Associate Professor of Chemistry, $1000. Heinrich Schapper, Associate Professor of Physics, $1300. (In charge of Department) Brainard Mitchell, Adjunct Professor of Mechanical Engineering, $1000. Ellis B. Critzer, Instructor in Mechanical Engineering, $900. Estelle M. Blake, Instructor in English, $1000. C. C. Alexander, Instructor in English, $1000. Augusta Nelkin, Trainer of Teachers, $1000.

Figure 1: Minutes of the board resolution of June 11, 1907

[1] Physics is an essential subject for engineers, so it had to be taught.
[2] This value would be equivalent to about $29,000 in 2007.



Figure 2: Fayetteville Square view west, circa 1900. ***Photo courtesy of the University of Arkansas Libraries, Digital Collections.***

position of the dean of men from 1923 to 1937 (see the text box).

B. The Time Period

To get a perspective of the period when the department was formed, let us try to imagine what was going on at that time. The country had a population of about ninety million, the state had a population of about 1.5 million and Fayetteville's population was about 4,500. Figure 2 shows a photograph of the Fayetteville Square from that period. Apparently, a crowd had gathered for some special event. On the transportation front, Ford's Model T went into production that year and sold for $850 (an equivalent value of $19,350 in 2007), and the Wright brothers had invented the first gas-motor-powered manned airplane just a few years earlier. The Model T was the first mass-produced car, and it arguably changed our transportation culture. Of local importance was the fact that Fayetteville was now connected to the rest of the country by railroad, a development that ended Fayetteville's isolation. Figure 3 shows a photograph of the Frisco train station from that period. The university's enrollment had grown to about 550–600 students, and the university had organized itself into various colleges. Physics was under the College of Liberal Arts, Sciences, and Engineering. Music and fine arts were placed under the Conservatory of Music and Arts. The College of Agriculture and Agriculture Experimentation station had been formed. The Preparatory School was still functioning. Medical and law schools in Little Rock and the Branch Normal College in Pine Bluff [3] had been established. The library had one librarian and one assistant librarian. The College of Liberal Arts, Sciences, and Engineering had twenty-one faculty members, and a total of eleven people served as adjuncts, assistants, and instructors. Several new buildings had been constructed on the campus. And finally, no history of any part of the university would be complete without a mention of the athletics. Figure 4 shows a picture of the football field from that period.



Figure 3: Frisco train station, circa 1910s. ***Photo courtesy of the University of Arkansas Libraries, Digital Collections.***

[3] A fascinating account of how "separate but equal" education was practiced in Arkansas is given by Leflar [Ref. 3, 273–288].

Giles Emmett Ripley

The First Professor and Head of the Physics Department

Professor Ripley came to the University of Arkansas in 1908 from North Dakota, where he had been a professor of physical sciences at State Normal School in Valley City. He was a native of Indiana. In his own words:[1] "Giles Emmett Ripley was born in Adams County, Indiana on June 18, 1874. He received his education in the public schools of Indiana, the Normal School at Marion, Indiana, Purdue University and at the University of Chicago." At Purdue, he received his BS in 1899 and MS in 1902. He spent the summers of 1907 and 1908 at the University of Chicago, where he studied under Robert Millikan.[2] Millikan had started his work on measurement of electron charge in 1906; therefore it is likely that Ripley had participated in that experiment.

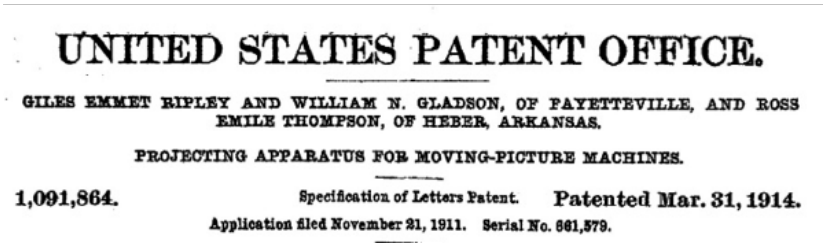


Figure 1: Giles Emmet Ripley. Undated. *Photo from Ref. 3.*

Before coming to the University of Arkansas, he held several positions:[3] "Professor of Science, Eastern Indiana Normal School (now Ball State University), Muncie Indiana, 1899–1900. Headed Department of Physics and Chemistry, High School, Racine, Wisconsin, 1900–1902, and high school, Marquette, Michigan, 1904–1905. Professor of Physical Sciences, State Normal School, Valley City, North Dakota, 1905–1908." During the intervening period between 1902–1904, he tried his hand at business in Winchester, Indiana but in 1904 decided to go back to teaching.

Ripley had one research publication and that before coming to the University of Arkansas. He had presented a paper at the Annual Meeting of the Indiana Academy of Sciences in botany entitled, "Absorption of Water by Decorticated Stems" in December 1898, which was published in the *Proceedings of the Indiana Academy of Sciences*, but its exact reference cannot be found.[4] The University of Arkansas was not a research institution at that time, so he immersed himself in teaching and the administration of the department (as well as other administrative and service duties, as described below) during its formative years until his retirement in 1940. He was very interested in technology and produced a number of inventions during his tenure here in association with William M. Gladson (dean of engineering and later vice president of the university) including an improved motion picture apparatus. He held a number of patents.

Ripley was appointed the first dean of men in 1923 and stayed in that position until 1937, also serving concurrently as professor and head of the Department of Physics. He also served on numerous committees, including as chairman of the Commencement Committee for many years and chairman of the Committee on Semicentennial Exercises in 1922. The *Arkansas Alumnus*, March 1929 described his job thus: "G.



UNITED STATES PATENT OFFICE.

GILES EMMET RIPLEY AND WILLIAM N. GLADSON, OF FAYETTEVILLE, AND ROSS EMILE THOMPSON, OF HEBER, ARKANSAS.

PROJECTING APPARATUS FOR MOVING-PICTURE MACHINES.

1,091,864. Specification of Letters Patent. Patented Mar. 31, 1914.

Application filed November 21, 1911. Serial No. 661,579.

E. Ripley, Dean of men at the University, has an unusual combination of jobs. He helps students get started. Four years later, he helps them quit. And between the two extremes, he keeps them 'in line' while they are in school." In the same article, Ripley is quoted describing his role: "The Dean of Men has the great task of working with youth, of trying to maintain his own youth so that better understanding may exist between student and dean, acquiring through all this the friendship of worthwhile youth engaged in worthwhile tasks. In this last there comes to him new courage and aspirations which makes his task worthwhile." Regarding keeping students "in line," apparently Ripley was very firm about enforcing discipline. Leflar [Ref.3] describes the following incident: "Dean of Men, presided over a disciplinary case in which several students, including some in whom Governor Bailey was personally interested, were expelled. Ripley would not back down on the expulsions, and Futrall backed him. Ripley resigned as Dean of Men but continued as a full-time physics teacher." Futrall was the president of the university.

Ripley was a member of the American Association for the Advancement of Science, the American Institute of Electrical Engineers, and the Association of Science and Mathematics Teachers, among others. He was listed in *Who's Who in America*.

Ripley retired from the University in 1940, remaining the Physics Department's head until that time. He passed away on January 31, 1943.



Figure 2: Dean Giles Ripley. ***Photo courtesy of the University of Arkansas Libraries, Digital Collections.***

The University has named a dormitory in honor of the above-mentioned William Gladson and Giles Ripley as Gladson-Ripley Hall. First known as Gladson House and Ripley House upon opening in 1954, these buildings were later fused to create what is now known as Gladson-Ripley Hall.

He had two sons and one daughter: Vincent Marsh Ripley, Kenneth Clay Ripley, and Mary Pauline Ripley.

[1] This is taken from a biographical sketch he wrote himself and is now in the Special Collections of the University of Arkansas Libraries. A copy is in the Physics Archives. It is handwritten on a yellow pad in pencil. It is not clear when he wrote it, but we think that it was written shortly after he was appointed here. One clue that it was written during that period is that it stops with the appointment at the University of Arkansas.

[2] This information is taken from a short biography provided by Giles Ripley's daughter, Mary Ripley Holcomb, to the senior author of this book. It is now in the Physics Archives. Millikan, in his famous work, measured the charge of an electron for the first time, for which he was awarded a Nobel Prize in 1923.

[3] Ibid.

[4] A Google scan of this article is available, and a copy is in the Physics Archives.

What was happening in technology? Of particular interest to the field of experimental physics is the invention of the vacuum tube, which revolutionized electronics. The vacuum diode had been invented in 1904, and the triode was invented by Lee DeForrest in 1906. Arguably, the invention of the vacuum tubes led to the birth of what we now call the field of electronics, and it is hard to imagine how experimental physics could have been done without those advances.

And of course, we are particularly interested in what was happening in the field of physics. The field which is now commonly known as modern physics was in its very early stages of development. By modern physics we mean understanding the structure and properties of atoms, nuclei, subatomic particles, and condensed matter, as well as an understanding of fields. The two pillars on which most of our current understanding rests are quantum theory and the theory of relativity. Einstein had just published his special theory of relativity in 1905, but it had yet to be widely known and accepted. The general theory was yet to be published. Many developments had taken place, which led to the development of quantum theory: Planck had explained black-body radiation using energy quantization in 1900, and in 1905 Einstein had proposed quantization of radiation to explain the photoelectric effect. It was in 1907 that Einstein proposed quantization to explain the temperature dependence of heat capacities of solids. While the charge-to-mass experiment of Sir J. J. Thomson in 1897 had shown that all matter consists of electrons, Millikan's oil-drop experiment, which determined the value of electronic charge, was still in progress. The nuclear model of the atom was to be proposed by Rutherford and Marsden in 1911, and the Bohr Model of the atom was not proposed until 1913. It is in this context that we must look at the university's first proposed curriculum for a degree in physics.



Figure 4: Athletic Field, circa 1900s. ***Photo courtesy of the University of Arkansas Libraries, Digital Collections.***

C. Curriculum for a Degree in Physics

The curriculum for a BS degree in physics was defined for the first time in the *Catalogue of 1907–08 and Announcement for 1908–09* [1] and it is reproduced in figure 5. Note that this course was to begin in September 1908. The curriculum had to have been developed by Professor Schapper because Professor Ripley only joined the department that year. It is possible that electrical engineering professor Gladson, who was much interested in physics and x-rays and radio, would have been involved in the development of this curriculum. Figure 6 shows the syllabi of the physics courses.

For convenience of discussion we have reproduced below the requirements for the physics degree.

Twenty-two hours of physics courses were

[1] *Catalogue of 1907–08 and Announcement for 1908–09* was published in the summer of 1908. In the terminology of that period, the catalogue is a retrospective of what happened in the previous academic year and the announcement contains the course listings and syllabi of the courses to be taught in the following academic year.

required, including:

Precision of Measurement
Theoretical Electricity
Kinetic Theory of Gases
Thermodynamics
Heat
Light
General Theory of Light[2]
Mathematical Physics
Acoustics
Journal Club
Thesis

Twenty-one additional hours of math courses were required including[3]:

Differential and Integral Calculus
Analytical 3-D Geometry
Differential Equations
Partial Differential Equations
Descriptive Astronomy

In addition, eleven hours of chemistry, seven hours of electrical engineering, and one hour of civil engineering were required, while the remaining hours were devoted to languages. This curriculum is very heavy in technical subjects and has very little of the liberal arts.

Students took eighteen hours of courses per week in addition to journal club and thesis (seventy-six hours in four years). As well as we can tell, one hour meant one hour of a year-long course.

This curriculum was perhaps not out of line with the standard physics curriculum of that time. Remember, Einstein had given his theory of relativity only two years earlier, quantum theory was in its infancy, and the Bohr Model was yet to be proposed. Although the electron, radioactivity, and x-rays were discovered, we only see the electron mentioned in the syllabus shown in figure 6. Advanced Physics, offered in the sophomore year, introduces the "notion of an Electron." It is doubtful that many of the advanced courses were taught, except for those taken by the engineering students, since there were no physics majors until the late 1920s.

The *Catalogue for 1907–08 and Announcement for 1908–09* (figure 6) shows that Professor Schapper was still listed as "in charge" of the department. Apparently, Professor Ripley's appointment did not make the publication deadline for this catalog. It is interesting to look at the syllabus a little bit more closely. We notice

COURSE FOR THE DEGREE OF B. S. IN PHYSICS.*

FRESHMAN YEAR.	Hrs. per week.	SOPHOMORE YEAR	Hrs. per week.
Mathematics 1*c*, 2*c*	6	Mathematics 4*a*, 4*b*	5
Physics 1	3	Physics 2, 2*a*	5
Chemistry 1	3	Chemistry 2, 3, 5	5
English 1	3	French 1	3
German 1	3		

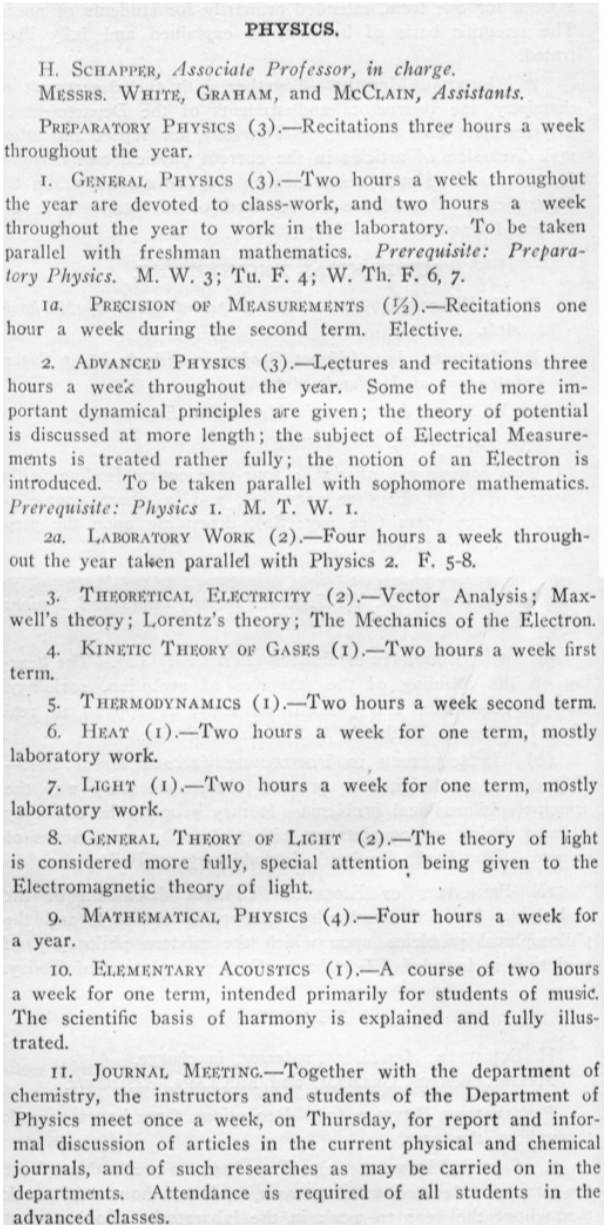
JUNIOR YEAR	Hrs. per week.	SENIOR YEAR.	Hrs. per week.
Mathematics 6*b*, 9*a*, *b*, 16	7	Mathematics 18	3
Physics 6, 7, 9	4	Physics 3, 4, 5, 8, 9	10
Chemistry 8	1½	Chemistry 12	1½
E. E. 5, 12	3½	E. E. 6, 8	3½
C. E. 1	1	Thesis	
Scientific German and French	1	Journal Meeting	
Journal Meeting			

*This course begins in September, 1908; only the first two years can be offered at present.

Figure 5: Curriculum for a BS degree in physics as it appeared in the 1907–08 catalogue.

[2] This course included the EM theory of light.
[3] Astronomy was taught by Mathematics Department at that time.

in particular the following: Theoretical Electricity, taken in the senior year, included Vector Analysis, Maxwell's theory, and Lorentz theory. Therefore, it was probably similar to what we call today a course on electromagnetic theory. The course also included "the Mechanics of the Electron." General Theory of Light included the electromagnetic theory of light. In spite of the scarcity of equipment (see below), the curriculum included a significant amount of laboratory work, more so than today. And finally, the curriculum included a weekly Journal Meeting of students and instructors of physics and chemistry. All advanced students were required to attend so that they could participate in "report and informal discussion of articles in the current physical and chemical journals, and of such researches as may be carried on in the departments."



PHYSICS.

H. SCHAPPER, *Associate Professor, in charge.*
MESSRS. WHITE, GRAHAM, and MCCLAIN, *Assistants.*

PREPARATORY PHYSICS (3).—Recitations three hours a week throughout the year.

1. GENERAL PHYSICS (3).—Two hours a week throughout the year are devoted to class-work, and two hours a week throughout the year to work in the laboratory. To be taken parallel with freshman mathematics. *Prerequisite: Preparatory Physics.* M. W. 3; Tu. F. 4; W. Th. F. 6, 7.

1a. PRECISION OF MEASUREMENTS (½).—Recitations one hour a week during the second term. Elective.

2. ADVANCED PHYSICS (3).—Lectures and recitations three hours a week throughout the year. Some of the more important dynamical principles are given; the theory of potential is discussed at more length; the subject of Electrical Measurements is treated rather fully; the notion of an Electron is introduced. To be taken parallel with sophomore mathematics. *Prerequisite: Physics* 1. M. T. W. 1.

2a. LABORATORY WORK (2).—Four hours a week throughout the year taken parallel with Physics 2. F. 5-8.

3. THEORETICAL ELECTRICITY (2).—Vector Analysis; Maxwell's theory; Lorentz's theory; The Mechanics of the Electron.

4. KINETIC THEORY OF GASES (1).—Two hours a week first term.

5. THERMODYNAMICS (1).—Two hours a week second term.

6. HEAT (1).—Two hours a week for one term, mostly laboratory work.

7. LIGHT (1).—Two hours a week for one term, mostly laboratory work.

8. GENERAL THEORY OF LIGHT (2).—The theory of light is considered more fully, special attention being given to the Electromagnetic theory of light.

9. MATHEMATICAL PHYSICS (4).—Four hours a week for a year.

10. ELEMENTARY ACOUSTICS (1).—A course of two hours a week for one term, intended primarily for students of music. The scientific basis of harmony is explained and fully illustrated.

11. JOURNAL MEETING.—Together with the department of chemistry, the instructors and students of the Department of Physics meet once a week, on Thursday, for report and informal discussion of articles in the current physical and chemical journals, and of such researches as may be carried on in the departments. Attendance is required of all students in the advanced classes.

Figure 6: Syllabi of physics courses in the 1907–08 catalogue.

The following year's catalog (*Catalogue of 1908–09 and Announcement for 1909–10*) does show Professor Ripley as Professor, and he had one Assistant, S. A. Rowland. By this time, Professor Ripley had a chance to influence the growth of the department. One new course, The Teaching of Physics, had been introduced, and the course descriptions became more detailed. The curriculum changed little during the following few years.

Physics enrollment in 1908–09 was 149 [Ref. 2, 254], although no physics degree was awarded until 1928. Most of the students in the physics courses had to have been engineering students.

Prior to 1907, physics had been part of the electrical engineering department housed in the old Engineering Building. Physics continued to be housed in that building after separating from electrical engineering. However, in 1907, $1,000 was spent building a temporary wooden structure of fifty feet by forty feet to house physics laboratories. The building was, however, very short lived. It burned down in 1909, along with all the physics apparatus that the department had collected over the years [Ref. 2, 254]. This is covered in greater detail in chapter 5.

2.

The Early Years

1908–1936

A. Introduction

In this chapter we describe the early years of the Physics Department after its start in 1907. Unfortunately, no detailed information is available until 1926 beyond the limited information included in the catalogs. Departmental annual reports from 1926 onward are available in the Physics Archives.[1] Courses offered by the department during this period are discussed in chapter 6 and will not be discussed here, except the following observation that the first physics degree was awarded in 1928. Therefore, there were probably no physics majors until about 1925. So, as the 1917–18 catalog shows (see chapter 6), the department had added courses such as Elementary Physics (a non-mathematical course with applications to everyday life), Household Physics, History of Physics, and Teaching of Physics — courses which might appeal to majors other than physics. By the late 1920s, most of these courses were eliminated, and the department seemed to have defined its mission to primarily educate science and engineering students.

The 1908–09 catalog lists Ripley and an assistant, S. A. Rowland. Professor Ripley's name appears in the catalogs as the sole faculty member until 1911 and as head of physics in all catalogs up to 1940, when Dr. Lloyd. B. Ham became department head.

After 1911, attempts were made to add another faculty member to the department, but none of those appointed stayed for very long. The following names, in addition to Ripley's, appear in the catalogs: Instructor A. J. Thomas, 1911–12; Associate Professor Jacob Kemp (PhD, University of Illinois at Urbana-



Figure 1: Samuel R. Parsons. Undated. ***Photo courtesy of the University of Arkansas Libraries, Digital Collections.***

[1] All of the information presented in this chapter has been obtained from the university catalogs, department's annual reports, or other memoranda in the departmental files. Any reference to "report" generally means the department's annual report.



Figure 2: Wesley M. Roberds. Undated. *Photo from History1.*

Champaign), 1912–14; Instructor Bernard Brown (MS, University of Chicago), 1914–17 (Brown's name disappears from the 1917–18 catalog, but he reappears as assistant professor in the 1918–19 catalog); Assistant Professor Oswald Blackwood, (BA, Boston University), 1919–20; Assistant Professor Paul Bayley (AM, University of Illinois at Urbana-Champaign), 1920–21; and Assistant Professor Charles Hill (PhD, University of Illinois at Urbana-Champaign), 1921–23. It appears that it was not easy to find and retain qualified physicists at that time (a list of all faculty employed from 1907 to 2007 is given in appendix IV).

In 1923, two new faculty members were hired, Drs. Charles B. Crofutt (instructor) and Samuel R. Parsons (assistant professor), bringing the faculty strength to three for the first time. Crofutt had obtained his doctorate at the University of Iowa, while Parsons had obtained his at the University of Michigan. Parsons had worked on the design and testing of air cooling for aircraft engines during WWI. The first research papers in national journals from this department came from these two gentlemen. Coincidentally, both papers were published in the same year, 1926 (see chapter 9).

Apparently Dr. Crofutt left the department in 1926, but Wesley M. Roberds (MA, University of Kansas) joined the department in 1927 as an instructor, keeping the faculty size at three. He returned to the University of Kansas for one semester in 1934 to complete his PhD. Roberds developed an x-ray laboratory and also built numerous pieces of physics demonstration equipment, some of which he published in physics journals. Roberds was to continue serving the department until 1942, when he took a position with RCA and later with the North American Aviation Corporation. It was he, along with physics student George L. Harvey, who designed and built the first remotely controlled scoreboard for the football stadium.

Professor Parsons passed away in 1931, and Dr. Ham was hired as an assistant professor in 1932 to replace him. He had obtained his PhD from the University of Illinois at Urbana-Champaign and came here from New York University. His field of specialization was acoustics. Ham had done some developmental

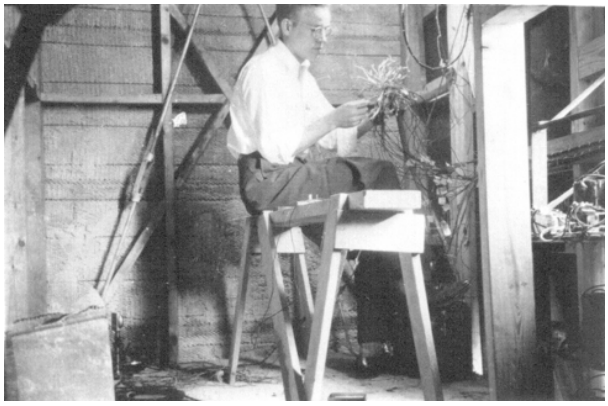


Figure 4: George Harvey working on wiring the football scoreboard. Undated. *Photo archived in the Physics Department.*

work on electroplating at the National Bureau of Standards during WWI and frequently served as an acoustical consultant. Ham made a lifelong commitment to this department, retiring in 1957.

B. 1926–1929

So let's take a snapshot of the period 1926–1929, the first period from which information about the department is available in the form of annual reports. In this period, the department had three full-time faculty members: Ripley, Parsons, and Roberds. However, it is not clear how much teaching, if any, Professor Ripley was doing because he simultaneously held two administrative positions: head of the Department of Physics and dean of men. The department was housed in Physics Hall, a two-story frame building, but the state of the physical facilities was very bad, as described below.

Number of Students Taught and Faculty Teaching Loads

In fall 1927, student enrollment was 198, out of which 181 students were in elementary courses and seventeen in two advanced courses.[2] Presumably, the students in the advanced courses were primarily engineering students. The elementary courses included seven recitation sections and nine laboratory sections. In the spring of 1928 semester, 150 students were enrolled in elementary courses (six recitation sections and eight laboratory sections), whereas twenty-three students were enrolled in three advanced courses. Thus, a total of 371 students were taught during the academic year. The average teaching loads for Parsons and Roberds was fifteen credit hours per faculty member per semester. The actual contact hours were twenty-one in the fall and twenty-four in the spring. Presumably some of the additional contact hours are due to recitations[3], which do not carry credit hours, and due to the fact that one credit hour of lab corresponds to two clock hours.[4] This teaching load was typical of the entire period.

The *1928–29 Annual Report* notes that two[5] new courses in x-rays were introduced with fifteen students enrolled. It notes that "Mr. Roberds has put on this course all the time he could get, and under his direction a number of pieces of apparatus have been made for it."

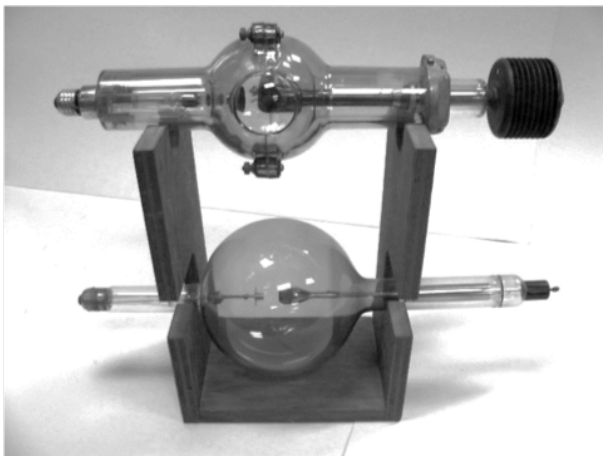


Figure 5: These Coolidge tubes were used by Professor Roberds in the 1930s to produce x-rays. On display in the Physics Lobby.

[2] Advanced courses presumably meant 300-level courses, which were Electricity and Magnetism, Electrical Measurements, Mechanics, and Electron Theory. It is possible that they also included 200-level courses which were Heat and High Temperature, and Light.

[3] We are not quite sure of the meaning of *recitation* as appropriate to that period. We have used the current definition, where a recitation session is different from, and is in addition to, the lecture session.

[4] The contact hours do not include laboratory and demonstration setup and tear down, supervision of student assistants in these tasks, if applicable, and repair, maintenance, and ordering of equipment and supplies. Neither does it include lecture preparation, grading, etc.

[5] Both courses, at the 300 level, were similar in content, but one was for physics majors with more quantitative treatment.

Laboratories and Apparatus

It appears that an incredible amount of effort was being applied to introduce new experiments in the instructional laboratories and to maintain the existing ones. For example, the 1926–27 report notes that "thirty-five new experiments were introduced into the advanced courses, six of which can be used later, if it seems desirable, to supplement the course in Electron Theory, which up to date has been entirely theory. Apparatus for two more experiments suitable for Electron Theory has been ordered and expected before July 1." Also, apparatus for several experiments were being built. A considerable amount of equipment was built in-house by the faculty and students.

The equipment that was being purchased and built at that time mostly related to optics, photography, spectroscopy, and x-rays, besides the usual electrical measurement equipment. As pointed out above, quite a few pieces of equipment were built in-house, and just two examples from the 1928–1929 academic year are an x-ray tube of Roberds's design built in the physics and engineering shops and a harmonic synthesizer built by a student assistant in the physics shop. X-ray was Roberds's area of interest, and some of his equipment still exits. Some of the equipment purchased during this period is on display in the Physics Lobby. A few of the equipment inventories also exist in the Physics Archives, and a portion of the 1928 inventory is shown in figure 7 below.



Figure 6: A microammeter purchased in 1924 on display in the Physics lobby.

The construction and use of lecture demonstration equipment is mentioned prominently in the reports of this period. Apparently, there was a great emphasis on lecture demonstrations and laboratory experiences. Student assistants, not necessarily physics majors because there were very few of them, were used to set-up and repair laboratory and demonstration equipment and to assist in grading.

Laboratory Manual and a Textbook

A laboratory manual was prepared, and a textbook for the elementary course was in progress. Preparation of the textbook was problematic due to lack of time on the part of faculty, and progress could only be made during vacations.

Support Services[6]

The department had its own shop and its own library. The 1928–29 report clearly uses the words "departmental shop." The shop was used by students and faculty to construct and repair the laboratory equipment. The department did not have a professional machinist but employed a student to do the machining. The same report

[6] A detailed account of all support services is given in chapter 12.

states that "three major pieces of apparatus, and some thirty minor pieces, have been constructed by the staff[7] and student assistants, besides many small jobs of repairs."

There is clear evidence for the existence of the Physics Library, and it seems to have been completely independent of the main library. Every year during this period, the departmental budget shows money spent on books, journal subscriptions, and binding. The Physics Library was located in the Physics Hall itself. The 1926–27 report states, "The Physics Library has been moved back into this building," and that, "Forty-six volumes of periodicals have been bound, and 25 books purchased, in addition to the periodicals to which we subscribe." In 1928–29, the department subscribed to seven periodicals.

Research

Efforts were being made by the faculty to do research under the most difficult of circumstances. These included lack of time and space and poor quality space. The 1928–29 report cites: "For Lack of time, research is practical only in vacations; and for lack of space, hardly practical at all. The bit of research completed last summer was started two years previously, but the apparatus was twice taken down to make room for classes." Lack of time and space and the inability to make sensitive electrical measurements due to excessive vibrations in the building were cited consistently as hindrances to carrying out research. In spite of this, some of this work did result in publications. These papers were mostly on the development of new equipment (see chapter 9 and Ref. 6).

Building

Physics Hall, the two-story wood-frame building in which the department was housed from 1918 to 1936, was entirely unsuitable for the basic needs of the department both in quality and quantity of space. Reports available in the departmental files indicate that not enough space

Physics June 30, 1928

1	Second Law of Motion Apparatus (Gaertner Corp)		150 00	150	00
4	Jagabi Rheostats, Nos. 25023, 25567, 20758, 25902, (Jas. Biddle)		10 00	38	40
1	Sonograph (L. E. Knott Appar. Co)			27	50
10	Bunsen's Clamps "		40	4	00
2	Ostwald Viscosity Pipettes (Cent. Sci. Co)		1 30	2	60
2	Lenses Reading Glasses "		1 00	2	00
2	Vernier Calipers "		3 00	6	00
1	Bernard's Wire Cutting Pliers "			2	10
1	Knipp's Alpha Ray Track Apparatus "			35	00
1	Vacuum Tube (Cathode Ray Oscillograph tube) (Graybar Elect / Co)			54	25
1	" " Socket "			5	75
1	Polarizing Photometer			575	00
1	Vacuum Thermocouple Type 203 (Graybar Elec. Co)	8/15/27		13	09
4	Standard Precision Thermometers (Palo Co)	10/5/27	1 35	5	64
1	Radio Electro Miscroscope (Gaertners)	10/17/27		120	00
1	Cooper Hewitt Labare "	"		150	00
1	Camera Attachment fo Wavelength Spectroscope (Gaertners) /	"		100	00
1	Plate holder (Gaertners)	"		4	00
2	Baly's Absorption Cells (Gaertners)	"	10 00	20	00
1	Condenser Experimental (Cenco)	10/12/27		15	00
1	Wallace Replica Grating "	"		6	00
1	Wallace Diffraction Grating "	"		16	50
1	Color Slide Westcott's "	"		3	00

Figure 7: A page from the 1928 equipment inventory.

[7] Faculty were referred to as staff at that time.

was available for laboratories to expand even when there was demand, and there were no large lecture rooms where demonstrations could be performed, to name just a few limitations. There was only one place in the whole building where sensitive galvanometers could be used. More details on this building can be found in chapter 5.

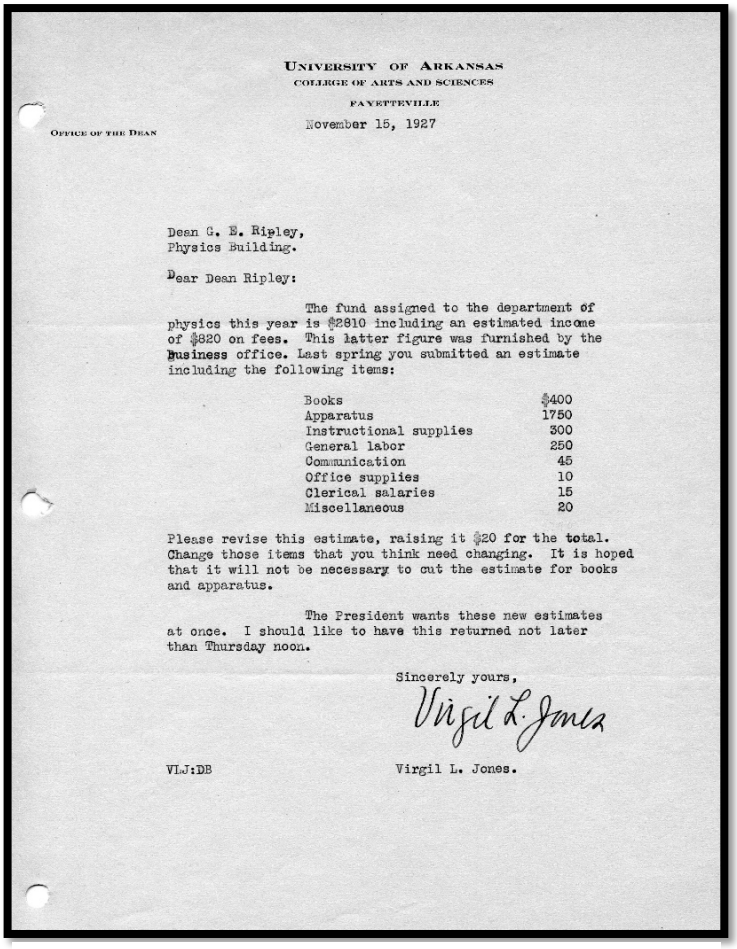
Budget and Administration

The Department was allocated approximately $2,000 by the College of Arts and Sciences as maintenance funds. In addition, the department realized about $800 from fees. The 1929–30 catalog indicates that students taking laboratory courses in this period had to pay a fairly substantial laboratory fee: three dollars for General Physics and X-Rays and six dollars for Electrical Measurements (thirty-seven and seventy-four dollars in 2008 values, respectively). In addition, students were charged a breakage fee if they broke or damaged laboratory equipment. Thus the department had about $2,800 to work with (an equivalent value of about $35,000 in 2008). It is interesting to look at how the funds were being spent. Figure 8 shows the budget allocation for the 1927–28 fiscal year.

It appears that Professor Ripley's work as dean of men required considerable time and Dr. Parsons was working as a de facto department head by taking responsibility for the day-to-day business of the department. This is indicated by the fact that a March 20, 1928 letter in the departmental files by Virgil Jones, dean of the College of Arts and Sciences, is addressed to Dr. Parsons informing him that the Committee on College Policy had approved his estimate of the budget for the next year. Dr. Parsons's role in departmental administration seems to be corroborated by Franklin R. Wintker Jr. (BS 1931), who had extensive correspondence with the authors of this history in the early 1990s. In one of those letters he writes, "This is a note of appreciation to the department for being there when I needed them. I would extend special appreciation to Dr. Parsons (now long deceased) who headed the department and tried his best to make a good student out of me."

The department did not have a secretary; a student was employed to take care of the clerical work. A sum of $250 was allocated in the budget for student assistants, which included clerical as well as technical work.

A note of special significance: the



UNIVERSITY OF ARKANSAS
COLLEGE OF ARTS AND SCIENCES
FAYETTEVILLE

OFFICE OF THE DEAN

November 15, 1927

Dean G. E. Ripley,
Physics Building.

Dear Dean Ripley:

The fund assigned to the department of physics this year is $2810 including an estimated income of $820 on fees. This latter figure was furnished by the business office. Last spring you submitted an estimate including the following items:

Books	$400
Apparatus	1750
Instructional supplies	300
General labor	250
Communication	45
Office supplies	10
Clerical salaries	15
Miscellaneous	20

Please revise this estimate, raising it $20 for the total. Change those items that you think need changing. It is hoped that it will not be necessary to cut the estimate for books and apparatus.

The President wants these new estimates at once. I should like to have this returned not later than Thursday noon.

Sincerely yours,

Virgil L. Jones

VLJ:DB Virgil L. Jones.

Figure 8: A letter dated November 15, 1927 from Dean Virgil Jones outlining the 1927–28 budget allocation to the department.

first physics degree was awarded during this period. Roy R. Sullivan received a BA degree in 1928.

C. Going Forward: 1930–36

This period covers the era of the Great Depression, which was also the final period of the department being housed in the Physics Hall. Despite the limitations imposed by the lack of suitable physical facilities and the retrenchment imposed by the Great Depression, the department was making progress. More advanced courses were taught, there were one or two physics majors and the department had its first graduate students, laboratory equipment collections were expanding as were the collections of books and periodicals in the Physics Library, and serious attempts to carry out research were being made. We explore all of these aspects of the department's activities in greater detail below. Most of the information below is obtained from the department's annual reports and budget estimates available in the Physics Archives.

As mentioned previously, Professor Parsons left the university in 1931, and Dr. Ham was hired as an assistant professor in 1932. Thus the number of faculty in the department remained at three — Ripley, Ham, and Roberds. While Mr. Roberds was on study leave in spring 1934 to complete his PhD at the University of Kansas, Dr. Reinhart filled in for him. The faculty size of three, of course, included Professor Ripley, who, in addition to being the head of Physics Department was also the dean of men. It is not clear how much teaching, if any, he was able to do. As mentioned previously, Dr. Parsons was even shouldering most (or all) of the administrative duties within the Physics Department. It appears that upon Parson's departure, Dr. Ham took over the administrative duties. As a matter of fact, the *1935–36 Annual Report* is signed by Dr. Ham. All of the available documents suggest that Parsons continued to act as the de facto head of the department until 1931, and Dr. Ham took over that role until 1940 when Ripley formally retired.

The department faced severe budget constraints, not surprisingly, during the Great Depression. The maintenance budget decreased steadily to $1,575 in 1932–33, to $1,000 in 1933–34, and to $850 in 1934–35, before bouncing back to $1,700 in 1936–37. Incredibly, the estimates for income from fees remained in the $800–$900 range in spite of a significant drop in enrollment. Perhaps the buffer provided by the fees helped the department wait out this period. Records indicate that the budget for apparatus plummeted from $1,750 in 1927–28 to an estimated budget of $475 in 1934–35, although there were at least two special allocations of funds to the department during this period of retrenchment, one of $375 for equipment and another $150 for purchase of books for the Physics Library.

To alleviate some of the department's space problems, a mezzanine was added to give some additional floor and shelf space in 1930. However, this was hardly a permanent solution to the department's space woes. As early as 1931, "possibilities of additional space in some other building" were being discussed in departmental meetings (see *1930–31 Annual Report*). The *1933–34 Annual Report* makes an ambiguous statement: "It is hoped that the addition of the new buildings will bring to a close our cramped conditions of work. We need about three times our present floor space. The new quarters would have —." It is not clear whether availability of some supplemental space or a move of the department to an entirely new space was being considered. However, by 1935, it is clear that the department was planning to move into new quarters in University Hall, although the building was not mentioned by name in the reports. With the help of a student assistant, Roe Watkins,

detailed plans of where each of the department's facilities would be located were drawn up and discussed in the departmental meetings. The report details specific plans for each elementary laboratory, a room for photography, a sound-proof room for acoustics research, a room for x-ray work, a dark-room, rooms for a shop and Physics Library, and a lecture room with adjoining apparatus room, in addition to other facilities. Finally, the department moved into its new quarters in University Hall on May 16, 1936.

Reports on the Physics Library during this period are rather fragmented, although there were funds budgeted for the acquisitions of books in each year's budget estimate. It appears that the book budget suffered severely during the depths of the Depression, although the department did receive a couple of special allocations during this period. Books were being acquired each year. Details can be found in chapter 12, section E. In spite of the crushing teaching loads, physics faculty were keen to keep up with the latest developments in physics. The following statement taken from the *1933–34 Annual Report* is insightful:

> Forty-two new books have been purchased for the library this year of which thirty-six were obtained through the recent special appropriation of $150. Practically all of these books have been published since 1932. Physics has witnessed many important and profound changes both through experimental and theoretical work since 1932. One needs only to mention in atomic physics that the positron, neutron and the two isotopes of hydrogen were unknown previous to about 1932; that in sound, the whole field of absorption of sound (theory and experiment) has taken an entirely new course; that in mechanics, the quantum theory is taking on a new significance to visualize the importance the recent additional books are to us.

The enrollment in all physics courses (both semesters combined) dropped steadily from 363 in 1930–31 to 289 in 1933–34. The enrolment increased to 387 in 1934–35, receiving modest help from a new course, Survey of Sciences. That year's annual report states: "The course was successful, apparently, in attracting non-technical students who desired knowledge in the field of physics." Enrollment rebounded to a very healthy 455 in 1935–36. We do not know what special efforts the faculty made to increase enrollment. Enrollment in advanced courses held steady during this period but spiked at forty-four in the spring 1936 semester.

Many course offerings changed during this period, but we notice one development of significance: in the 1932–33 academic year, a 400-level course was introduced for the first time. The course was titled Introduction to Theoretical Physics, and it was basically a course on mechanics. It covered topics such as D'Alembert's Principle, restricted freedom of motion, Hamilton's equations, least action, Euler's differential equations, gyroscopic phenomena, canonical equations, wave equation as applied to atomic problems, and the principle of relativity.

The faculty's teaching loads remained as high as in the previous period, that is, about fourteen to fifteen credit hours per semester and about twenty actual contact hours per semester.

There was one physics major enrolled in the 1934–35 academic year, and two in the 1935–36 academic year. The number of physics majors increased steadily in subsequent years.

The annual reports from 1934–35 and 1935–36 indicate that one graduate student was enrolled in the Physics Department each year (possibly the same student). This is the first time a graduate student has been mentioned. It is also indicated that the graduate student was working on an experimental thesis. The 1935–36 report also mentions that two physics graduate students

applied for the 1936–37 graduate fellowships, but neither qualified because these fellowships were available to students of high scholastic achievement only. Therefore, clearly, the department had graduate students for the first time in the middle of the 1930s. However, the university's graduation records (available from the Office of Institutional Research), as well as our own alumni records, indicate that the first master's degree in physics was awarded in 1939[8] to Halvor Darracott. The second master's degree was awarded to George L. Harvey in 1940, who had earlier received his BA degree from our department in 1938.

Support services such as construction of apparatus, providing shop services, cataloging of apparatus, assistance in research, and clerical work were being provided by student assistants. The 1935 and 1936 reports give the specific assignments of each student by name. In this list we can identify only one physics major who has appeared on our graduates list. For each of these two years, there was one female student assigned to physics. Not surprisingly, the female students were assigned the clerical work, while the males were assigned the technical work. A reflection of the times.

In spite of the budgetary retrenchment, a significant number of new equipment was purchased and built. Just a few of the examples of major equipment in the former category are a cathode ray oscilloscope for $370 (about $6,000 in 2008), a Leica camera for $139, and an acoustimeter for $230; two examples of the latter are x-ray tubes and an ionization chamber.

In spite of the space limitations, both in quality and quantity, and lack of time and money, credible efforts to carry out research were being made. Wesley Roberds published four papers during this period, mostly in the area of development of new instruments for teaching and research. Dr. Ham started his research in acoustics, and there is reference to a number of papers presented by him at national meetings. However, no journal paper was published by him until 1939, when he published a paper in the *Journal of Acoustical Society of America* in collaboration with Darracott. According to a statement in History1,[9] Ham often said how fine that old frame building was for some of his acoustics work because it was so quiet. This is rather surprising in view of the statements in the department's annual reports about the building having too much vibration noise. Ham was a charter member of the Acoustical Society of America and was later elected a fellow of that society.



Figure 9: George L. Harvey (BS, 1938; MA, 1940), the second person to receive a master's degree in physics. He was the one who built the first remotely controlled score board referred to earlier in this chapter.

[8] The earliest physics thesis in the library is that of Halvor T. Darracott, who graduated in 1939 with an MS degree. The title of his thesis was *The Vibratory Characteristics of Vibrafram.*

[9] Hereafter we will refer to this previous history of the Physics Department as History1 [Ref. 7].

Ham (and in one case his student) presented papers at national scientific meetings such as those of the American Physical Society, Acoustical Society of America, and the American Association of Physics Teachers. Both Roberds and Ham also made presentations for the Arkansas Academy of Sciences and Arkansas Educational Association.

The department had a rather large involvement in service and outreach activities, which included the annual organization of Engineer's Day (see below), leadership roles in Sigma Xi and the Arkansas Academy of Sciences, semi-public talks at Sigma Xi and other clubs, and in classes like astronomy (taught at that time by the Mathematics Department) and scientific German, to name just a few.[10] Professor Roberds continued to x-ray students with injuries when requested by the university physician (thirty such requests were made in 1929–30 alone). The department organized Engineer's Day annually with forty or more demonstration experiments set up and attended by roughly six hundred students each year.

During the period covered in this chapter, three students received bachelor's degrees. They were Roy Sullivan in 1928, Franklin Wintker in 1931 and Nicholas Smith in 1934. Sullivan went into forestry research after being awarded a PhD from the University of Minnesota. After a number of positions elsewhere, Wintker joined General Electric X-Ray Corporation for a successful career that ended in retirement as district manager of the South Central district in 1971.

It is incredible indeed what was being accomplished with effectively just two faculty members.



Figure 10: Franklin R. Wintker (BS, 1931) standing at the entrance of radio station KUOA on the university campus. He was the second person to receive a bachelor's degree in physics at the university and served as "program man" during his senior year and for a time after graduation. Cadet Colonel Wintker is in his uniform and ROTC was required of all male students. *Photo courtesy of Mr. Wintker.*

[10] Examples of talks and presentations include: Psychological Phenomena in Light and Psychological Phenomena in Sound (Psychology Club); Diffraction of the Electron (Alpha Chi Sigma Club); Diathermy, A New Cooperative Research in Physics and Medicine (Medical Club); Historical Development of Theories in Spectroscopy (Math Club); and Spectra and Demonstrations in Spectroscopy (Astronomy class).

3.

Physics in Old Main

1936–1952

In this chapter we describe the further evolution of the department during the period from 1936 to 1952, when it was housed in Old Main (University Hall). The chapter is divided into two parts. The information presented in part I is obtained from what is available in the departmental annual reports and university catalogs of that period. Part II is mostly an eye-witness account by the senior author of this book. Part I is further divided into three sections, corresponding roughly to the prewar period, the WWII period, and the postwar period. We start this chapter with physics moving into Old Main — a vast improvement over the previous small, wood-frame building — and ending when the department had vastly outgrown the space available to it there. The defining characteristic of this entire period was a severely understaffed, overworked faculty. In spite of this disadvantage, there was no lack of ambition on the faculty's part. During the war era the department's normal operations were completely upended as it had to teach a large number of army trainees. No sooner had the war ended in 1945, than the faculty had to cope with educating a large number of students, both veterans and regular students. At the same time, the number of physics majors and graduate students grew. For the first time, the department carefully outlined a plan to emphasize research and introduced more graduate level courses. Serious deliberations about starting a PhD program began to take place. None of this was easy, particularly because it was very difficult to find qualified faculty in the postwar era.

Part I

A. Prewar Period: 1936–1942

This period is marked by the department's new quarters and an overstretched faculty trying to cope with teaching a growing number of students, as well as an increase in physics majors. Also, the department awarded its first graduate degree in 1939, followed by a second in 1940. Dr. Ham's research in acoustics was bearing fruit.

The biggest change the department experienced over the previous period was its new quarters, as it moved into Old Main in May 1936. The space available to it more than doubled, from an estimated less than five thousand square feet in the Physics Hall to about eleven thousand square feet in Old Main (this being the gross square feet of space, i.e., including hallways, stairwells, rest rooms, etc.; see chapter 5). The quality of space was also vastly superior. This allowed the department to better fulfill its mission, and there was a general satisfaction with the new space among the faculty. Even though severely constrained by a lack of staffing, the department was able to do more than it previously could within a very limited and inadequate maintenance budget. The following

statement reproduced from the *1936–37 Annual Report* dated May 27, 1937 (written by Professor Ham and submitted to Dean Ripley) summarizes the situation:

> Our new quarters have proven very satisfactory in our first year of operation. With space for properly handling our equipment and with modern utilities, as usually found in well-equipped facilities, we are experiencing much more use for our apparatus. Our students are able to perform their experiments without being in each other's way, and without waiting for space or for some electrical utility.
>
> Because of the more adequate space for lectures and laboratories, and because of the increased use of apparatus, we find that additional maintenance funds are especially urgent for increases in student help and increase of supplies and apparatus repairs.



Figure 1: Professor Lloyd Ham, circa 1950. ***Photo courtesy of the University of Arkansas Libraries, Digital Collections.***

However, by 1940, as enrollment increased, the department was running out of space, and a request was made for additional space as well as for realignment of existing space for better utilization. Nothing came out of that request.

The department's estimated budget for the 1937–38 academic year was $3,100 ($2,100 maintenance plus $1,000 from fees). This is not too different from the estimated budget of $2,900 a decade earlier (see chapter 2). The budget covered laboratory equipment and supplies, shop equipment and supplies, student wages, books and periodicals, and everything else that the department needed. The first item alone consumed about 50 percent of the budget. Because of increasing enrollments and an increased number of majors and graduate students, the budget was coming under pressure. For example, the cost of an x-ray machine or a spectrometer needed for instructional laboratories was over $1,000 for each. Budgetary pressures were so high that even the Physics Library's subscription to *Scientific American* — which Professor Roberds frequently referred his students to for articles on x-rays and other topics — was on the chopping block.

The department continued to work with effectively just two faculty members, Professors Ham and Roberds, until 1937. Ripley stepped down as dean of men in 1937 but remained head of the Physics Department until 1940[1] when he retired. Presumably he took on a higher teaching load from 1937 to 1940 than he was able to before that. Ham and Roberds's formal teaching loads continued to be about fifteen credit hours

[1] Apparently, Ham was still managing the department on behalf of Ripley even during the 1937–40 period, as evidenced by the fact that all the memos and reports in departmental files were written by Ham.

per semester per instructor. The corresponding clock contact hours were about twenty-two hours per faculty per semester. To put these teaching loads into perspective, the department cited a scientific study[2] that found that the instructional load in physics defined as a ratio (hours outside of class divided by those in class) at Oregon State Agricultural College was 2.3 for demonstration lectures, 1.5 for recitations, and 2.3 for laboratories, not including time for maintenance, repairs, and purchase of supplies and equipment. This is the *additional* load, that is, 2.3 hours are required to set up and tear down demonstration for each hour of lecture. Using these and other arguments, pleas were made for additional faculty. But these were of no avail. In 1940 Professor Ripley retired and Professor Ham officially became the head of the department.

As we look through the annual reports during the period of 1936 to 1942, memos written by Professor Ham to Dean Ripley and Dean Jones (dean of College of Arts and Sciences), and a five-year plan prepared by Ham in 1937, it becomes clear that the department was making desperate appeals for one more instructor and increased funding for equipment and student help based on increasing enrollments. In an October 1937 memo, Ham wrote to Ripley that for several years, enrollments in combination lecture-recitation classes had been exceeding thirty-five and that enrollments in lab sections had been exceeding thirty, whereas they should have been thirty and twenty-four, respectively. Based on projected enrollments, these numbers were going to continue to increase unless more instructors were hired. Total enrollment increased from 303 (with thirty-three in advanced courses) in 1932–33 to 432 (with fifty-five in advanced courses) in 1936–37. The 1937 five-year plan notes that lab sections could become twice the ideal size. Teaching loads were expected[3] to go up to 17.2 credit hours and 27.6 clock hours per faculty for Roberds and Ham in 1938–39, exclusive of time spent on maintenance, repair of equipment, supervision of student help, and so on. The department was relying on an army of student employees and student assistants to help fulfill its mission. In 1939–40 there were eight student employees and nine student assistants who were helping with tasks such as repair, maintenance, setup, grading, machine shop, and clerical work. The difference between student employees and student assistants in this context is unclear.

There was general frustration among faculty that they had no time to do more developmental work in intermediate and advanced courses and were not able to spend more time on development and supervision of advanced laboratories. It was noted that rapid advances were being made in nuclear physics and cosmic rays and that a seminar-type course was needed to bring students' attention to the new developments. An argument was made to hire another instructor who could teach graduate courses in mechanics, quantum mechanics, and thermodynamics.

After Ripley's retirement in 1940, Mr. Adam Beiler (MS, University of Illinois at Urbana-Champaign) was hired as an instructor**.** His field of expertise included conduction of electrons in gases, spectroscopy, and band and Raman spectra. In the summer of 1941, after just one year, Beiler left the university to join Westinghouse Manufacturing Company. The department faced a serious situation as there was a severe shortage of physicists. In Ham's words: "In ordinary times replacement would be a matter chiefly of paying the price. Today, both the demand for physicists and for armed forces

[2] *The American Physics Teacher* 5, 71–74 (1937).
[3] February 22, 1938 memo from Ham to Dean Jones.

represents a very different picture. There is a greater demand, probably for physicists (pure and applied) at the present time than for scientists in any other field."[4] Dr. Ham felt that the department needed faculty in the fields of molecular physics, spectroscopy, and x-ray spectroscopy because these were replacing old methods of chemical analyses. That is why Beiler was hired in the first place. The inadequate program in physical sciences in the school systems had been ignored for a long time, which led to a very low number of university students in those subjects, and that had now caught up in the job market. WWII was being called the physicist's war, but there was a serious shortage of physicists.

Upon Beiler's resignation, the department faced such a serious situation that Ripley came out of retirement for one year as a professor emeritus instructor to help the department with its teaching obligations during the 1941–42 academic year. And then, to compound the problem, Professor Roberds resigned in 1942 to accept a position with much higher pay. Due to age limitations and ill health, Ripley could not continue to teach past 1942. Fortunately, however, the department was able to hire two new faculty members that year, Dr. Harold E. Clark and Dr. Paul C. Sharrah, to replace Ripley and Roberds.

The above represents a somewhat dark picture of the department struggling with a lack of faculty and funds, but let us look at the bright side. Both the undergraduate and master's programs were beginning to grow. In May of 1937 the department had four physics majors, two of whom were about to graduate with honors and were accepted into graduate schools. One, Hugh Gingerich, was going to the University of Illinois at Urbana-Champaign on scholarship as a graduate student in mathematics and was going to study both mathematics and physics. The other, Howard Thorpe, was going to graduate school in physics at Tulane University on an assistantship. The department awarded its first graduate degree (an MS) in 1939 and the second degree (an MA) in 1940, and Dr. Ham's first research paper based on work done at the University of Arkansas was also published in 1940.

While research was not formally a part of undergraduate curriculum during that period, even for honors students (see chapter 6, section III), the Physics Department did have undergraduate students participate in research, mostly in Dr. Ham's acoustics work. We find the following statement made in relation to faculty teaching loads which substantiates this conclusion: "research work in a department organized on an undergraduate basis must be considered essentially as an extra-curricular activity, or as an avocation. The time this kind of work takes cannot be evaluated easily in terms of student credit hours."[5]

Despite being burdened with very high teaching loads, the faculty were engaged in ambitious projects. Two six-foot-diameter parabolic reflectors and a 250-450 KV Van de Graaff generator were being built in 1942 for demonstration purposes. The generator was going to be six feet high with a thirty-inch sphere capable of producing twelve-to-fifteen-inch sparks. They also wanted to build a hands-on physics museum. The need for a seminar course to call the attention of major and minor students to current literature in physics was cited, but the faculty were frustrated that there was no time to develop such a course.

We end this section with a bit of trivia about that period, as it may be of interest. The

[4] *1940–41 Annual Report* dated June 7, 1941.
[5] May 1939 annual report.

department did not have a telephone of its own until sometime after 1940. In the summer of 1940, a case was made by Ham to the Dean for the need for a telephone to contact vendors of physics equipment and to receive their return calls. A telephone was available for the Physics Department's use prior to 1940 in Dean Ripley's office, but that option was lost after his retirement.

B. The War Era: 1942–1945

As mentioned in the last section, in 1942 the department was facing the prospect of being reduced to a faculty of just one. However, it was fortunately able to hire two new faculty members, Mr. Harold E. Clark (MS, Washington University in St. Louis) and Dr. Paul C. Sharrah (PhD, University of Missouri), both as assistant professors, which kept the faculty level at three. Sharrah was to make a lifelong commitment to serve this department. The addition of two new, young faculty members reinvigorated the department. Professor Ham wrote in the *1942–43 Annual Report*: "With three men prepared to do advanced work, we set up an ambitious new program streamlined for the new scientific age in which we are living." However, the department soon found itself teaching large numbers of US Army trainees, and this program had to be delayed for a few years. The same report continues, "The new program had no more than been set up when the war training program in physics began to weigh heavily on us. It is very probable that much of this program will have to be set aside for a successful and necessary war training program in physics." This was to be the case.

Meanwhile, there was a nationwide shortage of trained physicists. As early as May of 1942, Henry A. Barton, the Secretary of the War Policy Committee of the American Institute of Physics, sent letters to the deans of graduate schools asking them to prepare for very high physics



Figure 2: Professor Paul C. Sharrah, circa 1948. ***Photo archived in the Physics Department.***

teaching loads in the coming years. It was stated that because of expected higher enrollments in engineering courses, inclusion of physics as an essential subject in navy training programs and as a recommended subject in army training programs, the physics teaching loads could increase by as much as 100 percent. Since a large amount of teaching was done by graduate assistants, the departments were urged not to lose this manpower. To this end, deans were encouraged to give graduate students every opportunity to register for graduate work that summer without interruption to keep them from being inducted into the army. It was argued that this would be a direct contribution of the Physics Departments to the war effort, not only by providing training to the armed forces, but also by increasing the scientific pool for future war efforts. Barton also sent letters to the presidents



Figure 3: Instructor Bruce Kellar, circa 1960. ***Photo archived in the Physics Department.***

of universities and urged them to use every effort and ingenuity to hire adequate teaching staff to meet the challenge. The committee expected a shortage of at least two thousand teachers. The shortage was further aggravated by the fact that many physicists had left the universities to join the war effort in other ways. It was also suggested to train physics teachers by drawing them from other physics-related fields.

Professor Ham noted [6] that about four thousand additional professional physicists would be needed by 1944, whereas the number of PhD physicists produced annually was only about 350.

Against this backdrop of teacher shortages, the Physics Department received its first batch of trainees during the 1942–43 academic year. Ham reported that in the "three air corps flights together with the 350 basic engineering trainees," an equivalent of 1,800–1,900 extra students were taught that year.[7] The department's war training program came to an end on March 3, 1945. A first-person account of that period is given by Paul Sharrah in chapter 13. Sharrah estimates that about 3,500 trainee students were taught by the department during this period.

Accommodating that many additional students in the laboratories was a special challenge. Advanced laboratories were converted into elementary labs, and the advanced lab equipment was stored away in boxes. The Physics Department had already prepared for the additional labs by purchasing additional equipment ahead of time using a special allocation of funds. Still, there were challenges including that of space shortage, management of additional equipment, and additional administrative work that having that many students represented. The mechanics of purchasing, classifying, and distributing supplies presented a continuous heavy burden on a staff already stretched to the limit. Mr. Bruce Kellar was employed to take care of the equipment and prepare apparatus for laboratories, but he worked as a machinist as well because the supply of student assistants had become practically non-existent. Gradually, he was also assigned teaching duties.

Just when the department needed the maximum staff, it appears that both Professors Clark and Sharrah were recruited away by the government, leaving Professor Ham alone. We find the following statements in the *1943–44 Annual Report* by Ham: "Uncertainties in draft board situations regarding Profs. Clark and Sharrah. . . . The loss of Mr. Clark in April and Mr. Sharrah in May left the Department with one

[6] *1942–43 Annual Report*

[7] Throughout this period the acronyms AAF (Army Air Forces), AST (Army Specialized Training Program; usually ASTP), ASTR (Army Specialized Training Reserve Program; usually ASTRP) are used without explanation. Sharrah refers to them as Army Air Corps and Army Specialized Training Program trainees (see chapter 13).

member only. . . . The departure of the other two members of the department has placed many routine burdens of the physics department on one person." No details as to where these two gentlemen went and for what period, or as to what they did, is available in the departmental reports and memos. However, Sharrah's own statement in part II of this chapter seems to provide a partial answer: "Sharrah worked on torpedo depth control systems for the Naval Ordnance Laboratory in Washington, DC during WWII." While commenting on the departmental staffing issues, Ham in a 1944 memo to President Harding mentioned that personally he had had no time off since 1941. It seems odd that just when the government needed the department to teach its military trainees, it drafted away its teachers.

However, the department was able to hire temporary teachers, some of them from other departments. Three of them were added in the summer of 1944 when Clark and Sharrah were drafted. The following names of temporary teachers can be found in various documents, but the list is not all-inclusive: Miss Gladys Boyed from geology, Mr. H. W. Houghton, Dr. F. M. Sparks, Mr. Richard Warren, Mr. Bruce Kellar, and Mr. Whittington. They were all released upon the end of the trainee program in March of 1945. In June of 1944, Ham wrote that "only 5 percent of the work in physics has been taught by a regular member of the staff." Managing the department's teaching obligations using temporary instructors was seriously challenging, and the task was Dr. Ham's. There were frequent changes in the instructors, and they had to be trained, especially in the use of equipment.

It appears that the managers of the trainee program in the military either had no idea, or were insensitive to, the nature of physics courses. The department did not know how many students to expect and when, and had no time to prepare for them. The following quotations regarding the uncertainties are taken from the departmental reports: "sudden end of AST program in March," "approaching collapse of AAF program by July 1," "sudden addition of 450 students near the end of the program," and "sudden addition of 330 ASTR students before July 1." Moreover, programs changed frequently for students. For example, for AAF students, "the course was changed from time to time with little warning, students were taken out entirely or were transferred to another group of more advanced training, and often whole squadrons dropped physics for a brief flying period and then picked it up again at some later time."

What was happening to the university students during this period? Enrollments fell precipitously as young men were drafted into the armed forces. What was happening to physics majors? Starting in 1942, promising physics majors had dropped out and joined some branch of the armed forces.

Mr. Clark resigned in 1944 to take a position with Western Cartridge Company in Alton, Illinois. After his departure, President Harding changed Clark's position to an instructorship, citing the need to conserve funds.

In the summer of 1945, the department found itself preparing for the postwar era. One of the biggest problems was a lack of space to store the apparatus. Even during the period when the trainees were here, the equipment that was not being used at that particular time had to be stored in boxes because there was no other space. Apparatus had to be stored in several hundred boxes stacked ten boxes high. The department planned to keep some of the apparatus that had been bought for the trainees. Other equipment was to be sold off. For some time, the department had been asking for a mezzanine floor with eight feet of ceiling clearance to be constructed in the space below parts of the first-floor hallway of Old Main. But now the need was urgent, as the equipment had to be stored before the advanced laboratories could be brought back

to life. The mezzanine floor was constructed by 1946, and there were at least ten advanced laboratories (300-, 400-, and 500-level) being taught at that time (see chapter 6).

The department needed to prepare for a large increase in the number of undergraduate students in the postwar era. It was expected that the increase was going to be due not only to regular students but also veterans (most, if not all, funded by the GI Bill). Ham was concerned about the special needs of the veterans. In the *1944–45 Annual Report* he writes: "The precollegiate veterans will, apparently, present fundamental problems in instruction. Sympathetic understanding of problems confronting these people of little educational background as well as skilled teaching will be important among the essentials required of the instructor. Frequent changes of instructors of these groups will be fatal in the accomplishment of the presumed aims for this group. Apparently, a second group will start this fall. Our department therefore faces increased difficulties to the extent this form of service broadens." We need to be reminded that Clark had resigned and that the department was reduced to a faculty of two.[8] There were about thirty physics courses in the catalogs of this period.

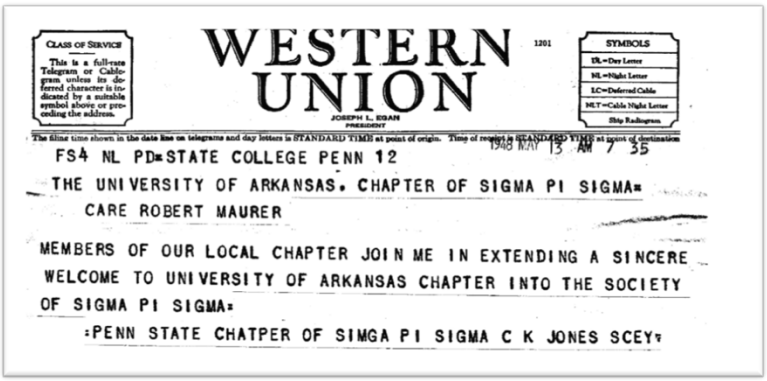
It is worth taking a moment to consider what was happening nationwide. In February 1945, the American Institute of Physics (AIP) issued a bulletin entitled: *The Future Supply of Highly Trained Scientists.* It pointed out that there were reasons to believe that there would be a critical shortage of highly trained physicists in the immediate postwar period. The reasons cited were twofold: first, that there would be a large demand for more physics teachers, since there would be a large increase in the number of undergraduate students, both traditional students and veterans, and the lack of potential graduate students in the pipeline to assist in teaching would further aggravate the problem; second, that the government and industrial programs were growing. At the same time, the number of new PhDs granted in 1944 had dropped to mere fifty-five. An immediate deficit of two thousand PhD physicists was predicted. This indeed had a direct impact on our department, as we will see in the next section. By August of 1945, AIP was taking a proactive role in helping physics departments nominate their most intellectually able recent undergraduates for National Research Council Predoctoral Fellowships funded by the Rockefeller Foundation. Our department nominated Henry Palmer Hotz and Howard T. Head.

C. Postwar Period: 1946–1952

No sooner was the war over than the department found itself facing new challenges in the postwar era. Enrollment had already started increasing in 1945, and the department faced a critical shortage of staff at all levels. The number of physics majors, which had dwindled during the war era, started to grow again, and a chapter of Sigma Pi Sigma was installed. The department made a concentrated push to start several new research programs and even tried to get approval to start a PhD program. The space shortage continued throughout this period, finally ending with the department's move to its present quarters in 1952. In many ways, this was the most consequential period for the further growth of this department into the Physics Department as we see it today. Much happened during this short period, and we owe it to the vision and hard work of two people: Professors Ham and Sharrah.

[8] The 1944–45 catalog lists Professor Ham, Assistant Professor Sharrah, and Instructor Bruce Kellar. Kellar, who was hired to manage the equipment while the trainees were here, was to be released from employment soon afterwards.

Sigma Pi Sigma Chapter Initiated in 1948



WESTERN UNION

1201

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THE UNIVERSITY OF ARKANSAS. CHAPTER OF SIGMA PI SIGMA=

CARE ROBERT MAURER

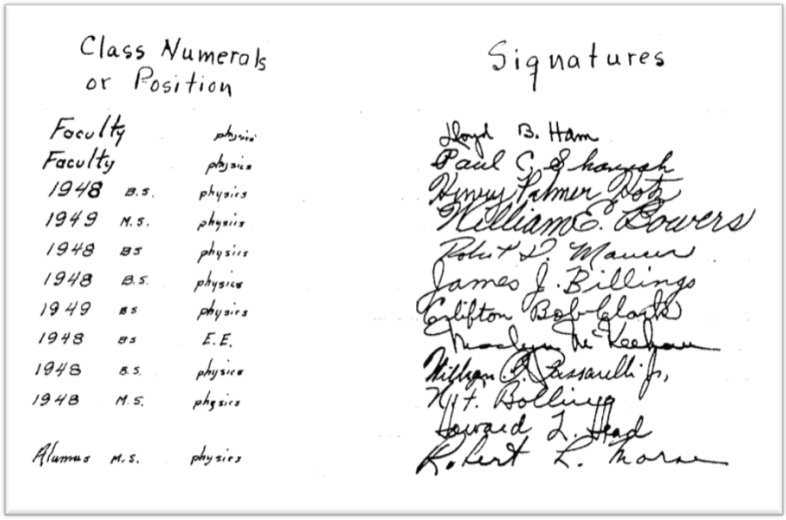
MEMBERS OF OUR LOCAL CHAPTER JOIN ME IN EXTENDING A SINCERE WELCOME TO UNIVERSITY OF ARKANSAS CHAPTER INTO THE SOCIETY OF SIGMA PI SIGMA=

=PENN STATE CHATPER OF SIMGA PI SIGMA C K JONES SCEY=

A telegram of congratulations received by Robert Maurer, the Secretary of the University of Arkansas chapter of Sigma Pi Sigma.

By the late 1940s, the department had a burgeoning physics majors' program (see chapter 6) and students wanted to form an honor society. Professor Ham did not encourage the effort much until 1947 because he felt that the number of students was not enough to make a viable organization. Ham had this to say in 1948: "About Christmas time of last year, the members from our department formed a temporary organization set up in much the same manner as the other honor organizations on the campus operating under the Student Honor Council. Early this spring the organization applied to the National Physics Honor Society, Sigma Pi Sigma, for a charter." The application for the charter was granted. Apparently, it was a significant achievement for the period. Telegrams and letters of congratulations from dozens of other chapters came pouring in. Many of them are preserved in the Physics Archives, and a telegram from Penn State University is reproduced here.

The chapter was installed on May 13, 1948 by Marsh W. White of Penn State University, executive secretary of Sigma Pi Sigma. There were twelve charter members, which included six undergraduates — Henry P. Hotz (president), Robert D. Maurer (secretary), James J. Billings (treasurer), Clifton B. Clark, Macklyn McKeehan, William O. Pasarelli Jr. — graduate student William E. Bowers, faculty members Lloyd Ham and Paul Sharrah (who was already a member from William Jewel College), and alumni N. F. Bolling (assistant professor of physics at Arkansas State Teachers College), Robert L. Morse (a local physicist), and Howard Head of A. D. Ring & Associates in Washington, DC. Mr. Head traveled from Washington to attend the ceremony. A dinner was held in the evening at Mary Maestri's, where Dr. White gave a talk entitled, "The Physicist in War and Peace." The dinner was even attended by the president of the university, Dr. Lewis Webster Jones.



Class Numerals or Position			Signatures
Faculty		physics	Lloyd B. Ham
Faculty		physics	Paul C. Sharrah
1948	B.S.	physics	Henry Palmer Hotz
1949	M.S.	physics	William E. Bowers
1948	BS	physics	Robert D. Maurer
1948	B.S.	physics	James J. Billings
1949	BS	physics	Clifton B. Clark
1948	BS	E.E.	Macklyn McKeehan
1948	B.S.	physics	William O. Pasarelli Jr.
1948	M.S.	physics	N.F. Bolling
Alumnus	M.S.	physics	Howard L. Head
			Robert L. Morse

Roster of the charter members of the Sigma Pi Sigma chapter.

An active Sigma Pi Sigma chapter in the department continues to date.

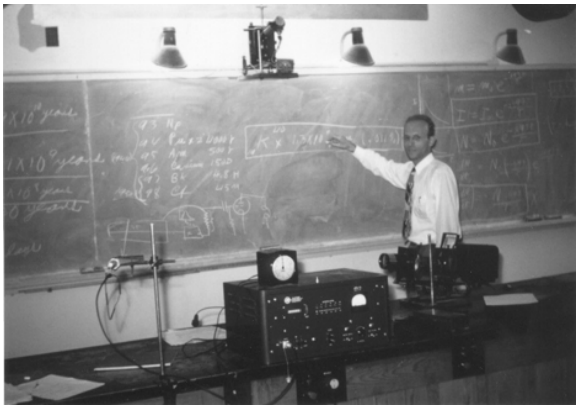


Figure 4: Professor Jean Camus in the Old Main physics lecture room, circa late 1940s. *Photo archived in the Physics Department.*

Staffing and Students

Upon the resignation of Mr. Clark and the release of all temporary instructors hired during the war period, only two instructors were left: Drs. Sharrah and Ham. In 1946, attempts were made to hire a replacement for Clark's position, but the problem was that practically no PhDs were granted during the war years. The department was trying to hire someone with expertise in the field of spectroscopy and allied areas of light and photography. This was to complement Ham's area of acoustics and electricity, and Sharrah's of x-rays, atomic and molecular physics, and radio. Against the backdrop of a nationwide shortage of manpower, the university was offering noncompetitive salaries. Documents available from that period suggest that a salary of $2,500–$3,000 was being offered, whereas the market required a minimum of $4,000. In spring 1946, Dr. T. F. Watson was hired to fill Clark's vacant position but asked to be released just two weeks after joining the department when he received an offer with much higher pay at Phillips University in Enid, Oklahoma. The department continued to muddle along with just two faculty members, Ham and Sharrah, assisted by a number of temporary teachers, student teachers, and teaching assistants. In the fall of 1947, Mr. Lingelbach was hired as an instructor (see below), bringing the permanent teaching staff to three. In the fall of 1947, when enrollment had peaked at five hundred students, the department had as many as six instructors: Ham, Sharrah, Lingelbach, and three temporary instructors. While the hiring of Lingelbach and use of temporary instructors did help the department meet its immediate teaching obligations, it did nothing to advance its long-term goals of strengthening its research. One exception was Mr. Jean Camus (diploma d'études supérieures techniques, University of Paris), who came here from France and joined the department as Assistant Professor in the spring of 1947. His area of research was spectroscopy, an area in which the department wanted to add a faculty member. However, Mr. Camus's visa expired in October 1947 and could not be renewed in spite of the intervention of Senator J. W. Fulbright, so he had to return to France.

In 1946, Dr. Ham made a strong case to Dean Hosford for creating the position of an equipment custodian. It was anticipated that such a person would manage all elementary laboratory and demonstration equipment, set up the labs, help set up the demonstrations, do machining and repair equipment and, when needed, fill in to teach laboratories. It was also anticipated that candidates for the position would have a BA or BS in physics. This would have, for the first time, created the position of a machinist and a laboratory equipment curator, rolled into one. The department used to employ six to ten student assistants to do these chores, but few if any students were interested in these roles now that they were being paid to attend school. The instructors were spending too much time on repairing equipment and on recruiting student help. Eventually, Mr. George Lingelbach was hired in fall 1947 to teach laboratories and manage apparatus. He had a BSEE degree from Kansas State University and had been teaching at

Springdale High School. It was anticipated that after the instructor shortage was over he would assume the duties of equipment custodian, but he never did. He continued to teach and coordinate the introductory physics labs until his retirement in 1966 after eighteen years of service.

In 1946 Professor Ham, for the first time, asked for a half-time position of a clerk (what we now call a secretary). Again, this job used to be done by student assistants, but the workload was getting to be too much for even those student assistants that could be found. Paperwork associated with GIs added to the regular growth of correspondence, examination stencils, and so on. There is no evidence that a clerk's position was granted to the department during the period covered in this chapter. From all indications it seems that the first time the department had a professional clerk was in 1952, after it moved into the Dickson Street building (see chapter 12).

The department continued to function using a large contingent of student assistants,[1] as difficult as they were to find. During the 1945–46 academic year, the department had eleven student assistants (five laboratory assistants, three machine shop assistants, and three clerical assistants). In addition, two of the graduate students worked as teaching assistants, presumably teaching labs. In 1946–47, there were ten technical and office assistants and ten student teachers. In 1947–48, the number of student assistants (technical and clerical) had grown to nineteen. In addition, there were eight teaching assistants.



Figure 5: Instructor George Lingelbach (right) with a teaching assistant in Old Main circa 1950. *Photo archived in the Physics Department.*

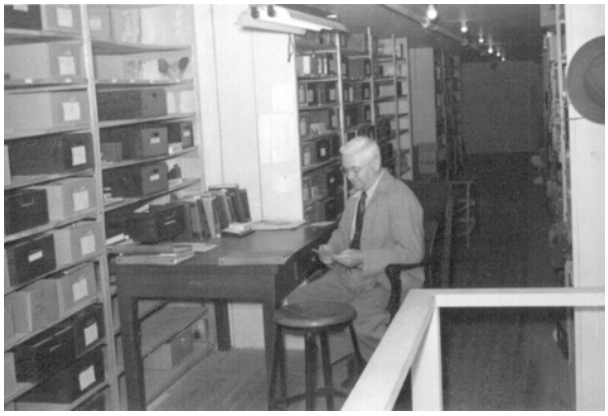


Figure 6: Lingelbach in the laboratory stockroom, circa 1950. *Photo archived in the Physics Department.*

During the prewar period, the department taught about 200–225 students, of which fifteen to twenty-five were enrolled in advanced classes. That number had risen to 360 students with about forty in advanced classes in fall 1946. It was anticipated that the peak would come in the fall of 1947 with as many as five hundred students. The prediction came true: there were five hundred students in fall 1947 and 460 in spring 1948. Thereafter, enrollment started to decline.

The number of physics majors and graduate students was also increasing. In 1945–46, the department had six physics majors and five master's students. In 1946–47, the number of physics majors had grown to eleven, while the number of graduate students remained at five. Five physics majors graduated in 1948, the largest number in one year at that time. Among them

[1] The numbers in this paragraph are arrived at by counting the names of all the assistants listed in the annual reports; it is likely that not all them worked the whole year.

were Robert Maurer, who was admitted for graduate study at, MIT, Harvard, and University of Washington in St. Louis; and Henry P. Hotz and James Billings who were admitted to University of Chicago. Maurer went to MIT, as did the 1949 graduate Clifton Bob Clark.[2] A fascinating account of what it was like to be a physics major here during that period in given by the distinguished alumnus Robert Maurer (see chapter 16).

The number of physics majors continued to grow in the following years. Ten students received bachelor's degrees in 1951 alone. The graduation statistics are given in chapter 6.

Meanwhile, the department's staffing woes continued in 1947 and beyond. In 1947–48,



Figure 7: Professor Herman Schwartz in his Old Main office circa 1950. *Photo archived in the Physics Department.*

Ham, Sharrah, and Lingelbach were the only permanent instructors. The department searched for PhDs to fill two positions, but the salaries offered were noncompetitive. A salary of $4,500 was needed, but only $3,000 could be offered. The search continued for two years until the last minute in fall 1949, when they found and hired Dr. Herman Schwartz (PhD, University of Pennsylvania) in theoretical physics. Camus also returned from France in July 1949. He had done fruitful research in spectroscopy at the Centre national de la recherche scientifique. Camus went to MIT to do research in the summer of 1950, and it was expected that he would receive a PhD from France based on the work he had already done.

Research and the PhD Program.

With a flourishing majors program already achieved, what followed was a period where the department's attention shifted to developing a credible research program suitable for a PhD degree, premature as that seems to be. It is commendable that, in spite of their heavy teaching and administrative loads, Ham and Sharrah were still doing research. A relatively large number of master's students did theses with Ham, and there is evidence of the involvement of undergraduates in his research as well. J. W. Keller, who obtained an MS (1948) with Sharrah on x-rays, was on an Ordnance Ozark (ORDARK) fellowship (see chapter 9). Both Ham and Sharrah regularly attended scientific meetings (mostly local, such as the Arkansas Academy of Sciences), sometimes with students, presented research results, and frequently traveled to attend summer lecture programs in places such as Oak Ridge and Ann Arbor to bring themselves up to date with new developments.

The university had established (see chapter 9) the Institute of Science and Technology (IST) in 1948 to promote research. Dr. Raymond Edwards of the Chemistry Department, under the umbrella of the institute, had obtained a large research contract with the Atomic Energy Commission (AEC), predecessor of the Department of Energy. The department wanted to avail itself of the opportunity to participate in

[2] Macklyn McKeehan, who was an electrical engineering major, a classmate of Maurer in physics classes, and a member of Sigma Pi Sigma, also went to MIT.

research at IST. Schwartz, in collaboration with Drs. Edwards and Smith in the Chemistry Department, worked under this contract. The department also wanted to add an experimental nuclear physicist to work on the AEC project. In the summer of 1950, the position was offered to Albert Saur, who was finishing his PhD at the University of Illinois at Urbana-Champaign. Professor Ham, in his *1949–50 Annual Report*, described his appointment as: "the beginning of what we hope will develop into an adequate research program in nuclear physics for essential inauguration of a PhD program in physics on campus. Graduate programs have more vigor where many men are working in some coordinated field. Dr. Edwards and Dr. Smith in chemistry as well as Dr. Schwartz in our department are directly concerned with nuclear work. Dr. Sharrah of our department also has interest in this field."

Ham recognized that as a prerequisite to starting a PhD program, several things needed to be established, including a master's degree with a broad basis (as opposed to in just two areas, acoustics and x-rays) at a high scholastic level, and more advanced and graduate courses. Schwartz had already added courses in electromagnetic theory (a two-semester sequence), quantum wave mechanics, and nuclear theory, but more graduate-level courses needed to be added. Beside more graduate faculty, the department also needed a machinist and an electronics expert.

The budget woes of the previous period seem to have ended. In 1949–50 the maintenance budget was $6,000, plus $9,000 allotted for major equipment acquisition.

In January 1950 Professor Ham submitted a proposal for starting a PhD program to the graduate school on the Physics Department's behalf. It pointed out the minimum needs of the department to start a PhD program. The proposal was not approved, perhaps because of the department's very poor research infrastructure and the need for a large investment of resources by the university. The history of the start of the physics PhD program is given in chapter 7.

Over the next few years, the faculty made a very concentrated effort to strengthen graduate course offerings and research programs toward preparing the department for a PhD program. A major step had already taken place with the hiring of Schwartz. He contributed to improvements in the graduate course offerings and Physics Library, and together with Sharrah organized a seminar on cosmic rays that led to the start of research in that field. He also participated in research on the existing AEC project through IST, as pointed out above.



Figure 8: Professor Albert Saur (right) with Professor Ham in the former's office in Old Main circa 1950. *Photo archived in the Physics Department.*

In addition, extensive discussions ensued among faculty (Saur, Sharrah, Schwartz, Ham, Camus, and Bennett) about the PhD program requirements such as entrance requirements, course work, and exams. Willard Bennett (PhD, University of Michigan), discoverer of plasma pinch effect, was on the staff of IST but also participated in the Physics Department's teaching activities.

In 1950–51, using existing research expertise, the department tried to organize its research along the following lines:

1. Cosmic rays and nuclear physics (Saur, Schwartz, and Sharrah)
   a. Cosmic rays
   b. Counting techniques (proportional and scintillation)
   c. Cloud chamber
   d. Beta-ray spectrograph (180 degree magnetic lens)
2. Physical electronics (Bennett)
3. Theory (Schwartz)
4. Other possibilities
   a. Optics and spectroscopy (Camus)
   b. Sound and acoustics (Ham)
   c. X-rays (Sharrah)
   d. Solid State (Harvalik et al.)

Zaboj V. Harvalik Jr. (ScD, University of Prague) was employed by the ARNO (Arkansas Naval Ordinance) project (see chapter 9) and was also listed as a member of the physics faculty.[3] It was anticipated that, in addition to the faculty members mentioned above, the department would be able to hire two more: one in nuclear physics, and one in solid-state physics. Finally, it looked like the department would be able to establish a credible research program.



Figure 9: Professor Willard Bennett circa 1950. ***Photo archived in the Physics Department.***

Sharrah received a $3,000 grant from Research Corporation for starting research on cosmic rays and was assisted in this work by Schwartz. This appears to be the department's first external research grant. Sharrah organized a series of experiments on energy losses and particle discrimination. Sharrah also continued the research on x-rays and nuclear physics that he had started at Oak Ridge National Laboratory in the summer of 1951. Schwartz also continued work on the AEC project through IST, as well as the work he had started at Brookhaven National Laboratory, where he had spent the summer.

The rest did not go according to plan.

Saur was delayed in the start of his research on beta-decay due to late allocation of funds for equipment and space. Space was finally allocated in the Chemistry Building. Bennett was delayed in the completion of his lab in the new wing of the Engineering Building. He had a new, innovative design for a mass spectrometer, unique for its cost, weight, and selectivity. It was built at the National Bureau of Standards in Washington, DC. He received many inquiries and invitations to give talks on this design.

Then came a serious blow to Ham's plans for research in the department during the 1951–52 academic year. Drs. Bennett and Saur, as well as Mr. Camus, resigned. Nearly a year after Saur resigned, Ham was able to find someone to replace him to work on the AEC project: Dr. Berol L. Robinson, who had received his PhD at Johns Hopkins University. It was expected that he would build a beta-ray spectroscope and start his own research as well. The addition of

[3] The 1950–51 catalog lists physics faculty as: Professors Ham, Harvalik, and Bennett; Associate Professors Sharrah and Schwartz; Assistant Professors Saur and Camus; and Instructor Lingelbach.

Robinson to the faculty helped, but problems in teaching advanced courses in electronics, light, and spectroscopy remained. The next addition to the faculty was not to come until 1954.

Physical Facilities.[4]

Now, what was the situation with respect to the physical facilities during this period? As mentioned previously, Ham had requested the construction of a mezzanine in the first-floor hallway of Old Main to create about nine hundred square feet of space for the storage of equipment used in elementary labs. Well, the mezzanine was built in the summer of 1945. This was of some help for the storage of equipment but nothing else. In 1948–49, Sharrah negotiated for some additional space in the old journalism quarters, which resulted in an additional office, a small lead-lined x-ray room, and a lecture room on a shared basis. The space shortage was increasingly affecting the department's opera-tions. On February 19, 1948, Ham submitted a proposal for a new physics building to the Building Committee, which was considering proposals for new buildings on campus. This was not the first time that he had submitted a proposal for a new building — the first had been submitted in August 1944, but nothing came out of it. The new proposal was mostly an updated version of the first and was detailed, visionary, and well-thought-out. He proposed an independent physics building with net useable space of approximately twenty-six thousand square feet. He wanted the building to be independent so that additional wings could be added as the department's needs grew, particularly the need to facilitate new areas of research. The importance of physics research and teaching in the modern world was emphasized by citing applications in areas such as biophysics (use of radioactive isotopes), spectroscopy and spectrophotometry (for chemical analysis), electron microscopes (use of electron optics), x-ray diffraction (for study of liquids, crystals, and minerals), supersonics (for material testing), medical physics (for electrocardiography, roentgenography, radioactive isotopes, hearing aids, vision, etc.), and geology, to name just a few.



Figure 10: Physics faculty in Old Main, circa 1950. Front row (left to right): Albert Saur, Herman Schwartz, Llyod Ham, Willard Bennett. Back row: George Lingelbach, Paul Sharrah, Jean Camus. *Photo archived in the Physics Department.*

[4] See also chapter 5.

His proposal included two lecture rooms, well equipped for lecture demonstrations, four elementary laboratories, several specific advanced laboratories and research laboratories, equipment storage space, six faculty offices, a library, main office, and machine shop. In other words, it was a fairly modest but well-thought-out plan.

This building was never built. However, these needs were addressed in 1950 when a building being built on Dickson Street for the Physical Plant was quickly adapted for the Physics Department. The Engineering School had just had a review team visit the campus, and the team reported that the crowded and poorly developed space for physics in Old Main was a detriment to the engineering program. From fall 1950 to fall 1951, the physics faculty spent considerable time on the design of space within the new building, and it was rapidly finished. The department started moving to the new space in May 1952. This was to become its permanent home. A description of that building and the circumstance leading up to it are described in detail in chapter 5.

Part II

The following is Sharrah's eyewitness account of the period when the Physics Department was in Old Main (edited for brevity).

A. Teaching and Research in Old Main

What was going on in Old Main in the 1930s and 1940s? Teaching, teaching, teaching! Good teaching! And some research in your spare time. Heavy teaching loads, up to twenty-one credit hours during World War II. This extra load was for extra pay — a 50 percent increase.

Class attendance was required, and classes were scheduled for five and one half days. The Saturday morning classes were finally eliminated in the 1960s as night classes and the ninety-minute Tuesday–Thursday classes came into vogue.

Another strictly followed procedure in those days was the reporting to the deans and the registrar of four-week grades and ten-week grades. This procedure kept both students and professors on their toes. Semester grades were usually reported on time because paychecks were withheld until grades were received in the office of the registrar.

There was always a shortage of teachers, and the graduate program was small so that well-qualified senior physics and engineering students assisted with the laboratory teaching and demonstrations and in the physics shop. They are well remembered and were a joy to work with. It was not until the early 1960s that graduate enrollment increased sufficiently for there to be enough graduate assistants to teach all of the elementary laboratories. Most of the faculty called this progress, but some of us still remembered those bright, eager, and competent undergraduates we had been able to employ. There are some advantages to the undergraduate in being associated with a small school where they will be especially appreciated and utilized.

The Physics Department was indeed small, usually only three or four professionals at a time, but there were certainly some memorable people.

It is interesting to remember those early undergraduate and graduate students. Several of them continued with graduate studies here or elsewhere and several went on to obtain a PhD. Some served in industry or government laboratories, and some became teachers. Several had military service and at least three had a military career. One became a commercial airline pilot, and some went into privately owned businesses. One was awarded the Oersted Medal

by the American Association of Physics Teachers for outstanding teaching, and another had outstanding success in pacemaker development. At least one did some important work in the early space program (see chapter 15).

B. A Look Back at the Period in Old Main

The record of the Department of Physics during the sixteen years in Old Main was interesting. We had gone through a major war. We had learned how to turn out majors and graduate students, and made majoring in physics a little more popular. Veterans returning from WWII would look up the Physics Office and say that they wanted to major in physics.

We were becoming more involved in research, largely at first through the efforts and funding of the Institute of Science and Technology (IST). Some of the IST physicists were strongly motivated in research and had been employed specifically on research projects.

We were now teaching a "modern" vacuum tube electronics course and were developing the theoretical physics courses to include quantum mechanics.

We had established the physics honors society Sigma Pi Sigma and assisted with the establishing of a chapter of the scientific research society Sigma Xi. The department was active in the Arkansas Academy of Science, and Dr. L. B. Ham served as secretary and as president of the chapter. One faculty member served on the three-man library committee, and one served on the commencement committee.

At an earlier time, an x-ray diffraction facility was initiated by Roberds, and it was equipped in 1951 with a completely new North American Philips x-ray instrument funded by university funds. A Littrow spectrograph was also obtained using the same funds (see chapter 9).

Also earlier, the head of physics, Ripley, served as dean of students. One physics faculty member, Wesley Roberds, built and installed the first remotely controlled scoreboard at the football stadium.

C. Other People During 1936–52

The University was indeed small in the 1940s. Old Main housed most of the departments of the College of Arts and Sciences, now called Fulbright College.

When the physics head office was on the main floor of Old Main, it was nice to be able to walk directly across the hall to the Registrar's Office with Fred Kerr, down the hall north to the Business Office with Bunn Bell, George Stubblefield, Jacob Sharp, and Frances Lehman. The business practices were very antiquated, but an error could be corrected at once. Now that we have computers, one usually has to wait to get something corrected.

We often went upstairs to the typing and mimeograph facility of General Extension where the women and Director Libern L. Hilton worked with the machines, upstairs from the English Department, the Speech Department with Virgil Baker (he owned and flew his own Piper Cub airplane), Sociology and Social Welfare with Mattie Cal Maxsted, to Foreign Languages with Marinoni, Passarelli, McMillan, and Strauss, to the Museum with Sam Dellinger, to the Art Department on the top floor with Ralph Hudson, the office of the dean of arts and science with Hosford and Nichols and to the office of the graduate dean with Jordan and later Adkisson. Dr. Dwight Moore of the Botany Department was in the south tower office at the third or fourth floor level for a time.

Professor Walter J. Lemke and the Journalism Department were housed in the north end of the basement in Old Main.

Only history, political science, mathematics, chemistry, geology, philosophy and psychology were in other buildings.

4.

Going Forward

So far we have described the development of all aspects of the department from 1871 to 1952 in a chronological manner. A different approach is taken from here onward. Different aspects of the department, such as undergraduate programs, graduate programs, research, and departmental administration, are covered in separate chapters. This topical approach will allow us to better focus on each aspect of the department. This short chapter has been included to provide continuity from the chronological style of the previous chapters to the topical style of the following chapters.

The choice of the year 1952 to make this transition is appropriate. The department moved into the Physics Building located on Dickson Street in the summer of 1952, and that building became its permanent home. Simultaneous to this move was the establishment of the Physics Library as a branch of the main library, the hiring of the first departmental secretary, an increase of space for research laboratories, and the transfer of the machine and carpentry shops to the Physics Building. This led to the establishment of the PhD program a few years down the line and an unprecedented growth of the faculty and research thereafter.

Chapter 5 describes the many buildings that the department occupied over its life. Brief histories of the undergraduate and graduate programs are described in chapters 6 and 7, respectively. Evolution of the research programs is described in chapters 9 and 10. The astronomy program is discussed in chapter 8, and the administration and support services are discussed in chapter 12. A valuable perspective on the department can be obtained by looking through the eyes of other people who were or continue to be part of this department. To this end, a few faculty and alumni reminiscences are presented in chapters 14 and 16. Accomplishments of a few alumni are highlighted in chapter 15.

The department celebrated its centennial in 2008, which is described in chapter 17.



Figure 1: The Physics Building on the south side of Dickson Street. The department moved into this building in 1952 and has been there since then. ***Photo courtesy of the University of Arkansas Libraries Digital Collections. Undated.***

5.

Buildings and Physical Facilities

In this chapter we will describe the spaces occupied by the Physics Department throughout its history. We are going to deviate a little bit from our stated goal of covering the department history from 1907, when the department was established, to its centennial year of 2007–08. We will actually include even the period from the start of the university in 1871 to 1907 when physics instruction was being carried out by instructors of chemistry, engineering, and other subjects. As can be seen from the timeline presented in the text box, physics instruction, and research when it started, must have been carried out in seven buildings. We describe below each building and its use in as much detail as we can determine from the available documents. This has been supplemented by personal recollections of the two authors for a combined period spanning about seventy years.

A. Original University Buildings (1871–1875)

Before the university's permanent brick building, University Hall, was constructed in 1875, the university's entire operation was conducted in three temporary wood-frame buildings. Obviously, physics instruction was also in these same buildings. The following description of the buildings is based entirely on a letter [Ref.5] written by William Waggener (see Prologue I), the first graduate of the University.

He describes the first building as a "little two-story frame, standing hidden among the black-oak trees." He says about the first year: "During this time the only building used for instruction was the two-story frame above mentioned (the dwelling and other farm buildings standing somewhat to the eastward, and afterward removed, were, during this time otherwise occupied)." Waggener describes the second building: "Likewise a two-story frame, but larger in all dimensions than the first, [the building] was erected during the summer vacation between the first and second years. It stood to the westward of the first building and was united with the first by hallways, roofed over and enclosed. During the following summer vacation an addition of corresponding size was made to and in the rear of this second building. This third part had the chemical classrooms and laboratory on the lower

Buildings Used by Physics

- **1871–1875** The original university buildings
- **1875–1893** University Hall (Old Main)
- **1893–1904** Science Hall (Chemistry and Physics)
- **1904–1918** Engineering Hall
- **1907–1909** Physical Laboratory building
- **1918–1936** Physics Hall
- **1936–1952** University Hall (Old Main)
- **1952–Present** Physics Building
- **1994** Renovation and expansion of the building

floor, and general classrooms on the upper floor." Waggener additionally discusses the buildings: "At the end of the fourth year of work, (near about the middle of June, 1875) the main building was so nearly completed that the closing exercises for that year were held in the chapel of that building."



Figure 1: University Hall just when its construction was being completed. The track in front is perhaps a wheelbarrow track. Physics was taught here from 1875 to 1893. *Undated Photo. Courtesy of the University of Arkansas Libraries, Digital Collections.*

B. Physics in Old Main (1875–1893)

University Hall, or Old Main, was the principal home for physics in two distinctly different periods. The first period, from 1875 to 1893, will be described below as accurately as possible from the information that is available.

Old Main was completed in 1875 and received an especially positive description in the 1877 catalog, but no details were given about specific space assignments. The names University Hall and Old Main have been used interchangeably throughout the years. The building was officially named Old Main at its rededication in September of 1991.

The courses and housing details of the several departments in Old Main, including physics, were finally carefully defined in the 1889 catalog: "The main front of the building is divided into offices, recitation rooms, and laboratories. The offices of the President and the Commandant, and the rooms of the Preparatory and Musical departments are on the first floor, the Departments of Mathematics, Engineering and Physics, Ancient and Modern Language, and Pedagogics, have convenient rooms on the second floor, while the Departments of Agriculture & Chemistry and Biology and Geology are accommodated on the third floor. Above, on the fourth floor, are the commodious and well-furnished halls of the Literary societies."

Exactly the same description of the space assignments in Old Main are given in the 1891 catalog, except that engineering was also using some of the space with geology on the third floor.

The laboratories in Old Main received a detailed description in the 1892 catalog (p. 31):

> In the laboratories of the University opportunities are afforded for practical instruction in chemistry, mineralogy, physics, botany, zoology, entomology, horticulture and civil, mechanical and electrical engineering. [. . .] The Chemical Laboratories are well supplied with apparatus and have accommodations for twenty students in qualitative analysis and quantitative analysis, and twenty-two students in general chemistry. The appliances are of the latest design, gas and water at every desk, and all requisites for chemical work.
>
> The new physical laboratory will accommodate twenty-eight students. It is fitted with a small dynamo and a fair supply of general apparatus for work in practical physics.

See Prologue II for a photograph of this laboratory.

Even though the university was small and much of the teaching must have been similar to

high school or academy work, at least at first, one can hardly imagine having all of the laboratories, including the physical sciences and the biological sciences and engineering and agriculture, all in Old Main. Some agricultural work and mechanical arts work did move out to their own quarters fairly early.

C. Physics in Science Hall (1893–1904)

In 1893, Physics moved into a new building, listed as Science Hall and used by chemistry and physics. Physics was in Science Hall from 1893 to 1904, and chemistry apparently occupied the building for one more year until the Chemistry Building north of Old Main was completed.

This, a two-story brick building, fifty by sixty feet, was built for chemistry and physics in 1893 on the south side of the campus at a cost of $2,000 [Ref. 2, 319] and was supposed to have been only a temporary structure. A floor plan as well as a photograph of the building was displayed in the 1894–95 catalog and it is shown here.

The following description of the Science Hall is taken from the 1897 catalog: "This building, designed especially for the departments of Chemistry and Physics, is a substantial two-story brick building, 50 by 60 feet. On the first floor

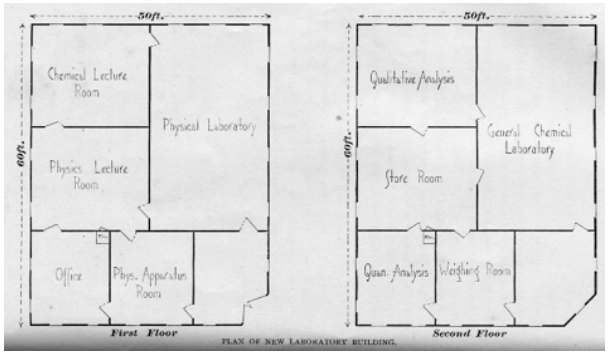


Figure 2: Floor plan of Science Hall where physics was taught from 1893 to 1904. This floor plan was published in the 1894–05 catalog where it was labeled as Physical Laboratory. From all indications, this does appear to be the floor plan of the Science Hall.

are the lecture rooms of the two departments, the physical laboratory and storerooms, and also the private laboratory of the professor in charge. On the second floor are the chemical laboratories, including a laboratory for general chemistry, a laboratory for qualitative analysis, and a laboratory devoted to quantitative analysis; also a storeroom for chemical supplies, a weighing room, and a hallway. The building is supplied with gas, water, and steam heat, and with modern appliances for technical work. It will accommodate about 100 students."

The 1894–95 catalog (p. 23) describes the Physical Laboratory as "a room 20×40 feet and is provided with large tables suitable for use in performing experiments in general physics and

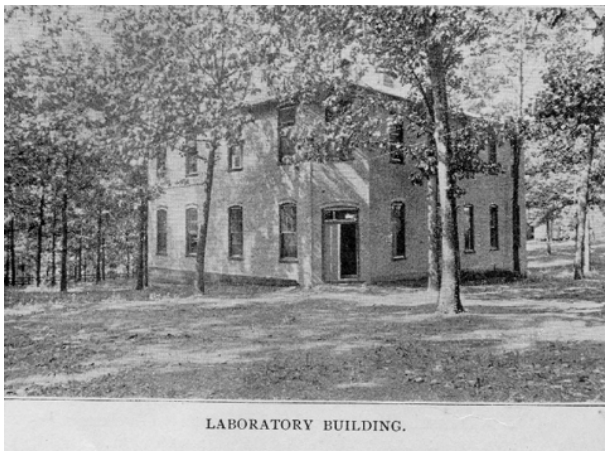


Figure 3: A photograph of the Science Hall as it appeared in the back of the 1894–95 catalog. The photo was labelled as "Laboratory Building."

physical measurements. It has also two pillars built up from ground and independent of the rest of the building for accommodation of delicate instruments which would otherwise be disturbed by the vibrations of the floor. The storeroom of physical apparatus is supplied with instruments suitable for illustrating the principles of physics and there is also apparatus for the use of the students."

The 1901–02 catalog also describes the metallurgical laboratory in the building. There

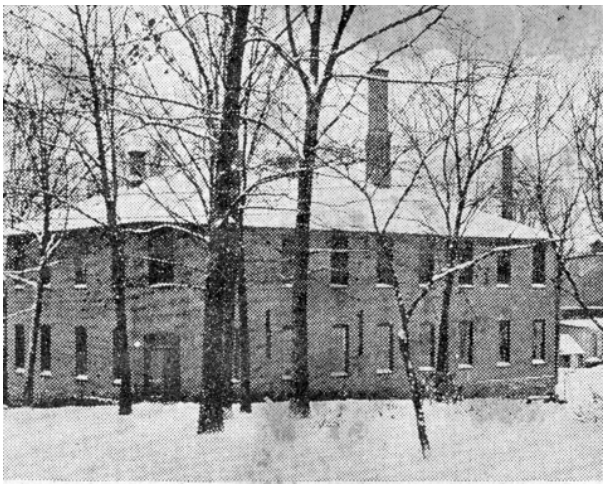


Figure 4: A photograph of the expanded Science Hall as it was published in the 1902–04 catalog.

apparently was some further improvement and expansion, and later catalogs said that the building would accommodate 150 to 200 students. Its dimensions are now given as fifty by ninety feet.

Science Hall is again described in the 1905–06 catalog, but all of its space has been assigned to chemistry.[1] It would appear that physics went into the Engineering Hall in 1904, as physics courses were indeed being taught by electrical engineering faculty at that time.

Science Hall suddenly disappears from the university scene around 1905. According to the 1907–08 catalog: "This building was condemned and taken down. The next general assembly is expected to appropriate money for a new physical laboratory."

D. Physics in Engineering Hall (1904–1918)

Physical Laboratory (1907–1909)

Physics was entirely housed in Engineering Hall from 1904 to 1918, except for the use from 1907 to 1909 of a short-lived small frame building as a physical laboratory. It was during this period (1907–08 academic year) that physics was given the status of a separate, independent department. Engineering was to use Engineering Hall until 1927 (1927–28 catalog, 27) when a new engineering building was placed in operation on the southeast edge of the campus.

The 1916–17 catalog (p. 22) has a description of this building:

> Engineering Hall, erected in 1904, lies a short distance south of Old Main. The first story is built of native sandstone, and the upper two stories are of brick trimmed with lime-stone. The building contains the offices, recitation rooms, drawing rooms, and testing laboratories of physics, and civil, electrical, and mechanical engineering departments.
>
> The physical laboratory is located on the first floor. It is equipped with modern instruments in quantity sufficient for the laboratory work of the courses in physics.



Figure 5: Engineering Hall, where physics was taught from 1904 to 1918. This building was renamed Commerce Hall after the Engineering Building was built in 1927. *Photo courtesy of the University of Arkansas Libraries, Digital Collections, dated 1928.*

[1] A separate building was built for chemistry just north of Old Main in 1905. It was still serving the university in 2008, having housed law and psychology and geography and several other activities since 1935, when chemistry went into other new space south of Vol Walker Hall.

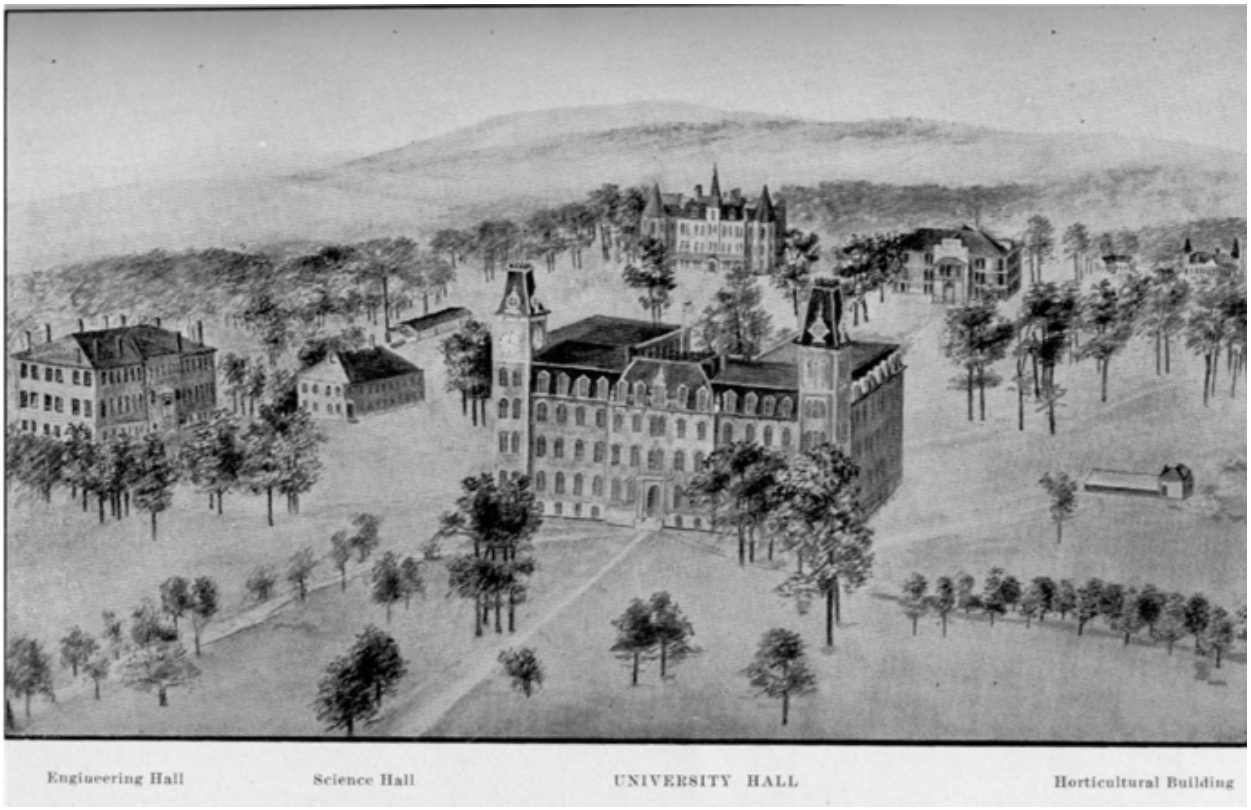


Figure 6: This one picture in the 1903–04 catalog shows three buildings where physics was taught: University Hall (1875–1893, 1936–1952), Science Hall (1893–1904), and Engineering Hall (1904–1918).

Physics was being taught in the electrical engineering department, but space, especially for laboratory work, was difficult to find. A small wood-frame building was constructed in 1907 to house the physics laboratories, but it was very short-lived as it burned down in 1909. The following [Ref. 2, 254] summarizes the physics condition which was to continue for about a decade: "The department has had to move about from time to time and occupy quarters as were available. In 1907 an earnest appeal was made to the legislature for a building, but without avail. The board then appropriated a small sum for a frame building as a temporary structure and the apparatus was moved into it. Much of this was old and of little practical use, though it was estimated to be worth $5,000. In 1908, $1,700 was expended for new apparatus, but one night in October, 1909, all of this, together with the building, went up in smoke without a dollar of insurance. The board then generously appropriated $2,000 for new apparatus to tide over until the legislature can be induced to provide for the department."

The 1908–1909 catalog actually describes this "physics building" for the physics laboratories as, "forty by fifty feet, devoted exclusively to laboratory work in Physics. The assembly room, and a smaller room in Engineering Hall are used for recitations. The laboratory is divided into two large rooms, containing at the center a space of ten by ten feet as the general storeroom. Solid oak tables on piers independent of the floor fulfill the conditions of required steadiness, as do also the galvanometer posts similarly built. Numerous cases contain a good supply of apparatus."

The exact location of the above physical laboratory is shown in some of scale drawings of the period to be almost exactly sixty feet south of

the south-east corner of Engineering Hall. This would put it about where the west entrance of Bell Engineering is located now. The fire that destroyed the laboratory building is described in an entry in the 1909–1910 catalog: "The frame building formerly used as a physical laboratory was destroyed by fire in the fall of 1909. Temporary quarters have been provided for the department in Engineering Hall. The next legislature will be asked for an appropriation for a building and suitable equipment."

The above statement is repeated in the 1910–11 catalog. It was not easy to get funds for physics. The destruction of the equipment compelled the discontinuance of physics courses for the balance of the 1909 fall term.

Thus the "physical laboratory" was to be in Engineering Hall for several years, up until physics went into its own large frame building in 1918.

This coupling of physics and engineering had several positive results. One was that the advanced course in electricity and magnetism was developed substantially under the auspices of electrical engineering. Another was the fact that electrical engineering actually initiated the development of physics into a separate department in 1907. Also of interest is the fact that Professor Giles Ripley of physics and Professor William Stelzner of electrical engineering did some early work together on radio, and Professor William Gladson, also of electrical engineering, worked on x-rays and is reported to have operated the first x-ray machine in Arkansas and started the university's first radio station, KUOA.



Figure 7: Physics Hall. The first building exclusively for Physics Department, 1918–1936. ***Photo courtesy of the University of Arkansas Libraries, Digital Collections. Undated.***

E. Physics in Physics Hall (1918–1936)

Finally in 1918 a two-story frame building was built for the Physics Department at the south end of the campus drive. Thus, during a period of eighteen years from 1918 until 1936, physics had its own quarters for the first time, in the form of a somewhat primitive two-story frame building under the formal name Physics Hall.

The following is a part of a memo in the departmental files dated April 27, 1936. This paragraph gives some background information on the origin of the 1918 frame building: "The present physics quarters were designed originally as a one-story structure to be used by Professor Stelzner (EE Professor) and Dean Ripley for teaching radio and allied work. This was at a time when such work was very important in the war service. While in the process of construction in the fall of 1918 the plans were suddenly altered to provide a building of two stories with attic space. Soon after the signing of the Armistice in November 1918, the Physics Department was moved to its present quarters." The above is taken from the April 27, 1936 memo.[2] The writer of the above memo is unknown, but it sounds very much like Dr. Ham, the second head of physics. More is quoted from this memo later in section F of this chapter.

An aerial view of the campus printed in the

[2] It is reprinted as appendix A in a report entitled *Space Needs of Physics* prepared by Dr. D. O. Pederson in 1982 [Ref. 8].

1933 issue of *Razorback* shows this two-story frame physics building barely discernible among the trees just northwest of the early Engineering Hall and northeast of the heating plant and shops. The campus map displayed in the 1934–35 catalog clearly shows the physics building southwest of Old Main, about one-third of the way from Old Main to where Science Engineering Hall is now located.

This frame building has a very brief description in the 1927–28 catalog (p. 27): "This is a two-story frame building containing ten rooms for lectures and laboratory work in physics." It is estimated from the photograph and from the scale drawing of the period to have measured approximately forty by sixty feet.

George L. Harvey (BS 1938, MA 1940), in a June 1995 letter to Sharrah, has a few choice words to say about Physics Hall:

> When I arrived at the University in 1935, the Engineering School had a fairly new building and the Chemistry Department had just moved into a new building. The Agriculture building was new or was soon finished, and there was a new library building. What about the Physics Department? It was housed in an old two-story frame building, perhaps a shed [. . .] It was a disgrace to the campus. The following year the Department was given some room in the basement and first floor of Old Main.

A 1921 report of the US Commissioner of Education [Ref. 3, 159], requested by the Arkansas General Assembly, was candid and not very complimentary about the University of Arkansas at that time. Among other things, it criticized the buildings on the campus as, "cheaply constructed," and commented that they were "mostly devoid of toilet," "fire hazards as there is no central heating plant," and so on. Regarding the physics building, it reports, "[they] are so cold in the winter as to interfere with the work of students and faculty and menace the health of occupants."

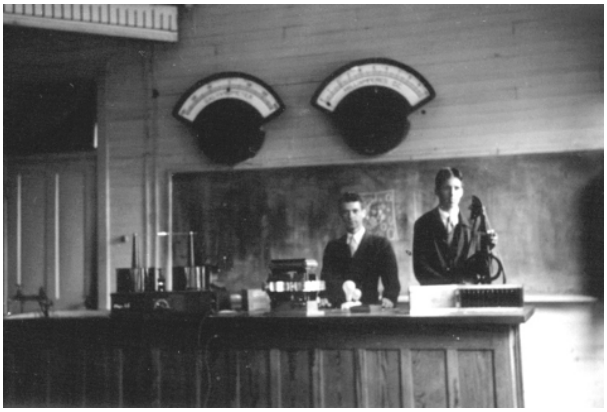


Figure 8: The lecture room in Physics Hall, circa 1930. *Photo from History1.*

This same physics building receives a much more upbeat description in the university's own view (1919–20 catalog, 25): "Physics Hall, built in 1917, is located southwest of Old Main. It is a two-story building containing ten rooms well arranged for lecture and laboratory work in physics. On the first floor are two laboratory rooms, a large lecture room, a storage room, and an office room. The second floor includes a large lecture room, a laboratory room, a photometric room, a workshop room, and a library. The building is equipped with gas, water, and electric light and is steam heated. The lecture room tables are wired for both alternating and direct currents, piped for water, gas, high pressure steam, high pressure air, and vacuum work. Concrete piers are provided for all delicate work in the laboratories and for the delicate balances. The equipment of apparatus is fairly complete and is of exceptional quality and of sufficient variety and duplication to permit the instruction of large sections in the laboratories."

While the above is the university administration's view of the building, the following excerpt taken from the *1927–28 Annual Report* of the Department gives its perspective of the same building: "Our most



Figure 9: University Hall. The Physics Department was located here from 1936 to 1952. ***Photo courtesy of the University of Arkansas Libraries, Digital Collections. Undated.***

urgent need at present is much more space, and a building free of vibration. There is only one place in the building where sensitive galvanometers can be used, such as are required for the course in Electrical Measurements, the course in high temperatures, and much other advanced laboratory work. For a period of three days last December, following hard rain, we were obliged to abandon all experiments involving sensitive galvanometers."

The same report goes on to say: "There is a need for a large lecture room, seating two hundred to three hundred students well equipped with demonstration apparatus, for use in the elementary course."

After eighteen years in this building, the department had to move yet again, this time back to Old Main in 1936.

When physics moved into Old Main for the second time in 1936, this frame building was moved to a new location, about twenty-five to thirty yards to the south, and used for university band [Ref. 1, 101]. The building was finally razed in 1963 to make room for the construction of the Science Engineering Auditorium.

F. Physics in Old Main — Second Time Around (1936–1952)

Thus for a second time, physics found itself housed in University Hall, by now being more familiarly called Old Main. Physics was fairly comfortable and adequately provided for in Old Main, at least as a teaching department, until it overgrew the space in the mid-forties.

The department was moved into the basement and first floor space vacated by the university library when it moved to Vol Walker Hall, the New Carnegie Library. This new space provided approximately eleven thousand square feet of floor space for physics, and this was further expanded to include approximately two thousand additional square feet in the north end of the basement of Old Main in 1949. This Old Main space was occupied by physics from 1936 until 1952, when it had to move again.

Let us hear the description of the physics space in Old Main from someone who was there by quoting more lines from the April 27, 1936 memo introduced in section E above.

> In all probability the Physics Department will be moved to its new quarters (Old Main) about May 16. The work will not be completed by that time but sufficiently progressed so that the remainder of the year's work may be completed in the new quarters [. . .] The total new space for the Physics Department will be around eleven thousand square feet. The difference in space is much greater than what it looks to be on the surface because of the much greater efficiency to which the new space may be used.
>
> The general plan of the new quarters consist in having all the advanced work in the southwest (basement floor) wing of the old library quarters, having a total space of about four thousand five hundred square feet. The elementary work will be

housed on the first floor wing above and has a total capacity of about four thousand six hundred square feet. It is believed that the concrete floors of the basement coupled with the heavy wall of the building structure will provide vibrationless quarters for the more delicate work of the advanced laboratories.

[. . .] The elementary quarters on the first floor have one lecture room, two laboratories, a small recitation room, an apparatus room each for the laboratories and the lecture, and a general store room with elevator going to the basement. The equipment for the elementary lecture table will be modern in every respect including three independent dead lines and several 110 volt lines. The elementary lecture room is located in the southwest corner of the wing to take advantage of the sun light for certain demonstrations in light. The additional store rooms in the new elementary section of the Physics Department will take care of elementary apparatus which now has to be housed in the main laboratory or placed anywhere that a room may be found. With the two elementary laboratories we can accommodate larger laboratory sections or have a first semester and a second semester laboratory class operating at the same time. A show case is located in the corridor of the elementary quarters. This will be used to display certain apparatus and self-operating demonstrations.

In the advanced laboratories there are separate accommodations for electricity, optics and heat, mechanics, x-rays, photography, and sound. The photographic dark room accommodates not only students doing photographic work but is ample for concave grating work. The sound room is sound proof and reverbrationless. It is purposely placed in the center of the wing so that sound from the outside striking the building will not penetrate the room which itself is made of sound proofing material inside and outside. Because of the number of instructors at present on the staff the rooms of the advanced laboratories are made easily intercommunicating. The modern electrical features are a specialty in these laboratories.

All sources of electricity originate in the generator room. In this room there are found a distribution panel which provides for various kinds of electrical service to the different rooms such as battery service and motor-generator service. Three direct current generators give us a range of voltages from zero up to about 600 volts. We have also one high frequency generator. The switch board will have also an auto-transformer which will allow us to obtain alternating voltage from 0 up to 110 volts. These various electrical services are distributed to the laboratories over sixteen dead lines (i.e., shared service lines). There are six of these independent dead lines going into the elementary laboratories and ten to the advanced laboratories. A further convenience of the generator room is that our storage batteries will all be housed at the end of this room and will be connected with the switch board. We will therefore be able to get battery service to any room without carrying storage batteries by hand around the laboratories. The batteries will be charged with a new six ampere charging unit. They may be charged also by means of motor generator units.

The shop, advanced lecture room, one office and library will be located in the first three rooms on the east side of the corridor entering Old Main

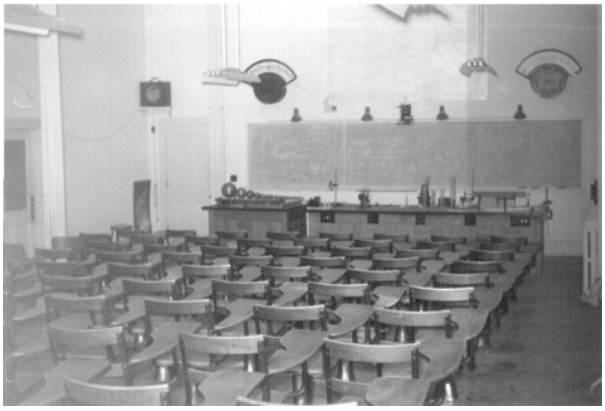


Figure 10: Physics lecture hall in Old Main, southwest corner, circa 1950. *Photo from Histoty1.*

> from the south. The advanced lecture room will be equipped the same as the elementary lecture room except for wall galvanometers. The location of the shop prevents the noise it makes from penetrating the elementary or advanced laboratories. The other Physics Department office is found on the first floor where the old library office was located.

There was one major problem in the advanced laboratories. The steam lines for the heating ran through trenches passing along the basement hallway and into the advanced laboratory rooms. The lines were covered by metal grills, and the heat in the hallways and especially the laboratories was often too much. That hamster that hid among those pipes didn't stay there very long.

An additional large physics lecture hall and an office and laboratory were added in the north end of Old Main's basement when journalism moved to Hill Hall in 1949 [Ref. 3, 220]. This office was used by Sharrah, and he and Schwartz initiated some interesting cosmic ray research there. The new laboratory was used for a year as a modern physics laboratory and then became the location of the new Philips x-ray diffraction unit.

The Physics Library housed the department's little collection of books and magazine subscriptions. It consisted of two shelves housed in one corner of a faculty office that was first used by Sharrah and then by Schwartz. See chapter 12, section E for more on the library.

The Old Main space contained a stock room for demonstration equipment, and it was well developed and organized. Ham and Roberds had taken considerable interest in developing demonstrations. Ham was in regular attendance at the University of Iowa Physics Colloquium and brought back many ideas for teaching devices. Sharrah got excited about demonstrations and won first prize in 1955 at the Iowa Physics Colloquium for a demonstration of the electromagnetic pump he and Lingelbach had built. The pump had been described in a late nineteenth century article in the *Physical Review* and was being used to pump liquid metals in nuclear reactors.

It seems that Professor Roberds made much use of the physics shop to build interesting devices. It was he who designed and built the first remotely controlled scoreboard for the football stadium, as mentioned previously. A student, usually from engineering, was employed to fabricate demonstration devices. Sharrah had replaced Roberds, after Roberds resigned to go into industry, and become responsible for the demonstrations, while Dr. Ham continued to direct the laboratory work.

The Physics Department could boast that it had two of the largest pieces of demonstration equipment around. One was a seventy-two-foot Foucault pendulum extending from the top of the building, down between the beautiful wooden stairway railings, all the way to the basement. The other consisted of two six-foot-diameter concave reflectors used to focus sounds transmitted the full length of the basement hallway.

It was rather convenient and interesting to be housed in Old Main in the 1940s. For one thing, almost all of the departments in the College of Arts and Sciences were in the same building. Only chemistry, geology, mathematics, and the departments of psychology and philosophy were in other buildings. The museum was in Old Main, and the art department was there until about 1948. The registrar's office, the business office, the graduate school office, and the typing and mimeograph service were all there. We had the advantages of a small college.

The department had, however, grown way out of space. So much so that a mezzanine floor had to be built in 1945 in the first floor hallway. The lower part had an eight-foot ceiling, and the

upper part was used for storage of the instructional laboratory equipment. Professor Ham submitted a proposal to the university in 1944 for a new physics building, but nothing came of it. In 1948, he again submitted a proposal for a new physics building. It was a very well-thought-out proposal with net useable space of twenty-six thousand square feet and space for future expansion as the department's needs grew. More details on this are given in chapter 3, part 1, section C. That proposal was not funded, but the department did eventually move into new quarters on Dickson Street in 1952, as described below.

G. Physics on Dickson Street (1952–1994)

Finally, in 1952, the department moved into its own building on Dickson Street on the south side of campus. Since we have been in this building for over half a century and are going to be in it for the indefinite future, the building and its utilization will be described in considerable detail. Therefore, for convenience, description of this building has been broken up into two sections comprising two periods: before the remodeling and expansion (1952–1994) and 1994 afterward.

When the department moved here, this was a rather quiet side of campus. Some thought that physics was now too far removed from the center of the campus.

a. Dickson Street Building Proposed

One fine fall day in late 1950, Professor Ham, head of the Physics Department, walked out of his office into the hallway of Old Main to be confronted with a terse statement from President Lewis Webster Jones that Ham was to specify what physics would want in a building. This information was to be provided in two weeks.

The Engineering School had just had a review team visit them and, among other things, their report said that the crowded and poorly developed space for physics in Old Main was a detriment to the engineering program.

President Jones approached T. C. Carlson, vice president for finance, to find out what money was available. A fund was being reserved to build a new Buildings and Grounds (later called Physical Plant) facility on the south side of Dickson Street. Jones decided that this money would be used to build the Physical Plant Building immediately, but that it would be used "temporarily" by the Physics Department.

When this word *temporary* came to the attention of Dr. Ham and the department it was time for another departmental meeting. In the departmental discussion, the elements of timing and the extent of temporariness in the relocation project were the chief points of concern. The situation in 1951 is aptly described in a February 28 memo from Dr. Ham to arts and sciences dean G. D. Nichols and graduate school dean V. W. Adkisson:

> We can safely assume that permanent housing in part may be obtained within a reasonable time. Therefore, we believe that the best interests of the Department will be served by remaining in its present quarters with overflow work accommodated in the new building on the same basis as for other departments or divisions of the University. Overflow work refers to research activities and to certain advanced laboratory work.
>
> The relocation of the Physics Department into the admittedly temporary quarters will imply obviously that the suitable permanent housing has been pushed into the future for an unpredictably long time.

b. Meeting with President Jones

Dean Nichols was contacted, and he and Ham, along with faculty members Willard Bennett, Paul Sharrah, George Lingelbach and Herman Schwartz, made an appointment to see President

Jones. They did not know then that he had just participated in some difficult conferences in Little Rock on the financial needs of the university. Jones stood behind his desk with one of his habitual cigarettes, nervously shuffling some papers. He did not ask them to have a seat. He pointed down at the floor and shouted "temporary, temporary, you will retire out of that building!" They were out of his office in less than ten minutes. Dean Nichols told the rest not to worry. They didn't. The department has been in the building since 1952 and many faculty members have indeed retired out of it, including both authors of this History.

L. L. Browne, Buildings and Grounds director, did not know that he would never be permitted to move Buildings and Grounds into this Dickson Street building. He would come down the hill frequently and look through the building, even late in the 1950s, as though he were planning where to put things. The large physical plant complex on Razorback Road was added much later and was in use by 1971.

The Physics Department was given complete control of the space layout of the upstairs and downstairs floors of the west wing and central wing, totaling about 13,600 square feet (approximately 60 percent) of the over 20,000 square feet of total usable space. This was true even though it was being said repeatedly that this building was to eventually revert to Physical Plant offices and shops.

The Department of Physics planned to move into this space in the spring and summer of 1952 and has been there ever since.

c. Building Planned

Just how did this Physics Building on Dickson Street get designed? One Saturday afternoon in early 1951 there was a meeting with an architect from Fort Smith to lay out the space to be used by physics. Drs. Ham and Sharrah, along with L. L. Browne and a representative of the architecture firm from Fort Smith, established the floor plan. Ham had done much work on this in advance and most of his ideas were accepted. He insisted that there be an elevator, for example, and that the primary offices be of adequate dimensions. Five large offices were provided. These offices had adequate room for books, small experimental setups under development, and a chalkboard for teaching small groups.

It had been made clear that the east wing, both basement and first floor, were off limits to the Physics Department. The Institute of Science and Technology (IST)[3] as well as other research projects were to go there. Elaborate laboratory tables, sinks, and air ventilation equipment were installed in this space. If only physics could have had a fraction of that money spent on its space. Narrow hallways were to characterize the east wing because less traffic would be expected in the research areas.



Figure 11: Dickson Street Physics Building. View southwest. ***Photo archived in the Physics Department. Undated.***

It was also made clear at about this time that the building would actually be called the Physical Science Building. We were most

[3] See chapter 9 on early research, 1907–1952.

surprised. The use of the term Physics Building was finally accepted during the 1960s. It only shows how hard it was for physics to establish itself in the pecking order of things, at least in the minds of some of the higher administrators.

d. Ham Describes New Building

In a slightly more joyous vein, Dr. Ham describes the building to the former students in his customary Christmas letter dated December, 1951.

> For us Physicists, the highlight of this year is the new Physics Building, plans of which were announced rather unexpectedly by Pres. Jones about a year ago. It is to cost three hundred thousand dollars is being built on the south side of Dickson Street next to the temporary Institute of Science and Technology Building with appropriations allotted to Buildings and Grounds but has been designated for use by the Physics Department until money is available for a permanent unit to house Physics. Actually the building has been rather loosely labeled "Physical Science Building" because it will also house physical science research which involves government contracts, the theory being that such contracts are more easily obtained if good housing facilities are available. It is a U-shaped, two-story, hadite block and brick structure facing north and the Physics Department will occupy the west half. The total instructional space will be about the same as our present set-up (in Old Main) but such space will be better organized. We hope to be in the building not later than September.

It was an exciting time, and in the December 1952 letter to former students, Dr. Ham continues to talk about the new Dickson Street building.

> This is the first Christmas Season since moving to our new Physics Building. The rooms on the east end, both ground and first floor, are reserved for physical science research work, the remaining space belongs to the Physics Department. The department now enjoys better facilities than it had.
>
> Authorization for this new building was announced about the middle of the school year 1950–51. The President wanted our plans outlined to the architect within two weeks. We long had certain rather specific plans in mind and were able to make our wants and needs known by the end of four weeks. Building started late in the fall of 1951 and was finished, except for minor details, in June of this year. We conducted a few of the elementary laboratories in this new building near the end of spring 1952. Regular occupation began in September of this year.

e. Initial Space Utilization

By September of 1952 the Physics Department had fully moved into the Dickson Street building, and the department was ready to teach all the physics lectures and laboratories there. The floor plan of the building is shown[4] on the following pages.



Figure 12: Dickson Street Physics Building. View southeast. ***Photo archived in the Physics Department. Undated.***

[4] This floor plan is basically as it was when the building was constructed, except that Room 110 was subdivided into

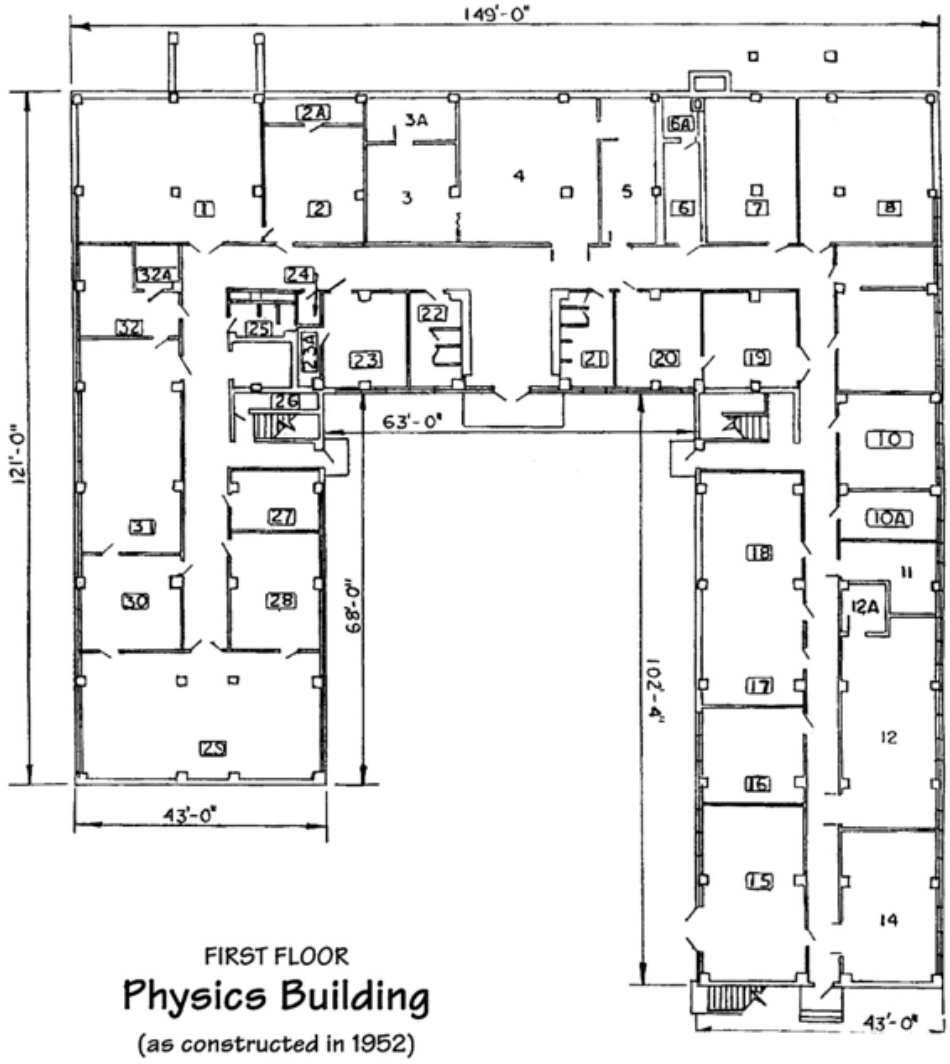


Figure 13: Floor plan of the first floor (sometimes referred to as the basement floor) of the Physics Building.

In the short time that had been available for planning, it is no surprise that the elementary lecture space and laboratories were similar to the equivalent Old Main spaces in use from 1936 to 1952.

However, the rooms set aside for advanced laboratory and research work on the first floor, or basement floor, were far more adequate than the Old Main space had been. There was plenty of space for the advanced laboratories in Old Main, but it wasn't all that well organized. The new building provided an electrical

110A and 110B later, and a couple of other rooms may have been subdivided as well.

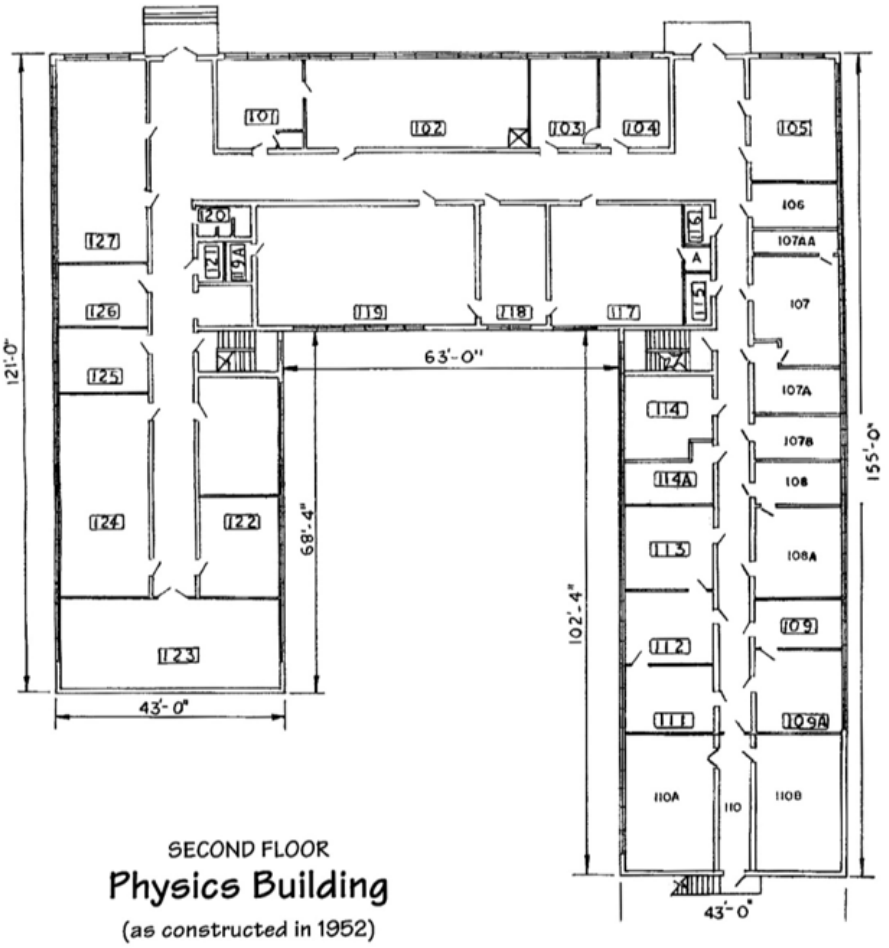


Figure 14: Floor plan of the second floor.

measurements laboratory, a modern physics laboratory, an electronics laboratory, an instructional optics laboratory, an x-ray laboratory with a lead-lined room, the Philips x-ray diffraction facility, an acoustics laboratory with sound absorbing walls, and a laboratory for the Littrow spectrograph. Four dark rooms were established, and the Littrow spectrograph room had its own dark room. Film was an important sensing tool in physics then. In the early 1960s, a subcritical nuclear reactor was installed in one of the rooms in on the first floor. It was funded by a grant from Atomic Energy Commission (AEC) to Professor Zinke. The reactor, approximately two meters in diameter and two meters high, or perhaps somewhat smaller in all dimensions, consisted of an aluminum cylinder contained



Figure 15: The main lecture room, Room 119. The interior of the entire building was unpainted initially with visible cinder blocks reminiscent of a factory warehouse. *Photo archived in the Physics Department. Undated.*

inside a block pit and built from the ground up.[5]

Probably the most noticeable improvement in the new Dickson Street physics space as compared to Old Main was the provision of adequate storage. Six storage rooms were provided and two of these were quite large.

But even the advantage of having adequate storage eroded during the first few years due to demand for research space. But probably the saddest loss of all was the disappearance of adequate space to store and develop physics demonstrations. Only one of these original six storage rooms remained by 1974. And by 1978, only a small closet was left to store lecture demonstration equipment.

The loss of storage space was partially offset through the years by the addition of wall storage cabinets in many of the laboratory rooms. But it was very difficult to get the money to do this. The department chairman[6] came very close to being "called on the carpet" for pushing this work too vigorously. These cabinets were built and installed in the early 1960s by carpenter Leonard Gabbard of the Research Services shop.[7]

A few of the basic teaching facilities as provided in the original space may be worthy of noting. The rooms used for lectures included 117, 118, 119, 127 (which doubled as instructional laboratory space), 104 and later the large room 110. Some small class groups met in the laboratory room 28, and room 1 was much used for summer institutes (see chapter 13). Some small lecture classes or seminars were held in offices.

At first all of the elementary laboratories were on the top floor. Rooms 123, 124, 127, and, for a time, 108 served the physics and physical science laboratories. The honors section of the university physics laboratory worked in room 1.

Later, the elementary physics laboratories moved to the first-floor rooms 29, 30, and 1. The physical science laboratory for elementary teachers was in room 124. Astronomy laboratory used room 123 and Physics and Human Affairs used room 127. Musical chairs.

One other significant improvement the Dickson Street building made over the Old Main space was the provision of space for the Physics Library (room 102). This room had an area of 714 square feet and housed many of the magazines and physics reference books. This was quite an improvement over the two large bookshelves called the Physics Library in Old Main (see chapter 12). The library expanded into the Physics Office space (room 101) in 1972 to add another 272 square feet, for a total of 986 square feet.

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[5] Zinke also taught a course on reactor physics for a short time. The reactor was transferred to mechanical engineering sometime in the 1970's.

[6] Sharrah, one of the authors of this book.

[7] At that time, the machine shop and the carpenter shop were for university wide use and were administered by unit of the university called Research Services. See chapter 12.

Room 101 on the top floor was the office of the head of the department from 1952 until about 1972. Ham, Sharrah, and Day worked there. Then, room 103 became the chair's office, and 104 became the department office. Day, Pederson, Richardson, Lieber, and Hermann worked there.

More and more of the east wing was assigned to physics as time went on. Sharrah and Schwartz used room 105 for cosmic ray laboratory. This room later became a classroom. Chemistry, geology, and physics used the research space in the east wings for the next few years, as the research programs in the IST (see chapter 9) were gradually phased out or were absorbed into the various academic departments by 1957. Brenton Stearns, Berol Robinson, Ray Hughes, Otto Zinke, Richard Anderson, and Charles Richardson used the east wing space primarily for research.

The summer programs (see chapter 13) along with increased research activity made it necessary to introduce various window air conditioning units as time and funds permitted. Teaching space, room 1, research space rooms 8 and 9, and two or three other rooms in the east wing were being cooled by small units by 1960.

f. People at Work — The Early Years

Let us look at the people and facilities again. Ham, head of physics, was working in the head office (room 101). This was a large office adjacent and just west of the Physics Library (room 102). In the Physics Library, one would see the only secretary working on an Underwood mechanical typewriter and then a few years later on an IBM Selectric.[8] Half of her salary came from university library funds as late as 1960. There would be only one secretary until the 1970s, except for the short-term supplementary help during the summers in the science institutes.



Figure 16: The southwest corner of the Physics Library (room 102) served as the office for the only secretary that the department had. She had the dual duties of library clerk and physics secretary. Just to the right of this picture was a door leading into the office of the head of the department (room 101). ***Photo archived in the Physics Department. Undated.***

Dr. H. M. Schwartz worked in his office in the front of the building (room 103) and had a fairly advanced classical mechanical desktop calculator with a motor drive for his research. He and Veronica Fink spent hours and hours calculating the ground state of helium. Their work held the world record for accuracy. The clunk-clunk-rattle-rattle sound of that machine still echoes through those two offices and the library and the hallway. This work was part of the chemistry department's Atomic Energy Commission grant. Dr. Schwartz later spent a year at the University of Tel Aviv and wrote a textbook on relativity when he returned.

Dr. Sharrah studied and wrote in room 104, and taught several small classes there. Dr. Sharrah would go to Oak Ridge, Tennessee for the summers of 1951, 1952, 1953, and for the complete year starting in the summer of 1954 and extending to late summer 1955.

Most of the advanced teaching was done in room 117, a lecture room with an inclined floor and seating arrangement. Later, this room was

[8] These typewriters and the mechanical calculators are on display in the Physics Lobby.

used for the planetarium (see chapter 8).

George Lingelbach had the responsibility of the elementary laboratories and taught a section or two of college physics. His office was in room 125 on the west side of the top floor. He also supervised the student shop, housed originally in room 123, and moved to room 15 around 1964. Room 126 had one or two graduate students, including Frank Biggs.

Dr. E. S. Amis of the chemistry department had a research project in one of the east rooms upstairs. Dr. R. F. Kruh of the chemistry department had his office downstairs. He and Sharrah wrote a successful joint proposal to the AEC in 1956. This space (downstairs) would be used later by Dr. Harold MacDonald of the Geology Department.

James Pearson and another short-term employee of the IST operated the Littrow spectrograph in room 8. The Philips x-ray machine in room 20 continued to serve the IST, while physics graduate student B. S. Garrett and Paul Sharrah served as operators.

George Kirsch and Leonard Gabbard worked from 1952 to 1960 in the machine shop and carpenter shop, both housed in rooms 15 and 14 respectively. Both shops were operated by Research Services.

These rooms were to house the university's first computing center with its IBM-650, and the Research Services shops were moved into a large building at the old fair grounds. The IBM-650 was used from 1960 to 1964, when an IBM-7040 was installed in the computer space provided in the new Science Engineering Building. The IBM punched cards[9] still dominated the scene and would be used until the late 1970s.

Dr. Brent Stearns worked in an office on the east wing upstairs during the 1950s. He and Dr. R. H. Hughes were codirectors of one of the ordnance research projects, Arkansas Research Naval Ordnance, ARNO[10], in the IST for a time after its original director, Z. V. Harvalik, went to the US Army Research Center at Ft. Belvoir, Virginia. Stearns was completing his thesis for the PhD and went on to Tufts University.

Dr. Berol Robinson was employed part time from 1952 to 1956 on the AEC grant with chemistry and established an excellent nuclear physics research laboratory in two of the rooms in the east wing.

Thus in the 1950s there were usually four or five full-time faculty members, two or three graduate students, and one secretary directly involved in physics working in the building. The Research Services shop, chemistry, geology, and IST research personnel added five or ten other workers for a total of between fifteen and twenty people in the building.

The move in 1952 from Old Main to the Dickson Street building was no "quantum leap." But it was significant that there was space for the department to use for research expansion later. Thus from 1959 and onward for the next two decades when the faculty was increasing and graduate research was developing, the department could provide research laboratories of reasonable size in the east wing, where the IST and other activities had originally operated.

When physics could have moved into the new Science Building directly south of the old Chemistry Building in the 1960s (originally designated Science Building B), the department told arts and sciences dean R. F. Kruh that we would rather stay in "inadequate space temporarily than be moved into inadequate space permanently." There was not enough room in that Science Building for both chemistry and physics.

[9] Some of the equipment of that era is on display in the Physics Lobby.
[10] See Ch.9 on Early Research, 1907–1952.

g. Space Utilization in the 1980s

The above description is based on the recollections of one of the authors of this history (Sharrah). The other author (Gupta) joined the department in 1978. In 1993, Gupta wrote a history of the building covering the 1978–1993 period. [11] The following is based on his recollections and what was recorded in that history at that time.

Following the start of the PhD program in 1959, the department and its research program grew rapidly. By 1978, the department had thirteen faculty members, most of them active in research. As mentioned above, the department gradually gained much of the space in the east wing, but not all. Geology still occupied some of the space toward the far end of the east wing, both upstairs and downstairs. Rooms 101 and 102 were still the Physics Library with room 101 being used for books and room 102 being used for journals and seating. There was also a card catalog and a desk for the secretary. The secretary mostly worked as a typist (manuscripts and proposals) and also checked the books in and out and shelved them. The secretary was entirely on the Physics Department payroll. Room 103 was the chair's office, and room 104 was the departmental office. A single secretary used to staff that office. Room 105 was a classroom, and room 119 was the sole lecture hall, seating about seventy. There was no other classroom in the building, so some of the elementary labs doubled as classrooms for small classes when labs were not scheduled in those rooms. Room 117 housed the planetarium (see chapter 8), while room 118 was used for meetings and doubled as a lunchroom. The west wing still contained mostly teaching labs and a couple of faculty offices. The east wing contained mostly research labs and faculty offices. Research labs were as follows: Pederson, rooms 107 and 107AA (solid-state physics); Day, rooms 108A and 114 (nuclear magnetic resonance); Zinke, rooms 112 and 113 (thermodynamic properties); Salamo, room 8 (quantum optics); Hughes, rooms 9, 17, and 18 (atomic physics), and 19 and 20 (laser operated ion source); Richardson, room 10 (optical and thermodynamic properties of levitated single particles), Anderson, room 23 (atomic physics). Room 15 was being used as the student machine shop. The department was extremely short of space. So much so that most of the graduate student desks had to be squeezed into a single room, 109A. Just before Gupta arrived, Zinke had graciously vacated room 112 for Gupta's lab. This room turned out to be totally unsuitable for Gupta's needs. Then Hughes graciously vacated rooms 17 and 18 for use by Gupta, Salamo, and Anderson as their laboratories. The rooms needed to be renovated, and Gupta finally had a suitable lab (although shared with Salamo and Anderson) after a wait of eighteen months.

The building had no central air conditioning, but most of the faculty offices and research labs had window units, or a unit hung from the ceiling if the room was without a window. This was an improvement on the 1960s, and Zinke has given a fascinating account of this period in his reminiscences (chapter 14). The air conditioning units were purchased by the department from its own funds and were not considered part of the building, so Physical Plant charged the department to service them. At some point, almost all the windows except in the front were painted blue, factory-like, to eliminate direct sunlight into the rooms as the windows had no blinds or curtains. The blue paint made the building very unsightly. The window air conditioning units only enhanced the unsightly look of the building.

There was almost no money to buy new furniture. Zinke describes the situation when he

[11] Ref. 8.

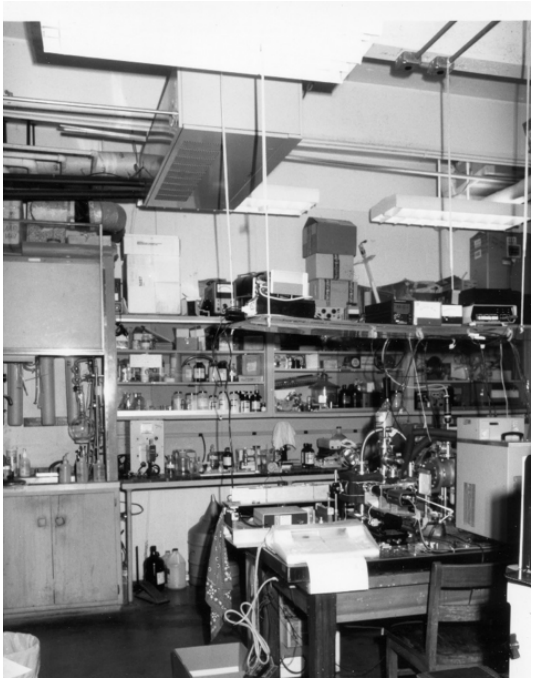


Figure 17: All research labs were characterized by exposed plumbing, exposed fiberglass ceiling on second floor, concrete floors, and so on in 1990. This is Professor Richardson's laboratory. *Photo by Rajendra Gupta, 1990.*

joined the department in his reminiscences (chapter 14). The situation was not much better in the 1980s.

Starting in the mid-to-late seventies, the department started to build a strong group of researchers in quantum optics and laser physics (chapter 10). This put additional stress on the already extreme shortage of space, bringing it to what can only be described as a critical shortage. The new faculty in experimental areas had to wait a long time to get laboratory space. This seriously compromised their competitive position to obtain research grants and recruit graduate students. For example, in 1982, newly hired faculty member Surendra Singh did not even have an office and was given a desk in the computer room. He had to share even that space with a graduate student of Gupta's. Singh only received a faculty office after a wait of eighteen months, when Dr. Day moved to Miami University in 1983. Larry Merkle, hired in 1983, never received an independent lab. Salamo graciously gave a small amount of space in his own lab to set up Merkle's experiment. Merkle finally left the department in 1988. Allen Hermann and Zhengzhi Sheng had to use two apartments in a nearby apartment building (Dickson Street Annex) for their superconductivity research. In addition to the lack of space, the quality of space was completely unsuitable for modern state-of-the-art research. The building had not been renovated since it was built in 1952. The laboratory rooms had inadequate electrical power, inadequate cooling water, and inadequate environmental control.

The situation was not much better on the instructional side. For example, the department did not have an adequate lecture room where large physics courses (College Physics, University Physics, Physics and Human Affairs, and Astronomy) could be taught. These courses had to be taught in many lecture rooms all over the campus, and it was practically impossible to carry lecture demonstration equipment back and forth. The space for introductory laboratories was also very limited. For example, Physics and Human Affairs and Physics for Architects had to share a laboratory, which created many scheduling problems. The Physical Science laboratory had to be moved out of the Physics Building in the early '80s due to lack of space, and eventually the course was dropped.

The Physics Library had totally outgrown the space. Journals were stacked up to the ceiling, and one had to use a tall ladder to access many of them. As the need for shelving space grew, more and more of the seating space was taken away for stacking journals. Eventually, the library became like a warehouse, with almost nonexistent seating space.

The appearance of the building could only be described as disgraceful, with its blue factory-like

windows, concrete floors, warehouse lighting, and window air conditioning units. Moreover, exposed fiberglass in the ceilings posed a serious health hazard, as exposure to fiberglass has been shown to cause cancer in laboratory animals.

The Physics Department did not have the use of the entire Physics Building until about 1985, when, due to Chair Pederson's efforts, Geology was moved out of the building. This created a bit of more research space. Also, through Pederson's efforts in the early 1980s, several improvements in the infrastructure were made. Additional power was brought into the building to power the new ion lasers that the department had acquired, chilled water was brought into the building and a few fan-coil units and a closed-cycle laser cooling water system were installed in some of the laboratories. Moreover, several of the research laboratories were renovated. While these improvements did enable the department to meet its research mission, although with considerable difficulty, they were only patchwork solutions to a very difficult and pervasive problem. Moreover, these improvements did

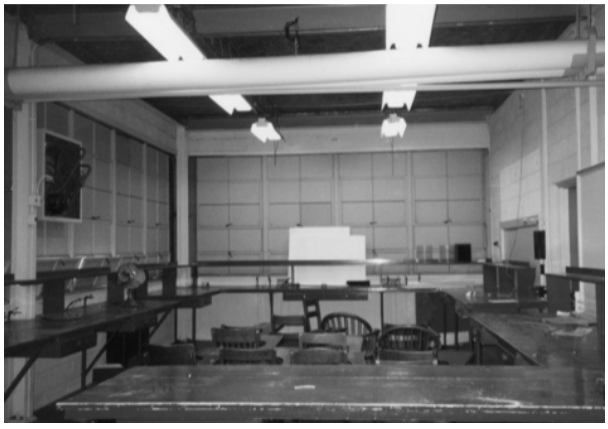


Figure 18: An introductory physics laboratory, 1990. Note the open fiberglass ceiling, exposed plumbing, painted windows, an exhaust fan instead of an air conditioning unit in the widow, and unlaminated counters. The room doubled as a classroom for small classes when a lab was not scheduled. *Photo by Rajendra Gupta*



Figure 19: The Physics Library, 1990. Note the journals stacked to the ceiling and sitting in boxes under the tables. Note also that there was almost no seating space left as shelves had to be built on top of the tables.



Figure 20: The first-floor hallway of the east wing, 1990. Note the power cables and utility pipes below the ceiling, concrete floors and dimly lit incandescent lights. This submarine-like look prompted the visiting parents of a new graduate student to ask: "Son, are you sure that you have picked the right place for graduate studies?" *Photo by Rajendra Gupta, 1990.*

nothing for the instructional space.

In 1989, Gupta was asked to become the chair of the department. During his negotiations with the dean, Gupta was given funding for an additional secretary, which necessitated moving the Physics Office to a larger space. The office was moved into room 105 and the chair's office to room 106. He was given $10,000 for minimal renovation of room 105 to convert it from a classroom to an office.

h. Building Renovation and Expansion (1994–2008)[12]

Gupta was very much interested in helping the department solve its space problems almost from the time he joined in 1978, perhaps because of his own difficult experience in obtaining a suitable lab space for his research. In 1982, Chair Don Pederson appointed a committee consisting of Gupta, Richardson, and Zinke, with Gupta as chair, to determine the space needs of the department. The committee promptly submitted a report to the Department with the conclusion that the department needed about thirty-six thousand square feet of NAS (net assignable space), about twice what was available then. Pederson then followed up with his own, much more detailed, report for submission to the administration [Ref. 8]. As with all previous attempts to find additional space for physics, nothing came of this effort.



Figure 21: Front hallway. Door to Dickson Street on the left is not visible. *Photo by Rajendra Gupta, 1990.*

The department's building problems finally gained the attention of the administration in the 1988–89 period due to the media publicity received by the department's superconductivity work led by Professors Hermann and Sheng. A new research space for the Chemistry Department had been a high priority for the administration for some time, and the administration then saw an opportunity to seek legislative funding for a joint physics and chemistry research building in the legislative session of spring 1989. Under this plan, physics and chemistry research laboratories would have been housed in a new building attached to the Chemistry Building. The research building was projected to cost $16–17 million. The legislature appropriated $11 million for the building, but only $3 million was funded in the A-category, and $8 million was in the B- and C-categories. Even out of the $3 million, only $1 million was released by the governor. There was no time horizon apparent for the rest of the funding.

In June of 1989, a user committee was appointed by the administration to make plans for the building with John Hehr, associate dean of Fulbright College, as chair and with representatives from physics and chemistry faculty, Finance and Administration and the

[12] One of the authors of this history, Gupta, was intimately involved in obtaining funds for, planning and implementing the renovation of the building. It was difficult for him to write this section without appearing to be self-serving. However, for the sake of historical record, he has chosen to describe his role as accurately and objectively as possible.

Physical Plant. The physics representatives were Rajendra Gupta and Charles Richardson. The details of the committee and its recommendations are given in a report entitled *The Physics Building*, which was authored by Gupta and contains a historical account of Physics Building renovation [Ref. 8]. Suffice it to say that it was made clear to Gupta and Richardson that this building was only for the research laboratories; physics faculty offices, the Physics Library, instructional laboratories, and classrooms were to remain in the Dickson Street building. Not even offices for the graduate students were permitted in the new building. Eventually, when funds became available, physics was going to be moved to the space vacated by chemistry in the old Chemistry Building. This was going to be the space made available by the move of only the chemistry research labs; the rest of the Chemistry operations were to remain in that building. There was not enough space to be vacated in the Chemistry Building to fully accommodate the needs of physics. There was only going to be enough space for the physics faculty but none for the instructional laboratories; space was to be found for them elsewhere. And no solution seemed possible for the need for a large lecture room where physics demonstrations could be carried out. Gupta and Richardson found the plan to be totally unacceptable. The majority of the committee recommended that the project be carried out, with Gupta and Richardson dissenting. Chair Gupta called a faculty meeting, and physics passed a resolution unanimously protesting the plan to split the department for the "foreseeable future." A letter signed by the entire faculty was sent to the administration.

Gerry Bomotti, a very congenial fellow, had recently become the vice-chancellor for Finance and Administration. One fine day, unannounced, he showed up in the Physics Department, popped his head into Gupta's office and introduced himself. He said that he wanted to look around at the building. Gupta gave him a tour of the wretched condition of the building and told him about the needs of the department. Having been involved with the building issue for nearly a decade, he had all the facts and figures at his fingertips. Bomotti pointed out that the building was structurally sound and could be renovated. He suggested that an extension of about thirty thousand gross square feet could be built in the back in two phases, Phase I to be built immediately and Phase II in about five years. It appeared that physics would get its plan approved immediately, while chemistry might have to wait for a long time. On January 25, 1990, the faculty voted nine to one in favor of the plan.

Meanwhile, the NSF announced plans to award $19 million for modernization of academic research facilities. Each institution could only



Figure 22: Exterior of the Physics Building after renovation and expansion. On the right is the entrance to old building (research space) and on the left is the entrance to the Phase I expansion (instructional space). ***Photo by Rajendra Gupta, 1994.***



Figure 23: Front entrance (on Dickson Street) to the research wing (old building) of the Physics Building. ***Photo by Rajendra Gupta, 1994.***

submit one proposal. In January 1990, the university administration invited various science departments to submit internal proposals. Gupta submitted one on behalf of physics. In February, the administration selected the physics proposal. NSF guidelines were that they would not fund any new construction, and they would pay, on a cost-share basis, only for the space directly used for research. The Physical Plant estimated the total renovation cost to be $1.7 million, out of which $1.14 million was for research laboratories. Gupta wrote a proposal to the NSF based on the Physical Plant's cost estimate. The proposal for $1.14 million was submitted to the NSF ($572,000 from the NSF and $572,000 from the university), with John Hehr as principal investigator and Gupta as coprincipal investigator. The competition was in two phases. In Phase I, the NSF picked 172 out of 425 total proposals received. Our department was one of them. In each of the four categories, the physics proposal received between "truly outstanding" to "highly meritorious" rating from all the reviewers. A more detailed Phase II proposal was written by Gupta and, happily, in January 1991 the NSF granted physics $500,000 (out of a total of 172 Phase II proposals, seventy-eight were funded).

While the NSF application was pending, the planning for renovation and Phase I expansion was supposed to have been going on, because this project was supposed to be undertaken whether the NSF funding was awarded or not. However, there was very little movement. No one in the Physical Plant bureaucracy was willing to make the necessary decisions, and there was very little leadership from the dean's office. Once the NSF grant was received, however, things started moving. Because the grant had a deadline, people who could not make decisions some weeks before suddenly started making them. In retrospect, it is clear that the renovation would probably not have taken place without the leverage of the NSF funds.

The next year and a half, from January 1991 to May 1992, were spent in the planning. The Little Rock architectural firm of Wellborn Henderson Associates was hired. The Physical Plant had estimated that the renovation plus Phase I expansion would cost $2.77 million: approximately $1.7 million for the renovation of the old building and approximately $1 million for Phase I expansion. Vice-Chancellor Bomotti funded the project for $2.77 million. But the architect found that the Physical Plant's estimate of $1.7 million for renovation was at least a million dollars short. There were numerous meetings between the architect and the Building Committee (Gupta, Hehr, Richardson, and Salamo) to work out the details, make compromises to reduce the cost, and so on. While the faculty agreed in principle to reduce the scope of the renovation, they found it difficult to make specific cuts. Compromises had to be made on many things, including some things that were specified in the NSF proposal, in order to get the project moving. The old renovated building was to be converted into a primarily research building, while the Phase I expansion was for instruction only. Gupta made several cost-saving decisions and reduced the size of Phase I expansion to just one-to-one replacement of the instructional space lost in the old building.

The project was still way over the initial budget. Gupta, Hehr, the architect, and the Physical Plant representative then met with Bomotti in the Administration Building. Bomotti looked at the latest cost estimate and said that until the cost can be aligned with the budget, the project would not proceed. Frustrated, Gupta told Bomotti that the project scope had been reduced as much as possible and that no further cuts could be made, that if they could not do it right then they should not do it at all. This was Gupta's spontaneous reaction without any forethought to the possible consequences. Bomotti abruptly collected and picked up all of his papers, stood up and tersely said to Gupta: "Okay, we will proceed but understand that if the bids do not come out favorable then the project will not be undertaken," and walked out of the conference room. In retrospect, it is clear that Bomotti had very little choice as renovation of the old building as a research space had to proceed because the NSF grant had been accepted and the university had committed to abide by the NSF conditions. Phase I of the building expansion was also necessary because all of the physics instructional space, according to the NSF proposal, was going to be converted into research space. The design was finally completed, and the bid was advertised on May 15, 1992 and opened on June 2, 1992. Fortunately, the bids came out favorable, Bomotti was able to come up with some additional funds, and the contract was awarded. Construction started on July 21, 1992. The total cost of the project, including architect's fees, contingency, telephone and local area networking, asbestos removal, geological studies, laser tables, furnishings, and more, turned out to be approximately $3.9 million dollars. This included some of the funds (such as for new furniture) that Gupta was able to get Bomotti to add on as the project proceeded.

To facilitate the work, the renovation was



Figure 24: Entrance to the instructional wing (Phase I expansion). ***Photo by Rajendra Gupta, 1994.***



Figure 25: A typical introductory physics lab in the Phase I expansion. ***Photo by Rajendra Gupta, 1994.***



Figure 26: Laser Spectroscopy Laboratory in the renovated research space. Graduate student, Quifang He, is on the left. ***Photo by Rajendra Gupta, 1994.***

done in stages, while physics was occupying part of the building. All of the department's instructional activities (including all of the laboratories) were temporarily moved to the Science Engineering Hall and Bell Engineering Center. This turned out to be a very difficult task. It took about a year to find appropriate space and to modify it to suit physics's needs. By far the most difficult part turned out to be maintaining the department's research activities during the renovation. There were continual problems with construction dust and heavy metal fumes from welding getting into optics research laboratories, interruption of power and laser water, vibration of floors and walls, and so on. About a year into the project, activity slowed down and very little progress was being made as the renovation turned out to be far more complex than anticipated. Both the architect and the contractor were pointing fingers at each other and complaining that they were losing money, and there was no leadership by the Physical Plant, which was supposedly supervising the project. Finally Gupta offered to make the entire east wing basement available to the contractor at one time if they would guarantee that the project would be finished in a specified time. Moreover, he de facto took over supervision of the project from the Physical Plant. This finally brought the project to completion in the summer of 1994, and all the operations of the department were moved back to their proper spaces. This was certainly an emotionally draining period for everyone, particularly Gupta, as he was trying to not only manage the project's progress but also keep all of the department's operations functioning properly. This period may well have been the most difficult period in the history of the Physics Department. Had it not been for Bomotti being in the right place at the right time and the leverage of the NSF grant, we are certain that the renovation and Phase I expansion would never have taken place.

The new wing (the product of Phase I expansion) consisted of instructional space only: six introductory physics laboratories, a small classroom, a seventy-seat lecture room, a stock room and a laboratory curator's office. The old building was converted to research laboratories, faculty and graduate student offices, the Physics Library and administrative office. The renovation was so extensive that the renovated building had the look of a newly constructed building. Classes were offered in the new wing starting in the second summer session of 1994. The floor plan is shown on following pages. The space utilization in the renovated building was as follows:

On the upper floor, the Physics Library moved across the hallway into an expanded space, room 221. The library housed journals, seating, and a desk for library staff in room 221 and books in room 221A, while 221B was the librarian's office. The Physics Department office was in room 226, and the chair's office was in room 227. The rest of the rooms on the upper floor were mostly faculty, postdoc, and graduate student offices. Downstairs, the machine shop moved into an expanded space consisting of room 101 for the main shop and room 102 for the student shop. The rest of the rooms on this floor were the research labs with the exception of modern and optics, laser, and nonlinear optics labs. In Phase I expansion, rooms 243, 244, 245, 248, 134 and 135 were instructional labs used for University Physics II, University Physics I, College Physics, Physics for Architects, Astronomy, and Physics for Human Affairs, respectively. Rooms 132 and 133 were the classrooms. The lecture room, Room 133, was later named after Paul Sharrah, thanks to the efforts of Chair Surendra Singh. Charles Richardson organized the dedication of the room along with a memorial for Sharrah. The details can be found in the Spring 1997 issue of *Reflections*, the departmental newsletter.

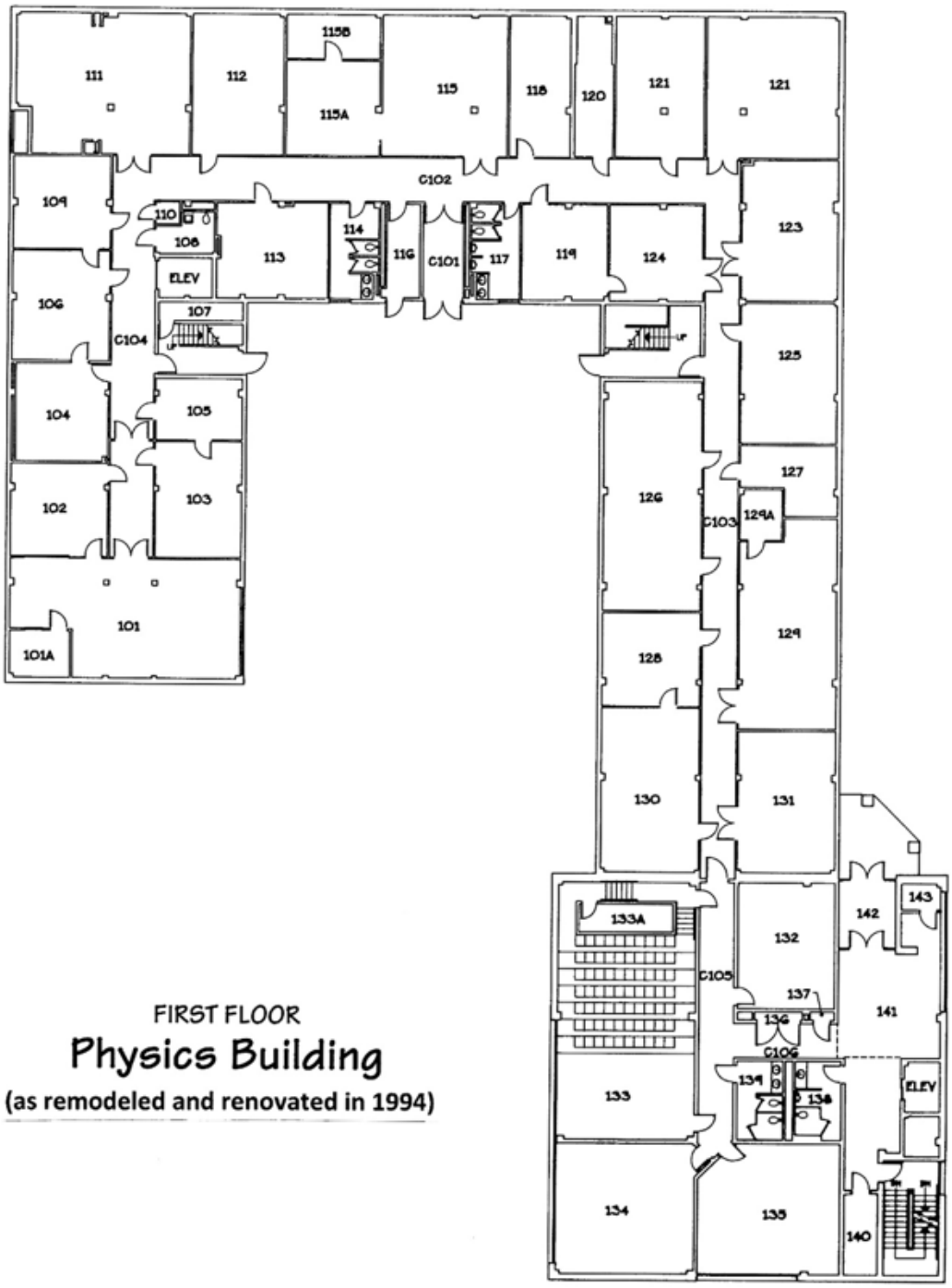


Figure 27: The floor plan of the first floor of renovated and expanded Physics Building. The part on the bottom right is the Phase I expansion.

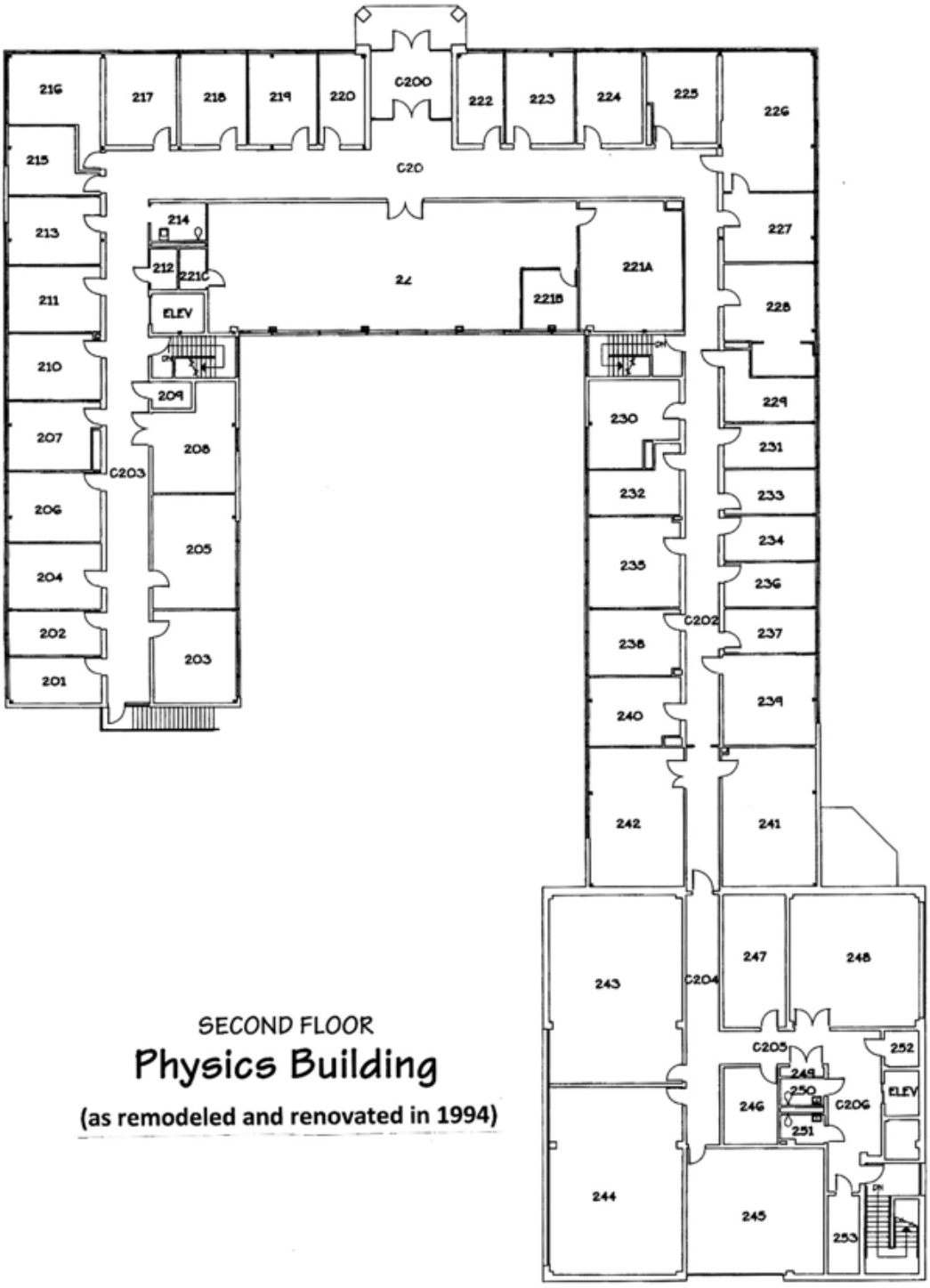


Figure 28: Floor plan of the second floor.

The department felt a sense of euphoria when this project was completed. To celebrate, a grand reopening ceremony was held on September 9, 1994, which is described in the next section below.

i. Grand Reopening Celebrations

The reopening ceremony was held on September 9, 1994. Chancellor Dan Ferritor did the traditional "ribbon-cutting" by flipping a switch, which caused a lightning spark to travel up a Jacob's ladder to burn the ribbon. The grand reopening ceremony was attended by Bernard Madison, dean of Fulbright College; Don Pederson, vice-chancellor for Academic Affairs; Chancellor Daniel Ferritor; B. Alan Sugg, president of the University of Arkansas system; special guest Professor Elsa Garmire, director of the center of laser studies at the University of Southern California; various administrators; members of the legislature and board of trustees; current and former faculty; students; alumni; staff and friends. The grand reopening ceremony was followed by an open house. All facilities, including the research laboratories were open for the visitors to tour. In addition, special exhibits and demonstrations were set up. The festivities were concluded with a banquet in the evening at the Fayetteville Hilton.

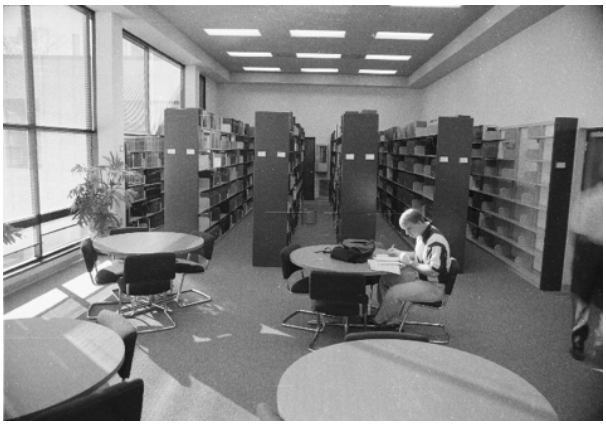


Figure 29: The new Physics Library. Compare with Figure 19. ***Photo by Rajendra Gupta, 1994.***

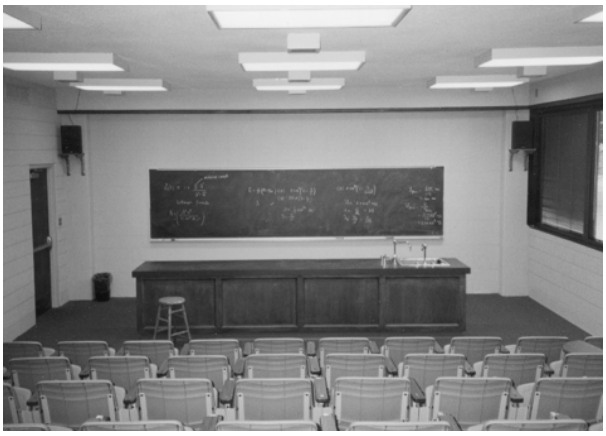


Figure 30: Paul C. Sharrah Lecture Room (Room 133). ***Photo by Rajendra Gupta, 1994.***



Figure 31: First floor east wing hallway. Compare with figure 20. ***Photo by Rajendra Gupta, 1994.***



Figure 32: The front hallway opening to Dickson Street on left. Compare with Figure 21. ***Photo by Rajendra Gupta, 1994.***

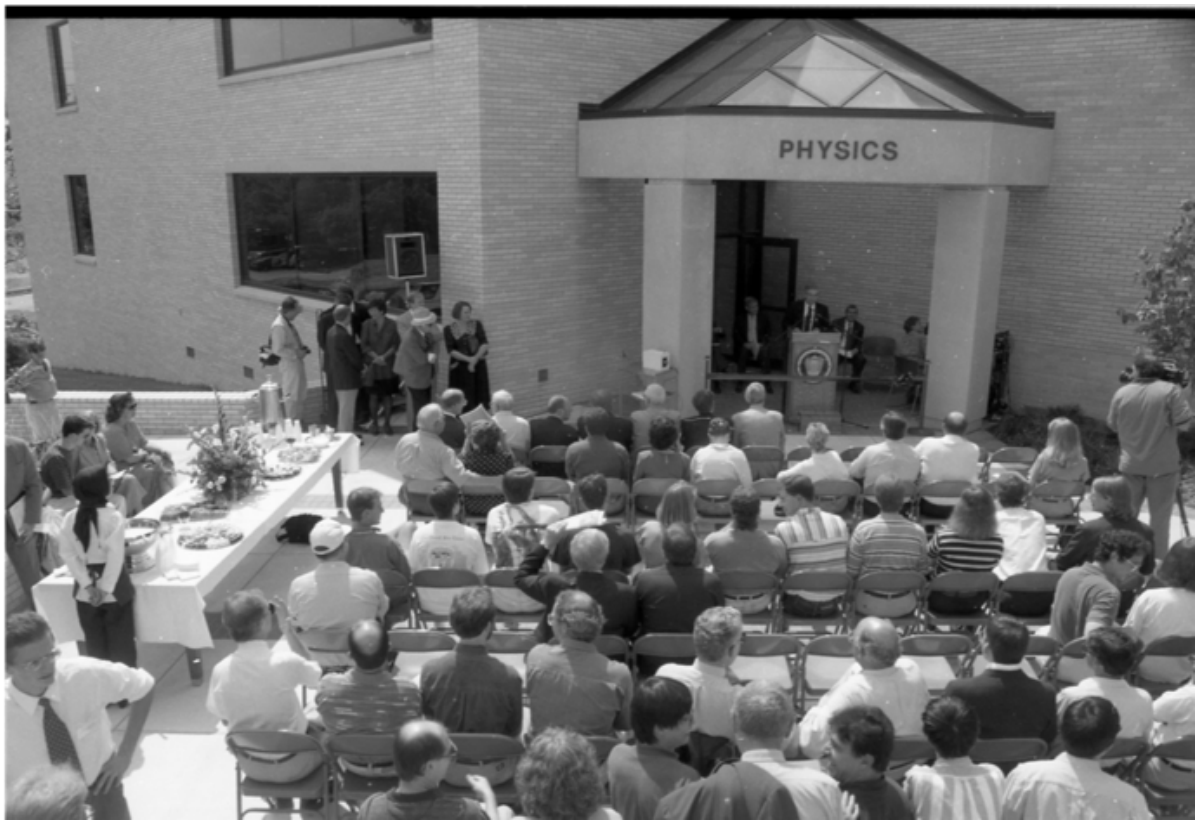


Figure 33: The Grand Reopening Ceremony at the entrance to Phase I expansion on September 9, 1994. Dean of Fulbright College, Bernard Madison, presided.



Figure 34: Chair Rajendra Gupta thanked everybody who contributed to the success of this project, but especially the faculty for their cooperation in spite of a huge disruption to their research. Chancellor Ferritor (partially hidden) looks on.



Figure 35: Professor Michael Lieber spoke on behalf of the faculty to thank Gupta for obtaining the NSF grant and managing the project.



Figure 36: Chancellor Ferritor did the ribbon-cutting by throwing a switch to start a spark in a Jacob's Ladder. The spark traveled up the ladder to burn the ribbon. President Sugg watches from behind the podium.



Figure 37: President Allan Sugg and special guest Professor Elsa Garmire react to a physics demonstration following the opening ceremony.

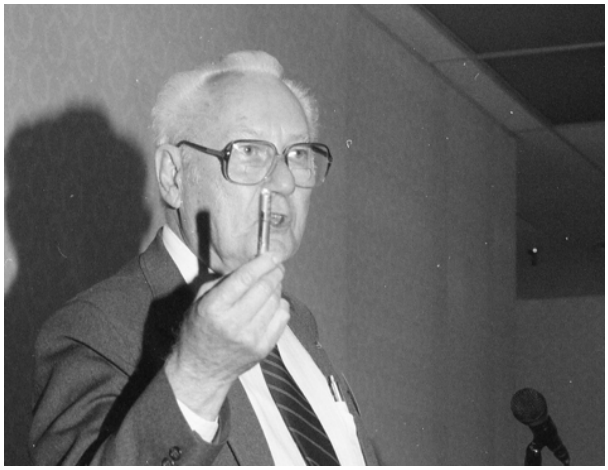
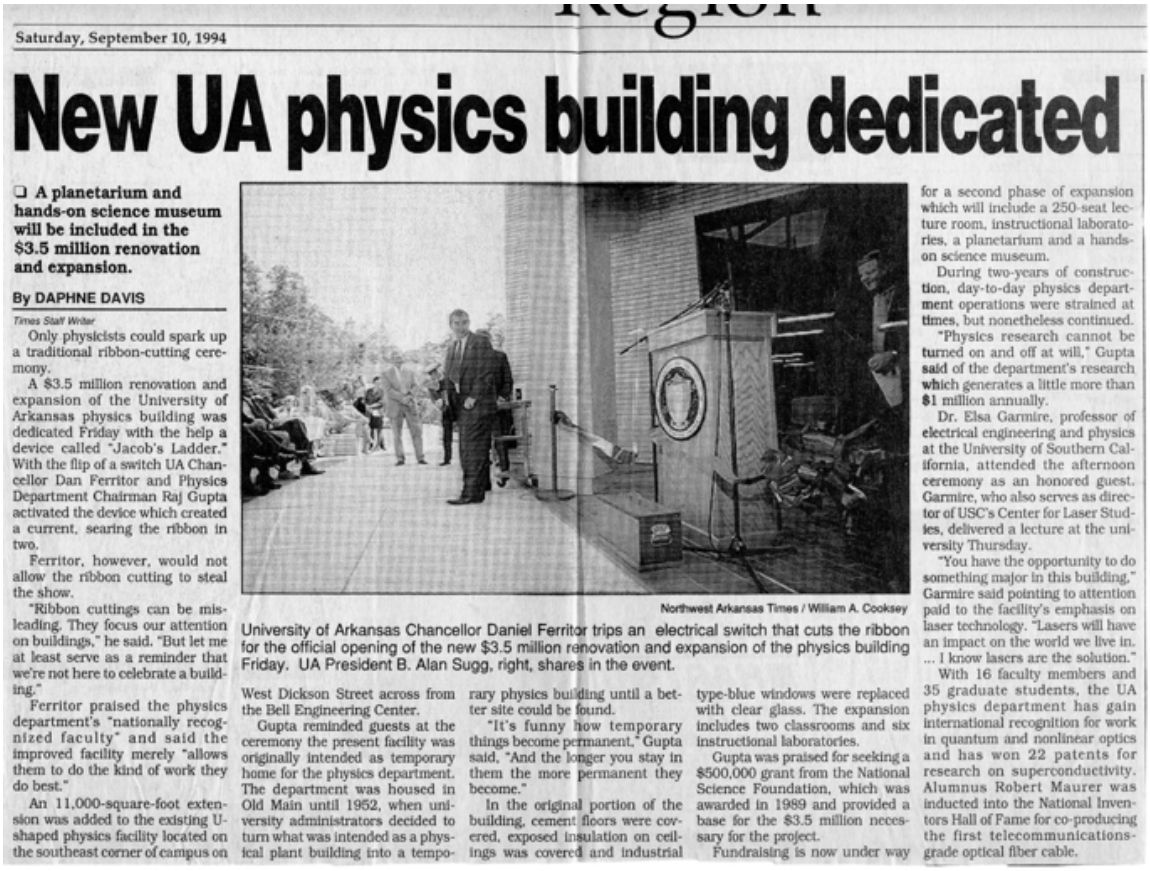


Figure 38: Emeritus Professor Paul Sharrah gave a short talk on the history of the Physics Building at the evening banquet.



Saturday, September 10, 1994

New UA physics building dedicated

❑ **A planetarium and hands-on science museum will be included in the $3.5 million renovation and expansion.**

By DAPHNE DAVIS

Times Staff Writer

Only physicists could spark up a traditional ribbon-cutting ceremony.

A $3.5 million renovation and expansion of the University of Arkansas physics building was dedicated Friday with the help a device called "Jacob's Ladder." With the flip of a switch UA Chancellor Dan Ferritor and Physics Department Chairman Raj Gupta activated the device which created a current, searing the ribbon in two.

Ferritor, however, would not allow the ribbon cutting to steal the show.

"Ribbon cuttings can be misleading. They focus our attention on buildings," he said. "But let me at least serve as a reminder that we're not here to celebrate a building."

Ferritor praised the physics department's "nationally recognized faculty" and said the improved facility merely "allows them to do the kind of work they do best."

An 11,000-square-foot extension was added to the existing U-shaped physics facility located on the southeast corner of campus on West Dickson Street across from the Bell Engineering Center.

Gupta reminded guests at the ceremony the present facility was originally intended as temporary home for the physics department. The department was housed in Old Main until 1952, when university administrators decided to turn what was intended as a physical plant building into a temporary physics building until a better site could be found.

"It's funny how temporary things become permanent," Gupta said, "And the longer you stay in them the more permanent they become."

In the original portion of the building, cement floors were covered, exposed insulation on ceilings was covered and industrial type-blue windows were replaced with clear glass. The expansion includes two classrooms and six instructional laboratories.

Gupta was praised for seeking a $500,000 grant from the National Science Foundation, which was awarded in 1989 and provided a base for the $3.5 million necessary for the project.

Fundraising is now under way for a second phase of expansion which will include a 250-seat lecture room, instructional laboratories, a planetarium and a hands-on science museum.

During two-years of construction, day-to-day physics department operations were strained at times, but nonetheless continued.

"Physics research cannot be turned on and off at will," Gupta said of the department's research which generates a little more than $1 million annually.

Dr. Elsa Garmire, professor of electrical engineering and physics at the University of Southern California, attended the afternoon ceremony as an honored guest. Garmire, who also serves as director of USC's Center for Laser Studies, delivered a lecture at the university Thursday.

"You have the opportunity to do something major in this building," Garmire said pointing to attention paid to the facility's emphasis on laser technology. "Lasers will have an impact on the world we live in. ... I know lasers are the solution."

With 16 faculty members and 35 graduate students, the UA physics department has gain international recognition for work in quantum and nonlinear optics and has won 22 patents for research on superconductivity. Alumnus Robert Maurer was inducted into the National Inventors Hall of Fame for co-producing the first telecommunications-grade optical fiber cable.

Northwest Arkansas Times / William A. Cooksey

University of Arkansas Chancellor Daniel Ferritor trips an electrical switch that cuts the ribbon for the official opening of the new $3.5 million renovation and expansion of the physics building Friday. UA President B. Alan Sugg, right, shares in the event.

Figure 39: There was wide coverage of the event in local media, including the *Northwest Arkansas Times*, the *Morning News*, and the *Arkansas Democrat-Gazette*. Here is a story from the *Northwest Arkansas Times*, September 10, 1994.

j. Phase II Expansion

It was time to shift attention to Phase II of the expansion project. Phase II of the physics expansion was planned to have, among other things, a 1,600-square-foot planetarium, a discovery room (a hands-on science museum), a 250-seat lecture room with attached demonstration room, an undergraduate student lounge, a computer room for the use of undergraduate students, intermediate level laboratories (optics, laser physics, modern physics, electronics), and an additional classroom. Blueprints for Phase II were drawn up by the architect. Unfortunately, Bomotti left the university just when the finishing touches were being put on the renovation and Phase I expansion. Gupta asked for a meeting with Bomotti and Hehr just before Bomotti was to leave. Gupta asked Bomotti to open an account for Phase II and put a token amount of money in it as the administration's commitment to Phase II. Bomotti looked to Dean Hehr for support for this idea. But Gupta got no support from the dean's office. Gupta then tried to get funding for Phase II by seeking private money for a planetarium as leverage to secure Phase II expansion. He tried to urge the university to apply to the Walton Foundation and to the Keck Foundation. Unfortunately, the dean's development office itself was underdeveloped and did not know how to proceed. Phase II remains unfunded to this day, while the university's priorities have changed. Chair Surendra Singh, who succeeded Gupta, and Bernard Madison, the then dean of the Fulbright

College, tried to obtain private funding for a Science Center in the late 1990s. It was envisioned that the Science Center would have a planetarium, a hands-on science museum, and space for the Physics Department's instructional and outreach activities. An architect was hired by the dean to draw up the plans. However, the plan never got any support from higher administration.

The euphoria that we felt right after the renovation and Phase I expansion were completed was short lived, however, as the department experienced a sharp increase in its research activities and rapidly ran out of research space. By 2008, all the instructional labs were moved out of the Phase I building to Science Engineering Hall, and the basement (which was a storage space) was finished and converted into space for the machine shops. All the other space in Phase I, with the exception of Rooms 132 and 133, had been utilized for other purposes including a research lab, graduate student offices, and Microelectronics-Photonics office. In the old building, Rooms 101 and 102, vacated by the machine shops, were converted into a molecular beam epitaxy (MBE) lab. An appendage to the old building had to be built outside of Room 101 into the courtyard in order to house the mechanical equipment for this lab (such as HVAC). And Phase II remained unfunded.

By 2008, the department's operations were spread over four buildings: the Physics Building, Dickson Street Apartments (Physics for Architects lab and postdoc and graduate student offices), Science Engineering Hall (Physics and Human Affairs, College Physics, University Physics, and Astronomy labs), and the old geology building (postdoc and graduate student offices). The Physics Department's space needs had become acute again.

6.

Undergraduate Degree Programs, Courses, and Curricula

In this chapter we will describe the undergraduate program by presenting a few snapshots of the program at various times during its hundred-year history. We have already described the curriculum in 1907–08, the year the department was established and the physics major defined for the first time. So we will start this chapter with 1918. By necessity, this chapter is rather long. Therefore, the chapter has been divided into two parts. In part I, a picture of the evolution of the physics courses and curriculum over the century is presented using a few snapshots of the curriculum at various times as derived mostly from the catalogs of those years. It should be kept in mind that they are just snapshots and do not represent a comprehensive picture. Part II consists of comments on some particular aspects of the undergraduate program, degrees and courses.

Part I

Snapshots of Physics Curricula over the Century

A. Physics in 1918 (Catalog of 1917–18)

We take a look at the *Annual Catalog of 1917–18* (and *Announcement 1918–19* published May 1918). There were still only two teachers in physics, Professor Ripley and another person whose name was not available at the time of publication. We note that while the requirements for a major in physics were defined in the 1907–08 catalog, no physics degree was awarded until 1928. Therefore, the department had added courses that were suitable for majors other than physics. The catalog specifically mentions agriculture, home economics, law, and medicine, in addition to chemistry and engineering. Thus, the course offerings included the following courses: Elementary Physics with laboratory (a non-mathematical course with applications to everyday life), Household Physics with laboratory, History of Physics, and Teaching of Physics.

A major in physics required thirty-four credit hours, including Elementary Physics and laboratory (eight), General Physics and laboratory (eight), Advanced Physics and laboratory (eight), Heat (three), Electrical Measurements (three), Light (two), Mathematical Physics (three or six), and Recent Advances in Physics (six). The numbers in parentheses indicate the number of credit hours. For some inexplicable reason, the number of required course credits adds up to be more than thirty-four.

B. Physics in 1928 (Catalog of 1927–28)

This year has a special significance as the year the first physics degree was awarded. The first physics degree in 1928 was a BA degree, and the

second in 1931 was a BS degree. When this first physics degree was granted, the *University of Arkansas Bulletin*: *Annual Catalog 1927–28 and Announcement 1928–29* listed three physics teachers: Professors G. E. Ripley and S. R. Parsons and Instructor W. M. Roberds.

Thirty semester hours of physics were required for the major in physics. A total of ten physics courses are listed in the *Bulletin*, and seven of those were above the introductory level. The seven courses above the introductory level were Heat and High Temperatures (233), Light (243), Electricity and Magnetism (313), Electrical Measurements (323), Mechanics (333), and Electron Theory (343). All of the upper-level physics courses except the first two were taught in alternate years. The numbers in parentheses represent the course numbers and are included here to indicate the level of courses.

The electron theory course emphasized the study of electrical discharge in gases and had become a vital part of physics. The course, in addition, covered thermionics (which was necessary for understanding the operation of vacuum tube devices), photoelectricity, x-ray, and theories of atomic structure. A textbook *Ions, Electrons and Ionizing Radiations* by J. A. Crowther of the University of Reading (Longmans, Green & Co.) went through several editions in the 1920s and 1930s and represents a good example of the materials being taught during that period.

Electrical measurement courses were an important part of physics instruction at that time. Potentiometers, bridges, galvanometers, quadrant electrometers, standard cells and other classical electrical measuring devices were vital components of the physics research laboratory. Some of these devices are on display in the collection of historical equipment in the lobby of the Physics Building.

What is particularly noteworthy is the emphasis on laboratory work. In addition to the laboratory components in the introductory courses, as usual, two of the 200-level courses had laboratory components, and in addition there was a two-semester stand-alone laboratory course.

The 1927–1928 Physics Department was located in a two-story frame building containing ten rooms for lectures and laboratory work in physics described in chapter 5.

C. Physics in 1935 (1934–35 Catalog)

The 1934–35 physics faculty consisted of Professor Ripley, Assistant Professor Ham, and Mr. Roberds (instructor). The list of courses had risen from ten in 1928 to fourteen with eleven courses above the introductory level. The 1934–35 catalog still listed thirty semester hours as the requirement for the physics major.

Calculus was required for the major, and courses in differential equations and partial differential equations were recommended.

The physics courses listed seem to have been rather standard for the period. The list included electricity and magnetism, atomic physics, heat, x-rays, acoustics, sound, photography, light and photography, and introduction to theoretical physics. Sound and light and x-rays were taught at two levels, one for the general students and the other for physics majors. The x-ray course, for example, had all of the students together for some lectures with an additional session devoted to specialized advanced subjects, such as x-ray diffraction. Courses in acoustics and x-rays and photography represented the research interests of Ham and Roberds, respectively.

A junior-level mechanical engineering course in mechanics could be counted toward the requirement for a major or a minor in physics. This was the only advanced mechanics course available to the physics majors at that time except for what might have been taught in sound and theoretical physics courses.

For some unknown reason, the electrical measurements course was absent from the 1935

curriculum. It was listed in the 1928 catalog and was again very prominent in the 1940s and 1950s. The number of credits permitted in the advanced laboratory, however, had been increased to six hours, and presumably some of the electrical measurement experiments may have been absorbed into the advanced laboratory course.

The 1934 catalog still listed two introductory physics courses of essentially the same design except for prerequisites. One was for students who had not had high school physics and the other was for those who did have a high school physics course. At later times, mathematics was treated as the primary prerequisite for the introductory physics courses with less attention being paid to whether or not the student had studied physics in high school.

Astronomy was taught in the mathematics department and one astronomy course listed there was taught by Assistant Professor Richardson.

The mathematics courses went as high as partial differential equations, functions of a complex variable, higher geometry, and an intermediate level course in the theory of equations and determinants.

D. Physics in 1945 (1944–45 Catalog)

The catalog published April 1, 1945 includes the announcement of courses for the 1945–46 school year. The 1945–46 announcement still shows only three faculty members in physics, Professors Ham and Sharrah and Instructor J. Bruce Kellar. Robert Morse joined the teaching group later as an instructor. A fourth part-time teacher was a common practice for a few years in the 1940s and 1950s. These included at various times Camus, Antoine, Raible, Doughty, Testermann, Bennett, Leonard, Good, Damon, Oxford, Clayton, Williams, Jones, Harvalik, Saur, Nurmia, Scobie, Saporoschenko, Bolling, Pierce, and others, as described in chapter 3, which describes the World War II period. At that time the supply of regular students had dwindled, and the department was very heavily engaged in teaching the army trainees.

The twelve-week term system implemented briefly during WWII to accommodate army training was removed and the university was to return to the eighteen-week semester system for fall 1945 classes. This change was announced at the last minute, so the course announcements were somewhat confused. For example, the major in physics required forty-five term hours, while the university had reverted to semester schedules.

The university enrollment more than doubled after the war, as described in chapter 3. For the first time in the department's history, the physics majors program was to take off, shown in part II, section A below.

The number of courses offered in physics had exploded by 1945 to twenty-eight courses, and this number did not include the elementary laboratory courses. How could these be taught? Several were taught only in alternate years or on demand. No junior-level mechanics course was offered and a course in engineering was frequently used to supplement the physics offerings in this area well into the 1950s. A course on electronics and radio perhaps represented the war-time interest. What is striking among the course offerings is the number of stand-alone laboratory courses: Electrical Measurements Laboratory, Electro-Acoustics Laboratory, Photography Laboratory, Light laboratory, x-ray Laboratory (two courses), Electronics Laboratory, Atomic Physics Laboratory, and a course on Methods of Physical Analysis with an accompanying laboratory. Photography was soon dropped from this listing, as it had not been taught since Dr. Roberds resigned in 1942.

The elementary courses had large enrollments as the GI's came to college in large numbers. Most of these sections had seventy-five students,

for a total of about three hundred students in introductory physics. Physics majors took courses in mechanics, electricity and magnetism, electrical measurements, electronics, heat and thermodynamics, sound, light, x-rays, atomic physics, and introduction to theoretical physics. The x-ray course would continue to be a significant part of physics for twenty-five years.

The one astronomy course, Descriptive Astronomy, was taught by Dr. Guerdon Nichols in the Department of Mathematics and Astronomy. The advanced mathematics program listed essentially the same courses as those listed in 1934, with the addition of a course in the theory of numbers and a course in statistics.

E. Physics in 1960 (1959–60 Catalog)

There was a radical change in the course offerings over the fifteen-year period since 1945. Now relativity, quantum theory, and solid-state physics had been included in the undergraduate curriculum, in addition to atomic and nuclear physics. It is worth noting that the PhD program in physics was started in 1959; therefore, there were now graduate courses (500- and 600-level) as well. Our discussion below is confined to courses up to 400-level only.

The faculty consisted of Professors Sharrah and Schwartz, Associate Professor Hughes, Assistant Professors Clayton and Zinke, and Instructors Lingelbach and Petz.

The BA degree required a thirty-semester-hour major and mathematics through differential equations. 300-level courses on analytical mechanics and electricity and magnetism provided foundation for other intermediate and advanced physics courses.

The BS degree required a thirty-six-hour major. Mathematics through 300-level differential equations was required, and Fourier Analysis and a number of more advanced mathematics courses were strongly recommended. The 400-level physics courses offered included Mechanics and Electricity, Heat and Thermodynamics, Optics, Sound, Atomic and Molecular Spectra, and Solid-State Physics, while relativity and quantum theory were taught as part of Atomic Physics I and II. 400-level laboratory courses included those on electronics, optics, and atomic and nuclear physics. This catalog lists thirty courses, excluding graduate-level (500- and 600-level) courses.

There were two suggested plans by which students could pursue this major. Plan A, the "accelerated program," started with Engineering Physics, later called University Physics, in the fall semester of the freshman year simultaneously with calculus. Plan B was a BS program that started physics during the second semester of the freshman year, again simultaneously with calculus. This brought about delaying the intermediate and advanced courses by about a semester or a year. It is known that many freshman students not quite ready for calculus did make use of it.

One trend not evident from a study of the 1960 schedule is the emphasis that was being placed on honors studies. This program was developing rapidly. Honors sections of the two-semester introductory courses were taught. A junior-level honors course of independent study was introduced. An honors colloquium was also a part of this program for a time. The college honors program is discussed later in this chapter.

A very significant strengthening of the undergraduate degree program was the introduction of the two-semester atomic physics course in the senior year (which included relativity and quantum theory). In the late 1950s and early 1960s there would be as many as fifteen students in this course, as it could be taken by both seniors and first-year graduate students. A course similar to this (renamed Modern Physics) was taught later.

Also noted in the 1960 BS program is the recommendation that those planning on entering

graduate school should take two foreign languages. This last requirement would soon be relaxed to require only one foreign language, Russian or German. By 1969 even this foreign language requirement was completely eliminated.

This catalog also lists a Physical Science Department offering a single course: Introduction to Physical Science. The faculty consisted of Professors Sharrah and Clayton of physics and Noyce of chemistry. See the next section for more details on this department.

F. Physics in 1970 (1969–70 Catalog)

The 1969–70 catalog lists eleven physics faculty members: Professors Day (chairman), Clayton, Hughes, Schwartz, Sharrah, and Zinke; Associate Professors Hobson and Richardson; and Assistant Professors Anderson, Chan, and Jones.

Thirty-eight courses, exclusive of elementary laboratories, are listed. This included five 2000-level courses, eleven 3000- and 4000-level courses (excluding projects and directed studies courses), sixteen 5000- and 6000-level courses (exclusive of seminars and research courses), and six courses designed for teachers.

A Bachelor of Science in physics and a Bachelor of Arts in physics are defined. The BA degree program required 124 semester hours, and the BS program requires 136 semester hours.

The BS degree program required thirty-six semester credit hours in physics, and the BA program required thirty semester hours. The BS degree also required more courses in advanced mathematics than the BA degree. This included a course in differential equations and Laplace transforms and two additional courses to be selected from an approved group. Most of the physics students elected the two-semester course in applied mathematics or the two-semester course in advanced calculus.

Concentrating primarily on the undergraduate (up to 4000-level) courses, several of the advanced physics courses had been expanded to two semesters, and many of the courses were taught on demand or in alternate years. Mechanics and Electromagnetic Theory was a two-semester course. There is no course with the title Quantum Mechanics, but quantum mechanics, along with theory of relativity, was taught in a two-semester course on modern physics. This course also covered application of quantum mechanics to atomic, nuclear, and elementary particle physics.

At the introductory level, a third semester had now been included in the University Physics sequence taken mainly by science and engineering majors. Simply called University Physics III, this course covered modern physics. Though initially taught as a course on nuclear physics and reactor physics in 1960, in a year or two it was modified to cover the broad field of modern physics.

Six of the undergraduate courses were listed as primarily satisfying certain requirements for prospective science teachers, and most of these courses were taken from time to time by teachers in the summer institutes (see chapter 13).

The general education (for nonscience majors) program first established in the early 1950s was now clearly defined by the college. Certain basic general education courses were required of all students and listed in three groups: Literature and Fine Arts, Natural Science, and Social Studies. This general education program was very successful under Dean Nichols, who saw that faculty received due credit for teaching and were rewarded for developing and teaching these general courses. A two-semester sequence, Introduction to Physical Science, satisfied the requirements for general education in Natural Science. The course was listed under a separate department called Physical Science. See part II, section F below for more on general education courses.

The descriptive astronomy course and two additional astronomy courses, Observational

Astronomy and Advanced Astronomy, were now being taught by the Department of Physics. A popular one-credit-hour course in celestial navigation was added the next year. Its description sounds very much like the practical astronomy course Professor Droke had taught a half a century earlier.

G. Physics in 1982 (1981–82 Catalog)

This catalog lists fourteen physics faculty members: Professors Anderson, Chan, Day, Hobson, Hughes, Richardson, Sharrah, and Zinke; Associate Professors Lieber, Pederson (chairman), and Salamo; and Assistant Professors Gupta, Lacy, and Milonni.

A total of approximately sixty courses were offered, exclusive of elementary laboratories, and exclusive of special courses for teachers. Of these, approximately thirty were primarily undergraduate courses (4000-level or below). Many of the courses were taught only in alternate years or on demand, but they covered a broad range of physics.

The BS degree program still required thirty-six credit hours, but the BA program requirement had dropped from thirty to twenty-four hours. The total hours required for the BA was still 124, but the BS requirement has dropped from 136 to 132. A minor in physics was defined.

Many new courses appeared in this catalog: The World of Physics, a one-credit-hour course designed to introduce freshmen physics majors to the subject of physics; PHYS 1023: Physics and Human Affairs (see part II, section F); PHYS 1044 and 1054: Physics for Architects I and II; and a short-lived course, PHYS 1061: Programmable Calculator Laboratory. For the BS physics major, the classical areas were well represented, including a new course on mathematical physics. New elective courses included 3000-level Energy and Society, and 4000-level courses Plasma Physics and Elementary Particle Physics. But Modern Physics I and II had been dropped, and no quantum mechanics were taught except for whatever was covered in the 3000-level University Physics III.

During the 1970s and early 1980s, a considerable emphasis was placed on the BA degree (see part II, section B). Therefore, a number of courses designed primarily or specifically for the BA were introduced. These included: Introduction to Electronics laboratory I and II, Electronics, Physical Mechanics, Modern Physics, and Atomic and Nuclear Physics Laboratory. The x-ray diffraction course had been dropped, but an optics course for teachers and a reactor physics course had been added. A timely course in energy and society had been introduced in the early 1970s.

The astronomy course listing had increased from one course in 1967 to three in 1969–70 and twelve courses in 1981–82. Selected astronomy courses could be used to help fulfill the requirements for a physics degree.

Seven courses were now listed for science teachers but could also be taken by BA students.

Under the Physical Science Department, three courses were listed, including one for elementary school teachers.

H. Physics in 1996 (1995–96 Catalog)

This catalog lists seventeen physics faculty members (including Donald Pederson, vice-chancellor for academic affairs, and Xiong, a temporary physics faculty member): Professors Chan, Gupta (chairman), Harter, Hobson, Lieber, Pederson, Richardson, Salamo, Sheng, and Singh; Associate Professors Gea-Banacloche, Lacy, and Vyas; and Assistant Professors Filipkowski, Oliver, Xiao, and Xiong.

The courses offered number approximately sixty, not counting the introductory laboratories, with about thirty courses being primarily undergraduate level (4000-level or below). Again, many of these courses were listed as on demand or alternate year courses.

Almost all of the courses designed specifically for the BA in the 1970s were no longer being offered and had now been listed as on demand. In addition, Energy and Society, Plasma Physics, Nuclear Physics, and Elementary Particle Physics were also listed as on demand. The former two had not been taught for years, and the latter two were only taught very infrequently. For some reason, the 4000-level Mathematical Physics course is also listed as on demand. On the other hand, a four-credit course on quantum mechanics and relativity called Modern Physics had been introduced.

The BS degree program required thirty-eight credit hours of physics, and the BA program required twenty-six semester hours. Each program required total of 132 and 124 hours respectively. Two additional college-wide requirements had been introduced: a writing requirement and an assessment of student learning. The latter requirement could be satisfied by writing a research paper. The former was generally satisfied by a senior thesis, an honors thesis, or a research paper.

Requirements for departmental honors were now clearly spelled out. The requirements included taking honors courses when available, six hours of honors research, and an honors thesis. The department had introduced honors sections of University Physics I and II and the laboratories associated with these courses.

Four courses were listed under the Physical Science Department. The general physical science course (called Survey of Chemistry and Physics) was now a one-semester, four-credit-hour course (including the laboratory). Also included in the physical science listing were courses titled Physical Science for Elementary Teachers and Higher Order Thinking in Science.

I. Physics in 2008 (2007-08 Catalog)

The catalog lists eighteen faculty members (including Pederson, vice-chancellor): Distinguished Professors Salamo and Xiao; Professors Bellaiche, Gea-Banacloche, Gupta, Harter, Lacy, Lieber, Pederson, Singh (chair), Thibado, and Vyas; Research Professor Vickers; Associate Professors Fu, Oliver, and Stewart; and Assistant Professors Chakhalian and Li.

The number of courses offered had not changed significantly over the last couple of decades. About sixty courses were offered. Several of the courses were offered on alternate years, and several were listed as irregular. Many courses are listed at both 4000- and 5000-level, and some 4000-level electives had a BS and BA version. The 4000- and 5000-level courses were taught together, but, in principle, less was expected of the students enrolled in the lower level courses. Similar thinking applied to BS and BA versions of the courses. Most of the old BA and other courses that were listed as on demand in the 1995–96 catalog had now been eliminated.

The BS degree now required forty hours of physics out of a total of 124 course hours. Students could pursue any one of the following five areas of concentration: professional (used by those who planned to enter graduate school in physics), optics, electronics, computational, and biophysics. For each concentration, a set of electives had been specified beyond the common core courses. The core courses, beyond the three-semester introductory physics sequence, were 3614: Electromagnetic Theory, 3614: Modern Physics (including special relativity, quantum theory, and statistical mechanics), and 4073: Introduction to Quantum Mechanics. The college's writing requirement and assessment of learning were still in force. Analytical Mechanics and Thermal Physics were only required for the Professional concentration, which did indeed have a comprehensive curriculum. But alas, there was not a single required laboratory course.

The BA degree required twenty-four hours in physics out of a total of 124 hours required by the college. This degree was recommended for

premed, journalism, business, and prelaw students and specified a set of requirements much less rigorous than those for a BS degree.

For both degrees (and each concentration of the BS degree) an eight semester plan for graduation was given.

J. 1908–2008 Summary of Courses and Curricula

The department started with just one faculty member and one assistant (1908–1909 catalog) and a listing of about ten courses. While the number of courses offered remained about the same, the faculty grew to three by 1928. Then number of courses offered increased to about fourteen by 1935, while the faculty size remained at three. By 1945, the number of courses listed exploded to about twenty-eight with faculty size still at just three (see chapter 3).

Growth in the faculty size came with the introduction of the PhD program in 1959. There were seven faculty members in 1960, offering thirty undergraduate and ten graduate courses. By 1982, the faculty grew to fourteen, and the total number of graduate and undergraduate courses grew to about sixty. From there on, the number of courses offered has remained steady, while the faculty grew to eighteen in 2008 to support the increasingly successful graduate program.

Approximately 149 students were enrolled in physics courses in 1908–09, 200 students in 1939–40, and 575 in 1947–48, according to the figures cited in History1. The total enrollment in all physics and astronomy courses[1] increased to about 3,100 in the 1993–94 academic year and to about 4,400 in the 2007–08 academic year (including summer sessions). The number of physics degrees awarded are discussed part II below.

Part II

Comments on Degree Programs and Courses

A. BS Degree

The department had a very successful BS program in the late 1940s, 1950s, and 1960s, as can be seen from the graduation rates shown in table 1. And it is not only these numbers that demonstrate success; the graduates were also being admitted to good graduate schools. For example, Robert Maurer (BS, 1948), one of our distinguished alumni (see chapter 15), went to MIT for graduate studies where he completed his PhD in three years. In a letter to Rajendra Gupta dated August 19, 2009, he said of our undergraduate program: "MIT was like being hit by a train but McKeehan and I had no more trouble with our preparation than most of the other PhD candidates. Of course, there were others entering with us that made the rest look mediocre. Murray Gell-Mann and the undergraduates from MIT (they only kept their best students) were examples that seemed to coast along."[1]

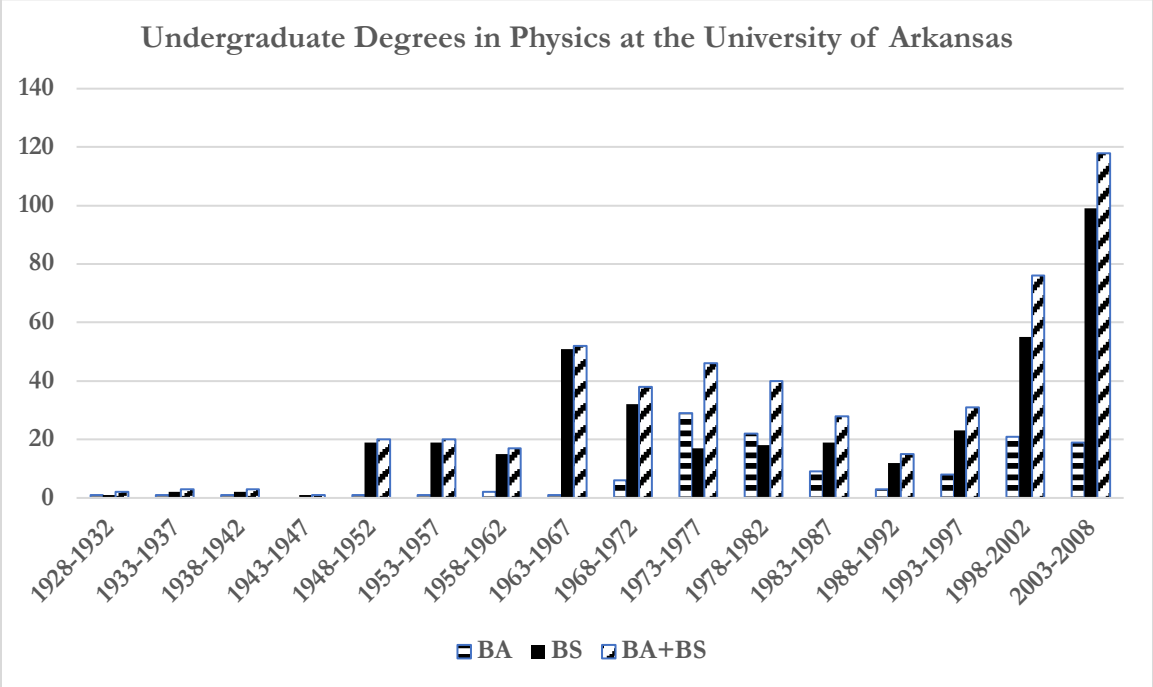
The BS program gradually failed to attract as many students as in the past in the 1970s, 1980s, and early 1990s, as shown in table 1. This may have been due to a combination of factors. First, after the initiation of the PhD program, the department's focus was divided between its

[1] Office of Institutional Research, University of Arkansas. Courtesy of Gary Gunderman.

[1] Gell-Mann and McKeehan were classmates of Maurer at MIT. Gell-Mann was the recipient of the 1969 Nobel Prize in physics for his work on the theory of elementary particles. McKeehan was Maurer's classmate at the University of Arkansas as well as at MIT.

Year	BA	BS	BA + BS	Nationwide BA + BS
1928–1932	1	1	2	
1933–1937	1	2	3	
1938–1942	1	2	3	
1943–1947	0	1	1	
1948–1952	1	19	20	
1953–1957	1	19	20	
1958–1962	2	15	17	
1963–1967	1	51	52	
1968–1972	6	32	38	14,216
1973–1977	29	17	46	10,977
1978–1982	22	18	40	10,820
1983–1987	9	19	28	11,417
1988–1992	3	12	15	11,783
1993–1997	8	23	31	10,129
1998–2002	21	55	76	9,154
2003–2008	19	99	118	13,033
Total	125	385	510	

Table 1. The first three columns show the physics BS and BA degrees awarded at the University of Arkansas over the century. The last column shows the total number of bachelor's degrees awarded nationwide at PhD granting institutions from 1968 onward. Data prior to 1965 is not available. ***From the American Institute of Physics Statistical Research Center, 2016, courtesy of Patrick Mulvey.***



graduate and undergraduate programs. With very limited human resources, the faculty did the best it could. Second, the decline seems to be mildly correlated with the national trend until the early 1990s, as shown in table 1. The problem was primarily related to the retention of majors. Even though we were getting a fair number of freshmen physics majors, we could not retain most of them through graduation.

However, there was a rejuvenation of our undergraduate program in the mid-1990s. There were two primary reasons for this. First, in 1994 the department hired a new faculty member, Gay Stewart, to focus exclusively on the undergraduate program and do research in the field of physics education. See chapter 10 on more about this appointment. Second, the university hired a new chancellor, John White, in 1997. He made it one of his top priorities to recruit very high-ability students nationwide by offering them lucrative scholarships. He raised private funds for the scholarships. Whenever there is a pool of high-ability students, there is a higher percentage of physics majors among them. There is also a much higher rate of retention among high-ability students.

In the following we describe Professor Gay Stewart's efforts to recruit and retain physics majors. An article on this effort by John Stewart, William Oliver III, and Gay Stewart was published in *American Journal of Physics* 81, 943 (2013). We enumerate below the major points made in that article.

1. Recruitment in the introductory physics courses and retention by effective advising and mentoring was a crucial first step. Most science and engineering students are required to take University Physics I and II in their freshmen or sophomore year, while some majors go so far as to require University Physics III. An effort was made by the instructors of these courses to reach out to those students who did particularly well in exams and ask them to consider adding physics as a second major or consider switching majors. This was followed up by advising and mentoring of these students by these instructors as well as by others. Faculty involved in advising were primarily Gay Stewart, William Oliver, Claud Lacy, Reeta Vyas, and later John Stewart.
2. A multitrack physics major gave students the flexibility to choose an area of concentration: professional, optics, electronics, computational, or biophysics (see part I, section I). Only about a quarter of our majors went to graduate school in physics, while another quarter attended graduate school in other disciplines or pursued high school teaching, medical school, and other professional programs. The flexibility of a multitrack major helped students to tailor the program to their interests and career goals.
3. University Physics I and II, each student's first introduction to college-level physics, were taught using an inquiry-driven format (see section E).
4. Students were encouraged to participate in ongoing research and write an undergraduate thesis.
5. There was an increased awareness of good teaching among faculty, and teaching assistants were trained in good teaching practices.
6. There was an active chapter of the Society of Physics Students (SPS), and a room was made available to them. In this room, designated the SPS lounge, students could gather and do homework in groups, collaborate, and build stronger sense of community.
7. Students were encouraged to involve

themselves in outreach activities, such as high school physics day.

These efforts paid off, as seen in the graduation rates in table 1.

B. BA Degree and Expansion in the 1970s

An expanded BA degree program in physics was initiated in the 1970s. The number of BA degrees granted in physics soared in that decade, and the number of BA degrees granted in physics actually exceeded the number of BS degrees, as shown in table 1. This sudden increase in the number of degrees granted in the BA program in the 1970s was no accident, but the result of a well-planned and orchestrated strategy.

This exciting and productive program resulted primarily from the innovative work of Professors Anderson and Clayton. It was designed to prepare students to enter professional fields that required a strong science basis and a strong background in general education, rather than graduate studies in physics.

Both the BS and BA degree programs had coexisted from the very beginning of the university. While the details varied throughout the years, the BS program always had a strong emphasis on science and mathematics, while the BA program permitted a broader range of studies in other fields. For a time in the very early days, the BS program and the BA program actually required the same number of courses in physics, but the BS program emphasized German and other European languages needed for advanced work in the sciences. By 1928, the BS degree required a greater total number of science courses and included two science minors.

By 1970, the BS was definitely "recommended for those interested in graduate work in physics or professional employment," while the BA was for "the student who wants to take a broader program of study in the arts and social sciences while majoring in physics" (1969–70 Catalog). The two programs still drew on the same list of courses with only the total number of physics and mathematics courses and general education courses differing. The BS required a greater number of courses in both physics and mathematics: thirty-six hours of physics (total 136) to the BA's thirty (total 124).

The number of hours and especially the details of the course selections required for the BA degree in physics were modified drastically during the 1970s, as signs of change were evident. The department was diligently trying to find new areas of service to bolster its enrollment figures. An ill-fated attempt was made in the early 1970s to develop a program to train physics majors for industry using the BA program, for example.

A memo prepared by Professor Michael Lieber in 1993 describes the effort to use the BA program to prepare students for industry and the far more successful plan to emphasize the BA degree for students heading into varied professions, especially medicine:

> The situation changed in the early '70s. At first the department thought it might develop the BA into a distinct applied physics degree, somewhat along the lines of the program at Yale. To this end an industrial physicist from Gulf-General Atomics Corporation, Dr. Alan Larson, was hired to assist the department to develop the industrial connection. However, we quickly learned that industries preferred a general, conventional physics background based on the hard core BS program. The Applied Physics program died, and Dr. Larson moved on to Georgia Tech in Atlanta, Georgia.
>
> However, in 1971, Prof. Richard J. Anderson and the Undergraduate Affairs Committee he headed refashioned the BA program, creating three new courses with an applied and lab-oriented flavor: Physical Mechanics (mechanics with an acoustics component), Fields and Waves (practical electromagnetism) and a course in

> Modern Physics (with laboratory). The new program was based on the non-calculus introductory course, had fewer mathematical requirements, and fewer and less mathematical upper level physics courses (a total of 24 semester hours of physics as compared with the 36 for the BS), but required the student to do 9 hours of approved junior-level work in a "secondary emphasis" area, such as agriculture, chemistry, zoology or even physics (for those who started out on the BA path and later decided to go to graduate school in physics).
>
> Stimulated by "seed money" in the form of six $400/year scholarships, the new BA program proved quite successful for a while — at one point there were over 40 BA majors, about the same as the number of BS. The number of BA degrees granted in physics during the period 1973 to 1982 slightly exceeded the number of BS degrees granted during that same period (table 1).[1]
>
> The largest BA group proved to be the premeds. They found that having physics as a major, rather than the far more common biology or chemistry major, made them stand out. For a while we had a 100 percent acceptance rate into medical school!
>
> Gradually, the number of students in both programs began to fade, but the BA faded more rapidly.

The following informative memo was prepared in 1994 by Professor Anderson, the principal proponent of the very successful BA program developed at Arkansas to educate physics students for varied professions. This report from Anderson is from a paper he and Clayton published in February 1972, in the *Arkansas Alumnus* entitled "Something 'New' for Science Students." Amazingly enough, much of this "new" idea they developed then was proposed anew in 1993 in an invited editorial in the *American Physical Society Forum on Education*.[2] But that is exactly what our Physics Department was doing in a big way in the 1970s.

Let us hear from Anderson and Clayton and the *Arkansas Alumnus* article of February 1972 (edited for brevity).

> To obtain this degree with a major in physics, the student is required to satisfactorily complete twenty-four credit hours of physics, sixteen credit hours of mathematics, and nine credit hours of advanced level courses in what is termed a "special emphasis study area." This total of forty-nine credit hours still allows the prospective BA candidate a minimum of thirty-three hours to pursue studies in still other fields of interest, satisfy the entrance requirements of professional schools, or obtain a secondary school teaching certificate. [. . .]
>
> Some of the special emphasis areas are agriculture, anthropology, astronomy, audiology, biological sciences, business, chemistry, communications, computer mathematics, electronics, entomology, environmental sciences, geography, geology, management science, mathematics, physics, psychology, sociology, and teacher preparation.
>
> The new physics BA program is indeed a "student centered" program. The student is given the widest possible choice of career options and encouraged to use his elective hours to take additional courses (in addition to the nine hours required) in the emphasis area which is most appealing to him. The student is continually encouraged by the Department's faculty to enter a career in which he can be both happy and productive.

[1] This sentence has been corrected by Gupta, with Lieber's permission, since we now have more complete data.
[2] *American Journal of Physics* 62, no. 5 (May 1994): 395.

The BA majors fell off precipitously in the 1980s and 1990s, as shown in table 1, but members of the Physics Department felt that the BA program might have continued with reasonable success if someone had been willing to continue as its active proponent. The development and continuation of this program had required considerable time on the part of Anderson and other members of the department, even over and above merely teaching the special courses, and the demand to develop a more recognized graduate program placed great stress on the always only marginally staffed department. Successful education programs always seem to be "very labor intensive," to use a relatively popular term these days, and pressures on the faculty for success in their own research seem to compete with these ideas far too often.

However, there was a rejuvenation of the BA program in the late 1990s, as seen in table 1. With a renewed emphasis on the BS program in the 1990s, as described in section A above, physics majors in the BA program increased as well. Some students felt that a degree with fewer physics and math courses than the BS was more suitable for them. The BA degree was targeted at students with interest in medicine, law, business, or journalism.

C. Honors Program

In this section, we describe the history of the formation and evolution of an Honors Program in the College of Arts and Sciences. However, from very early on, even before a formal honors program was initiated, a university-wide mechanism existed for students to get an honors degree based purely on their achievement of a certain number of A grades in courses.

Starting with the graduating class of 1935, the College of Arts and Sciences implemented the following criterion for obtaining an honors degree in the College: "A system of honors based upon wide reading in the major subject and upon general reading followed by a general examination went into effect with the graduating class of 1935. Those candidates who pass the examination credibly are graduated *with honors*. Those who pass with distinction will be graduated *with high honors*." The above is quoted from the 1934–35 university catalog.

A formal honors program started with the appointment of a committee in 1954. Professor Harold D. Hantz, emeritus professor of philosophy and the coordinator of the honors program from 1958 to 1974, provided the following history of the honors program, 1954–1974, to Sharrah in 1993. An abbreviated version of that history is presented below:

> Honors Programs have been a part of American higher education for more than a century; however, the development of such programs in public institutions was slow. After World War II the rapid increase in enrollment was concentrated in public colleges and universities. These institutions struggled to educate the flood of students of widely differing abilities. Perhaps correctly they first provided remedial courses for the inadequately prepared, but before long it became clear that the talented were the forgotten student.
>
> The University of Arkansas was no exception. Accordingly, in the fall of 1954 Dr. G. D. Nichols, Dean of the College of Arts and Sciences, appointed a committee to determine what might be done for superior students. After five months of study the committee recommended an honors program with the general objectives of providing superior students with "opportunities for additional and independent study, to broaden and deepen both their own fields and their general educational backgrounds."
>
> The administration of the program was placed in an Honors Council, whose first duties

> consisted in the implementation of the junior-senior departmental independent study and research program. New developments were quick to follow. [. . .]
>
> As the program grew, a half-time Coordinator was appointed in 1958. In 1969, at the request of the Honors Council, the faculty added three student positions to the council.

The Junior-Senior Independent Study and Research Program "was originally, and remained the foundation of the Honors Program."

Hantz goes on to say,

> Another device to deal with standards within and among departments was outside examiners. Each candidate had an honors committee consisting of an adviser and a second member of the department as well as two outside examiners, a member from a related department and a member of the Honors Council.
>
> The committee structure worked well. Honors Council members became acquainted with a variety of programs and developed a sense of standards concerning several departments.
>
> It is noteworthy that the natural sciences provided the largest number of awards and the highest percentage. The program always had strong support from the natural sciences — something that could not be said in every program over the country.
>
> More specifically what did the graduates do? It is impossible to review the work of 299 students, but a few examples are worth noting. There was the student in botany who began his research as a junior and had seven papers published or in press by the time he was graduated. There were honors papers published in the *Journal of Inorganic and Nuclear Chemistry*, the *Physical Review*, and the *Review of Scientific Instruments*.
>
> From 1960 to 1973, 474 students earned 2,982 hours of college credit with a combined grade point of 3.04, which is decidedly above the average of regular students.
>
> A study of the years 1962–1965 showed that of the 198 full-time faculty of the College, 55 percent had served as instructors of honors sections, advisers for independent study and research, instructors of colloquia, members of the Honors Council, or members of the honors committees evaluating students.
>
> Not only were many faculty and students committed to the program but so were Dean Nichols, Dean Kruh, and Dean Anderson, who provided every possible support, often in budgetary depressed periods. It is very easy for a Dean to say, "Why teach 15 students in Honors Western Civilization when they can be absorbed in the other regular sections?" But they did not. They were consistently generous in supporting small sections and the other aspects of the program.

Richard Anderson, former professor of physics and honors director, 1982–89, provided the following history to Sharrah in January 1993:

> Since its inception in 1955, the physics faculty has been strong supporters of Honors Studies within the College of Arts and Sciences. They have acted as honors research advisors, served on honors examination committees, taught honors classes, or served on the College Honors Advisory Council. Throughout the years students also have played an important role in the development of the program. Over the period 1957 through spring commencement 1993 over sixty students have received their baccalaureate degrees in physics "with honors." The awarding of physics department honors was based primarily upon of the completion of an honors thesis and its defense in an oral examination administered by a faculty committee. Some students enrolled in special sections of regular classes that were designated honors classes (e.g., Western Civilization, English, etc.). During the 1960s the

physics department also offered a special honors section of the introductory calculus-based physics course. The enrollment pressures plus budget constraints forced termination of the honors section until once again in the 1980s Dean Anderson revived the practice.

Honors students in physics were recognized on campus as being well trained in their discipline and creative in their honors research projects. For most students the honors research project involved working with faculty and their graduate students on an ongoing research project. It was not unusual for honors students to receive recognition of their work by being named as a coauthor of a physics journal publication or meeting presentation. Some students, however, embarked upon special honors projects of their own design. For example, Jonathan Siegel designed an honors optics experiment dealing with the photo sensitivity of the eye and its capability to detect a "single" photon. Upon graduation Jon went on to receive a medical degree and served for a time on the faculty of Northwestern University. Students who were most successful in pursuing their honors research and who demonstrated outstanding achievement received their degrees with "high honors." Throughout the period 1960–75 the Physics Department was a leader within the College in the production of honors degrees.

With the rejuvenation of our BS and BA program in the late 1990s as discussed above, there was a corresponding increase in the number of physics majors receiving honors degrees. Meanwhile, in 2002 a $300 million commitment from the Walton Family Charitable Support Foundation enabled the university to establish the Honors College. During the five-year period of 2003–2007, thirty-three of our majors received an honors degree — one-third of all physics graduates during this period.[3] In addition, many received prestigious national honors such as Barry Goldwater Scholarships and National Science Foundation Graduate Research Fellowships.

D. Modern Physics

As we have seen in chapter 1, the course offerings in 1907 were all classical physics. In this section, we describe the evolution of courses on modern physics at the University of Arkansas. We suspect that the course listings for the physics major were similar to the listings in most colleges and universities during that period. Some parts of what may be considered modern physics were being taught in the late 1920s in courses titled x-rays and Electron Theory taught by Professor Parsons. The basic principles of quantum mechanics were only being developed in the 1920s, and it would take a little time to get quantum mechanics incorporated into the training of physics students.

Several good books did cover the broad field of atomic physics or modern physics. One of the first major textbooks on modern physics in English was written by F. K. Richtmeyer of Cornell University and published in 1928. The masterfully written textbook *Atomic Structure and Spectral Lines* by Arnold Sommerfeld was first published in German in 1919 and was in its fifth edition by 1931. A pedagogically useful *Atomic Physics* book was put together by members of the University of Pittsburg staff in 1933. This text was taught by L. B. Ham in the 1930s and later in the 1940s by Paul Sharrah. By that time, all of the physics majors and most of the chemistry majors were taking this one-semester course.

But the training of persons truly qualified to teach a bona fide course in quantum mechanics developed slowly. The first text in quantum mechanics was written by Condon and Morse in

[3] Data provided by Stephen Ritterbush, Honors College, 2016.

1928, but many graduate schools in the 1930s and even the early 1940s had faculties trained only in classical physics. Thus most of those obtaining graduate degrees in physics in the 1930s and 1940s would have been exposed to only one semester of quantum theory and possibly a course in atomic physics and a course in nuclear physics. Solid-state physics was also being introduced into the graduate schools by the 1940s.

Some elements of quantum theory were being taught at the University of Arkansas in the 1930s and 1940s as part of courses in atomic and nuclear physics. A two-semester course in atomic physics for senior and first-year graduate students was introduced at the University of Arkansas in 1960 using the excellent text by Robert B. Leighton. Professor Zinke was the first to teach this two-semester sequence and the enrollment was close to fifteen students.

The senior and first year graduate course mentioned above was in addition to a one semester atomic physics course taught at the junior level since the early 1930s. The first textbook used in this course was the aforementioned book of the same name published by the University of Pittsburg Staff. During the 1960s, a book written by Henry Semat also served this course very well.

A sophomore-junior level course in modern physics for engineering students was introduced at the request of the College of Engineering in the early 1960s. Engineering dean George Branigan had just returned from a conference in which the point was strongly made that engineering students must be exposed to modern physics in some form or other. He worked closely with the Physics Department on the details of initiating this course. At first the course was completely devoted to nuclear physics and reactor theory (textbook by Irving Kaplan), but soon it was changed to cover the broad field of modern physics, including some material on solid-state physics. A course with this general description was being taught as University Physics III into the 1990s with a laboratory component available. In 2007–08, a similar course was being taught as a four-credit, 3000-level course with the title Modern Physics, whereas the University Physics III course title was used for a different course (see section E).

A senior level (4000-level) two-semester course on Advanced Modern Physics (four credits each semester) was introduced in the 1960s. This course was a survey course on atomic, molecular, nuclear, and solid-state physics and covered quantum theory in the first semester. It was also taken by graduate students who entered our graduate program without having had a course in quantum theory in their undergraduate program. So many graduate students were taking this course that it was upgraded to 5000-level in 1977 but remained open to undergraduates. In 1998, this course was discontinued, and a stand-alone senior-level (4000-level) course in quantum theory was introduced.

Even though we are concerned with only the undergraduate courses in this chapter, we should mention that the first true course on quantum theory that was introduced at the University of Arkansas was at the graduate level (6000-level), and it was in 1948 or 1949. Professor Schwartz was the teacher. This was expanded to a two-semester course in 1954. A course in advanced quantum theory was introduced in the early 1970s and it was initially taught by Professor Michael Lieber.

E. Introductory Courses

We start this section in 1928, when the first physics degree was awarded. The 1928 and 1934 catalogs listed a general introductory physics course for students who had studied physics in high school and a similar course for those who had not taken such a course. No descriptions of

these courses are given, but these two-semester courses were to be taken by physics, engineering, and premedical students. One of the catalogs of this period lists the textbook as that by Millikan and Gale.

By 1942, two introductory courses were still being taught but with a major change in structure and purpose. An eight-hour college physics course, including laboratory, was taken by science and premedical students. It was taken normally during the sophomore year. This noncalculus (trigonometry based) course was taught with the title College Physics.

The second course being taught in 1942 was a ten-credit-hour course called Engineering Physics. It had a unique structure. The engineering students took a two-credit-hour course without laboratory entirely devoted to introductory mechanics in the spring of the freshman year. Then during the sophomore year an eight-credit-hour engineering physics course was taken again principally by the engineering students with a few science majors. This two-semester sequence included a one-credit-hour laboratory course each semester.

This unique, three-semester, ten-credit-hour course for the engineering students was very successful and was the pride of both the Physics Department and the College of Engineering. The department was complimented more than once for the progress the engineering students made in this three-semester offering. But course scheduling and staff shortage pressures had reduced the engineering physics course to a fairly standard eight-credit-hour course by the 1950s. This calculus based course, renamed University Physics, was taught until the 1997–98 academic year as a two-semester sequence. In the 1998–99 academic year, a third semester with laboratory was added (UP III). The third semester covers waves, physical optics, thermodynamics, kinetic theory, and elementary quantum mechanics. University Physics I and II courses, which cover mechanics, and electricity and magnetism, respectively, were restructured in the 1990s by Professor Gay Stewart. To describe this restructuring we quote from an article by John Stewart, William Oliver III, and Gay Stewart, *American Journal of Physics* 81, 943 (2013): The material is "presented using two 50-min lectures each week, and two two-hour laboratories. The additional time invested in the laboratory experience allows diverse learning experiences to be presented including hands-on inquiry-based activities. Small-group solving, TA-led problem solving, interactive demonstrations, and traditional experiments. Lecture in both courses uses a lecture quiz to manage attendance and provide feedback to the instructor." This is a deviation from the standard three fifty-minute lectures and one two-hour lab per week. Activity guides were developed for both semesters.

In the 1970s, Greg Salamo developed a new two-semester course titled Physics for Architects, specifically suited for architecture students. It also included a laboratory component. The course has been very successful and is still being taught.

F. General Courses for Liberal Arts Students and Nonscience Majors

As the elementary physics courses became more mathematical and contained material more relevant to science and engineering majors, fewer and fewer students took physics as a part of an overall general education program. One of the first attempts to correct this trend was the introduction of survey courses. A survey course in physics was taught from 1946 to 1958, when it was removed in favor of the two-semester physical science course with laboratory.

A one-semester course entitled Physics in the Home was required of the majors in home economics and was taught from 1945 until 1958.

A short course in physics and meteorology was taught by Drs. Ham and Sharrah for two years

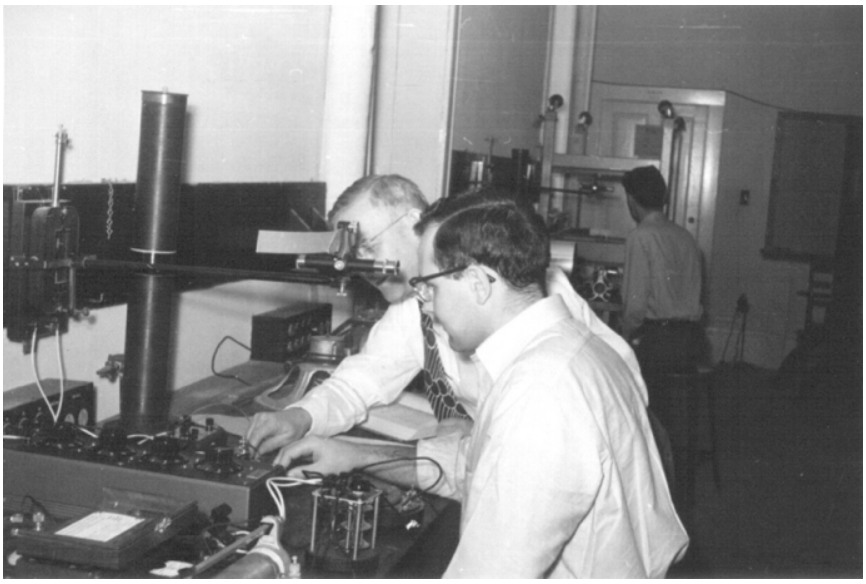


Figure 1: Professor Ham working with a student in a lab in Old Main, circa 1950. Note the wall-mounted galvanometer, a ubiquitous electrical measurement instrument of that era. *Photo archived in the Physics*

just prior to WWII as a part of the Civilian Pilot Training Program. A physics syllabus was prepared for the program.

If you like beautiful memories about good days in teaching, you will want to hear about the thrust put forth in the College of Arts and Sciences in the early 1950s. Under the leadership of Dean Guerdon D. Nichols, the college went above and beyond in its push for general education. They secured a Ford Foundation grant in 1951, and while the grant's primary goal of totally revolutionizing teacher education was not accomplished [Ref. 3, pages 190–195], the general education and honors programs born during this travail would thrive.

Broadly based general education courses at the introductory level were developed in several areas. A physical science course with laboratory was initiated in 1951. Dean Guerdon Nichols offered to send Sharrah to Harvard for a year to study and observe the course being taught there by Professor James Conant. Why didn't he go? He thought the university needed him!

Three separate courses were tried out on an experimental basis. One was taught by more than one teacher, each teaching material close to his discipline. This was probably the best idea, but the time required exceeded the teaching credit one could receive, and this along with the added administrative work caused it to disappear.

Professors William Noyce of chemistry, B. H. Gundlach of mathematics, Paul Sharrah of physics, Kern Jackson of geology, and Z. V. Harvalik of physics and the Institute of Science and Technology all contributed much to the early development of the physical science courses. Later, Professors Otto Zinke and Art Hobson taught many of the large physical science sections and continued to develop the course during the 1960s and 1970s. In relatively more recent times these and similar courses have profited from the work of Drs. Lothar Schäfer and George Blyholder of chemistry.

For several years, the physical science course was a two-semester six-credit-hour course, later changed to a one-semester course for four credit hours taught by the Chemistry Department.

The Physics Department took over astronomy instruction in 1967, and the courses were scheduled at night. Enrollment rose to over one hundred students. Then, when the introductory course was expanded to include laboratory in 1972, astronomy was also used by several colleges to satisfy the general requirement in physical science. This introductory course is still a very popular general education course.

A very successful physical science course for elementary teachers was developed by Dr. Glen T. Clayton of the Department of Physics around 1971.

Somewhat in a different vein and for a different purpose, a broadly based intermediate-level physics course called Energy and Society was developed by Professor Zinke in the early 1970s. This was during the "energy crunch," and the course was used primarily by the geology department. Zinke and Sharrah taught this course for two or three years.

An interdepartmental course in geophysics was offered for a few years, principally in the early 1950s. This course was taught by Lloyd Ham from physics and Kern Jackson from geology.

An interesting but somewhat lonely effort has been the development of a course entitled Physics and Human Affairs. This course, developed entirely by Art Hobson, is a one-semester course with laboratory and satisfies the general education requirements in arts and sciences, business administration, and education. At first the laboratory was essentially the same as that developed for the general physical science course, but it has been gradually modified to meet the goals of the new course better.

This course is described by Art Hobson and Tamara Snyder in 2016:

> Physics and Human Affairs (PHA) is a physics literacy course for non-science students. The goal was to develop a new kind of liberal-arts physics course that would not be simply a watered-down version of the traditional "straight physics" courses but would instead be directed more toward the social and humanistic interests of students in the arts and sciences, education, and business. It originated in about 1977 when Art Hobson began teaching such a course from his own notes and managed to have it included in the list of courses that help satisfy the science requirement for non-science students. PHA's unusual features include societal topics such as energy and environment, and a heavy emphasis, occupying 50 percent of the course, to modern topics such as quantum physics, relativity, and high-energy physics.
>
> From an initial enrollment of ten, PHA quickly jumped to some 220 students every semester. Hobson's notes soon evolved into a textbook, published under the title *Physics and Human Affairs* by John Wiley & Co. in 1982. Because PHA continued to be successful, with a waiting list of students desiring to sign up, the department expanded it to a maximum of 330 students (two sections of 165 each, usually taught by Hobson) per semester plus two summer sections at 50 to 100 students each (taught by others). In 1995, Hobson wrote a new textbook published by Prentice Hall under the title *Physics: Concepts and Connections* and currently in its fifth edition.
>
> The course has continued to prosper following Hobson's retirement from teaching in 1999. The course was taught by Tamara Snyder and occasionally by others after Hobson's retirement. The course has further expanded to 400 students in two regular sections of 200 each, every semester. Since 2005 there is also an honors section every spring.

G. Laboratories

Laboratories have been an integral part of introductory physics courses. We will return to



Figure 2: Professor Stearns (right) explaining operation of scintillation counter in atomic-nuclear laboratory. From a recruiting brochure, circa late 1950s.

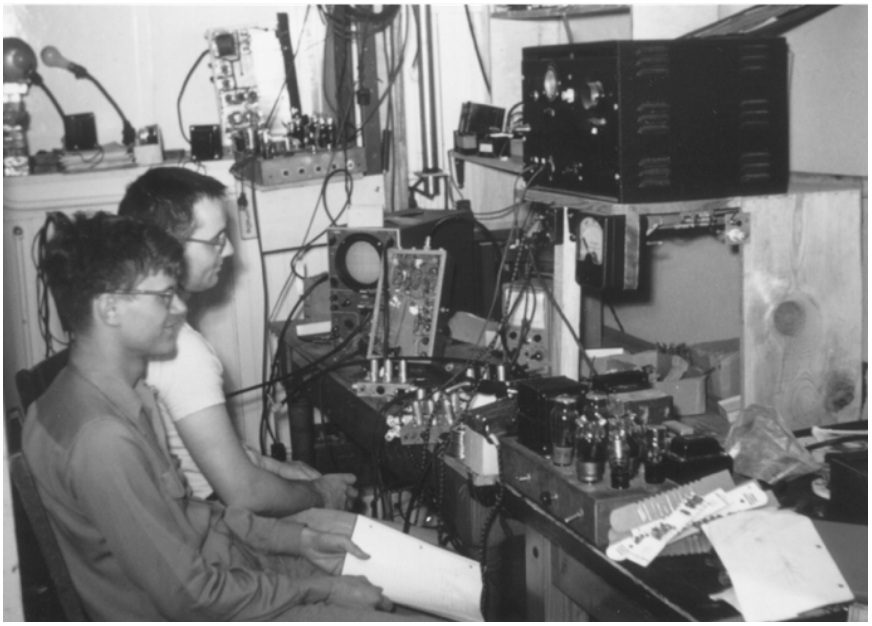


Figure 3: Students C. Cameron Allen, Jr. and Albert D. Sanders in atomic physics and electronics laboratory in Old Main, circa 1951.

them later in this section, but first we discuss other laboratory courses, both those that were part of lecture courses as well as those which were stand-alone courses.

Going back to the 1920s, we find that early in the department's history, laboratory was emphasized much more than it is today. In additional to there being laboratory components to the introductory physics courses, as usual, intermediate- and advanced-level laboratory exercises were also introduced in heat, light, sound and electrical measurements. A photography course was often included in the Physics Department offerings. As in many schools, the electrical measurements course was required of the electrical engineering students. Limiting ourselves to the "snapshot" years of part I of this chapter, the Electrical Measurements course listed in the 1927–28 catalog consisted of one hour of lecture per week and six hours of lab per week. The 1934–35 catalog lists a course on x-rays with a lab component. In addition, there are courses titled Laboratory Physics and Advanced Laboratory Physics. In addition to the above courses, the 1943–44 catalog lists a stand-alone course on x-rays (400-level), and courses on electroacoustics (vacuum tube amplifiers, microphones, noise, etc.; 300-level), photography (400-level), electronics and radio (500-level), and electronics (500-level).

In the 1940s, a novel but effective advanced undergraduate laboratory course was offered at Arkansas under the title Industrial Physics. This was a variable-credit course that could be taken for a total of four semesters and for a maximum of six credit hours. During the 1940s, this course provided good training for a number of physics majors and was frequently elected by the engineering students and students majoring in other sciences. A laboratory course in x-rays introduced in the early 1940s rounded out the early advanced laboratory offerings at Arkansas up until about 1970.

An electronics course has been offered in physics for some time, as mentioned above. Initially, of course, the course emphasized vacuum tube circuitry, but revolutionary changes took place because of developments in semiconductors and the invention of the transistor. In 1977, Donald Pederson, with the help of an NSF grant, developed a self-paced course in electronics. The course used Heath Company's self-paced modules from DC electronics to microprocessors. The grant also assisted in the first use of KIM and PET microcomputers in the department (see appendix V). This course is still being taught, but its contents have been completely overhauled.

A more recent version of the optics lab was

started by Raymond Hughes.[4] It was part of a three-credit-hour 3000-level optics course taken by most BA and BS students. In the 1978–1979 academic year, it was assigned to Gupta, who made a few changes and upgrades to it. The course was also upgraded to a four-credit-hour course. Sometime in the mid-1980s, Surendra Singh started teaching this course while completely overhauling the laboratory and introducing experiments on more modern topics. He was aided in this effort by a National Science Foundation Instruction and Lab Improvement grant in 1991. More recently, Reeta Vyas has started teaching this laboratory as well.

A senior/first-year graduate level (4000-level) laboratory course on modern physics had been taught since the 1960s. As far as we can determine, it was developed by Professor Charles Richardson, perhaps using some of the equipment left over from the Modern Physics Institutes that Sharrah and Clayton were directing in the 1960s (discussed in chapter 13, section VI). It was taught by Richardson until his retirement in 1997, except for a brief period from 1972 to 1975 when it was taught by Professor Donald Pederson. The students conducted experiments such as Franck-Hertz, x-ray diffraction, electron diffraction, Faraday effect and atomic spectroscopy. For a considerable period of time it was a required course for all first-year graduate students. Richardson was able to set up this lab when funds for this purpose were not readily available. He introduced a few experiments using surplus equipment from Professor Hughes's and his own research labs. He also used some homebuilt equipment. In 1998, Professor Gupta started teaching this lab, and it is still being taught. Around 1990, the university started charging students Teaching Equipment and Laboratory Enhancement (TELE) fee (see chapter 12). Thus, the department started receiving funds to upgrade and maintain the laboratories. Supported by these funds, Gupta was able to make major upgrades to the equipment. Gupta developed a new three-credit-hour graduate-level (5000-level) course titled Experiment and Data Analysis. This course is required of all graduate students but may be taken by undergraduates as well. He

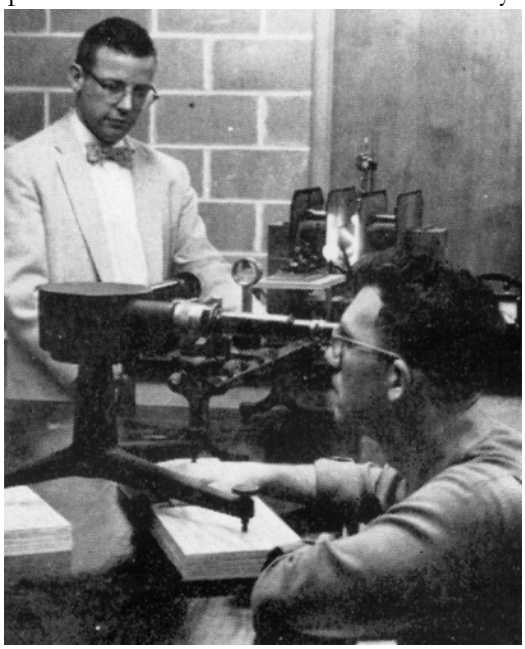


Figure 4: Professor Hughes (standing) and a student conducting an experiment on Zeeman effect in the optics laboratory. From a recruiting brochure, circa late 1950s.

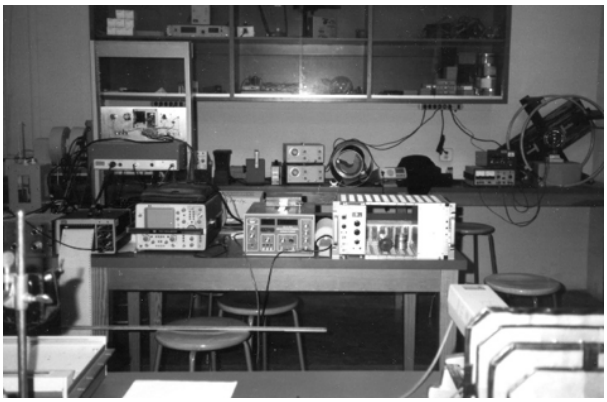


Figure 5: Modern Physics lab when it was being taught by Professor Richardson, circa 1980.

[4] The laboratory was part of a course in optics, and was not mentioned separately in the catalogs until 1975–76.

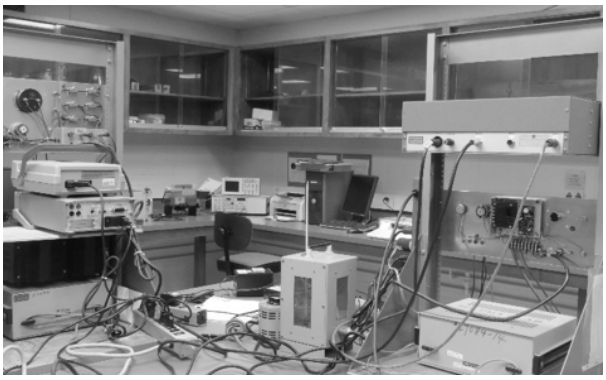


Figure 6: Some of the equipment used for Modern Physics Laboratory and Experiment and Data Analysis courses. *Photo by Rajendra Gupta, 2019.*

introduced several new experiments, such as optical pumping, pulsed nuclear magnetic resonance, and molecular fluorescence spectroscopy. The course shares the room as well as some equipment with the 4000-level Modern Physics Lab described above, except that the experiments conducted in the 5000-level course are more advanced.

Around 1980, Professor Greg Salamo set up a new variable-credit laboratory on laser physics. It is listed for the first time in the 1982–83 catalog as a variable credit, 5000-level course. It is primarily taken by graduate students, but it is also taken by some undergraduates and is therefore included in this chapter. Around 1991, Surendra Singh started teaching this lab and has made major upgrades to it. It is currently being taught by both Professors Singh and Vyas.

Now, returning to the introductory physics laboratories — all introductory physics courses have always had a laboratory component. One significant change in the operation of the elementary laboratories took place in the 1970s. The book *Laboratory Experiments in Physics,* by Schneider and Ham and published by the Macmillan Publishing Company in the 1930s, had been used for over three decades. While it had undergone several revisions, some of the material was becoming dated and it was decided to produce an in-house laboratory manual. Richard Anderson developed the first version, and he and the department decided to use whatever income accrued to fund freshman scholarships in physics. This proved to be very successful, and each year as many as ten freshman scholarships were granted. Urbano Oseguera produced a completely new version of the in-house physics laboratory manual in 1990. Further changes and improvements to these labs were made by William Oliver in the mid-1990s. Charles Richardson made significant modifications to the College Physics and University Physics laboratories and wrote lab manuals that were published by McGraw-Hill: *Physics Laboratory Manual (Electricity, Magnetism* and *Optics and Modern Physics).*

The next significant changes to the University Physics I and II (UP I and UP II) and College Physics I and II (CP I and CPII) Laboratories are described by Stephen Skinner, Laboratory Curator, as follows:

> In Fall of 1997 student computers were introduced in the University Physics I laboratory. The computers used a software program developed by PASCO Scientific along with priority interfaces and sensors to collect real-time data to capture motion and applied force. With the introduction of student computers, physics faculty with the assistance of the laboratory curator began to develop new labs and make significant edits to the current laboratory materials.
>
> Student computers were introduced in the UPII and CP laboratories in 2003 when the physics labs moved into new renovated space in the 1st floor of the Science and Engineering Building.
>
> In 2007 the University Physics I course was still holding traditional fifty-minute lectures three times a week while requiring students to meet twice each week for a total of four hours of

laboratory experience. The major difference for University Physics II was lecture only met twice weekly and the Friday lecture time was provided as additional office hours held by the course faculty in the laboratory. The educational purpose behind the UPI and UPII course and laboratory structure was to introduce students to the physical concepts and materials in lecture and then encourage application in a laboratory setting allowing students to discuss and learn together. UPI and UPII Students completed a series of 26 laboratory activities. The activities included traditional labs, inquiry based activities and guided problem solving sessions to prepare students for examinations. Students recorded observations, made conclusions and created graphs directly on the lab manual. Teaching assistants scored students based on participation and completion of assignments. The traditional post laboratory experience of writing a lab report was reduced to only two activities. Both UPI and UPII included honors section for both the lecture and laboratories. Students in the honors sections choose to either write a research paper or build a project connected to the course content. Each student is required to give a ten-minute presentation to their peers during the last weeks of labs.

In 2007 the College Physics I & II laboratories were still taught as a one-hour course required to be taken in the same semester as the lecture course. Students met once weekly for a two-hour lab and completed traditional lab experiments. The CP lab manual was an edited version of the University Physics I and II laboratory.

Gregory Salamo developed a laboratory for the new course Physics for Architects (see section E) in the late 1970s and also prepared a laboratory instruction manual for it.

The laboratory component of the course Physics and Human Affairs has already been described in above.

Astronomy laboratory and instructional materials have been prepared by Charles Richardson, Carol Webb, and Claud Lacy, as mentioned in chapter 8 on astronomy.

Professors William Oliver and Surendra Singh developed a new University Physics III laboratory and activities manual as well as the accompanying write-ups in 1997.

H. Society of Physics Students (SPS) and Sigma Pi Sigma.

As described in chapter 3, the local chapter of Sigma Pi Sigma, the national physics honor society, was installed on the campus in 1948. The Society of Physics Students (SPS), a national organization of physics students which any student with interest in physics could join, did not exist until two decades later. The national SPS organization was started in 1968 and a local chapter of SPS was installed on the campus the same year [Ref. 7, page 157].



Figure 8: An introductory physics laboratory, circa 1950s. Photo from a recruiting brochure.

7.

Graduate Degree Programs

A. Early Master's Degrees

The university offered a master's degree as early as 1887 [Ref. 2, 203], well before there were even advanced undergraduate courses. These degrees, apparently, were not very subject specific and consisted of directed study on the part of the candidate. As a matter of fact, William Waggener, the first graduate of the university in 1876, who became the founder of the Physics Department at the University of Colorado, returned to the university and received a master's degree in 1885.[1] This degree predates 1887, and it is perhaps for this reason that the university catalog lists his degree as honorary. Hale [Ref. 1, 186] describes the early master's program as follows:

> Graduate degrees were first offered by the University in 1887, but a Graduate School was not established for forty years. Early candidates were required to "take at the University, for a full scholastic year, four daily studies appointed by the faculty" before receiving a master's degree. The general supervision of the candidates was under the professors in a subject, or subjects studied. Later a thesis was required. A committee on graduate studies first appeared in the catalog for 1913–14.

To give definitiveness and recognition to advanced work, a graduate school was organized in 1927. John Clark Jordon was made dean. He was still the dean when the first master's degree in physics was awarded in 1939.

B. Master's Degrees in Physics

According to the graduation records of the university,[2] the first master's degree in physics was awarded to Halvor T. Darracott in 1939. He did his research under Professor Ham.[3] At that time, no subject-specific requirements were listed in the catalog. The graduate school had one set of uniform requirements that applied to students of all subjects. The following information about the program in effect at that time is derived from the catalog of 1938–39 and the announcement for 1939–40: an MS degree was awarded only in agriculture, business administration, education, engineering, or home economics. "For work done in other subjects the degree of Master of Arts is conferred. Students majoring in natural sciences may, however, at their option, receive the degree of Master of Science." Degree requirements for both MA and MS degrees were the same.

The requirements consisted of twenty-four semester hours with a thesis, or at the discretion of the head of the department, thirty semester hours with no thesis. The 1938–39 catalog states: "The student's choice of his major subject and

[1] The *Thirteenth Catalogue of the University* for the year ending June 11, 1885, under degrees conferred, has the following statement: "The following honorary degrees were conferred at the same and the subsequent meeting of the Board of Trustees." Two names were listed under Doctor of Divinity, and four names were listed under Master of Arts, among them "W. J. Waggener, Del Norte, Col." (see more on this in prologue I.)

[2] Source: Office of Institutional Research

[3] Thesis in University of Arkansas Special Collections

his specific courses is made in conference with the major professor and the Dean." A minimum grade-point average equivalent to a B was required, and the candidate was expected to pass a comprehensive oral examination. It is surprising to see that the graduate school requirements are not much different even today after some seventy years. Now, obviously, the departments choose the specific subjects to be taken. In 1939, the Physics Department only had three professors: Ripley, Ham, and Roberds. There was no course above the 300 level. The courses at the 300 level consisted of Electricity and Magnetism (Ham), Atomic Physics (Ham), Heat (Roberds), Acoustics (Ham), Sound (Ham), Photography (Roberds), Light and Photography (Roberds), Introduction to Theoretical Physics (Ham), and two courses in X-Rays (Roberds). The names in parentheses are those of the course instructors. Ripley is not listed as teaching anything.

A degree for natural science teachers, the MS in natural sciences was started around 1960 and later phased out in the 1970s. It is described in chapter 13.

C. PhD Degree in Physics

a. Initial Attempts to Start a PhD Program in Physics

In 1949, under the presidency of Lewis Webster Jones, it was determined that it was time to initiate doctoral programs within the graduate school [Ref. 3, 233]. The newly appointed graduate dean, Dr. Virgil Adkisson, was instructed to proceed carefully but ambitiously with this program. The departments, as an initial step, were to offer a better selection of advanced undergraduate courses as deemed appropriate.

Dr. Adkisson's first act was to visit a number of graduate programs both regionally and nationally, seeking to ascertain what the move into offering doctoral work would entail. A Graduate Affairs Committee of broad representation within the university was appointed as a study and advisory group to the dean.

Dean Adkisson and Dean Nichols of the College of Arts and Sciences held a meeting with all the departments heads who were interested in starting a PhD program within their departments. Subsequently, on January 3, 1950, Professor Ham submitted a proposal on the Physics Department's behalf. It was a carefully thought-out and well-researched proposal. It pointed out minimum needs of the department, for example, building space (about twenty-five thousand square feet as opposed to eleven thousand square feet that were available) and the minimum budgets for the Physics Library, maintenance, and equipment. On the staffing side, it proposed two additional graduate instructors (bringing the total number of instructors to seven), with differential teaching loads — that is, lighter loads for those with active research programs. It was proposed that a collaborative research program with Oak Ridge National Laboratory might be established. A minimum support staff of three was proposed, a machinist ("shop man") immediately, and an "apparatus man" and an electronics technician-cum-instructor ("electronics man") to be added shortly afterwards. The requested salary for the electronics technician and instructor was a minimum of $37,000, about ten times the salaries being offered to professors.[4] The proposal was not approved perhaps because of the high cost involved when starting from a very poor research infrastructure. However, PhD programs in biochemistry (at the Medical Center), education, chemistry, economics, English, history (discontinued in 1952), and philosophy were

[4] This is not a typographical error. The same figures are mentioned repeatedly in annual reports of that period.

initiated.

It is worth pointing out that when the PhD program was eventually approved in 1959, the department still did not have the three requested support staff mentioned above and did not even request them in the 1959 proposal. And, while the department had moved into a new building with more space, the quality of the space was hardly suitable for research (see reminiscence of Professor Zinke, chapter 14).

Over the next few years, the faculty made a concentrated effort to strengthen the department's academic and research program in order to prepare for a PhD program. A major step had already been taken in the hiring of Schwartz. He contributed to improvements in the graduate course offerings, improvements in the Physics Library, and was collaborating with two chemists on an Atomic Energy Commission-funded project through the Institute of Science and Technology (see chapter 9). Professor Ham tried to organize department's research along the following lines by capitalizing on the existing manpower in physics (see chapter 3, part I, section C): cosmic rays and nuclear physics (Saur, Schwartz, and Sharrah), physical electronics (Bennett), theory (Schwartz), optics and spectroscopy (Camus), sound and acoustics (Ham), x-ray (Sharrah), and solid-state physics (Harvalik, et. al.)

Extensive discussions were held among faculty (Saur, Sharrah, Schwartz, Ham, Camus, and Bennett) about the PhD program requirements. Records exist of many memos on this subject. Earliest on record is an internal proposal authored by Albert Saur, perhaps in fall 1950 or early spring 1951. It considers topics such as entrance requirements (BS course work, GRE, entrance examination); required courses (mechanics, statistical physics and thermodynamics, electromagnetic theory, mathematics, quantum mechanics, atomic and nuclear physics, and several possible optional courses); an oral qualifying exam given the first year (to test not knowledge but problem solving skills); a preliminary exam (written and oral) based on required courses, a final exam (dissertation defense), and two foreign languages. Although it is not too different than what we may have proposed a half-a-century later, it did seem to be a set of rather rigorous requirements.

A major setback, however, occurred in the 1951–52 academic year when Drs. Bennett and Saur, as well as Mr. Camus, resigned. This was a serious blow to Ham's plans for research and a PhD program in the department outlined above.

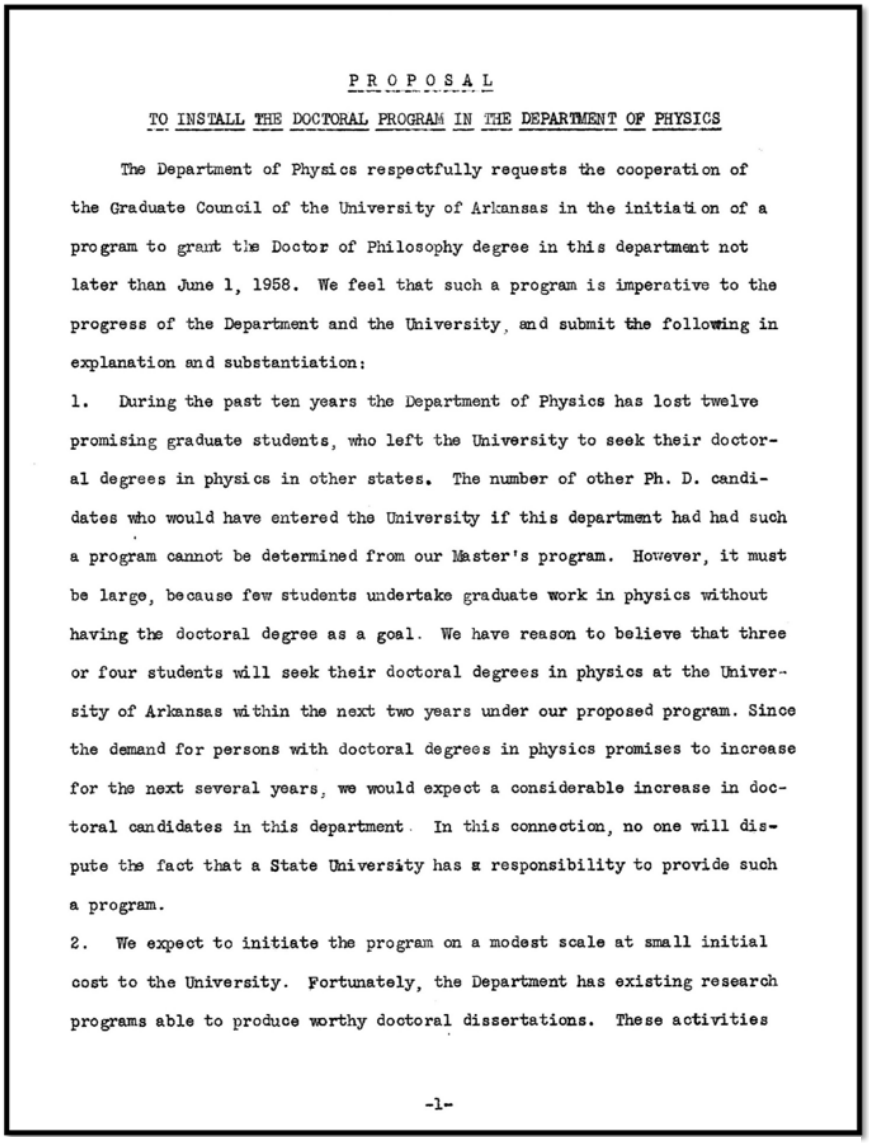
Lost ground was recovered by the addition of Berol Robinson in 1952, Raymond Hughes in 1954, and Glen Clayton in 1958. Robinson, however, was to leave the department before the successful PhD proposal was written in 1959.

b. The Successful Proposal for a PhD Program in Physics

Physics was one of the departments approved for a doctoral program in 1959 as a part of a second group of programs. Professor Raymond Hughes was the principal architect of the PhD program and the author of the winning proposal.[5]

At the time the program was approved, however, manpower, research support, and other visible assets in physics were quite limited. According to the 1959–60 catalog, there were only five members of the physics faculty: G. T. Clayton, R. H. Hughes, H. M. Schwartz, P. C. Sharrah, and O. H. Zinke, but Zinke joined the department in 1959, after the program was already approved. About all that could be said for the department was that there was a strong desire to succeed. Hughes once told the junior author

[5] A copy of the department's PhD proposal was found in the department's files and is now available in the Physics Department Archives. The first page of the proposal is reproduced below.



PROPOSAL

TO INSTALL THE DOCTORAL PROGRAM IN THE DEPARTMENT OF PHYSICS

The Department of Physics respectfully requests the cooperation of the Graduate Council of the University of Arkansas in the initiation of a program to grant the Doctor of Philosophy degree in this department not later than June 1, 1958. We feel that such a program is imperative to the progress of the Department and the University, and submit the following in explanation and substantiation:

1. During the past ten years the Department of Physics has lost twelve promising graduate students, who left the University to seek their doctoral degrees in physics in other states. The number of other Ph. D. candidates who would have entered the University if this department had had such a program cannot be determined from our Master's program. However, it must be large, because few students undertake graduate work in physics without having the doctoral degree as a goal. We have reason to believe that three or four students will seek their doctoral degrees in physics at the University of Arkansas within the next two years under our proposed program. Since the demand for persons with doctoral degrees in physics promises to increase for the next several years, we would expect a considerable increase in doctoral candidates in this department. In this connection, no one will dispute the fact that a State University has a responsibility to provide such a program.

2. We expect to initiate the program on a modest scale at small initial cost to the University. Fortunately, the Department has existing research programs able to produce worthy doctoral dissertations. These activities

-1-

Figure 1: First page of the PhD proposal

of this history that Sharrah, who was the chairman of the department at that time, must have been very persuasive with the graduate council, dean of the graduate school, and the arts and sciences dean for the program to be approved. Hughes added that after all it was a very weak proposal, since there were only three people doing research.

Of course it seemed necessary for the major university in the state to have a PhD program in physics, but this fact alone was not sufficient. Considerable work had to be done by the university, especially by the physics faculty.

A few details concerning the physics doctoral proposal and the process of gaining its approval are in order here.

The proposal was submitted by the Physics Department to the graduate school in 1958. The graduate dean and the graduate council, after a private session, sent the proposal back for clarification of certain points and rewriting by its principal author, Professor Raymond Hughes.

The chairman of physics, Professor Paul Sharrah, was called to another meeting of the graduate council in the graduate dean's office. Arts and Sciences dean Guerdon Nichols was also brought in for this conference.

One of the members of the graduate council leaned over to Sharrah and whispered, "I know why you are so calm and self-confident. You know that we are going to approve your proposal ultimately." Suddenly Sharrah was calm and self-confident.

At one point, after about thirty minutes of discussion, graduate dean Adkisson turned abruptly to Dean Nichols and said, "If we decide to give the go ahead to physics, will you give them your complete backing?" Dean Nichols looked at Sharrah and said quietly but sincerely, "Yes."

Dean Adkisson and Associate Dean Aubrey Harvey came to the department to talk directly with the physics faculty. The meeting was in room 1, the only air-conditioned classroom in

The Physics Proposal

The proposal was rather short, and it emphasized what the department already had and what little initial additional help it would require. This is in hard contrast to Professor Ham's 1950 proposal, in which he listed ambitious and costly needs of the department. The proposal pointed out that the department had existing research programs in atomic spectroscopy, X-ray diffraction, atomic collisions, and low energy nuclear physics, as well as two research grants from the Air Force and additional funds from AEC. It had laboratories adequate for the needs of the program and had a departmental library "of which we are justly proud." It pointed out that "during the past ten years the Department has lost twelve promising students, who left the University to seek their doctoral degrees in physics in other states" and that the department "is at a disadvantage in the recruitment of competent staff members in the absence of a doctoral program." The department, owing to its master's degree program, already offered several graduate level courses.

The proposal requested $5,000 for summer salaries and research supplies and $15,000 to fund the research start-up needs of the new faculty. Three faculty members needed to be recruited to fill existing vacancies.

Finally, the proposal concludes with this statement: "The Department realizes that the standards set for the PhD candidate must be very high and rigorously enforced to build our reputation for turning out top-flight students."

the Physics Building. The meeting was short, only about thirty minutes. We were becoming rather self-conscious and even apologetic about our obvious limitations. But it was Dean Adkisson who volunteered that we would be given approval to proceed because there was a clear and unanimous desire on the part of the department to go ahead.

The doctoral program in physics was approved in 1959 with the stipulation that the department obtain NDEA (National Defense Education Act) Title IV fellowships to support the doctoral program. These federally funded four-year fellowships gave the student a stipend comparable to an assistantship and a monetary supplement to the department to support the student's research efforts.

The PhD program was fortunate to be born in the early post-Sputnik era (which began after the USSR sent Sputnik into orbit in 1957) when congressional Cold War concern over possible Russian scientific and technological dominance led to a federal push to develop graduate programs in science and engineering. Neither the university nor the Physics Department had the resources to begin the PhD program; hence, the stipulation by the graduate school to obtain the fellowships was most relevant.

Proposals were written promptly for the NDEA Title IV fellowships. Four were provided by the initial proposal. These fellowships were to be a vital part of the physics programs for the next several years. Many of these NDEA Title IV fellows went on to teach in various colleges and universities. This was indeed the goal of that program.

Two other federal fellowship programs soon became available. These programs provided NSF traineeships and NASA traineeships and were funded by the National Science Foundation and the National Aeronautics and Space Administration respectively. These new programs forced the departments to compete with each other within the university for these fellowships. These two programs, like NDEA Title IV, supported the students' research programs as well as providing their stipends.

A one-time grant from the Baldwin Piano



Figure 2: Professor Raymond Hughes was the primary author of the successful PhD proposal. ***Photo archived in the Physics Department, undated.***

Company came at a propitious moment in the early 1960s and made possible the purchase of certain critical items. One such item was a helium vacuum leak detector.

Thus these three fellowship programs not only provided critical funds to assist the department to develop the doctoral program but also made it possible to attract promising students into the new graduate program. These special fellowship programs became less critical when reasonable research grant funding became available in physics. The funding of the graduate students on research assistantships supplemented by teaching assistantships became fairly adequate.

Professor Hughes guided the program for the next two decades.

c. Evolution of the Program

The creation of the PhD program in 1959, under the energetic stewardship of Professor Hughes, led to the first PhD graduate, William R. Pendleton, in 1964. His reminiscences are given in chapter 16 and give a glimpse of the PhD program during the 1959–64 period. According to the 1959–60 catalog, the department was already offering the following "Graduate Student Only" courses: Two semesters of Introduction to Theoretical Physics (theorems of classical dynamics and electromagnetic theory), two semesters of Selected Topics in Theoretical Physics (on demand), one semester each of Introduction to Quantum Mechanics, Quantum Mechanics, X-rays, Nuclear Physics, Introduction to Nuclear Theory, Statistical Mechanics, and Solid-State Theory. For a PhD degree, the student had to take, beyond the courses required for a master's degree, Introduction to Quantum Mechanics, Quantum Mechanics, Nuclear Physics, Introduction to Nuclear Theory, Statistical Mechanics and Solid-State Theory.[6]



Figure 3: Chairman Paul Sharrah persuasively navigated the proposal though the graduate council. ***Photo archived in the Physics Department, August 1961.***

[6] This information is derived from the 1959–60 Graduate School catalog.

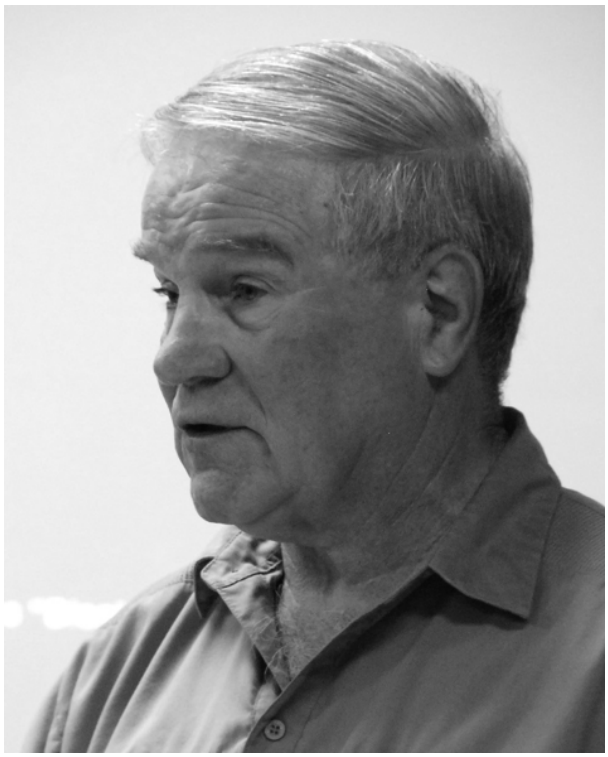


Figure 4: Professor William Pendleton, the first person to receive a PhD in physics from the University of Arkansas. This photo was taken in 2009 on the occasion of fiftieth anniversary of the PhD program. *Photo courtesy of Ken Vickers.*

The 1964–65 catalog shows that by the time Pendleton graduated in 1964, the faculty had grown to eight and the number of graduate-student-only courses had grown to eleven (excluding seminar and on demand courses). This included a course on electrodynamics. A further growth in faculty led to the creation of a number of new graduate courses over time, including Goldstein-Level Advanced Mechanics, two semesters of Jackson-Level Electro-dynamics, Mathematical Methods of Physics, and several post-quantum mechanics courses. In addition, courses were added to represent research interests of the growing faculty. For example, when the department was building a strong research program in laser physics and quantum optics in the early 1980s (see chapter 10), the course offerings included Laser Physics, Laser Physics Laboratory, Applied Nonlinear Optics, Laser Spectroscopy, Optical Properties of Solids, Quantum Optics, and Optical Coherence Theory (1983–84 catalog). In 2007–08, when the department was also building a strong program in condensed matter physics, the number of courses in this area had grown to five: Solid-State Physics, Condensed Matter Physics I and II, Advanced Device Design, and Advanced Device Prototypes. The total number of graduate courses (4000 and above) was thirty-seven (excluding seminars, and thesis and dissertation).

The original physics PhD program initiated in 1959 may have been modeled principally after the University of Wisconsin since the principal author was a recent Wisconsin graduate.

Prospective candidates had to pass a qualifying examination consisting of an eight-hour comprehensive written examination to be taken no later than the third semester of their graduate study. This was followed later by a candidacy examination (a graduate school requirement) to be completed at least nine months before completing all requirements for the degree. The examination consisted of a written and an oral section. If failed, a second attempt was allowed. And finally, of course, there was the final oral examination.[7]

Doctoral requirements included passing examinations in two foreign languages, which were conducted by the respective language departments. For several decades in the twentieth century, doctoral science programs in the United States required a European language prominent in science and research. Thus students in physics often studied German and French, and less commonly Italian and Russian. But by the second half of the twentieth century, physics and the other sciences had become

[7] Ibid.

stronger in the United States, and most of the relevant publications were in English. Thus, the foreign language requirements were relaxed, and for a brief time a computer language would be approved in place of one of the foreign languages. By 1975, the PhD candidates in physics at the University of Arkansas no longer had a foreign language requirement.

In 1978 the initial model, minus the foreign language requirement, was basically in effect. To be admitted to PhD candidacy, the student had to have first completed the coursework equivalent to a master's degree and must have passed a qualifying exam and a candidacy exam consisting of a written and an oral exam. There just seem to have been too many exams, and the deadline to pass the candidacy exam came way too late in the course of graduate studies. The process lingered on and on throughout the student's graduate studies. The junior author of this history, who was new to the faculty, observed that in one case the student failed his final attempt to pass the candidacy examination when he had already completed all of his research work and was in the process of writing his dissertation. This led to much acrimony between the student's dissertation advisor and the rest of the faculty. Therefore, Gupta pushed for a single exam (the candidacy exam) taken relatively early in the student's graduate studies and without the master's equivalency pre-requirement — two changes he modeled after Columbia University, his previous institution.[8] This was adopted by the faculty and was still in effect in its basic form during the period covered by this history (until 2008) even though the format of the qualifying exam has been changed numerous times. As a member of the Graduate Affairs Committee, Gupta also collected all the fragmented information that the graduate students needed to know in one place called the *Graduate Student Handbook* back in the early 1980s. The department has since maintained the production of these handbooks yearly, and they have become a vital resource for graduate students. The evolution of the graduate program since the early 1980s can be tracked by consulting the department's handbooks, which are available in the Physics Department Archives. The handbooks include information that is not available in the graduate school catalogs, for example, suggested semester-by-semester plans of courses to be taken, departmental requirements for earning, and renewing graduate teaching and research assistantships.

D. Faculty Recruitment

One significant potential advantage gained with the introduction of the PhD program was the ability to interest better qualified young PhDs to apply for a position at Arkansas and to retain some of the qualified physics faculty already here. However, the post-Sputnik era of the 1960s saw a shortage of qualified people for faculty positions. The department had to make an extraordinary effort to recruit new faculty. These efforts did pay off, and the department succeeded in hiring eight new faculty members over the decade following the approval of the PhD program. This is described in detail in chapter 10.

E. Graduate Student Recruitment

Graduate student enrollment was to increase, beginning in 1959 with the initiation of the PhD program in physics. During the early and middle 1950s, typically four or five graduate students would be pursuing a master's in physics at any given time. The number of graduate students in physics grew to over ten by the early 1960s, about

[8] This may have been the model being used at most universities at that time. For some reason, this department had not taken a new look at its examination requirements.

thirty in the early 1980s, and about forty in 2007–08.

In the early years of the doctoral program, at least three and as many as six graduate students would be on one of the three fellowships described above. There would also be six or eight teaching assistants and three or four graduate students on research assistantships. Sometimes the research and teaching assistantship assignments were combined for students who expressed a strong desire to become teachers. Most of the graduate students on the NDEA Title IV fellowships served at least one year, usually the last year, as classroom assistants. They attended all of the lectures in one of the large introductory sections, usually University Physics, assisted in taking the attendance and setting up some of the demonstrations, graded some of the papers, and made themselves available to substitute as lecturer in the course if needed. It was wonderful training for the graduate students and greatly enhanced the management of these courses. A number of these former graduate students indeed became successful teachers, an expressed goal of the early NDEA Title IV fellowship program.

Most of the graduate students came from smaller colleges. One college that provided us many good graduate students was William Jewel College in Missouri — the alma mater of Professor Sharrah. For many years these colleges were the principal sources of PhD-bound students nationwide. This has been changing slowly during the last few decades so that now the major portion of the PhD-bound graduate students come from universities in the United States and abroad.

During the post-Sputnik era, graduate programs in physics all across the country underwent major expansion. However, the supply of physics majors was not enough to satisfy the graduate student needs of all physics departments in the country. Our department was no exception. Many members of our faculty went out to visit and recruit at various colleges and universities in the area, but the shortage persisted. Brief recruiting brochures were produced by the department over time. They are available in the Physics Archives. A few pictures from them are shown elsewhere in this book.

Donald Pederson became the chair of the department in 1978. He decided to try a new strategy: appoint one person as the graduate recruiter, provide this person some relief from teaching but hold him accountable for the success or failure of recruiting. He also decided to put major financial resources into the recruiting effort, though the resources available to the department were meager (see chapter 12). Gupta joined the department a couple months after Pederson took office as the chair. He told Gupta that the lack of graduate students was the single biggest problem the department faced and that he wanted him to become the graduate recruiter. Gupta put in a major effort in this endeavor, and the strategies which produced the best results included: writing personalized letters to prospective students, continued telephone contact with those who had shown interest in the program (as result of a letter or a flyer) until an application was received, and ultimately inviting those who had applied to visit the department. This would not have been possible without the financial resources that were made available for this purpose. Airfare and hotel funds were provided, the prospective students were received and dropped off personally at the airport, lab tours were given, and again telephone contact was maintained until the offer was accepted or rejected. As part of this effort, an attractive recruiting booklet describing the department's research (and highlighting research in lasers and optics) was produced and mailed to a large

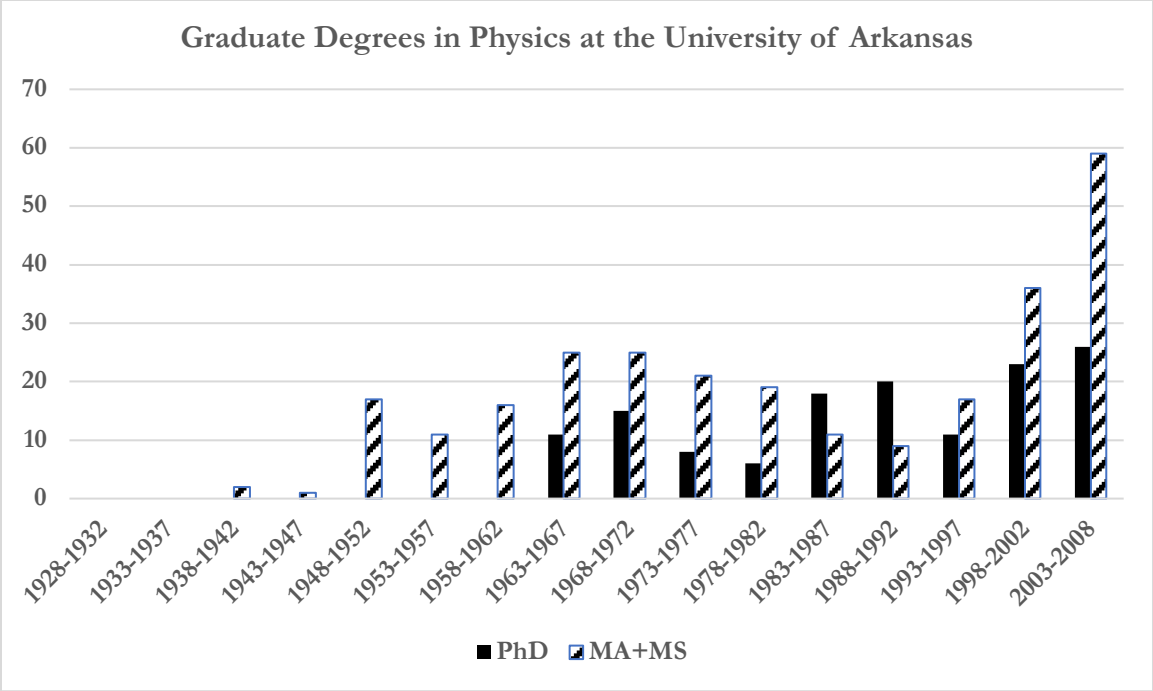
number of institutions.[9] This may have contributed to a surge in the number of

applicants. While this effort was going on, several new research grants were received in the department, continually increasing the demand for graduate students. In just a couple years, the number of graduate students with assistantships in the department nearly doubled, from sixteen[10] to thirty,[11] and almost all were domestic students. After about three or four years of effort, Gupta gave up this assignment to devote more attention to his research. Over the years, many people in the department have assumed the role of graduate recruiter, strategies have changed over time (such as relying on the Internet rather than mailings and color brochures), and the number of graduate students has continued to grow to keep pace with the demand. In 2007–08, the department had approximately forty graduate students, roughly half domestic and half international.

Year	MA	MS	MA + MS	PhD
1938–1942	1	1	2	
1943–1947	0	1	1	
1948–1952	0	17	17	
1953–1957	1	10	11	
1958–1962	0	16	16	
1963–1967	0	25	25	11
1968–1972	0	25	25	15
1973–1977	3	18	21	8
1978–1982	2	17	19	6
1983–1987	1	10	11	18
1988–1992	2	7	9	20
1993–1997	8	9	17	11
1998–2002	11	25	36	23
2003–2008	20	39	59	26
Totals	49	220	269	138

Table 1: Number of graduate degrees awarded by the Physics Department until 2008.

[9] Over the years, Gupta continued to produce updated versions until about 1999. Many of these can be found in the Physics Archives and provide a history of the evolution of the physics faculty and their research programs.
[10] Physics Department's *1978–79 Annual Report*
[11] Physics Department's *1981–1982 Annual Report*



F. Graduate Degrees Awarded

The table on the previous page gives the number of graduate degrees awarded. Data are also presented graphically. Over four hundred graduate degrees have been awarded, of which about 140 have been PhD degrees. Perhaps some conclusions can be drawn from these trends. These data do not include degrees awarded to physics students under the MicroEP program (see appendix VII). The very small number of PhDs from 1973–82 can perhaps be related to the paucity of graduate students in the department in that period. The subsequent increase was due to the successful graduate recruitment efforts. This was followed by a supply of graduate students from China becoming available. At the same time, the department was making a major effort to build a nationally visible research program in quantum optics in the 1980s, which also helped. The increase in master's degrees post-1998 is perhaps due to the fact that the department started granting master's degrees to all candidates en-route to a PhD upon passing the candidacy exam.

8.

Astronomy Program

With Contributions by Claud Lacy

A. Overview

Astronomy was taught from the very beginning of the university and was also a part of the preparatory school offerings. Professor G. W. Droke was an early teacher of mathematics and astronomy. The 1906–07 university catalog lists Professor George W. Droke and one associate professor in the mathematics and astronomy department.

Professor Droke taught astronomy from Moulton's *Introduction to Astronomy* and a Practical Astronomy course using the sextant and spherical trigonometry. He taught both in the preparatory school and in the College of Arts and Sciences. He served as dean of the College of Arts and Sciences from 1915 to 1925. He was honored approximately seventy years later when his grandson, James W. Droke, and James's wife, Kaye Barrett Droke, provided a beautiful mountain-top observatory southeast of Fayetteville to be named in Professor Droke's honor (see section C).

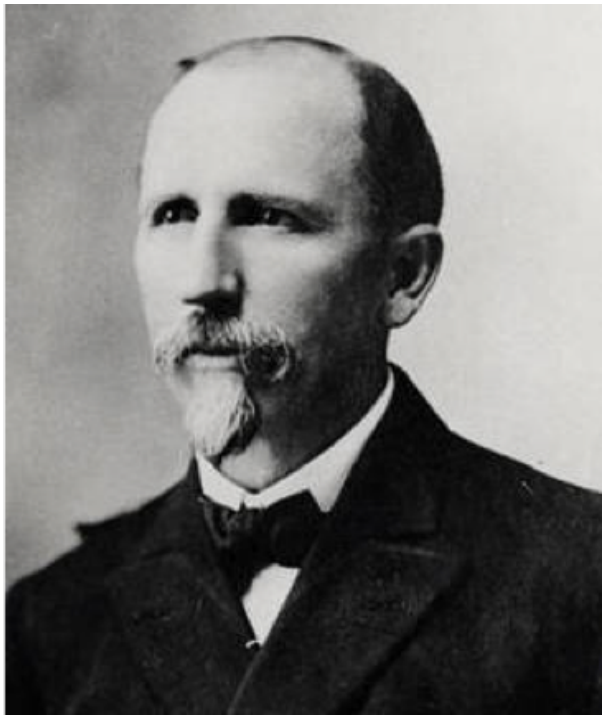


Figure 1: George Wesley Droke, mathematician, astronomy enthusiast, and an early astronomy teacher at the university. *Photo courtesy of the University of Arkansas Libraries, Digital Collections. Undated.*

Thus the astronomy course was listed in the department of mathematics and astronomy for many years. Two other professors of mathematics performed notable service to astronomy in the early years: A. M. Harding and Davis P. Richardson.

Mathematician and university president A. M. Harding gave public lectures on astronomy all over the state of Arkansas and in other states. He frequently carried a six-inch refracting telescope with him on the train or in his automobile to use in his lectures.

Davis Richardson was chairman of a committee consisting of B. H. Gundlach, also of mathematics, and Paul Sharrah of physics, who presented a proposal to the university administration in 1950 recommending the purchase of a planetarium, which was approved.

Professors Richardson and Gundlach were the primary planetarium demonstrators from 1954 until 1957, when Paul Sharrah and several of the

graduate assistants in physics began to make use of the planetarium as an occasional supplement to the physics laboratories. The planetarium was moved to the Dickson Street Physics Building in 1972 and used effectively until 1992, when the building's remodeling began (see section B).

The responsibility for teaching astronomy and the directing of the planetarium was taken over by Paul Sharrah in the Physics Department in 1967 when Professor Davis Richardson of the Mathematics Department retired. A single popular course called Descriptive Astronomy was the only astronomy course at that time. By 1969, enrollment had risen to well over one hundred students each semester in this one-semester course. It served as an elective for many students in various colleges and was used by some departments to satisfy certain requirements.

A course on elements of celestial navigation and a variable-credit-hour course in planetarium operation also became popular. These two courses frequently totaled thirty or forty students each semester. The planetarium programs for the public and schools became a highlight of the period.

Thus from the earliest times and up until 1972, there had been at least nine part-time astronomy teachers (see appendix III).

In the fall of 1971, Professors Stephen Day and Charles Richardson called Dr. Sharrah in Arizona, where he was on a sabbatical, and asked if he still believed that the department should teach astronomy and hire a full-time instructor to do so. We all agreed that we should do this, and Carol Webb from the University of Texas was hired in 1972 as an assistant professor.

An astronomy teaching laboratory was established on the roof of Kimpel Hall. Charles Richardson prepared an astronomy laboratory manual. Carol Webb and later Claud H. Lacy also prepared laboratory teaching materials.

When Webb left the department in 1980, Lacy from the University of Texas was employed to teach the astronomy classes and initiate astronomy research activities. Since then, the course offerings have been expanded both at the introductory level and at the advanced level so that physics majors can have a strong concentration in astronomy. The developments in the astronomy program since 1980 are described in detail in section D.

B. The Planetarium

As noted previously, Dr. Sharrah from the Physics Department was on a committee headed by Dr. Davis P. Richardson and Dr. B. H. Gundlach of mathematics, which proposed in 1950 that the university purchase and install a Spitz-A1 planetarium. The proposal was approved by the administration, and Professor Richardson was made responsible for obtaining the planetarium. The Physics Department cooperated with the management of the planetarium since its installation in 1951 in a temporary World War II structure located just north of the Fine Arts Center.

Planetarium demonstrations had been given



Figure 2: The planetarium projector and console in the Physics Building. ***Photo archived in the Physics Department. Undated.***

by the physics graduate assistants to each of the elementary physics and physical science laboratory sections at least once each semester. The department agreed to provide some of the cost of maintenance. In 1971, the temporary World War II building housing the planetarium was to be torn down. There was little apparent interest or leadership relative to the planetarium, so the Physics Department had the physical plant haul the planetarium projector to the Physics Building for storage. Dr. Glen Clayton, physics major John Fitzgerald, and Dr. Paul Sharrah went along with the truck on that day. Then Dr. Sharrah went off to the University of Arizona on sabbatical, and the Spitz instrument sat unattended except for some much needed repairs performed by Fitzgerald.

The planetarium dome and instrument were installed in refurbished space in the Physics Building during the summer of 1972 and was ready for use by August of that year (room 117). Beginning late in the summer and into the fall of 1972, newspapers and other announcements described the public demonstrations and invited school and youth groups to make appointments. The programs were initially given by members of the physics faculty: Michael Lieber, Charles Richardson, Carol Webb, Paul Sharrah, and lastly by Claud Lacy.

Sharrah was active in the regional and national planetarium organizations and attended a training session at Spitz in Chadds Ford, Pennsylvania. He served as president of the Great Plains Planetarium Association for one year and directed a meeting of the group in Fayetteville. He was made a fellow of the International Planetarium Society at its meeting in Richmond, Virginia in 1978.

Physics major John Fitzgerald assisted with the repair and made improvements on the already aged planetarium projector when it was reactivated in 1971–72. Two students, Lisa Lovett and Eliot Neel, were faithful demonstrators. Neel also helped greatly with maintenance and developed a good audio system. Lovett gave many of the demonstrations to the school groups and star talks at the public shows. Dianne McGuffy and Mrs. James Watson also were of much help as demonstrators and script writers. Some of these activities were a part of the planetarium course, and some were done on hourly pay.

Professionally produced programs were used, frequently with considerable modification and reduction in length. The little planetarium became a pleasant and effective audio-visual medium. The professionally produced programs chosen were always educational and entertaining, but we were determined that each and every program would spend a few minutes devoted to the "starry sky tonight." The students enrolled in a course in planetarium operation usually gave these live star talks, and they were well received by all age groups. The students enrolled in the planetarium course were required to have had at least one semester of astronomy before entering the course.

Many of these planetarium programs were followed by a viewing session in the astronomy laboratory located on the roof of Kimpel Hall. One or two telescopes and a pair of binoculars were used, and naked eye viewing was emphasized.

The total number of visitors, including the general public, school groups, and university students was as large as three thousand or more per year, and it is estimated that over forty thousand persons have attended planetarium programs at the university over the forty-one-year period starting in 1951.

Several students received additional astronomy teaching experience and college credit running the planetarium for school groups and public shows. The Spitz A-1 was shut down in 1992 when the physics building was renovated.

The Physics Department has written two

proposals since then for a new, modern planetarium, both complete with architectural drawings. None of these have been seriously considered by the administration either for funding or for seeking private money. Some of the details of this effort are given in chapter 5. The Spitz projector is now (2008) on display on a stand in the Space Center.

The planetarium programs were very much appreciated by the public and school children because there was no other planetarium in the area. When it was shut down in 1992, many schoolteachers called the department to inquire as to when the planetarium would be reopened. Once, children from an entire class of an elementary school wrote letters in their own handwriting to implore us to reopen the planetarium, and one child even offered to sell cookies to raise funds for it!

C. The Droke Observatory

In 1976, James W. and Kaye Barrett Droke donated the forty-acre Windcrest Estate, which sits atop an Ozark Ridge about twelve miles southeast of Fayetteville, to the University of Arkansas Foundation. The estate was donated in memory of Dean George Wesley Droke. Since Dean Droke was a professor of mathematics, logic and astronomy, and his grandson was an avid amateur astronomer, it was fitting that the Droke family provided the location and funding to build the James Wesley Droke Observatory in 1978 to house the sixteen-inch reflecting telescope funded by the National Science Foundation. The proposal to fund the telescope was written by astronomer Carol Webb. Dr. Claud Lacy replaced Carol Webb in the fall of 1980. By the end of the year, he had received funding from the Research Corporation to automate the telescope at Droke Observatory for photometric studies.

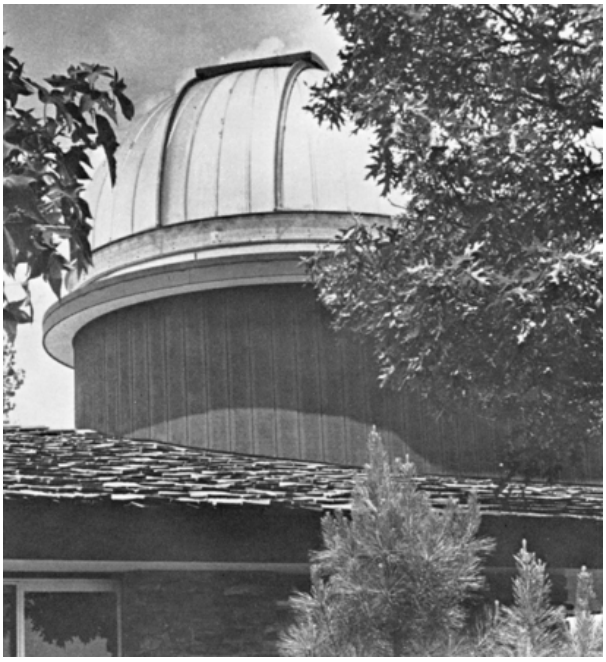


Figure 3: The Droke Observatory. ***Photo archived in the Physics Department, circa 1980.***

Claud Lacy provided public programming and frequently operated night viewing sessions with the Droke telescope from 1985 to 2000. The telescope and photometric instrument were computer-controlled, using a single-board KIM computer and an Apple II Plus microcomputer to interface the various controls on the telescope. The KIM controlled the micro-stepping motors that drove the rotation of the telescope's two axes of rotation and their associated preload torque motors for removing the backlash of the gear systems, as well as absolute encoders to monitor the positions of the axes. On the photometer, the stepping motor on the filter wheel and the photomultiplier tube's output pulses were controlled and monitored by the Apple computer. This system was one of the first integrated computer-controlled observing systems to be built anywhere, and was used by several undergraduate students for research projects monitoring eclipsing binary stars. The most extensive of these projects was that of Colleen Wilson, who obtained a complete light curve for the eclipsing binary star V1425 Cyg. This resulted in an honors thesis, and she graduated magna cum laude in physics in 1992.

She was later employed by NASA at their Huntsville, Alabama base, where she continues to do gamma-ray astronomy (see chapter 15).

The Droke telescope achieved a photometric precision of about 0.025 magnitude, which was short of what was desired for high-precision work, so beginning in around 1999, Lacy began work on a higher-accuracy photometric system based on a Meade LX-200 computerized telescope, an SBIG ST8 digital camera, and a Technical Innovations Robo-Dome on top of Kimpel Hall (see below). The Droke Observatory was not in use in 2008 (the telescope was removed in 2009 and the property offered for sale by the university later).

D. Astronomy Teaching and Research Program Since 1980

Astronomy courses taught since 1980 include Survey of the Universe, a large introductory course of up to 430 students for non-scientists, as well as the more specialized Solar System Astronomy, Stellar Systems, Astrophysics, and the graduate level course Planetary Systems. The advanced courses are taught on a rotating basis, and are often taken to fulfill elective requirements of the BA and BS physics programs, especially by students who will pursue a graduate degree in astronomy or astrophysics. The graduate level course is an elective in the space and planetary sciences graduate programs (see below).

Within a year of joining the University of Arkansas, Lacy received funding from the National Science Foundation to continue his photometric and spectroscopic observations of eclipsing variable stars at McDonald Observatory and received funding from the Research Corporation to automate the telescope at Droke Observatory (see section C) for photometric studies.

The Arkansas Center for Space and Planetary Sciences (SPAC) was established in 2000 with initial funding from a NASA EPSCoR grant. The center promotes research in space and planetary sciences and has a graduate program with MS and PhD degrees. The center was housed in the old museum building near the Arkansas Union at the end of the period covered by this history (2008). Several members of the Physics Department participate in the center's programs (see appendix VIII).

In 2000, Claud Lacy established a robotic observatory (the URSA WebScope) on the observation deck on the roof of Kimpel Hall, as mentioned above. The observatory consists of a ten-inch Meade LX-200 telescope sitting inside a Technical Innovations RoboDome with a SBIG ST-8 CCD camera and filter wheel, all controlled automatically by a computer in room 722, underneath the observatory. Observing requests are submitted to a web server, the observations

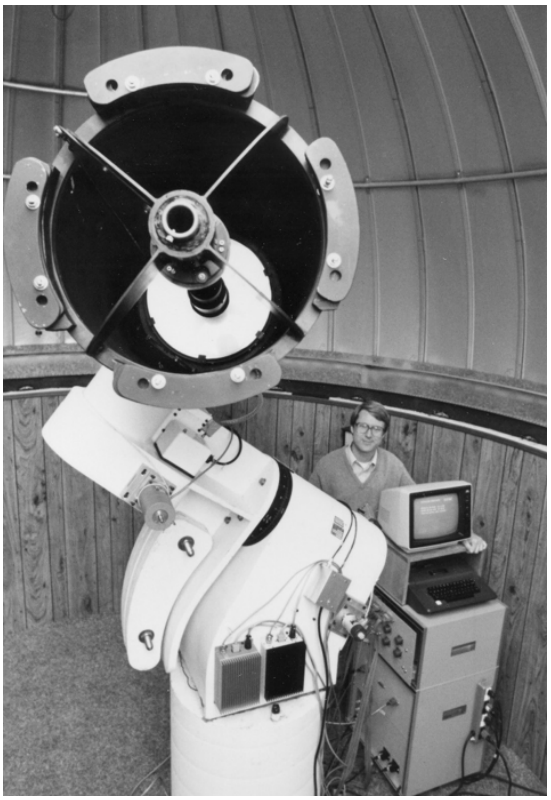


Figure 4: Professor Lacy with his automated telescope and the Apple II computer. *Photo archived in the Physics Department, mid-1980s.*

are automatically made at the next available opportunity, and then the user retrieves the observations from the server over the Internet. This project was funded by NSF grants in 2000 and 2005. The telescope is regularly used by undergraduate and graduate students for small research projects and by Lacy for long-term monitoring of eclipsing binary stars. About five hundred students per year now use this WebScope in their class work, and over a half million images have been obtained to date. Many research papers based on URSA observations have been published in peer-reviewed journals.

Starting in 2002, a consortium consisting of members of the University of Arkansas, Fayetteville (Claud Lacy); the University of Arkansas at Little Rock (Albert Grauer); the Arkansas School of Mathematics, Sciences, and the Arts (Brian Monson); and the NF Observatory (Bill Neely) was formed to design and construct a WebScope at a dark-sky site near Silver City, New Mexico. The telescope is a modified twenty-four-inch Cassegrain reflector, which sits in a roll-off roof observatory. The Neely-Frasca Observatory (NFO) WebScope began regular operations late in 2004 and has obtained to date over four hundred thousand images. Several research articles have already been published based on NFO research. The telescope is also used for teaching at all levels.



Figure 5: Professor Lacy with his URSA Webscope. ***Photo by Rajendra Gupta circa 2000.***



Figure 6: The Neely-Frasca Observatory. ***Photo from NFO website.***

In the years since, additional astronomy faculty were added to the department. Julia Kennefick was hired in 2007 as assistant professor; and Daniel Kennefick was employed as visiting assistant professor in 2003 (and appointed to a tenure-track position as assistant professor in 2009). Together with Claud Lacy and Marc Seigar (University of Arkansas at Little Rock), Julia Kennefick, an expert on observational aspects of high-redshift quasars, and her husband Daniel Kennefick, an expert on gravitational waves and the history of Einstein's General Theory of Relativity, formed the Arkansas Galaxy Evolution Survey (AGES) in 2008, initially funded by a grant from the NASA EPSCoR program. The grant funds postdocs and graduate students at Fayetteville and Little Rock. The major goal of the project is to determine how the masses of supermassive black holes in the nuclei of galaxies have increased over cosmic timescales.

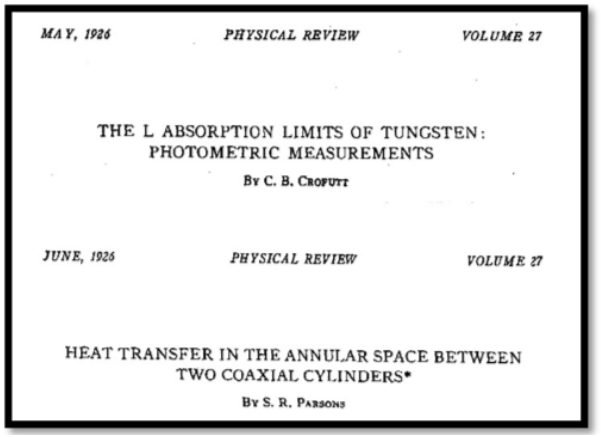
9.

Early Research

1907–1952

A. Beginning of Research

In the first half-century or so of the university's existence, teaching was the primary mission. The teaching loads were incredibly high, and research funding and facilities were nonexistent. Therefore, any research that took place was due to the individual Herculean effort on the part of the faculty.[1] Some evidence of creative activity in the Department of Physics can be found almost from the start of the department. Professor Giles Ripley, the first fulltime physics teacher, invented several devices for which he was granted US patents. The first one was a Projecting Apparatus for Moving-Picture Machines, for which he applied for a patent on November 21, 1911 and was granted on March 31, 1914. A scan of the title of that patent is shown in chapter 1. The first research papers from the Physics Department in national journals were published as early as 1926. Professors Charles Crofutt and Samuel Parsons published papers in two successive issues of *Physical Review* in 1926, and the title pages of both are reproduced here.[2] Both of them went on to publish one additional paper each in 1927 and 1929 [Ref. 6] before they left the university. All of this research was done under very difficult conditions. Professor Ripley in his *1927–28 Annual Report* comments on the conditions for research in the department at that time: "At present research is possible only in the summer vacation, because of both lack of time and space. It is restricted to a very limited kind of work, for lack of equipment. If time and laboratory space could be made available, a fairly extensive program of research could be laid out." In the same report, he describes the quality of space: "Our most urgent need at present is [. . .] a building free of vibration. There is only one place in the present building where sensitive galvanometers can be used."



MAY, 1926 PHYSICAL REVIEW VOLUME 27

THE L ABSORPTION LIMITS OF TUNGSTEN: PHOTOMETRIC MEASUREMENTS

By C. B. Crofutt

JUNE, 1926 PHYSICAL REVIEW VOLUME 27

HEAT TRANSFER IN THE ANNULAR SPACE BETWEEN TWO COAXIAL CYLINDERS*

By S. R. Parsons

Figure 1: Reproduction of the titles of earliest papers published by physics faculty.

One of the first initiatives to encourage research at the university began when the

[1] The exception was research in agriculture, because of the special funding and mission of the College of Agriculture and the Agricultural Experiment Station.

[2] Crofutt's paper is based on data collected at the University of Iowa, where he obtained his PhD. There is no indication in Parson's paper as to where the data were acquired, if other than the University of Arkansas. Both authors list their institutional affiliation solely as the University of Arkansas.

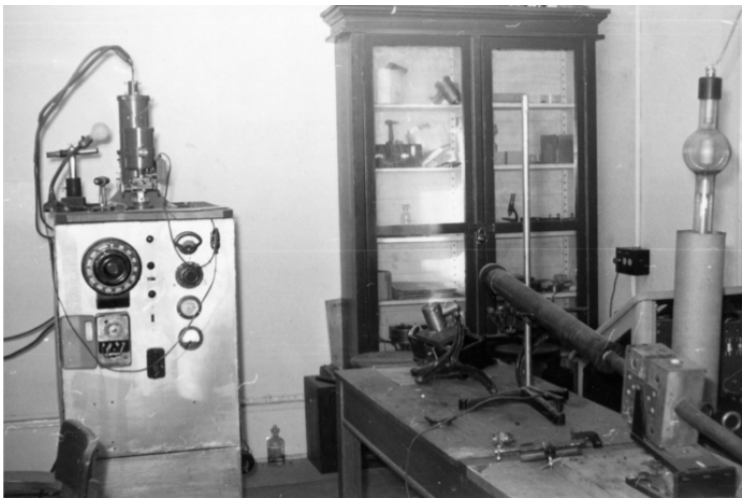


Figure 2: X-ray laboratory developed by Roberds and Sharrah. *Photo archived in the Physics Department,* circa 1940.

research committee of the university's Faculty Senate initiated a Journal series of research papers in 1923, and over eight hundred papers were listed during the next twenty-five years [Ref. 1, 189]. During this time, more than sixty books were authored by members of the faculty, including Wertheim's *Textbook of Organic Chemistry*, Harding and Mullins's *Analytic Geometry* text, and Schneider and Ham's *Experimental Physics for Colleges*. This was in spite of very high teaching loads.

While teaching was the main recognized responsibility of the faculty in those days, there were always rumblings that more research activity was needed in physics. Professor Wesley Roberds, who joined the Department in 1927 and started an instructional laboratory on x-rays, did some preliminary work in developing an x-ray diffraction facility. While he could not get a research laboratory on x-rays established, he did publish seven articles [Ref. 6], four of them on developing new scientific instruments (published in *Review of Scientific Instruments*) and three on instructional research.[3]

Professor Ham established the first research laboratory in the Physics Department in the 1930s. It was for research in acoustics.

Dr. Paul Sharrah, who joined the department in 1942, continued with the x-ray work initiated by Roberds and developed it into a research laboratory after WWII was over (this work was interrupted during the war; see chapter 3). The students in the mid-1940s often complained that if you were going to get a master's in physics at



Figure 3: Student James Roark in Dr. Ham's acoustics laboratory in a soundproof room. *Photo archived in the Physics Department, circa 1937.*

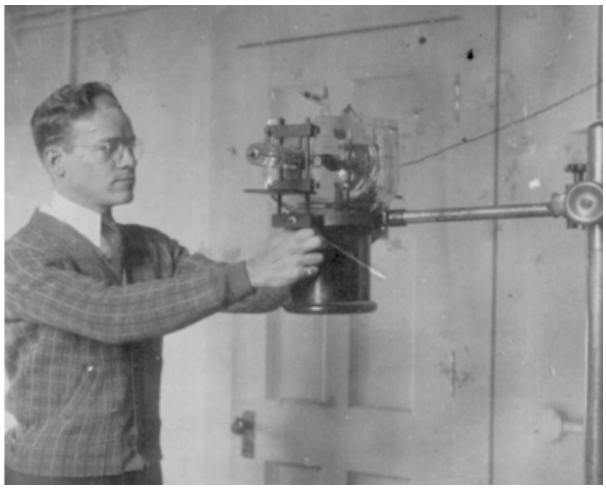


Figure 4: Student George Harvey in the x-ray lab. *Photo archived in the Physics Department, circa 1940.*

[3] A couple of Dr. Roberds's x-ray tubes are on display in the Physics Lobby.

Arkansas you had only two choices — acoustics under Ham or x-rays under Sharrah. The opportunities did start improving in the late 1940s.

B. University-Wide Efforts to Promote Research; ORDARK, ARNO, and IST[4]

A somewhat broadly defined university committee known as the Bureau of Research was established by the university in 1943 for the purpose of providing a university-wide administration and sponsorship of research. During and especially after World War II, contract research opportunities for the army and the navy became available to all universities. The University of Arkansas organized itself to make use of these opportunities.

The university obtained a large army ordnance contract, which came to be known as ORDARK (ORdnance ARKansas), in 1946. This was a classified project, that is, all of its work was secret, and the project could not serve educational purposes since the students could not participate in this research. Dr. Wladimir Grigorieff, recently of General Electric, was hired as its director. A new building on Dickson Street was constructed to house this project, and later came to be known as the Geology Building. The army paid for all operating costs of this project.

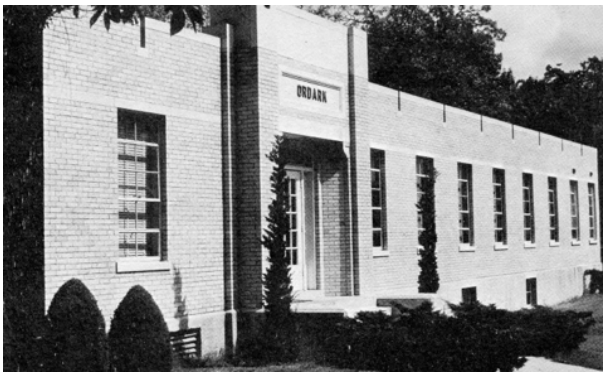


Figure 5: ORDARK Building on Dickson Street. ***Photo from an IST promotional brochure, archived in the Physics Department, 1952.***

Another classified project, Arkansas Naval Ordnance (ARNO) under the direction of Dr. Zaboj Harvalik, began in 1948. Because Harvalik was very active in the Physics Department, the department benefited much from the presence of ARNO even though it was classified.

Negative sentiments about both of these projects existed among the faculty because of the classified nature of research being carried out and the resulting lack of educational purpose.



Figure 6: Dr. Wladimir W. Grigorieff. ***Photo from an IST promotional brochure, archived in the Physics Department, 1952.***

[4] A significant part of the information in this section is derived from Ref. 3, 239–241.



Figure 7: A meeting of IST's Advisory Committee for Physical Sciences. From left to right: D. S. Burgess, professor of chemistry; Raymond Edwards, chairman of the Department of Chemistry; E. S. Amis, professor of chemistry; and Z. V. Harvalik, professor of physics. Photo from an IST brochure, archived *in the Physics Department, 1952.*

Professor Ham was among those who were against this type of contract research. Thus a new organization, called the Institute of Science and Technology (IST), was established in December 1947. Dr. Grigorieff was appointed as the director of this institute. While the institute performed unclassified research, ORDARK and ARNO were placed under its umbrella (Grigorieff was a very resourceful and aggressive administrator). IST, along with ORDARK and ARNO, was housed in the aforementioned ORDARK building.

A brochure published by IST in 1952 (and available in the Physics Archives) gives the history and mission of the Institute:

> The University of Arkansas Institute of Science and Technology began operation in December, 1947. In the Fall of that year, President Lewis Webster Jones invited representatives of Arkansas business, industry, and public and private agencies to the University campus at Fayetteville to obtain their suggestions on formulating a program which would enable the University to be of greater service to the people of Arkansas. As a result of that conference the Institute of Science and Technology was formed. To it were delegated the functions of coordinating and promoting fundamental research in physical science at the University; of assisting the industry through contractual research; of working in close cooperation with public and private organizations interested in the industrial development of Arkansas; and of helping to develop an expanded program of training in science and technology on the senior college and graduate levels. Subsequently, the Institute's activities were broadened to include work in social sciences and research in other fields.

ORDARK and ARNO were listed under the classified research section of IST in this booklet.

All physics-related research seemed to be in the area of nuclear physics. There were eight projects listed under the Nucleonics Division. IST had a large professional staff consisting of several physicists with professorial titles. However, none of them except Harvalik and Bennett (see below) were listed as members of the Physics Department in the university catalogs. Professor Herman Schwartz of the Physics Department was also listed among the staff of IST because of his work on an AEC project (see below).

According to Lefler [Ref. 3, 241], in 1951 the Institute had thirty-six specialists excluding clerical personnel, and it supported twenty-three graduate students. In 1952, it operated on a budget of $532,000, most of which came from the federal government.

So, how did ORDARK, ARNO, and IST help the Physics Department? Albert Saur and Herman Schwartz in physics were on half-time research appointments on an AEC (Atomic

Energy Commission) grant directed by Raymond Edwards and, later, Arthur Fry of the Chemistry Department. Later, in 1952, Berol Robinson, a newly appointed faculty member in physics, started work on gamma-ray spectroscopy with support from this AEC grant.

Dr. Zaboj Harvalik was on a joint appointment with physics and the ARNO project in the IST.

Dr. Willard Bennett, the discoverer of the plasma pinch effect, [5] was also on a joint appointment with physics and the IST. He, with the help of Dr. Maurice Testerman, worked on a RF mass spectrometer of an innovative design. He was engaged part time by physics for a semester or two to develop a much-needed course in electronics.

The newly appointed assistant professors Dr. R. H. Hughes and Brent Stearns served as interim directors of ARNO for one year. Jack Dodd was one of the graduate research assistants on this project and received an MS for his thesis on this work.

Sharrah worked for ORDARK for one summer and succeeded in settling a problem related to the powdered magnesium used by the army. Aubrey Harvey was the project leader on this grant and was able to write a good progress report for that summer. One of Sharrah's students, J. Walter Keller, was on an ORDARK fellowship.

The IST was finally phased out in 1953 [Ref. 3, 340–342], and Grigorieff resigned to accept a position at the Oak Ridge Institute of Nuclear Studies in Tennessee. Some of these grants materially assisted the sciences and other departments and were absorbed by them when the IST was dissolved. Many, however, were classified and related to practical weapons problems. These were deemed not to be the best for the academic needs of the graduate school. Sharrah served on many of the "hatchet" committees that dissolved the remaining contracts.

The Institute of Science and Technology made a positive, long-lasting impact on the university and especially the science departments. It showed that research funding could be obtained, that joint appointments for teaching and research were feasible, and that well-qualified scientific researchers would come to Arkansas. Never again would research take a back seat. It may not be overstating things to say that the IST laid a solid foundation upon which a strong graduate program could be built — work that began under the leadership of V. W. Adkisson when he became dean of the graduate school in 1949.

After the IST was dissolved, Provost L. H. Rohrbaugh served as research coordinator for a short time. Then, in 1955, a more meaningful arrangement was developed with graduate dean Virgil Adkisson serving as research coordinator and Dr. Aubrey Harvey serving directly with him as assistant research coordinator [Ref. 3, 342–344]. Harvey established the Office of Research Coordinator with a high level of performance and service, along with the backing and encouragement of Adkisson.



Figure 8: Dr. Ham continued his research in acoustics through 1940s and 1950s. *Photo archived in the Physics Department, undated.*

[5] Dr. Bennett was inducted into the National Inventors Hall of Fame in 1991.

C. Physics Research Inches Ahead

The Atomic Energy Commission (AEC) research grant obtained by Raymond Edwards in chemistry aimed to materially assist chemistry and physics for several years. Several joint appointments between this grant and the Physics Department were in effect well into the 1960s. Schwartz had the longest running of these joint appointment with physics and this grant.

In 1950–51, Dr. Ham tried to organize the Physics Department's research by capitalizing on the existing manpower of the time, which included Harvalik of the ARNO project and Bennett of the Institute of Science and Technology (see section B), both of whom were listed as part of physics faculty and were involved in teaching specialized courses in physics. This was the first attempt by the department to organize its research (see chapter 3, part 1, section C). But this effort faltered, as most people involved in this plan left the university.

Further significant progress in research in physics took place when Professor Berol Robinson joined the Physics Department and AEC project in 1952 and developed an excellent research program on gamma ray spectroscopy. However, Robinson was to leave the university in 1956. The department was having severe staffing problems in the mid-1950s. It was very, very difficult to recruit research faculty to a department without a PhD program.

Dr. Virgil Adkisson was made dean of the graduate school in 1949. President Jones encouraged a careful study of the graduate offerings and the advanced undergraduate offerings. The announcement came that the first PhD programs would be in operation by 1950 or 1951. The doctoral program in physics was to get underway in 1959 (see chapter 7).

D. Major Research Instruments

In 1947, President Lewis Webster Jones established a University of Arkansas Research Foundation, and much change was about to take place within the university.

The University of Arkansas Research Foundation decided sometime in the late 1940s that the university should spend some money to buy certain special research instruments. These instruments were a Littrow Spectrograph with quartz optics, a Philips x-ray diffraction machine with accessories and a Philips electron microscope with electron diffraction capabilities. The reason for these choices was not clear, but

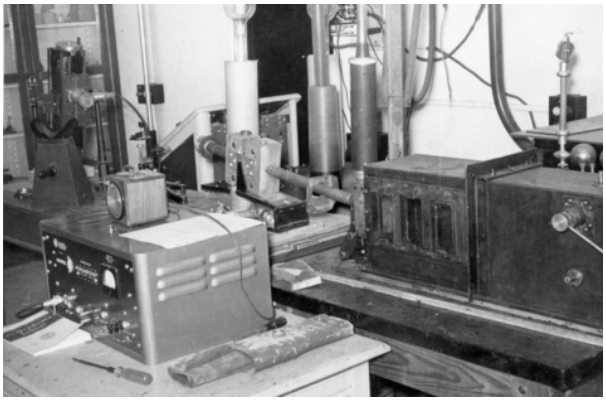


Figure 9: This unidentified picture is from the Physics Archives. It is fairly certain that this is a nuclear physics experiment and could possibly have been Professor Robinson's laboratory. ***Photo courtesy of the Physics Archive.***

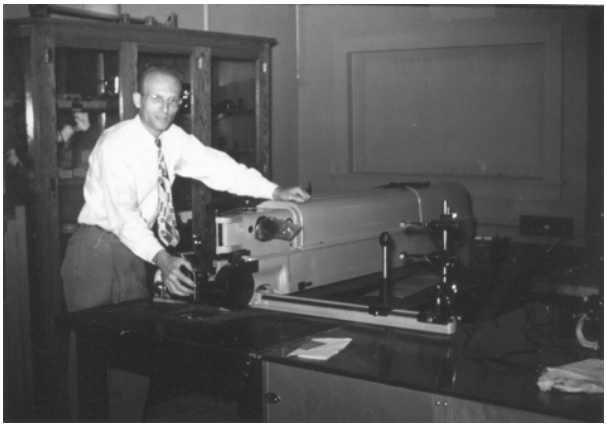


Figure 10: Jean Camus with his Littrow Spectrograph. ***Photo archived in the Physics Department, circa 1951.***

all three instruments did have an impact on subsequent research activities.

The committee held hearings to determine where these instruments would be housed and manned. The first two instruments were assigned to the Department of Physics, and the third was assigned to the Department of Botany and Bacteriology. The Department of Botany and Bacteriology moved into Old Main in 1952 and developed excellent space for the electron microscope.

The Littrow spectrograph and the Philips x-ray diffraction facility were initially used as service instruments for two or three years by projects in operation in the Institute of Science and Technology. An hourly charge was paid by the grant for this service. Jean Camus, James Pearson, and a third person were employed in succession to operate the Littrow Spectrograph. Graduate students Bill Good (later at LSU, New Orleans) and B. S. Garrett (later at Dayton Air Force facility) operated the x-ray machine under the direction of Dr. Paul Sharrah.

The electron microscope was much used by Dr. Lowell Bailey and others. Paul Sharrah used it and the Philips x-ray machine for a small but important summer project for ORDARK. Another electron microscope was purchased later for work in agriculture and chemistry, and geology and agriculture established x-ray diffraction facilities for their specific needs.

The Philips x-ray diffraction machine logged in the largest total hours of service. It also had a special room prepared for it in Old Main in 1951 and in the Dickson Street physical science building in 1952, where it was used by Professors Sharrah and Clayton for their research (see chapter 10). It was housed there until about 1975.



Figure 11: The Philips x-ray diffraction facility was established in 1950 in a room next to Sharrah's office in Old Main. Graduate assistants Bill Good and B. S. Garrett (shown in the picture above) operated the facility. *Photo archived in the Physics Department, circa 1951.*



Figure 12: Bill Good working in the x-ray lab. *Photo archived in the Physics Department, circa 1951.*

10.

Faculty and Research

1952–2008

In this chapter we describe the evolution of the department from mostly a teaching-focused department in 1952 to a research-focused department without at the same time losing sight of the value of a good undergraduate education. This chapter also relates how and why different areas of research in the department were developed. The presentation is mostly chronological. The next chapter (chapter 11) provides biographical profiles of the faculty hired during this period. If a date is preceded by the notation *circa*, then the date is derived from university catalogs. The catalog information could lag behind the actual date by a year or so.

A. Emergence of a Research-Focused Department: 1952–1975

When the Physics Department moved into its present quarters on Dickson Street in 1952, it had a faculty of five: Professors Lloyd Ham, Paul Sharrah, Herman Schwartz, Zaboj Harvalik, Berol Robinson, and instructor George Lingelbach. More space was available for research in this building than previously in Old Main. Moreover, the Physics Library — a necessary resource for research — was established in 1952 as a branch of the main library (see chapter 12). Moving forward, Dr. Ray Hughes joined the department in 1954, significantly strengthening the department's research. The establishment of the PhD program in 1959, followed by the hiring of several new faculty members in the late 1950s and 1960s, led to the evolution of a department which was more balanced between research and education. In this section, we describe the evolution of research in



Figure 1: Professor Ham in the department head's office in the Physics Building. ***Photo archived in the Physics Department, circa 1958.***

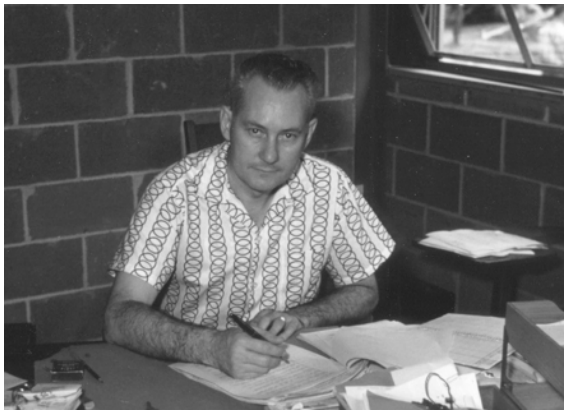


Figure 2: Professor Sharrah in his office in the Physics Building. ***Photo archived in the Physics Department, circa 1953.***



Figure 3: Berol Robinson in his office after moving into the Physics Building. ***Photo archived in the Physics Department, circa 1955.***



Figure 4: Ham in his new sound-proof laboratory in the Physics Building. ***Photo archived in the Physics Department. Undated.***

the department over the period of 1952 to 1975.

Let us start by recapitulating the status of the department's research in 1952. Ham was doing research in the field of acoustics. Sharrah was doing research in the area of x-ray diffraction. In 1956, he started a joint research program in collaboration with Dr. Robert Kruh of the Chemistry Department on the study of the structure of liquids by x-ray diffraction. A Philips x-ray machine (see chapter 9, section D) was used, and the project was funded by a grant from the Atomic Energy Commission (AEC) to the Chemistry Department.[1] When the junior author of this book joined the department in 1978 Ham's former laboratory, room 2, was being used as the optics (instructional) laboratory, and was still fully lined with acoustics tiles. Some of Sharrah's instrumentation was still in room 32. A closet-sized room, room 32A, (see chapter 5, section G) was lead-lined for radiation shielding. Schwartz, a theoretical physicist, worked in his office in room 103. He was calculating the ground state of a helium atom to a high degree of accuracy as part of the aforementioned AEC grant awarded to the Chemistry Department. He and an assistant, Mrs. Veronica Fink, spent much time on an electromechanical calculator performing this calculation. That calculator is still on display in the Physics Lobby. Schwartz later spent a year at Tel Aviv University and wrote a textbook on relativity[2] upon his return. Berol Robinson, supported by the above-mentioned AEC grant to the Chemistry Department, established an excellent nuclear physics research laboratory to do gamma-ray spectroscopy in two rooms in the east wing of the Physics Building. He left the university in 1956. Harvalik was primarily employed by the ARNO Project (see chapter 9) but was quite active in the Physics Department and was also listed as a member of the physics faculty. His research was transferred to the Physics Department in 1954–55.[3] His field was solid-state physics. He resigned in 1957.

In 1954, the department was fortunate to be able to hire Raymond H. Hughes. He had obtained his PhD from the University of Wisconsin and initiated research in the field of atomic spectroscopy. He had inherited a Hilger Littrow spectrograph (see chapter 9, section D) located in the northeast corner of the basement

[1] Glen Clayton used the same instrumentation later for a National Science Foundation-funded project to study selected liquefied noble gases.

[2] *Introduction to Special Relativity*, Herman M. Schwartz, McGraw Hill, NY, 1968.

[3] *1954–55 Annual Report* of the Physics Department.



Figure 5: Sharrah with the Philips x-ray machine in his laboratory in the Physics Building. ***Photo archived in the Physics Department, circa 1952.***

(room 8). Nearly the entire east wing of the basement was devoted to chemistry and geology at that time. In 1956, Hughes received a grant from the Air Force Office of Scientific Research to study isotope shifts in atomic spectra of medium-weight elements. This was the first research grant in the Physics Department, except for a small Research Corporation grant obtained in 1949 by Sharrah and Schwartz for some exploratory work on cosmic-ray-generated neutrons. The Littrow Spectrograph was a key instrument used by Hughes in the isotope shift measurements. This was just the start of a vigorous research program in atomic physics, involving many different techniques, over his entire career (1954–1990) that led to the award of thirty-five master's and nineteen PhD degrees under his direction. In 1968, he was elected to be a fellow of the American Physical Society — the first in the department. He was also the first to be appointed to a university professorship

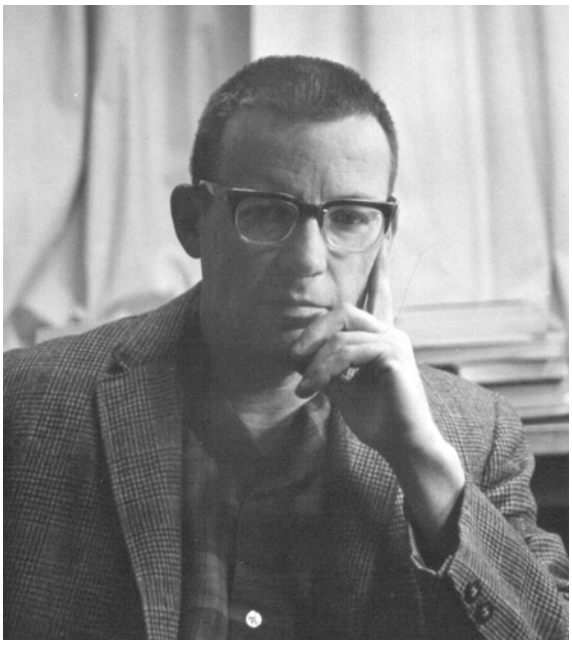


Figure 6: Raymond Hughes in his office. ***Photo archived in the Physics Department. Undated.***

around 1988.

The establishment of the PhD program in physics in 1959 (see chapter 7) gave a much needed boost to the department's research. What followed was an unprecedented expansion of the department. The administration must have had a high degree of confidence in the department and the leadership of Chairman Sharrah to grant it so many positions. During Sharrah's tenure (1957–69) nine new faculty members were hired, bringing the faculty strength to eleven by the 1969–70 academic year. However, hiring good people required extraordinary efforts in that post-Sputnik era.

Sharrah describes the situation in History1:

> One or two of the faculty, Sharrah and sometimes Hughes, or sometimes Schwartz, or Zinke would attend the national combined meeting of the American Physical Society and the American Association of Physics Teachers in New York every January. We would work continuously at the placement service room for the two or three days.

This was a very large and active meeting in those days. This effort would be repeated almost every spring at the American Physical Society meeting in Washington, DC. More than once the airplane fare and personal expenses were the responsibility of the chairman,[4] although we were usually reimbursed. To quote one of the presidential candidates in 1992, "it was a dirty job but someone had to do it."

But even with this gallant effort we returned more than once from one of these meetings with not a single serious applicant. It wasn't all perfect. After returning to the campus, many letters were written to departments and to new PhDs and many telephone calls were made. Likely candidates were brought in for an interview and we always got at least one colloquium presentation from them!

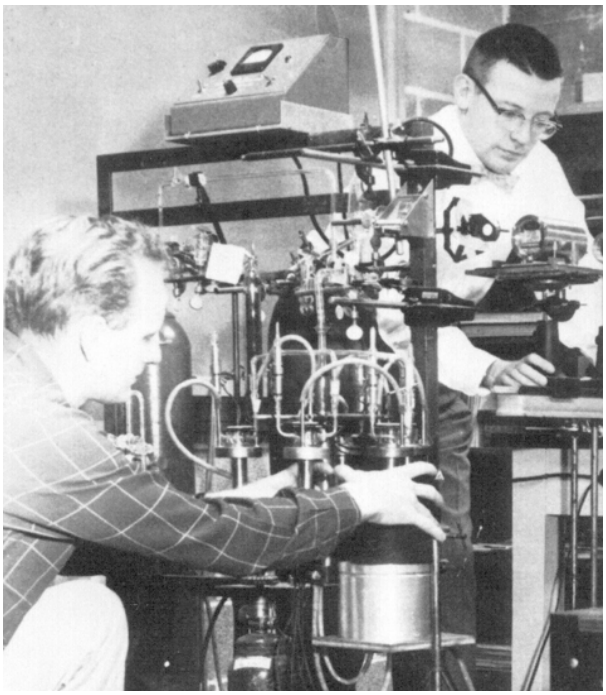


Figure 7: Ray Hughes's first experiment at the University of Arkansas. A Fabry-Perot interferometer and a Littrow Spectrograph were used to study isotope shifts in atomic spectra. Dr. Hughes (right) is working with graduate student Ted Donaldson. Photo from a Physics Department student recruiting brochure, circa 1956.

Even though there frequently was a critical need to hire more faculty to adequately staff the teaching as well as develop the doctoral program, there was a sincere effort only to fill the positions with physics faculty of promise. Sharrah tells how the teaching assignments were very much on the increase after the Korean War and the department didn't know how it would teach all the classes one January.

During the first ten years or so of the initiation of the PhD program, the department hired, in fairly rapid sequence, Glen Clayton (1958), Otto Zinke (1959), Stephen M. Day (1961), Charles Jones (1962), Arthur S. Hobson (1964), Charles Richardson (1966), Richard Anderson (1966), Fui Chan (1969), and Michael Lieber (1970). Most of these individuals have made a lifelong commitment to this department.

Again, Sharrah in History1: "Interestingly enough, most of the above individuals were employed as a result of information obtained through other contacts not directly related to the



Figure 8: A 150-KeV proton accelerator built by Hughes (center) and his students. It was used for atomic collision studies in the 1960s. Photo from a Physics Department student recruiting brochure of that period.

[4] The chairman at that time was Paul Sharrah.

APS placement service. S. M. Day, for example, applied from Rice University after Sharrah, almost belligerently on the telephone, asked the head of physics there, Prof. Bonner, if they produced any physics PhDs with an interest in and appreciation of teaching!"

The department had not decided to focus on any particular areas of research to expand into. Zinke had worked in nuclear physics and Auger electron spectroscopy at Washington University in St. Louis, Missouri, where he received his PhD in 1956. He had also worked on the separation of gases, particularly nitrogen and carbon dioxide, at Linde PLC (part of Union Carbide). At the University of Arkansas, he initiated and developed the time-of-flight technique for measuring the temperature of pulsed plasmas. He and his students were able to measure million-degree temperatures developed by plasmas produced by exploding gold wires and to explain through evidence the mechanism which produced such high temperatures. Glen Clayton was an undergraduate and graduate student at the University of Arkansas and received his PhD from the University of Missouri. He initially collaborated with Paul Sharrah and Robert Kruh (Chemistry Department) on x-ray diffraction from liquid surfaces. Later, he worked independently on x-ray diffraction of liquefied noble gases, funded by the NSF. Clayton resigned in 1972 to accept an administrative position at Stephen F. Austin State University in Texas. Charles Jones had received his PhD from Texas A&M University. His field was molecular spectroscopy. He resigned in 1970 to join East Texas State University as head of the department. Stephen Day came here from Rice University, as mentioned above, and his area of research was nuclear magnetic resonance (NMR) in solids. He set up a very promising laboratory for NMR here and one of his first experiments was on pulsed NMR on cesium fluoride.

Day has described the next few hires as follows:[5]

> The four experimentalists, Ray Hughes, Bud Zinke, Glen Clayton and myself were highly motivated to build the research programs into ones that were as strong as the ones we received

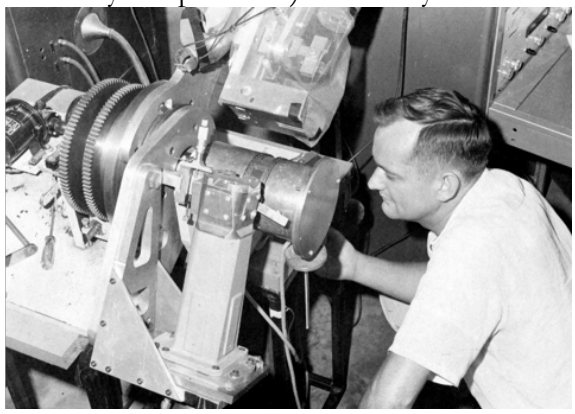


Figure 9: Glen Clayton working with the x-ray machine for study of liquified noble gases. ***Photo archived in the Physics Department. Undated.***

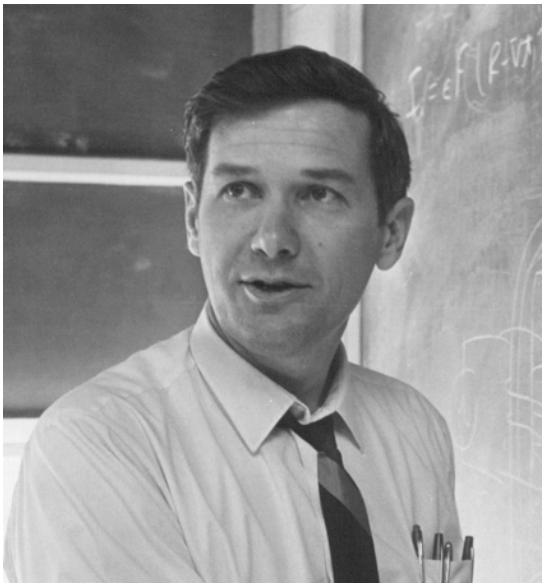


Figure 10: Otto Zinke, circa 1967. ***Photo archived in the Physics Department.***

[5] At our request, in 2009 Day provided a written account of his reminiscences of his early years at the university. Part of these reminiscences are reproduced in chapter 14. The complete document, on a CD, is in the Physics Archives.

our degrees from. It became very clear to the university administration that the department had a very bright future and it deserved exceptional budgetary support. The result was that five new faculty members were added to the department in a few years. As you can imagine this led to considerable discussion as to the research areas that should be emphasized in our recruiting and appointments. At times the discussions were heated but never acrimonious. I should say at this point we were a very democratically operated department. We decided we needed an additional theorist to Herman Schwartz and consequently Art Hobson was appointed. Next we chose to compliment Ray Hughes's success in atomic and molecular physics with three appointments in one year — namely Richard Anderson, Charles Richardson and Bill Plummer, a theorist in atomic physics. Bill's wife, Pat, also a theorist, joined the Chemistry Department on a postdoctoral appointment. Unfortunately, we lost our new theorist because the chemistry department would not give his wife a tenure-track appointment which she well deserved. F. T. Chan was appointed to fulfill our need for a theorist.

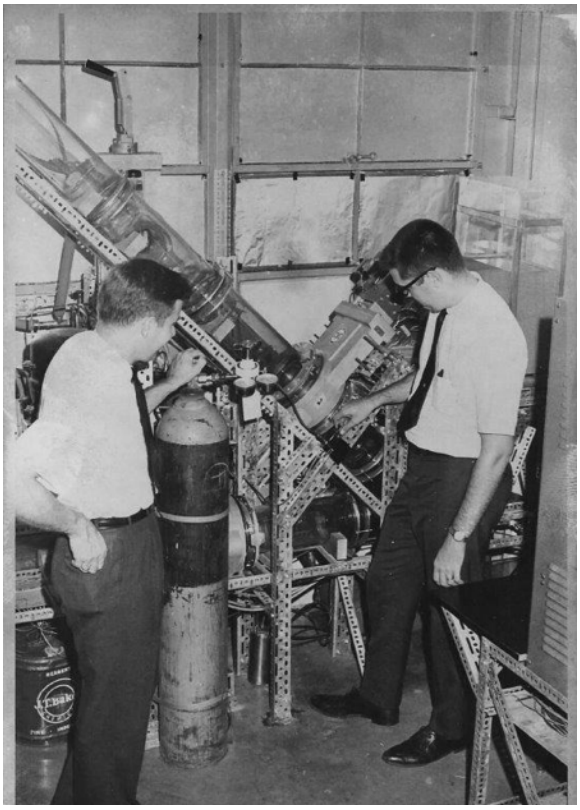


Figure 11: Zinke lab, circa 1968. This apparatus was used in a time-of-flight analysis of the positive-ion temperature of pulsed plasmas. Professor Zinke's group pioneered this technique at the University of Arkansas. Dr. Zinke is on the left and on the right is graduate student David P. Ross. *Photo courtesy of Professor Zinke.*



Figure 12: Stephen Day in his nuclear magnet resonance laboratory, circa 1980. *Photo archived in the Physics Department.*



Figure 13: Charles Jones. *Photo archived in the Physics Department, circa 1970.*

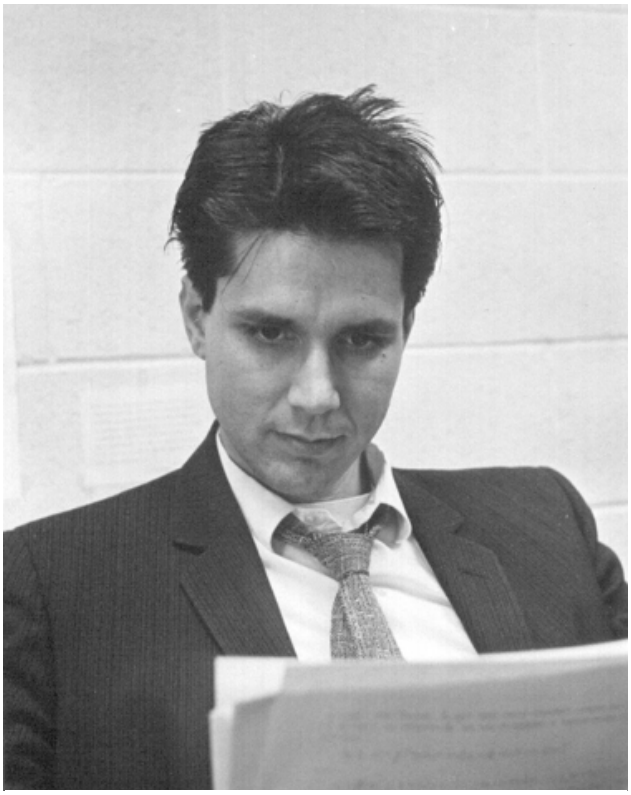


Figure 14: Art Hobson, circa 1967. ***Photo archived in the Physics Department.***



Figure 15: Charles Richardson, circa 1967. ***Photo archived in the Physics Department.***



Figure 16: Charles Richardson in his laboratory. This apparatus was used to study dynamics and light-scattering properties of microscopic levitated particles. ***Photo archived in the Physics Department, circa 1980s.***



Figure 17: Richard Anderson. ***Photo archived in the Physics Department. Undated.***

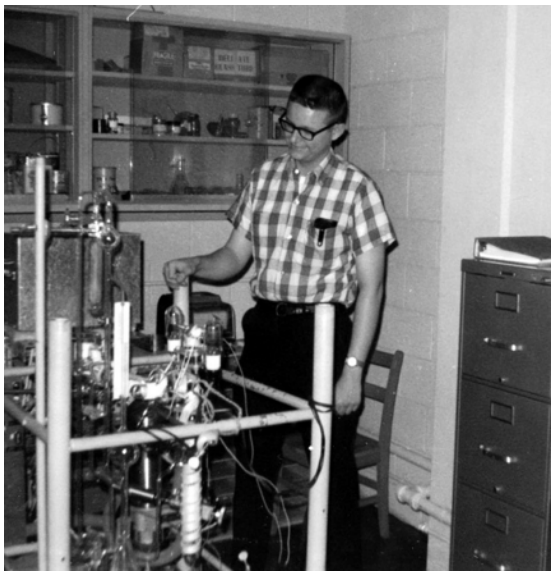


Figure 18: Charles Simpson in Anderson's lab filling a cold trap with dry ice for atomic collision experiments with cadmium, 1968. ***Photo courtesy of Mr. Simpson (BS, 1967).***



Figure 19: F. T. Chan. ***Photo archived in the Physics Department. Undated.***

Art Hobson had received his PhD from Kansas State University in 1964 in theoretical physics in the field of statistical mechanics. At the University of Arkansas, supported by two grants from the National Science Foundation, his research focused on applying the concepts and methods of the developing field of information theory to problems in theoretical statistical mechanics.

Charles Richardson received his PhD from the University of Pittsburgh, and his dissertation research used nuclear quadrupole resonance to study the structural phase change (second order) in chloranil. Thereafter he was a research assistant professor at the University of Washington and worked with Hans Dehmelt (Nobel Prize, 1989) where he detected the first magnetic resonance in the hydrogen molecule ion confined to an ion trap. He joined our department in 1966. He constructed an ion trap to study the HD+ molecule and later set up a separate experiment to measure Lamb shift in the n=3 state of deuterium. Both experiments remain unpublished. In the 1980s, he used the ion-trap technique to trap microscopic particles and perform novel experiments.

In the same year as Richardson (1966), Richard Anderson, who had just received a PhD from the University of Oklahoma, was hired. His area of research was also atomic physics. After joining our department, he collaborated with Ray Hughes on atomic lifetime measurements, in addition to conducting his independent research.

F. T. Chan, an atomic physics theorist, joined the department in 1969. He had received his PhD from the University of California, San Diego in 1967 working under Keith Brueckner and had spent the next two years as a postdoc at Cornell University. He started theoretical studies of atomic collision physics.

The department's theoretical physics was further strengthened when Michael Lieber joined the department in 1970. He had performed graduate work under Julian Schwinger (Nobel Prize, 1965) at Harvard University. He came to us after having done postdoctoral work at New York University. His fields of research were quantum electrodynamics and scattering theory, the latter with application to atomic collisions.

All of the new faculty hired during this era

brought an extraordinary amount of vitality to the department. Most of the research in the 1960s was externally funded, mostly by the NSF, and the mood among faculty was upbeat.[6] In the 1968–69 academic year, six of the faculty were externally funded out of a faculty of ten[7], two of whom were very new (Richardson and Anderson), only having joined the department in 1966, and had not had a chance to establish their research. Apparently the peak level of external funding came in 1965, and by 1969–70, funding had already dropped to about 50 percent of the 1965 level.[8] The vitality of the department in this ten-year period, 1963–72, is reflected in the number of graduate degrees awarded: fifty MS and twenty-six PhDs.[9] Day further recounts in his reminiscences:

> During this period we had a good balance between research and teaching but it was clear that enrollment was going to be a major factor in getting additional faculty positions and teaching assistantships. About this time the Mathematics Department relinquished the teaching of astronomy to us. They had been teaching celestial mechanics for years and Paul Sharrah thought that we should offer the astronomy courses including observational laboratories. . . .
>
> Professor Sharrah immersed himself into building the astronomy courses and observational laboratories which he did with considerable success. At this point the physics faculty agreed it was time to appoint an astronomer which we did with Carol Webb from the University of Texas.

Carol Webb was the first astronomer to be hired and came here initially as an instructor in 1972, having done graduate work at the University of Texas. She left the university in 1980. The resignation of Glen Clayton in 1972 offered the department an opportunity to hire a new faculty member. Donald O. Pederson, a solid-state physics experimentalist, was hired. He had obtained his PhD at Rice University and had done postdoctoral work at Texas Tech University. We were able to hire Pederson through a personal contact of Professor Day



Figure 20: Michael Lieber. ***Photo archived in the Physics Department. Undated.***



Figure 21: Donald Pederson. ***Photo courtesy of Don Pederson, circa 1977.***

[6] See reminiscences of Zinke in chapter 14.
[7] *1968–69 Annual Report* of the department. Unfortunately, 1957–1968 reports are not available.
[8] *1969–70 Annual Report* of the department.
[9] Data on graduate degrees awarded is available in chapter 7 on graduate degree programs.

with Pederson's postdoctoral mentor, Professor Marshall, at an APS meeting. He initiated research on ultrasonic velocity and attenuation measurements in superionic conductors. He became chairman of the department (1978–83), followed by many high administrative positions within the university.

It must be kept in mind that the 1960s and early 1970s was the period when the department began to move away from focusing almost entirely on undergraduate education to a more balanced focus on both undergraduate education and graduate education and research. From 1963 to 72, ninety bachelor's degrees were awarded (see chapter 6). Teaching loads were very high, as the department valued small classes. Day states: "In my first few years even the research-oriented faculty were teaching around 24 to 28 semester hours per academic year. We had not yet gone to the larger enrollment sections so we had only 30 to 35 students in the elementary physics classes." Otto Zinke states:[10] "During those early years, Glen and I had teaching schedules of 13 or more hours, and during several semesters I also had an additional six hours of supported research. We were pretty busy." Moreover, the department took over the teaching of astronomy in 1967 as well as operation of the planetarium,[11] and Paul Sharrah was running summer institutes in modern physics in the 1960s, jointly funded by Atomic Energy Commission and the National Science Foundation. This typically involved several members of the faculty (see chapter 13).

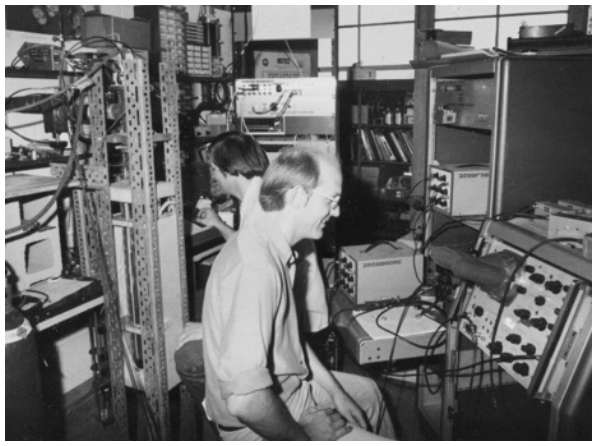


Figure 22: Donald Pederson in his laboratory. Graduate student John Brewer is in the rear. ***Photo archived in the Physics Department, circa 1978.***

Starting in the early 1970s, external funding started drying up along with the supply of graduate students. On the other hand, it became easy to hire faculty as recent PhDs seeking faculty positions flooded the market. After the Soviet launch of Sputnik in 1957, there was a realization that the United States was behind not only in space exploration but also in its emphasis on science education and research. Therefore, the US government had decided to make massive investments in this area. As obtaining external funding became easy, there was a massive expansion in graduate programs across the country. As the 1970s started, the external funding could not keep up with the expanded graduate programs. The expansion slowed down, and recent PhDs had difficulty finding jobs, which adversely affected the supply of graduate students. Our department was directly affected by these national trends. By the 1974–75 academic year, the department only had three grants[12] (two NSF and one NASA), while the faculty had expanded to thirteen. By 1978, only one active grant remained, and there were only sixteen graduate assistantships (teaching plus research). The department had difficulty filling even these sixteen positions and often had to seek graduate students from other departments to fill the available positions.

[10] See reminiscences of Zinke in chapter 14.
[11] More about the astronomy program can be found in chapter 8.
[12] *1974–75 Annual Report* of the department.

B. Development of a Program in Quantum Optics: 1975–85

In 1974, the department was in a position to hire a new faculty member. A decision was made to expand in areas related to lasers. Richardson recalls how this decision was made: "In the early '70s we had a faculty meeting to decide what area our next hire was to be in." He goes on: "I'm going to recall how our discussion went. It may not be too late to approve the minutes. I made a pitch for someone in Lasers, with three arguments. One, the field was close to atomic physics. Two, the field was new and so should be fruitful. And, three, it was cheap to start up. The faculty approved and we hired Greg, Raj, Suren, Peter Milonni, Howard Carmichael, Min Xiao."

The first faculty member to be hired in this area was Gregory Salamo, and he started in January 1975. He had received his PhD from City University of New York, having done dissertation research at the Bell Laboratories with Hyatt Gibbs. He had done postdoctoral work at the University of Rochester in the area of quantum optics under Leonard Mandel. At the University of Arkansas, he set up a laboratory for work on laser physics and quantum optics. Specifically, he started work on self-induced propagation of picosecond pulses and AC stark effect using a continuous train of optical pulses. Salamo turned out be a crucial player in determining the direction of future research in this department.

The next person to be hired was Rajendra Gupta, an experimentalist in the area of atomic spectroscopy. He joined the department in 1978. He had received his PhD from Boston University in 1970 and had spent the previous eight years at Columbia University in New York, the first four as a postdoc and the next four as an assistant professor in the research group of William Happer. At the University of Arkansas, he set up a laboratory for atomic, molecular, and applied laser spectroscopy and started work on the high-resolution spectroscopy of silver atoms and the application of photoacoustic



Figure 23: Gregory Salamo. ***Photo archived in the Physics Department, circa 1980.***

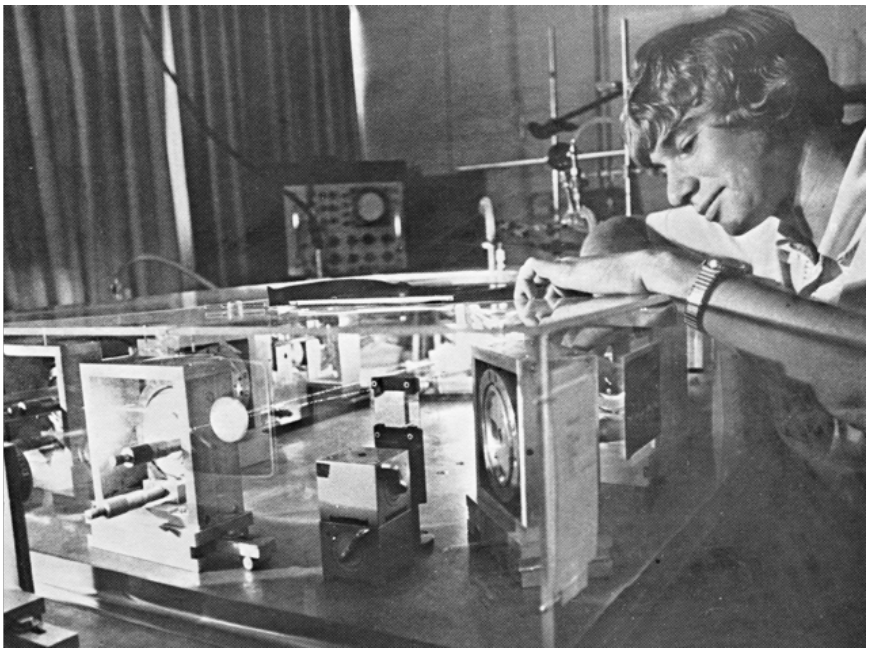


Figure 24: Gregory Salamo's quantum optics laboratory, circa 1980. On the right is graduate student Paul Breaux. Photo from a Physics Department's graduate student recruiting booklet, circa 1980.

spectroscopy to combustion diagnostics.

Meanwhile, Carol Webb resigned in 1980 and was replaced by Claud Lacy. Lacy had received his PhD in astronomy from the University of Texas at Austin in 1978. His area of research was on eclipsing binary stars, which he continued at the University of Arkansas. He was granted observing times for this research at McDonald Observatory in Texas and Kitt Peak National Observatory in Arizona, among others. More about astronomy research can be found in chapter 8.

As was stated earlier, the 1970s was the period when the department had started putting greater emphasis on graduate research. The existing teaching loads were simply incompatible with the time needed for research. At some point, introductory classes were consolidated into large sections, and teaching loads were reduced. When the junior author of this history joined the department in 1978, a teaching load of three courses per year was standard for research-active faculty.[13] A dramatic turnaround took place in 1980. The number of grants increased from just one in 1978 to eleven in 1980 (with a total faculty of thirteen). Almost everyone was funded. Multi-year awards (generally three years) totaled $1.086 million, plus $58,000 university matching.[14] At the same time, the graduate student situation turned around and the number of funded



Figure 25: Rajendra Gupta. ***Photo archived in the Physics Department, circa 1985.***

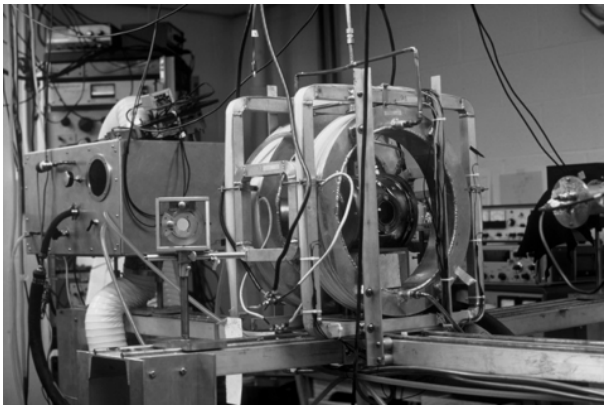


Figure 26: Apparatus for spectroscopy of silver atoms in the laser spectroscopy lab. This apparatus was built by graduate student Mahmood Soltanolkotabi. ***Photo by Rajendra Gupta, circa 1981.***

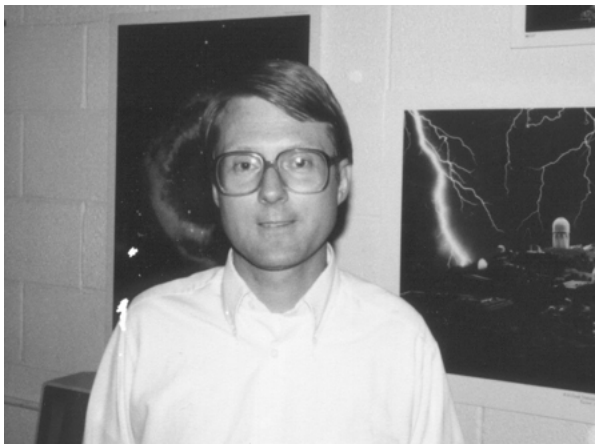


Figure 27: Claud Lacy. ***Photo archived in the Physics Department, circa 1985.***

[13]In the mid-1990s, Chair Singh was able to further reduce the teaching loads to one course per semester, on par with other research-active departments in the nation.

[14] This includes two NSF-EPSCoR grants: one awarded to physics with Salamo as PI and Gupta as Co-PI in the amount of $398,000, and one awarded to mathematical sciences with a physics component (Chan and Lieber) of $65,000. EPSCoR stands for Experimental Program to Stimulate Competitive Research. Source of information: Graduate student recruiting booklet, 1980 (a copy of this booklet may be found in the Physics Archives).

graduate students rose from sixteen in 1978 to thirty in 1981,[15] and all of these positions were filled. Details of this successful effort are given in chapter 7, section E. This was to result in an increased number of PhDs granted down the line. The number of PhD degrees granted by the department in the five-year period 1983–87 increased to eighteen from just six in the previous five-year period of 1978–82. At the same time, this increase resulted in a decrease in the master's degrees granted to eleven from nineteen during the same periods.[16]



Figure 28: Peter Milonni. ***Photo archived in the Physics Department, circa 1985.***

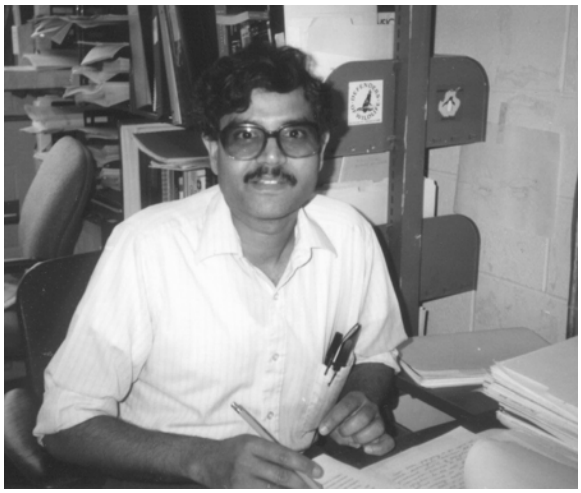


Figure 29: Surendra Singh. ***Photo archived in the Physics Department, circa 1985.***

The department was on the march and never looked back.

Greg Salamo was an enthusiastic advocate of further expansion in the area of quantum optics. With support from the faculty and under the leadership of Chairman Pederson, the department set out to recruit several promising physicists in the area of quantum optics. Three people were hired over a four-year period: Peter Milonni in 1980, Surendra Singh in 1982, and Howard Carmichael in 1983. Milonni, a theorist, had already established a reputation in the field of quantum optics. Singh, a fresh PhD under Leonard Mandel at the University of Rochester, had an impressive record of publications, several of them even independent of his advisor. Although he was an experimentalist, he performed theoretical work with equal facility. Carmichael, a theorist, had also established a reputation in the quantum optics community. Together they represented an impressive group in quantum optics. Milonni's work was in the general area of obtaining a better understanding of the quantum-mechanical nature of the electromagnetic field. Singh established a laboratory to study quantum noise and nonlinear dynamics in lasers and nonlinear optical processes. Carmichael started his work at Arkansas on the study of nonclassical quantum-statistical effects such as photon antibunching and squeezing, and in the general area of quantum theory of dissipative nonlinear optical systems.

The department started gaining a national reputation in quantum optics. With the optics group well established, the department decided to diversify somewhat and hired Larry Merkle in

[15] Annual reports of the department from 1978–79 and 1981–82.
[16] See chapter 7.

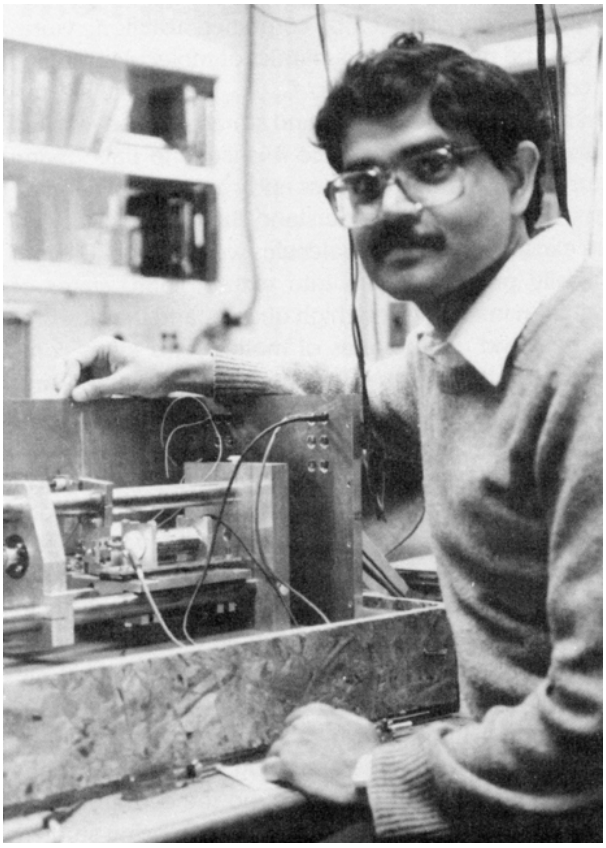


Figure 30: Surendra Singh in his laboratory, circa 1985. Photo from the Physics department graduate student recruiting booklet, 1986–87.

the area of optical properties of solids in 1983. Merkle left the department in 1988.

Peter Milonni went on an extended leave to Los Alamos National Laboratory, with occasional visits back to the department. William Harter, who was on the faculty of the Georgia Institute of Technology, was hired to fill Milonni's slot in 1985. His area was the theoretical study of molecular structure, dynamics, and spectroscopy. Specifically, he was developing new methods for the understanding of rotational and vibrational dynamics of atoms and polyatomic molecules in the presence of laser radiation.

With seven new faculty members added over a decade (1974–1985), the department received

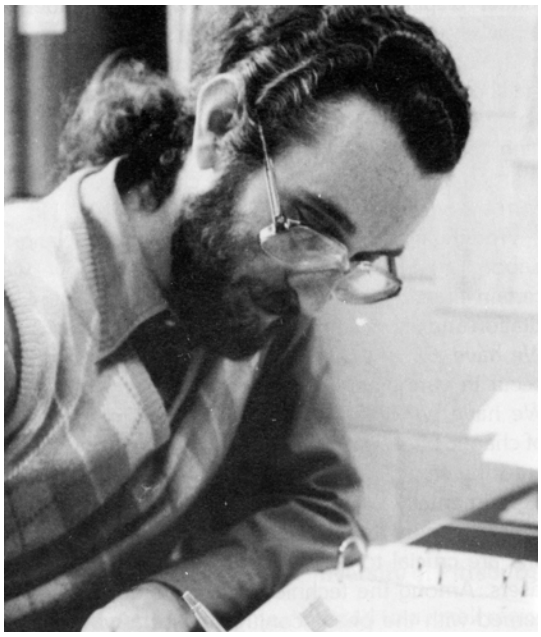


Figure 31: Howard Carmichael, circa 1985. Photo from the Physics Department graduate student recruiting booklet, 1986–87.

new vitality. In particular, four of the new members were in quantum optics. The external funding continued to be strong: In the 1984–85 academic year, there were fourteen active grants totaling about $950,000, excluding NSF-EPSCoR and University matching on grants, and there were twenty-seven publications dated to 1984.[17]

C. Breakthrough in Superconductivity and Rebuilding of the Quantum Optics Program: 1985–1995

Donald Pederson, who had been the chairman of the department since 1978, stepped up to become the associate dean of Fulbright College in 1983. The dean of the college then decided to conduct a national search for a new chair. While the search was ongoing, Michael Lieber served as the chair. As a result of the search, Allen Hermann was appointed as the new chair starting in 1986. Hermann, a condensed matter physicist, was a group leader at Jet Propulsion Laboratory,

[17] *1984–85 Annual Report* of the department.

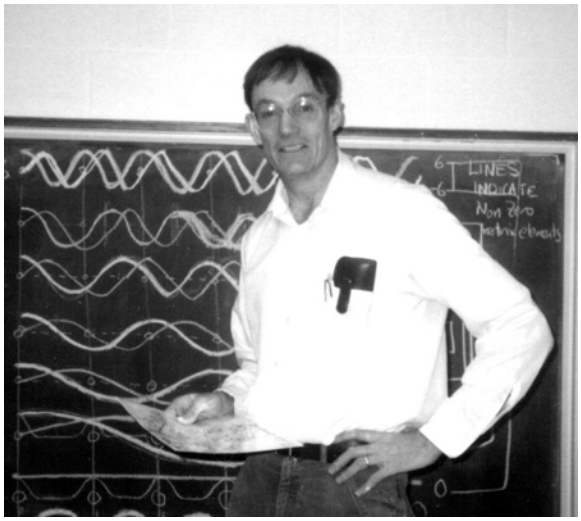


Figure 32: William Harter, circa 1987. ***Photo archived in the Physics Department.***

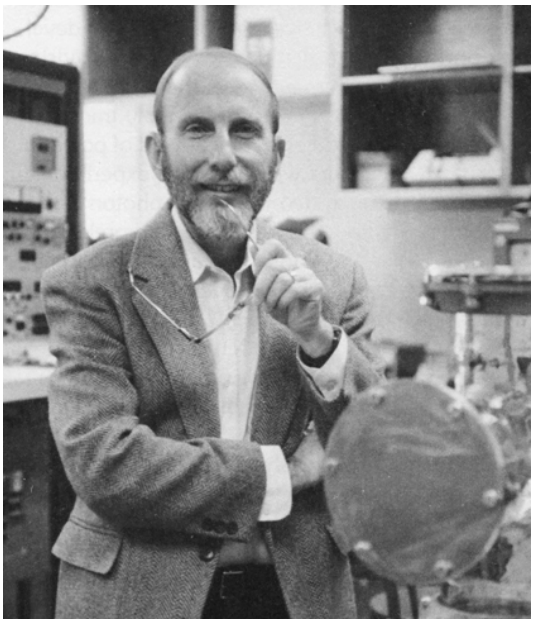


Figure 33: Allen Hermann, circa 1988. Photo from the Physics Department graduate recruiting booklet, 1988.

and earlier had been on the faculty of Tulane University.

Shortly after Hermann joined the department, high-temperature superconductivity was discovered by Müller and Bednorz, and Hermann became interested in it. He learned of Zhengzhi Sheng, who had recently received a PhD in chemistry under Paul Karoda and who was also interested in high-temperature superconductivity. Hermann hired Sheng as a postdoc. Sheng, working in Hermann's laboratory, discovered a thallium-based superconductor[18] with a critical temperature of 125 K,

[18] There is an interesting story behind the discovery of this compound, as told by Professor Julia (née Smith) Kennifick, who was an undergraduate student in this department and was involved in this research. She recalls:

> In the fall of 1987, my junior year in college, I began working with Dr. Allen Hermann (along with fellow undergraduate student Dan Viar) in his newly state funded superconductor labs. Viar and I were both assistants to Dr. Z. Z. Sheng, and our main duty to begin with was making samples according to Dr. Sheng's specifications. One day, I don't remember the exact date, Dr. Sheng came into our work room down the western hallway and he was very excited. He wanted to have a look at both of our notebooks. You see, Viar and I had been asked to make identical samples, which was the practice, but mine had superconducted and Viar's had not. Sheng therefore wanted to know what the difference was in what we had done. As it turned out, Sheng had written a formula that he had not intended in my notebook for me to make, a formula different from what he had written in Viar's notebook which was what he intended to write in mine. I don't remember the exact form of the difference between the two, and I believe Dr. Sheng kept our notebooks! The sample that I made turned out to be a record breaker for high-temp superconductors. I remember that Sheng just smiled and laughed. And after that he was always happy to have me work in his lab, even when he would not let other undergraduates enter. And he made sure that both Viar and I were included as authors on the published paper. During my senior year, I continued to work with Dr. Hermann, mainly on creating thin films from the newly discovered materials. We published a short paper on identifying the superconducting structures in the thin films.
>
> Reference: New 120 K Tl-Ca-Ba-Cu-O superconductor, Z. Z. Sheng, W. Kiehl, J. Bennett, A. El Ali, D. Marsh, G. D. Mooney, F.



Figure 34: The photograph shows the then-governor Bill Clinton (center) and Professor Sheng (right) watching levitation of a magnet above a superconductor. Professor Richard Anderson is demonstrating the levitation, and his hand and face are partially visible in the photograph. *Photo archived in the Physics Department, circa 1988.*

which was the highest-temperature superconductor known at that time and remained so until 1994.

This discovery, and Hermann's skills in public relations, brought enormous publicity to Hermann, Sheng, the department, and the university. The discovery of the Tl-superconductor was covered by popular press (sometimes more than once) such as the *New York Times, Wall Street Journal, Newsweek*, and in science journals such as *Science* and *Nature*, science magazines such as *Science News, Physics Today*, and *Chemical and Engineering News*. The discovery received extensive coverage in Arkansas media, radio, television, and newspapers. The initial discovery and the subsequent work continued to attract extensive media coverage, and Governor Clinton awarded a special grant of one million dollars to Hermann and Sheng to continue the work. They became something of folk heroes in the local media. Eventually, over twenty patents were awarded for this work, and some of the patents were licensed by the university for over one million dollars to Superconductor Technologies, Inc. Hermann left the department in 1989 to move to the University of Colorado. Sheng was appointed a research professor in the department and continued research on high-Tc superconductors. Sheng left the department in 1999. Detailed information on the superconductivity research at Arkansas is presented in appendix VI.

Larry Merkle resigned to accept a position at a Department of Defense laboratory in 1988. His resignation created a vacancy. At that time, we realized that we needed a dedicated person to devote full-time to undergraduate affairs. To some extent, Larry was doing this job, but his time was divided between these activities, research, and teaching. To this end, Urbano Oseguera was hired. He had obtained his PhD in theoretical high-energy physics at Boston University and had been on the faculty of the University of Mexico, Mexico City for the past twenty or so years. His charge was to develop new experiments and update antiquated equipment in the introductory physics laboratories, develop new laboratory manuals,

Arammash, J. Smith, D. Viar, and A. M. Hermann. Citation: *Appl. Phys. Lett.* 52, 1738 (1988)."

and develop relationships with the high school physics teachers in the state to facilitate recruitment of physics majors. However, Oseguera's tenure here was relatively short lived as he left the department around 1994.

While all eyes were focused on super-conductivity research, serious problems were beginning to develop in the Physics Department. Its once well-known optics program was crumbling. Peter Milonni, who had been on leave at Los Alamos National Lab, resigned from his position in the department. Carmichael resigned to join the University of Oregon, and the department was afraid that Singh would follow suit. Salamo had been on leave at a DOD laboratory, and it was not clear if he was going to return. Anderson resigned to join the NSF, and Hughes was due to retire in 1990. Unless new people were hired, the faculty was going to be reduced to ten. The department was finding it hard to recruit graduate students, and almost all new graduate students to join the department in 1988 and 1989 were from China.

Against this background, Gupta was appointed the new chair in May 1989. The dean promised him that he would be allowed to fill five faculty positions over the next three-year period and that necessary support would be provided for the department to rebuild itself. This turned out to be easier said than done. There was almost no money to provide start-up funds to the new faculty.

Therefore, two theorists were hired first, both in the area of quantum optics. Reeta Vyas joined the faculty ranks in the fall of 1989, followed by Julio Gea-Banacloche in January 1990. Vyas had obtained a PhD in nuclear theory from the State University of New York at Buffalo and was already living in Fayetteville, having married Surendra Singh, and had been doing some teaching in the department on a temporary basis. While in Fayetteville, she had changed her field to quantum optics theory and had already published papers in her new field. She continued her studies of the quantum statistical properties of light generated in nonlinear optical processes. Gea-Banacloche had obtained a PhD from the University of New Mexico under Marlan Scully and had done postdoc work at the Max-Planck-Institut für Quantenoptik in Munich. He had most recently been a staff researcher at the Instituto de Óptica, Consejo Superior de Investigaciones Científicas in Madrid. He started his work at the University of Arkansas with the



Figure 35: Reeta Vyas. ***Photo archived in the Physics Department, circa 1989.***



Figure 36: Julio Gea-Banacloche, circa 1991. ***Photo archived in the Physics Department.***

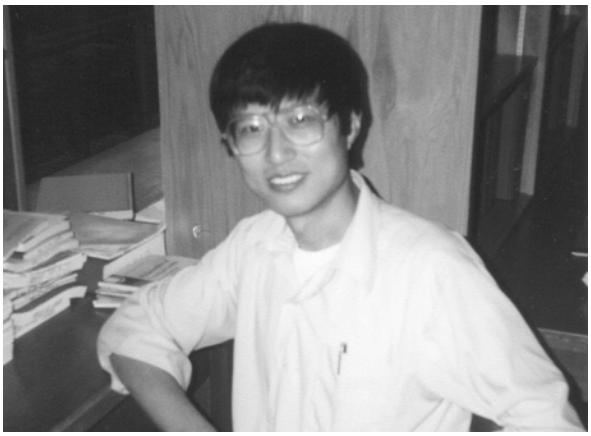


Figure 37: Min Xiao, circa 1991. ***Photo archived in the Physics Department.***

study of classical-quantum correspondence and how it might or might not apply to the case of radiation interacting with a single atom in a strong coupling regime.

The next task was to hire an experimentalist in the area of quantum optics. This task was much more difficult because the dean had no money to provide the needed start-up funds. After much persuasion on Gupta's part, the dean finally agreed to let the department hire a faculty member on the condition that Gupta was not going to ask him for any start-up money. The department was able to put together a package of $40,000 from the department's RIF account (see chapter 12) and was also able to get him an additional $35,000 from the graduate school. [19] Having secured these start-up funds, the department was able to hire Min Xiao, who had received a PhD under Jeff Kimble at the University of Texas at Austin and had done postdoctoral work at MIT. He joined the department in the fall of 1990. He set up a laboratory to work on quantum and nonlinear optics. Xiao was an experimentalist who was also equally adept at theoretical research. His initial work at Arkansas was on two fronts: theoretical studies of interactions between quantum states of light and atomic media; and experimental research using continuous wave diode lasers interacting with multilevel atomic systems to demonstrate electromagnetically induced transparency and related phenomena.

Meanwhile, Dr. Salamo returned from Washington in 1989. With five faculty members in quantum optics (Salamo, Singh, Vyas, Gea-Banacloche, and Xiao) and one in laser spectroscopy (Gupta), the faculty decided to next build a secondary area of concentration:

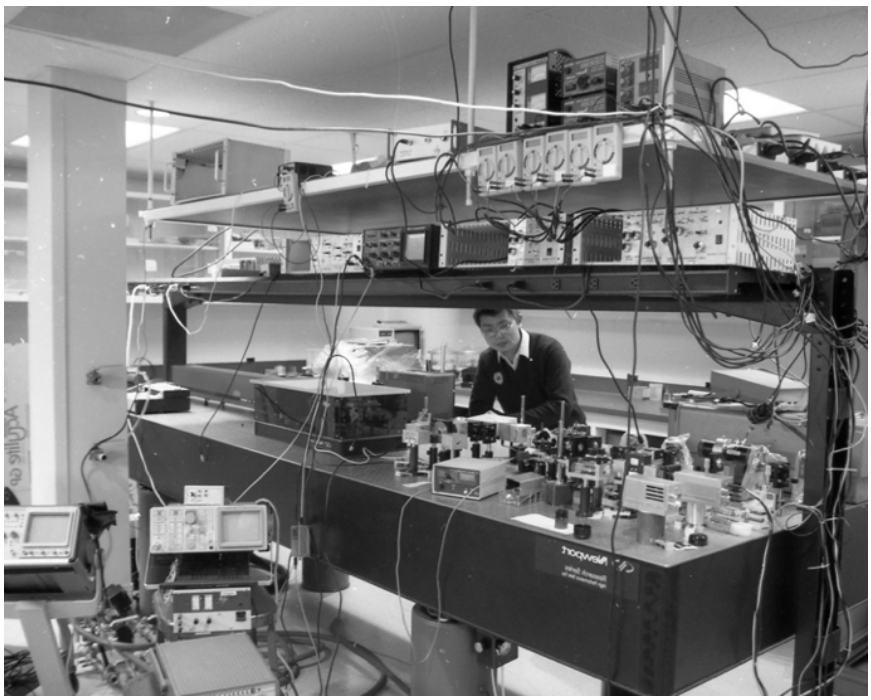


Figure 38: Min Xiao's laboratory for research in quantum and nonlinear optics, circa 1995. ***Photo by Rajendra Gupta.***

[19] Collis Geren had recently become the dean of the Graduate School. He was a chemist and understood the need for start-up funds.

condensed matter physics. However, due to the lack of funds, it was difficult to get authority to fill the next two positions that the dean had promised in 1989. Finally, we were able to fill these positions in 1992 and 1994 with two condensed matter experimentalists, William Oliver III and Mark Filipkowski. We were able to put together start-up packages of about $145,000 for Oliver and about $200,000 for Filipkowski by using a combination of funds from the dean of the College of Arts and Sciences, the graduate school, and the departmental RIF. These were the largest start-up packages that we had been able to offer up to that point in time.

Oliver joined the department in 1992. He had obtained a PhD at the University of Colorado and had done postdoctoral work at Arizona State University. He set up a laboratory to do fluorescence microscopy and Brillouin spectroscopy in condensed matter at very high pressures using diamond anvil cells. Our next faculty hire in 1994 was Filipkowsky, also in the area of condensed matter physics. Mark had obtained his PhD at the University of Connecticut and done postdoctoral work at the Naval Research Laboratory. Filipkowsky worked on setting up a laboratory to study novel magnetic materials through the use of techniques such as Superconducting Quantum Interference Device-based magnetometry and susceptometry and nuclear magnetic resonance. He left the department in circa 2002, and our department abandoned this area of research.

The next position that was filled was in physics education. This was not a planned area of growth for the department, however, this position came about somewhat fortuitously. Because of the special nature of this position, some space will be devoted to events leading up to it.

In early 1993, the university administration made available to all departments, on a competitive basis, a certain number of new



Figure 39: William Oliver in his laboratory, circa 1994. ***Photo archived in the Physics Department.***

positions specifically for the purpose of improving undergraduate instruction at the introductory level. The departments were supposed to write proposals detailing how they proposed to achieve this goal. Certain conditions were attached to these positions: the teaching loads were required to be twelve-credit-hours per semester for each semester (fall and spring), and summers were to be devoted to research. Research was required, and faculty members were to be evaluated on performance in teaching, research and service, as usual. These faculty members were to be paid on a twelve-month basis, and the positions were non-tenure-track. This was a three-year experiment at the end of which funding expired, but deans could, if they considered the experiment to be successful, continue out of their own funds. These positions came to be known as 562 positions because $562,000 was the total amount of money that was available.

Chair Gupta was disinclined to compete for a position because of the requirement of high teaching loads coupled with the requirement of research, as well as because of the temporary nature of the position. However, he called a meeting of the chair's advisory committee to seek guidance. Greg Salamo argued for competing for



Figure 40: Gay Stewart, circa 1999. ***Photo by Rajendra Gupta.***

a position and volunteered to write the proposal. He did, and somewhat to Gupta's surprise, the proposal got funded. However, the underlying problem remained: how to make this experiment successful given the constraints on the position. Gupta came up with a solution: seek a candidate with interest in *research* in the area of physics education. In this case, the classroom itself would be the faculty member's research laboratory. Faculty agreed.

A search committee with Charles Richardson, Greg Salamo, Julio Gea-Banacloche, and Surendra Singh with Richardson as its chair was formed. The position was advertised in September 1993 with the following description: "The present class will be divided into sections of 30 students each and a new model of instruction integrating lecture and laboratory will be developed," and "Highest preference will be given to candidates who have a keen interest in pedagogical research and a record of teaching excellence." While the position was advertised as that of a limited three-year term, Gupta had been negotiating with the dean for several months to convert the position into one on tenure-track, arguing that no good candidates — in particular female and minority candidates, which the department and the college wished to hire — could be attracted without the position being on tenure-track. Moreover, he needed the dean to grant TELE funds for laboratory improvement for this laboratory-based instruction to succeed. The department also needed some flexibility in teaching assignments and evaluation of education research. By the time the position was offered to a candidate in March 1994, the dean had agreed and obtained Vice-Chancellor Pederson's consent. Dr. Gay Stewart, a recent PhD in high-energy physics from the University of Illinois at Urbana-Champaign who had shown a strong interest in doing exactly the work we needed, was hired. The position that was offered was on tenure-track as a twelve-month appointment. However, the position was to convert to a nine-month appointment with 80 percent of the salary after three years. Over the years to come, Gay not only reinvented the way University Physics was taught and developed new instructional materials for it, but also made crucial contributions to the recruitment and advising of physics majors. For a short period, her husband, John Stewart, was also appointed to the faculty and helped in this effort. John had also received his PhD at the University of Illinois at Urbana-Champaign. Both left for West Virginia University in 2014.

Our next hire was Michael Henry, who joined the department in the Fall of 1995. He had received his PhD at Alabama A&M University. He started a laboratory to study nonlinear optical materials for possible applications in photonic devices. He left the department in around 2002.

D. Quantum Materials and Biophysics: 1995–2008

In the mid-1990s, Professor Salamo received a large grant from NSF-EPSCoR for research on GaAs quantum dots, wires, and wells, among other things. This was the start of the department's shift in focus from quantum optics to quantum materials. This area of research is a

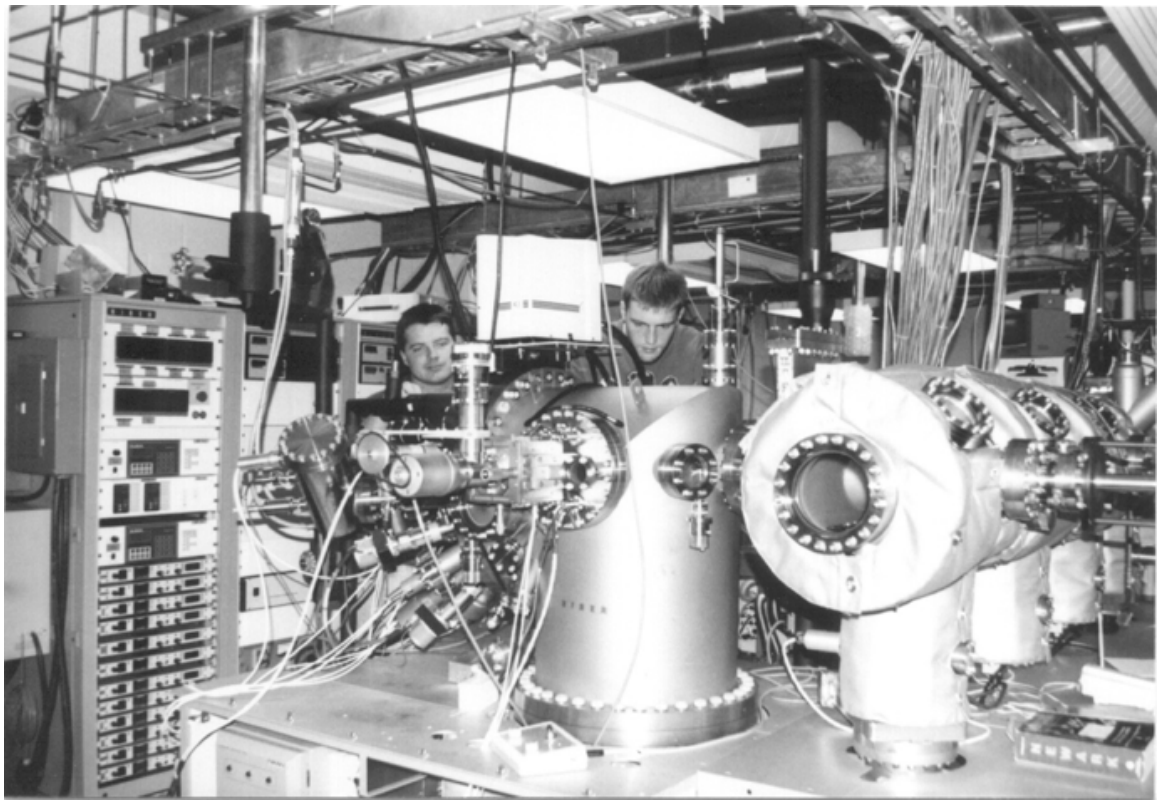


Figure 41: The molecular beam epitaxy facility in room 101 of the Physics Building, circa 1999.

subset of condensed matter physics that includes nanoscience. The work proposed in this grant required a molecular beam epitaxy (MBE) machine for producing nanoscale semiconductor structures. An MBE machine deposits materials epitaxially, atomic layer by atomic layer. The whole operation has to be carried out under very controlled conditions inside an ultra-high vacuum. This facility was set up with a cost of about a million dollars in room 101.

Because a faculty position was promised as part of the grant, a new faculty member with expertise in this area was hired to help set up this facility. Paul Thibado joined the department in 1996 after completing a PhD from the University of Pennsylvania and postdoctoral work at the Naval Research Laboratory. He and Salamo worked together to start this facility. The facility was unique in that it had a capability for in situ scanning tunneling microscopy (STM). Using this facility, they developed nanoscale materials and monolayer surfaces, which were analyzed by STM. The facility has led to very fruitful research programs in nanoscience on the campus.

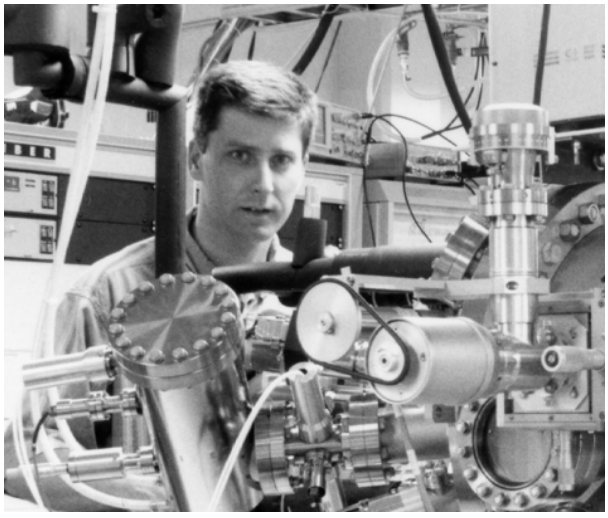


Figure 42: Paul Thibado with the MBE machine, circa 1999.

After just a couple years of research using this facility, Paul Thibado decided to set up his own



Figure 43: Paul Thibado with his new MBE machine, also in room 101 of the Physics Building after the old one was moved out to the nanoscience building. *Photo by Rajendra Gupta, 2019.*



Figure 44: Laurent Bellaiche, circa 1999.

independent research laboratory based on a combined MBE machine and a scanning tunneling microscope. His initial work using this new facility was on manganese-doped GaAs, and subsequently he has led a very successful program in the study of graphene.

Our next faculty appointment was in optics around 1999. Yujie Ding was hired as an associate professor. He had obtained a PhD at Johns Hopkins University and had been on the faculty of Bowling Green State University prior to coming to the University of Arkansas. Broadly speaking, his area of research was nonlinear optics. He left our department in 2002 to join Lehigh University.

Meanwhile, in 1998, a somewhat nontraditional appointment was made. Greg Salamo received a grant to start an interdisciplinary program which was named Microelectronics-Photonics (Micro-EP) Program. He selected Kenneth Vickers to initiate and lead this program. Vickers was a graduate of the university, having received both his BS (1976) and MS (1978) degrees here. For his MS thesis he had worked under the supervision of Don Pederson. He had worked at Texas Instruments, where most recently he was the engineering manager of IC wafer fabrication in Sherman, TX. He was appointed a research professor in physics in 1998 and led the Micro-EP program until his retirement in 2014. Details of the Micro-EP program are given in appendix VII.

At this point, the faculty decided to further strengthen the department in the area of quantum materials. Significant expansion of the department has taken place, with several new faculty being hired in this area. Laurent Bellaiche and Huaxiang Fu were hired, both in the area of computational condensed matter physics, in 1999 and 2002 respectively. Bellaiche had obtained his PhD from the Université de Paris VI (now part of Sorbonne Université), and came here after postdoc work at the University of Paris XI (under Karel Kunc), National Renewable Energy Laboratory in Colorado (under Alex Zunger), and Rutgers University (under David Vanderbilt). Huaxiang obtained his PhD at Fudan University in China, and came here after postdoc work at the National Renewable Energy Laboratory in Colorado and the Carnegie Institution for Science. Laurent Bellaiche started research at Arkansas by studying ferroelectrics and other materials by first-principle-based techniques and semiempirical computational

schemes. Bellaiche has developed a very large program in computational condensed matter physics. Fu's initial work focused on the study of unusual phase transitions in zero-dimensional ferroelectric nanodots and in one-dimensional ferroelectric nanowires. He also studied the electronic structures and optical properties of semiconductor nanostructures.

At this point, the department had successfully built up a very strong program in quantum materials. and had decidedly moved away from its core strength in quantum optics to that of quantum materials. At this point in time, Chair Singh wanted to develop a program in biophysics as the next area of growth. However, he asked Gregory Salamo to develop a strategic plan for further growth of the department. Salamo also suggested biophysics as the next area of growth, a recommendation with which the faculty concurred as well. In 2002, Jiali Li was hired. She had obtained her PhD from the City College of New York and had done postdoctoral work at Harvard University. She set up her laboratory, which included a facility to fabricate nanopores. She studied the properties of DNA and other biomolecules at the single molecule level by observing the change in electrical current as the molecules pass through the nanopores. She also studied the material and surface sciences involved in nanopore fabrication and nanopore technology development.

Further expansion in the area of quantum materials took place when Jacques "Jak" Tchakhalian joined the department in 2006. Tchakhalian had obtained his PhD from the University of British Columbia and had done postdoctoral work at the Max-Planck-Institut in Germany. He started up a laboratory to fabricate and characterize oxide interfaces, which are important in the understanding of strongly correlated systems. The fabrication was done by pulsed laser deposition, and a significant amount of the characterization was done in various laboratories around the world. We were unable to keep Tchakhalian, and he resigned in 2016 to join Rutgers University.

Consistent with the department's vision of building an area of strength in biophysics, Etan Gross was hired in 2006. He had obtained his PhD at Bar-Ilan University, Israel and came here after postdoctoral work at Case Western Reserve University and Cleveland Clinic. His area of research was the dynamics of neural networks. However, he left the university in 2011.

In 2007, the department made use of an



Figure 45: Huaxiang Fu. ***Photo by Rajendra Gupta, 2019.***

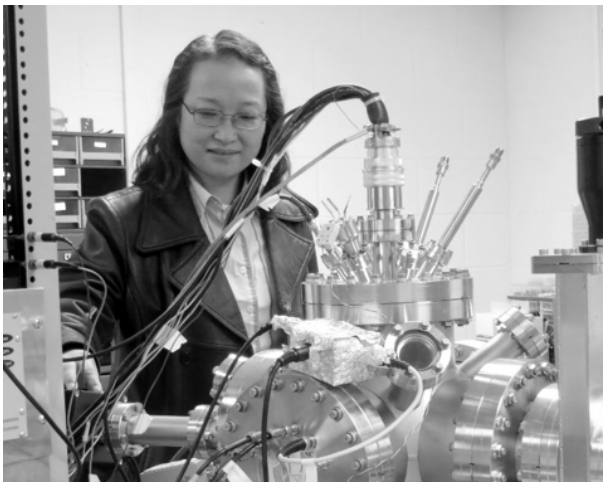


Figure 46: Jiali Li in her nanopore fabrication laboratory. ***Photo by Rajendra Gupta, 2019.***

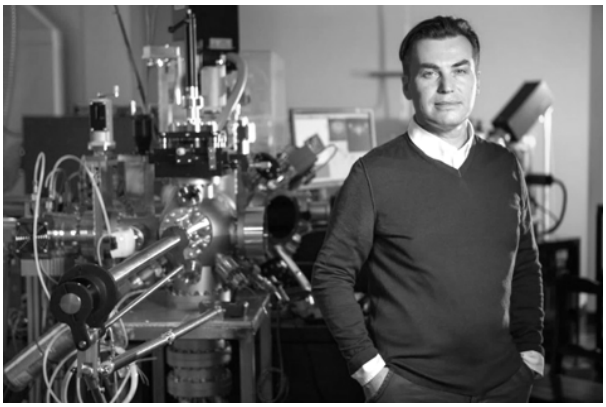


Figure 47: Jak Tchakhalian, in his laboratory. Photo from an October 2, 2014 University of Arkansas news item.

opportunity it had to expand the astronomy program. Julia Kennefick (née Smith), a native of Arkansas who had received her undergraduate degree at the University of Arkansas and PhD from Caltech before pursuing postdoc work at Ohio State University and Oxford University in England had returned to Fayetteville and had been doing some teaching for the department on a temporary basis. In 2007 she was hired as a tenure-track faculty member. Her research interests were in active galaxies, quasar luminosity function, black hole mass function, disk galaxy structure, and, most recently, exoplanet atmospheres.

By the department's centennial year, 2007–2008, the physics faculty had grown to twenty-one (including research professor Ken Vickers).

We end this section by a group picture of the centennial faculty. This picture was taken on the steps of the east entrance to Old Main on April 5, 2008, at conclusion of the department's centennial celebrations.

E. Research Infrastructure

The infrastructure required for research at the University of Arkansas was very slow to develop. Three examples are given below: building, support services, and start-up funds for experimentalists.



Figure 48: Julia Kennefick. ***Photo courtesy of Kennefick in circa 2009.***

As described in chapter 5, the Physics Building was totally unsuitable for modern research until it was entirely remodeled and renovated in 1994. To give just a few examples of the conditions, the windows were leaky, there was no insulation in the walls, and there was no air conditioning except for the few window units installed in selected rooms. Zinke, in his reminiscences (chapter 14) states that on one mild spring day in April, he and his students measured a swing in temperature of 12°C in his lab, while his experiment required temperature stability to a few tenths of a degree. When Salamo started his research at Arkansas, he needed an adequate water supply to cool argon-ion lasers. Such a water supply did not exist until chilled water was brought to the building in the early '80s. When Gupta started his research at Arkansas in 1978, he needed to exhaust toxic gases such as NO_2 out of the lab. No funds were available to install a proper exhaust system even though the research was externally funded and University officials had, as usual, certified that proper facilities would be provided for that research. Gupta and his students resorted to breaking a window panel and to exhaust the gases out of the opening.

Moreover, the building was extremely short of space. Gupta had to wait about eighteen months before he got adequate lab space, which even then had to be shared with two other faculty members. Singh did not even have an office of his own for about eighteen months after his hiring, until Steve Day resigned and vacated his office. Until that office became available, he was given a desk in the computer room, and even that room was shared with graduate students. Details of this and other examples may be found in chapter 5, section G.

The slow evolution of adequate support services is described in chapter 12. The



Figure 49: Physics Faculty in the centennial year. From left to right, front to back, Row 1: Associate Professor Huaxiang Fu, Professor Rajendra Gupta, Professor Julio Gea-Banacloche, Professor Reeta Vyas. Row 2: Assistant Professor Julia Kennefick, Assistant Professor Jacques Tchakhalian, Professor Laurent Bellaiche, Research Professor Kenneth Vickers, Associate Professor Jiali Li, Instructor Tamara Snyder, Laboratory Curator Stephen Skinner. Row 3: Professor William Harter, Associate Professor William Oliver, Professor Claud Lacy, Professor Michael Lieber, Professor and Chair Surendra Singh. Row 4: Professor Paul Thibado, Professor and Vice-Chancellor for Finance and Administration Donald Pederson, Distinguished Professor Min Xiao, Associate Professor Gay Stewart, Assistant Professor John Stewart, Distinguished Professor Gregory Salamo.

department did not have a full-time professional machinist until 1983 and lacked an electronics technician until around 2001.

The university's record for providing adequate start-up funds to new faculty in a timely manner was very poor. Zinke, hired in 1959, states that there were almost no funds to buy equipment. Day, hired in 1961, was given $500 to set up his NMR lab. Pederson, hired in 1972, was assigned a room to serve as a combination of office and lab and was given $750 to cover a partition, a blackboard, and a small amount for expendables. He states: "I borrowed equipment from others in the department and on campus and worked the government surplus system for years, accumulating enough equipment at almost no cost to begin making measurements." Salamo, hired in 1975, was given $2,000 and Singh, hired in 1982, was given $7,500. Two notable exceptions seem to have been Richardson, hired in 1966, who was given $10,000 to set up an ion-trap experiment, and Gupta, hired in 1978, who was given $14,000 to set up his spectroscopy experiment. However, Gupta also had to use these start-up funds as a required match on his Research Corporation grant, as there was no source of funds for matching external grants at the time.

Slow progress was made in providing adequate start-up funds over time. Progression toward this can be seen from the fact that Xiao, hired in 1990, was given $75,000 and Oliver, hired in 1992, was given $145,000. By the time Li and Tchakhalian were hired in 2002 and 2006 respectively, we had achieved parity with our peer institutions. They were given $400,000 and $475,000 respectively. This amount of start-up funding is now routine.

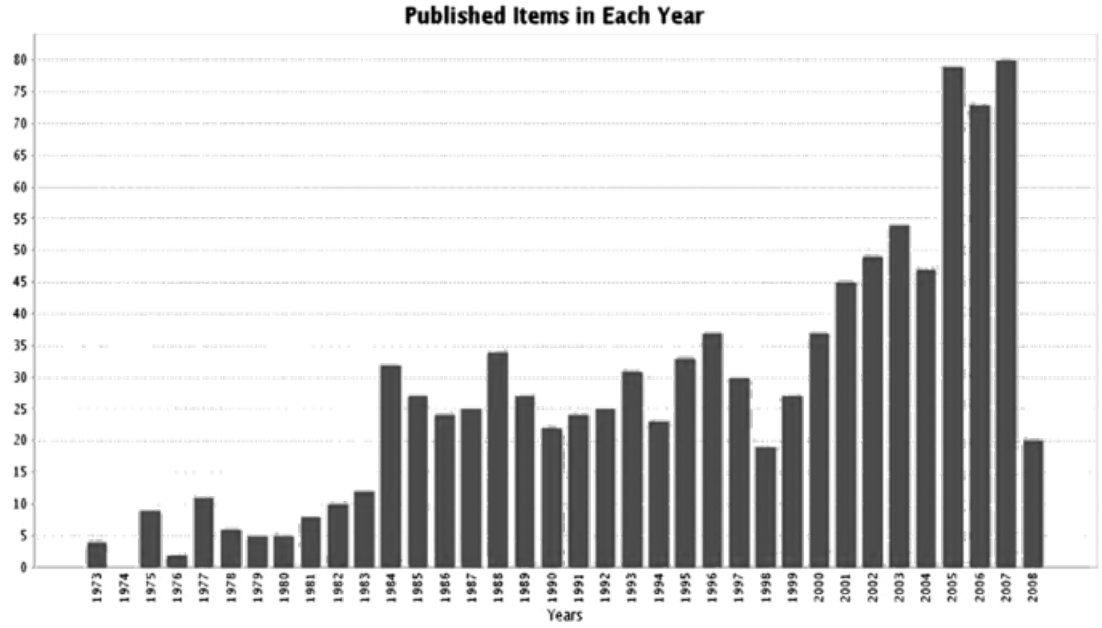


Figure 50: Number of publications by the physics faculty each year since 1973. Data for 2008 are incomplete.

F. Graduate Degrees Awarded, Research Funding, Publications, and Citations

As the department has developed into a full research department, so too have all the usual indicators of research activity. For example, the number of physics PhD degrees granted increased from thirty-one in 1988–1997 to forty-seven in 1998–2008 (with the 2008 data being incomplete). The details of all of the graduate degree data can be found in chapter 7.

External funding to the department[20] grew steadily from $2.6 million in the 2006 financial year, to $3.5 million in the 2007 financial year, to $5.5 million in the 2008 financial year. These figures represent new awards in each financial year. Each award was typically for a multiyear period.

We end this chapter with the growth of faculty publications each year shown in figure 50, and the number of citations to faculty publications shown in figure 51. In these graphs, both the publication data and the citation data are incomplete for the year 2008.[21]

G. Faculty Participation in Interdisciplinary Programs

Several of the departmental faculty members have participated in interdisciplinary programs. The principal ones are the Arkansas Center for Space and Planetary Sciences, the Institute for Nanoscience and Engineering, and Microelectronics, and the Photonics Graduate Program. These programs are described in appendices VIII, IX, and VII, respectively.

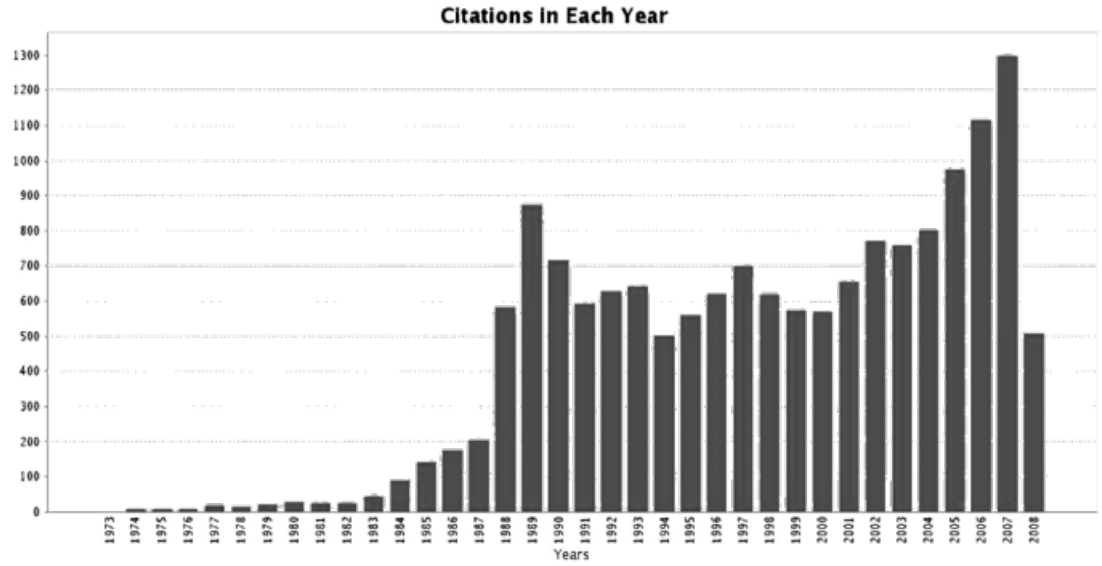


Figure 51: Citations to physics faculty publication each year since 1973. Data for 2008 are incomplete.

[20] Data derived from the department's annual reports.

[21] The data for these graphs were provided by the physics librarian at the time of the department's centennial celebrations in April 2008. Therefore, the data represent only the fraction of the year.

11.

Faculty Profiles

1952–2008

This chapter presents biographical profiles of faculty hired between 1952 and 2008. These profiles are deliberately limited mainly to research, even though many of the faculty may have made equally important contributions in the teaching program. The information about their contributions in the instructional programs may be found in chapter 6 and in chapter 7. To keep this chapter reasonably concise, the research descriptions are limited to a short paragraph. To learn more about the research contributions of individual faculty members, the reader may consult [Ref. 6], in which the title pages of their publications until 2008 have been reproduced. With rare exceptions, only the profiles of those faculty members who had tenure and served this department for a significant length of time are presented. If a date is preceded by *circa*, then the date is derived from the university catalogs, where information could lag behind the actual date by a year or so.



Figure 1: Professor Raymond H. Hughes in his office, late 1980s. ***Photo archived in the Physics Department.***

Raymond H. Hughes 1954–1990

PhD, University of Wisconsin–Madison, 1954

Positions Held at the University of Arkansas

Assistant Professor–Professor, 1954–1965
Professor–University Professor, 1965–circa 1988
University Professor Emeritus, 1990

Honors

Fellow of the American Physical Society, elected in 1968

Hughes started his research program at the University of Arkansas with isotope shift studies in the spectra of medium-weight elements using liquid-air cooled hollow-cathode discharge tubes, a Hilger Littrow spectrograph, and a large-aperture Fabry-Perot interferometer. He next studied polarization of light produced by electron impact on gases. He and his students built a 0–120 kV positive-ion accelerator and used it for atomic collision studies. He studied atomic lifetimes by using pulsed electron-beam excitation and made the first precision measurement of the Lamb shift in He^+. He and his students built a 0–30 kV accelerator to measure population of fine-structure states in fast hydrogen atoms produced by proton impact on gases. His last project before retirement was to develop a laser-generated multi-charge ion source by

focusing a pulsed laser on solid surfaces to produce hot plasma (in collaboration with Rich Anderson) and then to study the interaction of multicharged ions with solid surfaces (in collaboration with Don Pederson). His work was funded by multiple agencies throughout his career.



Figure 2: Professor Otto H. Zinke in his office. ***Photo archived in the Physics Department. Undated.***

Otto H. Zinke 1959–1988

PhD, Washington University in St. Louis, 1956

Positions Held at the University of Arkansas

Assistant Professor–Professor, 1959–1969
Professor, 1969–1988
Emeritus Professor, 1988–

Positions Held Prior to Joining the University of Arkansas

Linde PLC of Union Carbide, 1956–1957
Assistant Professor, University of Missouri, Columbia, 1957–1959

Zinke describes his research as follows:

> Pioneered time-of-flight technique for measuring positive ion temperature of pulsed plasmas and developed theory for generation of and measurement of multi-mega-degree plasmas. Invented novel technique for non-contact measurement of resistance and reluctance of metals called complex-reluctance bridge (CRB) and used it for measurement of diffusivities and dissipations of metals over cm lengths, as a novel method for a number of NDE problems, for determining magnitude and direction and strain of residual and applied stress in steels and for Thomson-effect measurements. Published alternating, magnetic-flux circuit theory and named imaginary component and net complex reluctance. Showed alpha-recoil technique could be used to date aboriginal pottery. Showed simple theory for eliminating monopole term of magnetic vector potential. Solved a never-resolved 19th century argument between Ludwig Boltzmann and Lord Kelvin by showing experimentally that Kelvin's equation for the Thomson effect was wrong. Devised a technique to produce hundreds of microVolts from thermocouple consisting of a single iron wire.

Stephen M. Day 1961–1983

PhD, Rice University, 1961

Positions Held at the University of Arkansas

Assistant Professor–Professor, 1961–circa 1972
Professor, 1972–1983
Vice-Chair of the Physics Department, 1968–1969
Chair of the Physics Department, 1969–1975
Associate Dean of Fulbright College of Arts and Sciences, 1979–1983

Visiting Positions

University of Nottingham, England, 1967–68 academic year

Day started a laboratory in nuclear magnetic resonance and, using this technique, performed experiments funded by a National Science Foundation grant to study the properties of CaF_2. His career in research was rather short, as he accepted several administrative positions within the university starting in 1968. In 1983, he moved to Miami University, Ohio as dean of arts and sciences. After seven years as dean and three as a faculty member at Miami University, he retired in 1993.



Figure 3: Professor Stephen M. Day on a visit to Fayetteville on the occasion of the celebration of the fiftieth anniversary of the PhD program, 2009. *Photo courtesy of Ken Vickers.*

Arthur S. Hobson 1964–1999

PhD, Kansas State University, 1964

Positions Held at the University of Arkansas

Assistant Professor–Professor, 1964–1974
Professor, 1974–1999
Professor Emeritus, 1999–

Visiting Positions

Stockholm International Peace Research Institute, Sweden, January–July 1985; worked on arms control issues.

Honors

Fellow of the American Physical Society, elected 1990
Robert A. Millikan Medal, 2006[1]

Books Published

Hobson, Arthur. *Concepts in Statistical Mechanics*. Gordon & Breach Publishers, 1971. A research monograph.

Hobson, Arthur. *Physics and Human Affairs*. John Wiley Publisher, 1982. A textbook for nonscience students.

Levi, Barbara G., Mark Sakitt, and Arthur Hobson, eds. *The Future of Land-Based Strategic Missiles*. The American Institute of Physics, 1989. Hobson also authored four of the book's chapters.

Hobson, Arthur. *Physics: Concepts and Connections*. 5th ed. 2010, Pearson Education, Inc. A textbook for nonscience students. The first edition was published in 1994, the second in 1998, the third in 2002, and the fourth in 2006,

Hobson, Arthur. *Tales of the Quantum: Understanding Physics' Most Fundamental Theory*. Oxford University

[1] This is the American Association of Physics Teachers' second-highest annual award.

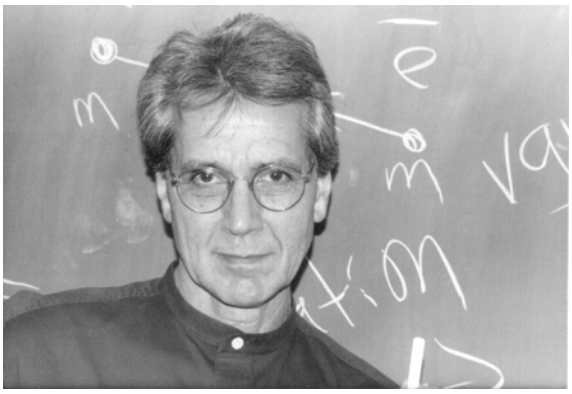


Figure 4: Professor Arthur S. Hobson. *Photo by Rajendra Gupta, circa 1999.*

Press, 2017. A non-mathematical presentation of the foundations of quantum physics, for scientists and nonscientists.

During 1964–1975, Hobson published fifteen papers and a research monograph in theoretical statistical mechanics, funded by two three-year National Science Foundation research grants. During 1976–1999, he focused on physics education and social issues such as arms control, publishing numerous papers and two textbooks (one of them in five editions) and developing a new course titled Physics and Human Affairs, which continues to be taught to some seven hundred University of Arkansas students every year. He teaches even more students through his textbooks, which are taught in similar courses on some 130 campuses nationally. He retired in 1999 but remains active; since retirement, his main research interest has been quantum foundations, on which he has published one book and several peer-reviewed papers.

Charles B. Richardson 1966–1997

PhD, University of Pittsburgh, 1962

Positions Held at the University of Arkansas

Assistant Professor–Professor, 1966–circa 1975
Professor, 1975–1997
Emeritus Professor, 1997–

Positions Held Prior to Joining the University of Arkansas

Research Assistant Professor, University of Washington, Seattle, 1962–1966

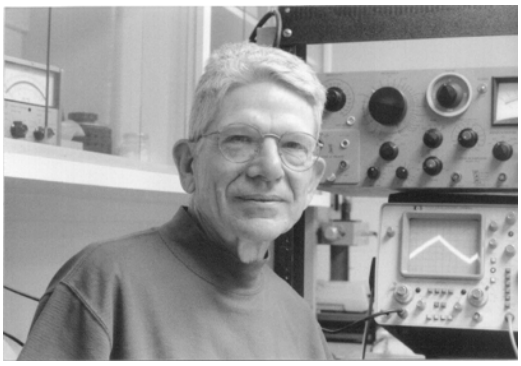


Figure 5: Professor Charles B. Richardson in the Modern Physics Laboratory. *Photo by Rajendra Gupta, circa 1999.*

Visiting Positions

Brookhaven National Laboratory, 1985
Naval Research Laboratory, 1989

At the University of Washington, in collaboration with Hans Dehmelt (1989 Nobel Laureate in Physics), Richardson detected the first magnetic resonance in the hydrogen molecule ion. The technique used trapped ions in ultrahigh vacuum. At the University of Arkansas, he and his students used the same technique to levitate microscopic liquid and solid particles to study various dynamics including phase changes and electrohydrodynamic breakup. He also studied Mie Scattering — the scattering of visible light — with emphasis on the liquid droplets as optical cavities. The work was supported by the National Science Foundation Division of Atmospheric Sciences.

He established or significantly modified laboratories in Modern Physics, Astronomy, Electronics,

College Physics and University Physics. He published manuals on the latter with McGraw-Hill Publishers.

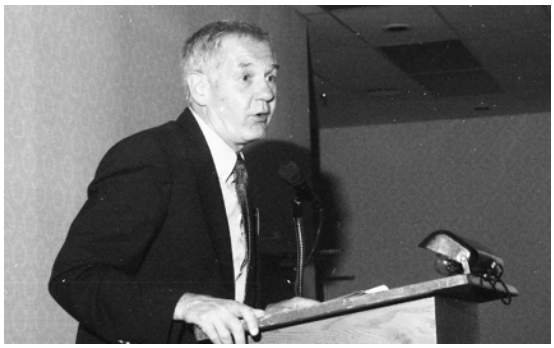


Figure 6: Professor Richard J. Anderson in Fayetteville on the occasion of the Grand Re-opening Celebration of the Physics Building, 1994. *Photo archived in the Physics Department.*

Richard J. Anderson 1966–1989

PhD, University of Oklahoma, 1966

Positions Held at the University of Arkansas

Assistant Professor–Professor, 1966–1976
Professor, 1976–1989
Vice-Chair of the Physics Department, 1973–1975
Director of the College of Arts and Sciences Honors Program, 1982–1989
Chair of the Natural Sciences Degree Program, 1977–1979
Arkansas NSF-EPSCoR Committee, 1979–1986

When Anderson joined the department in 1966, Ray Hughes had in progress a very successful program in atomic physics and gave Anderson an opportunity to collaborate while he was establishing his own research program. This collaboration, lasting over twenty years, resulted in work on a series of atomic lifetime measurements and on laser-operated ion sources, among others. Later, he collaborated with Greg Salamo on time-resolved analysis of collisional deactivation of metastable oxygen atoms produced by the photodissociation by a pulsed VUV laser. He also made important contributions in the area of undergraduate instruction and curriculum development.

He resigned in 1989 to join the National Science Foundation in Washington, DC., where he served as the head of the Office of Experimental Program to Stimulate Competitive Research, EPSCoR (1995–1998); senior program director in the Office of Systemic Reform, directorate of education and human resources (1993–95); and head of the Office of Experimental Programs (1992).



Figure 7: Professor Fui T. Chan in his office. *Photo archived in the Physics Department. Undated.*

Fui T. Chan 1969–2000

PhD, University of California, San Diego, 1967
Postdoc, Cornell University, 1967–1969

Positions held at the University of Arkansas

Assistant Professor–Professor, 1969–circa 1981
Professor, 1981–2000
Emeritus Professor, 2000–

Visiting Positions

Hahn-Meitner Institut, 1978–79

Chan started his research at the University of Arkansas on the study of problems in the theory of atomic collisions. Specifically, he (in collaboration with Michael

Lieber) applied Eikonal approximation techniques to the study of the collisions of electrons and ions with light atoms and ions. This work was supported by the Department of Energy. He then carried out theoretical studies of two-photon processes in hydrogen atoms, and that of a two-dimensional hydrogen atom. Toward the end of his career, his interests shifted to experimental physics, specifically, the fabrication and characterization of high-temperature superconducting thin films.

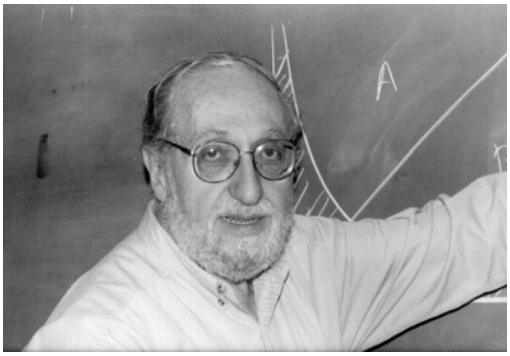


Figure 8: Professor Michael Lieber. ***Photo by Rajendra Gupta, circa 1999.***

Michael Lieber 1970–2011

PhD, Harvard University, 1967[2]
Postdoc, New York University, 1967–1970

Positions Held at the University of Arkansas

Assistant Professor–Professor, 1970–1983
Professor, 1983–2011
Emeritus Professor, 2011–
Chair of the Physics Department, 1983–1986
Vice-Chair of the Physics Department, 1992–1998

Visiting Positions

New York University, summer 1971
Institute of Theoretical Physics (now Kavli Institute for Theoretical Physics), 1988

Lieber's research was in the areas of quantum electrodynamics and scattering theory, the latter with application to atomic collisions.

Donald O. Pederson 1972–2014

PhD, Rice University, 1971
Postdoc, Robert A. Welch Foundation Postdoctoral Fellow, Texas Tech University, 1971–1972

Positions Held at the University of Arkansas

Assistant Professor–Professor, 1972–1984
Professor, 1984–2014
Professor Emeritus, 2014–
Chair of the Physics Department, 1978–1983
Associate Dean of the J. W. Fulbright College of Arts and Sciences, 1983–1985
Associate Vice-Chancellor for Academic Affairs (Acting CAO), 1985–86
Vice-Chancellor for Academic Affairs (CAO), 1986–1998
Vice-Chancellor for Finance and Administration (CFO), 1998–2014

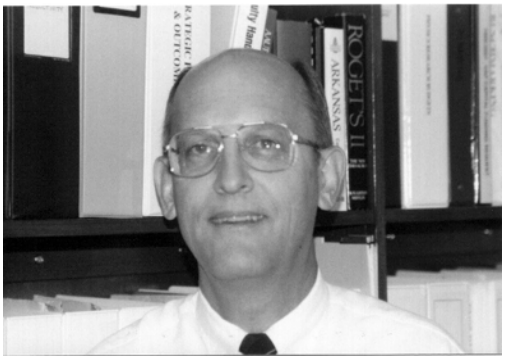


Figure 9: Professor Donald O. Pederson. ***Photo by Rajendra Gupta, circa 1999.***

[2] Dissertation research done under the mentorship of Nobel Laureate Julian Schwinger.

Visiting positions
Professor, Stephen F. Austin State University, summer 1977

Pederson's research was focused on experimental, condensed matter physics including: ultrasonic velocity and attenuation measurements in ionic solids, solid electrolytes, and high temperature superconductors; the synthesis and characterization of new high temperature superconductors (with Z. Z. Sheng); the interaction of laser-produced, slow, multi-charged ions with surfaces (with R. H. Hughes); and the thermal and optical properties of solid electrolytes and nonlinear optical materials (the latter with G. J. Salamo).

Gregory J. Salamo 1975–

PhD, City University of New York, 1973[3]
Postdoc, University of Rochester, 1973–1974.



Figure 10: Professor Gregory J. Salamo in his MBE Laboratory. *Photo by Rajendra Gupta, circa 1999.*

Positions Held at the University of Arkansas
Assistant Professor–Professor, 1975–1985
Professor–University Professor, 1985–1995
University Professor–Distinguished Professor, 1995–2004
Distinguished Professor, 2004–
Joe N. Basore Professorship, 2005–
Director of the Fulbright College Honors Program, 1985–1986
Associate Director of the High-Density Electronics Center, 1991–2012
Director of the Institute for Nanoscale Science and Engineering, 2010–

Visiting Positions
Army Night Vision Lab, 1987–1989

Honors
Fellow of the Optical Society of America, 2000
Fellow of the American Physical Society, elected in 2016
Council for Advancement and Support of Education Arkansas Professor of the Year, 2009
Baum Teaching Award, 2007
Joe N. Basore Professorship, 2005
Alumni Association Faculty Distinguished Achievement Award in Research, 1994
Research featured in Business News, 1994 and Science News, 1994
Research featured in Optics News, 1993 and 1994
Featured in nationally televised PBS documentary *Science is Golden*, 1998
Featured Scientist in "Research in Arkansas" in *Omni* magazine, 1983

[3] Salamo worked on his dissertation research at Bell Labs.

Outstanding Alumni University Research Professor, 1980

Salamo describes his research as follows:

> First, my research and teaching mentor at UA was Rich Anderson, who helped me beyond what words can express. My research had its beginning with the first theoretical and experimental observation of pulse train optical solitons (PRL 42, 887; PRL 78, 855). What was special about this were my students Mark Newbold and John Shultz. I also did some novel work with my colleague F. T. Chan on the first coherent coupling (PRA 33, 1677) between states that lengthen lifetimes which pre-dated work on electromagnetically induced transparency (EIT) a few years later. We also made the first observation and started a new field of photorefractive spatial solitons (PRL 71, 533). We did this with a good friend Moti Segev and an excellent student, Galen Duree. From here I took a new direction on MBE growth of quantum dots, wires, and wells with Haeyeon Yang, Philippe Ballet, Jay Smathers, Zhming Wang, and Yuriy Mazur who played such a huge role in building a productive growth facility starting in the mid-nineties. In a new field of study, with A. Q. Guo and Demetri Christodoulides, we made the first experimental observation (PRL 103, 93902) of what is now called PT Optics.



Figure 11: Professor Rajendra Gupta in his Laser Spectroscopy Laboratory, circa 1999.

Rajendra Gupta 1978–2010

PhD, Boston University, 1970
Postdoc, Columbia University, 1970–1974

Positions Held at the University of Arkansas

Assistant Professor–Professor, 1978–1985
Professor, 1985–2010
Chair of the Physics Department, 1989–1995
Professor Emeritus, 2010–

Positions Held Prior to Joining the University of Arkansas

Assistant Professor, Columbia University, 1974–1978

Visiting Positions

Visiting Professor, Air Force Institute of Technology, Wright Patterson Air Force Base, 1977–1978 academic year
Visiting Scientist, Air Force Aeropropulsion Laboratoty, Wright Patterson Air Force Base, 1977–1978 academic year.
Visiting Fellow, Princeton University, fall 1998

Honors

Fellow of the American Physical Society, 1998

Books Edited

Gupta, Rajendra, ed. *Laser Spectroscopy.* American Association of Physics Teachers, 1993.

Gupta and his students started a laboratory on laser spectroscopy at the University of Arkansas. His initial experiments were on the spectroscopy of atomic silver and NO_2 molecules, as well as exploration of photoacoustic and photothermal spectroscopy for application to combustion diagnostics. Later, he concentrated his efforts, with success, on the problem of simultaneous measurement of absolute minority species concentration, local temperature, and flow velocity in a laminar flame using photothermal deflection spectroscopy. Research was supported by the Air Force Aeronautical Laboratory, Air Force Office of Scientific Research, Army Research Office, National Science Foundation's EPSCoR program (Co-PI), Research Corporation, and Arkansas Science and Technology Authority.

Claud H. Lacy 1980–2015
PhD, University of Texas at Austin, 1978

Positions Held at the University of Arkansas
Assistant Professor–Professor, 1980–1997
Professor, 1997–2015
Professor Emeritus, 2015–

Visiting Positions
Texas A&M University, 1978–1980

Honors
Edith J. Woodward Award of the American Astronomical Society (twice)

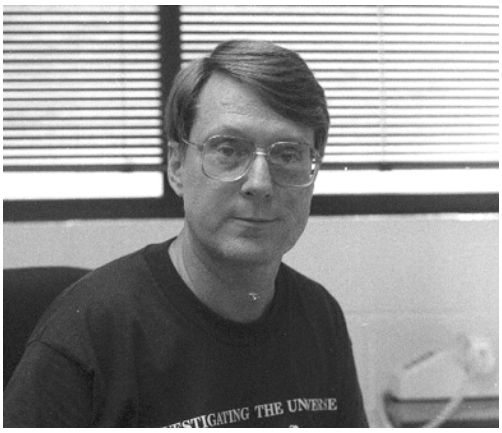


Figure 12: Professor Claud H. Lacy. ***Photo archived in the Physics Department. Undated.***

Lacy's work includes determinations of the absolute masses and radii of eclipsing binary stars in order to test the standard theory of stellar evolution. The theory matches observations in most stars but fails significantly in stars that have magnetic activity cycles, especially lower main sequence stars.



Figure 13: Professor Peter W. Milonni. ***Photo archived in the Physics Department, circa 1980.***

Peter W. Milonni 1980–1989
PhD, University of Rochester, 1974

Positions Held at the University of Arkansas
Assistant Professor–Professor, 1980–circa 1986
Professor, 1986–1989

Positions Held Prior to Joining the University of Arkansas
Air Force Weapons Laboratory, 1974–1977
Perkin Elmer, 1977–1980

Visiting Positions
Los Alamos National Laboratory

Honors
Max Born Award of the Optical Society of America, 2008

Milonni worked on the theory of high-power laser operation in media that can lase on several transitions simultaneously. He also worked on many problems which can broadly be described as, in his own words, "both pure and applied aspects of nonlinear science, especially in connection with the interaction between matter and intense laser radiation." Peter resigned in 1989 to join the Los Alamos National Laboratory.

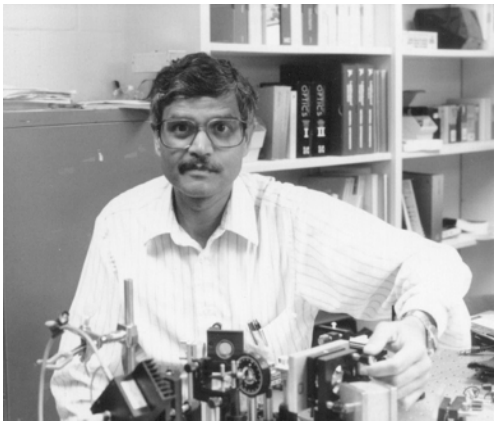


Figure 14: Professor Surendra P. Singh in his laboratory. *Photo by Rajendra Gupta, circa 1999.*

Surendra P. Singh 1982–
PhD, University of Rochester, 1982

Positions Held at the University of Arkansas
Assistant Professor–Professor, 1982–1992
Professor–University Professor, 1992–2016
University Professor, 2016–
Chair of the Physics Department, 1995–2002, 2005–2011

Visiting Positions
Visiting Fellow of JILA, University of Colorado, 1989–1990[4]

Honors
Fellow of the American Physical Society, 2003
Outstanding Referee of APS Journals, 2015

Books Published
Mathur, V. S., and Singh, S. *Concepts of Quantum Mechanics*. CRC Press/Taylor and Francis, 2008.

Singh's research at Arkansas falls under three broad categories. The first involves experimental and theoretical studies of statistical properties of light by photoelectric counting and correlation techniques. These studies provided some of the most stringent tests of laser theory and led to the development of new experimental and theoretical techniques to characterize and simulate quantum statistical dynamics. The second involves studies of nonlinear dynamics in laser systems. These studies revealed an extremely rich array of dynamical behavior including transitions between multiple steady states, oscillatory and chaotic states, and synchronized chaos. The third area of research is the generation of different families of laser beams, including optical vortex beams, and studies of their interference, diffraction, and polarization properties. Other research contributions include application

[4] Here, Singh worked with Nobel Laureate John Hall.

of optical techniques to study biopolymers, "rediscovery" of an interaction coupling angular momentum of light with electron spin and anomalous motion of free-standing graphene membranes.

Howard J. Carmichael 1983–1989

PhD, University of Waikato, 1976
Postdoc, City College of New York, 1977–1978

Positions Held at the University of Arkansas

Assistant Professor–Associate Professor, 1983–circa 1988
Associate Professor, 1988–1989

Positions Held Prior to Joining the University of Arkansas

University of Texas at Austin, 1979–1981
University of Waikato, 1981–1982

Visiting Positions

Visiting Associate Professor, University of Texas at Austin, 1988
California Institute of Technology, 1989

Honors

Max Born Award of the Optical Society of America, 2003

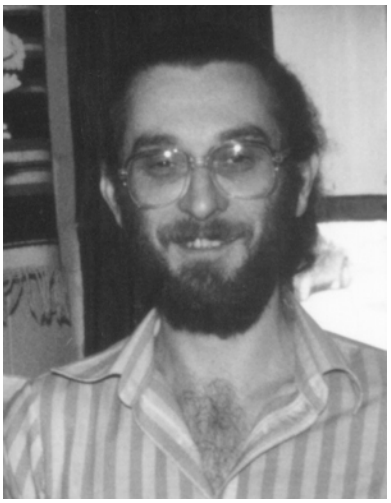


Figure 15: Professor Howard J. Carmichael in his office, circa 1987. *Photo archived in the Physics Department.*

Broadly speaking, at the University of Arkansas Carmichael conducted theoretical studies of nonclassical quantum statistical effects such as photon antibunching and squeezing in nonlinear optical processes such as parametric amplification and four-wave mixing. He also studied nonlinear effects in the interaction of a collection of two-level atoms with laser light inside an optical cavity and developed quantum trajectory theory for open quantum systems. Carmichael resigned in 1989 to accept a faculty position at the University of Oregon. Currently he is the Dan Walls Professor and chair of theoretical physics at the University of Auckland, New Zealand.

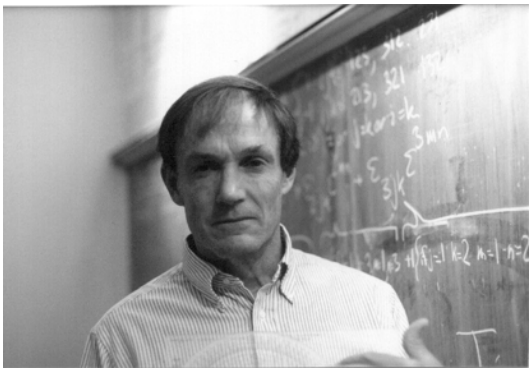


Figure 16: Professor William G. Harter. *Photo by Rajendra Gupta, circa 1999.*

William G. Harter 1985–

PhD, University of California, Irvine, 1967
Postdoc, University of California, Irvine, 1967–1969

Positions Held at the University of Arkansas

Professor, 1985–

Positions Held Prior to Joining the University of Arkansas

Summer Lecturer, NASA Glenn Research Center, summers of 1974, 1975, 1967, 1977, 1978
Assistant Professor, University of Southern California, 1969–1973

Associate Professor, Universidade Estadual de Campinas, 1973–1975
Associate Professor, Georgia Institute of Technology, 1976–1985

Visiting Positions

Visiting Lecturer, National Bureau of Standards, summer 1975
Visiting Fellow, JILA, Boulder Colorado, 1976
Visiting Theorist, T-12, Los Alamos, 1988–1989
Visiting Fellow, Harvard Center for Astrophysics, 1993–1994

Honors and Awards

Fellow of the American Physical Society, 1994

Books Published

Harter, W. G., and C. W. Patterson. *A Unitary Calculus for Electronic Orbitals*. Springer Verlag, 1976.
Harter, W. G. *Principles of Symmetry, Dynamics, and Spectroscopy*. Wiley Interscience, 1993.
Harter, W. G. *Classical Mechanics with a Bang!*. Web, 2001.
Harter, W. G. *Quantum Theory for the Computer Age*. Web, 2005.

Harter is credited with several major accomplishments: the U(n)-Sm theory of complex atomic spectra; the first theory of Superfine and Superhyperfine spectra in high symmetry molecules; and first theory of C60 rovibrational and hyperfine spectra that lead to its later proof of existence and later synthesis. He wrote chapter 32 in *The Handbook of Atomic, Molecular, and Optical Physics* (AIP 1995) and chapter 35 in *The Handbook of Atomic, Molecular, and Optical Physics* (Springer Verlag 2005).



Figure 17: Professor Allen M. Hermann in 1989. *Photo archived in the Physics Department.*

Allen M. Hermann 1986–1989

PhD, Texas A & M University, 1965

Positions Held at the University of Arkansas

Distinguished Professor, 1986–1989
Chair of the Physics Department, 1986–1989

Positions Held Prior to Joining the University of Arkansas

Assistant to Professor, Tulane University, 1967–1975;
Professor, Tulane University, 1975–1981
Task Manager, Solar Energy Research Institute (now National Renewable Energy Laboratory), 1981–1985
Technical Manager, Jet Propulsion Laboratory, 1985–1986

Honors

Fellow of American Physical Society, 1984

Shortly after Hermann joined our department, he became interested in the newly discovered high-temperature superconductors. He hired Zhengzhi Sheng, a recent PhD from the Chemistry Department, as a postdoc to help him pursue this research. The Sheng-Hermann team discovered that a combination of thallium, calcium, barium, copper, and oxygen in right proportions exhibited zero electrical resistivity up to a temperature of 125 K. This Tl-based superconductor remained the highest-temperature superconductor known for several years. Their further work consisted of the characterization of this superconductor as well as search for even higher-temperature superconductors. Hermann resigned at the end of fall 1989 semester to accept a professorship at the University of Colorado.

Zhengzhi Sheng 1987–1999

PhD, University of Arkansas, 1987
Postdoc, University of Arkansas, 1987–1989

Positions Held at the University of Arkansas

Research Professor, 1989–1999



Figure 18: Professor Zhengzhi Sheng. ***Photo by Rajendra Gupta, circa 1999.***

In 1994 Sheng described his research as follows:

> Since 1987, under the support of the Arkansas Energy Office, the Superconductor Laboratory has discovered a number of new superconductors, especially Tl-based superconductors both in bulk and thin film form.
>
> The ongoing work of the Superconductor Laboratory includes the search for new and even higher temperature superconductors, the improvements of Tl-based and Hg-based superconductors (including high-pressure synthesis), the thick and thin film deposition, and the theoretical understanding of the high Tc superconductivity."

Sheng left the University In 1999.



Figure 19: Professor Reeta Vyas in her office. ***Photo by Rajendra Gupta, circa 1999.***

Reeta Vyas 1989–

PhD, State University of New York at Buffalo, 1984

Positions Held at the University of Arkansas

Visiting Assistant Professor, 1984–1988
Research Assistant Professor, 1988–1989
Assistant Professor–Professor, 1989–2002
Professor, 2002–

Visiting Positions

Visiting Scholar, Universidade Federal da Paraíba, summer 1992
Visiting Scholar, Instituto de Física e Química de São

Carlos da Universidade de São Paulo, summer 1994
Visiting Scholar, Universidade Federal da Paraíba, summer 1996
Visiting Scholar, Universidade Federal de Goiás, summer 1996

Honors
Senior Member of the Optical Society of America, 2013

Vyas's initial research contributions were in nuclear physics on the Meson exchange effects on photodisintegration of deuteron and triton. After joining the University of Arkansas, she started working in the areas of theoretical quantum optics, laser theory, and photothermal spectroscopy. The first two areas involved both classical and quantum properties of light generated by various sources and its interaction with simple atomic systems. These investigations explored the boundary between classical and quantum descriptions of light with emphasis on those features of light that could only be understood using quantum theory. These nonclassical features of light included photon antibunching, nonclassical photon correlations, squeezing and entanglement in optical parametric oscillators, and atom or quantum dots interacting with quantized fields. Another research area was diffraction, interference, and polarization properties of different families of laser beams including orbital angular momentum carrying vortex beams and their effect on microsystems.



Figure 20: Professor Julio Gea Banacloche in his office. *Photo by Rajendra Gupta, circa 1999.*

Julio Gea-Banacloche 1990–

PhD, University of New Mexico, 1985
Postdoc, University of New Mexico, 1985–1986
Visiting Scientific Collaborator, the Max-Planck-Institut für Quantenoptik, 1986–1987

Positions Held at the University of Arkansas
Assistant Professor–Professor, 1990–2000
Professor, 2000–
Chair of the Department of Physics, 2011–2017
Associate Editor, *Physical Review A* (Quantum Information), 2000–2012

Positions Held Prior to Joining the University of Arkansas
Visiting Assistant Professor, Miami University, 1987–1988
Staff Researcher, Instituto de Óptica, Consejo Superior de Investigaciones Científicas, 1988–1991[5]

Honors
Fellow of the American Physical Society, 2004

Gea-Banacloche worked on theoretical quantum optics from 1990 onwards, branching into quantum information beginning in 1998. His work was supported on and off by various National Science

[5] Gea-Banacloche was on leave of absence from January 1990 through June 1991.

Foundation grants throughout this time. Some highlights include: his work on entanglement and quasiclassical trajectories in cavity quantum electrodynamics (Jaynes-Cummings model) (1990–1998); development of a theoretical model for Min Xiao's experiments on electromagnetically induced transparency in Doppler-Broadened media (1995, 2008); introduction of the "quantum bouncing ball" model, which is now referenced in a standard undergraduate quantum mechanics textbook (1999); work on decoherence and error correction in quantum computers (1998–2001); introduction of the notion of "quantum steganography," or the hiding messages in quantum data (2002); and his introduction and exploration of the notion of a minimum energy requirement for the operation of quantum computers (2002–2008).

Min Xiao 1990–

PhD, University of Texas at Austin, 1988
Postdoc, Massachusetts Institute of Technology, 1988–1990

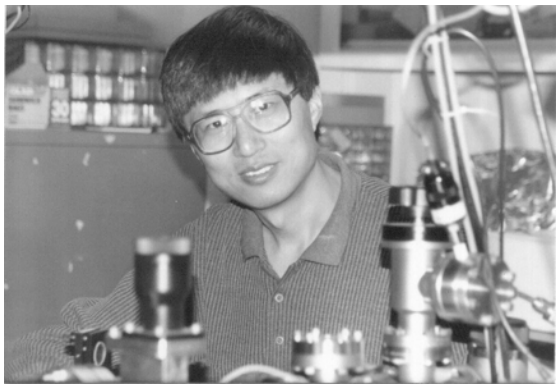


Figure 21: Professor Min Xiao in his laboratory. ***Photo by Rajendra Gupta, circa 1999.***

Positions Held at the University of Arkansas

Assistant Professor–Professor, 1990–1998
Professor, 1998–2004
Distinguished Professor of Physics, 2004–
Twenty-First Century Endowed Chair in Nanotechnology, 2006–

Visiting Positions

Adjunct Professor, Nanjing University, 2010–

Honors

National Science Foundation Young Investigator Award, 1994
Alumni Association Faculty Distinguished Achievement Award in Research, 1998
Fellow of the American Physical Society, 2004
Fellow of the Optical Society of America, 2004

Books Published

Zhang, Y., F. Wen, and M. Xiao. *Quantum Control of Multi-wave Mixing*. WILEY-VCH and Higher Education Press, 2013.

Joshi, A., and M. Xiao. *Controlling Steady-State and Dynamical Properties of Atomic Optical Bistability*. World Scientific Publishing, 2012.

Zhang, Y., Z. Nie and M. Xiao. *Coherent Control of Four-wave Mixing*. Springer-Verlag and Higher Education Press, Beijing and Berlin, 2011.

Zhang, Y., and M. Xiao. *Multi-wave Mixing Processes*. Springer-Verlag and Higher Education Press, Beijing, Berlin and New York, 2009.

Gao, J. Y., M. Xiao, and Y. Zhu, eds. *Atomic Coherence and Its Potential Applications*. Bentham Science Publishers, 2009. E-book.

Since he came to the University of Arkansas in 1990, Xiao's experimental and theoretical studies have covered many areas of physics, including quantum optics, nonlinear optics, atomic physics, and optical properties of semiconductor micro/nanostructures. His group made pioneering studies on the linear absorption and dispersion as well as nonlinear properties of three-level electromagnetically induced transparency (EIT) systems with continuous-wave low-power diode lasers under Doppler-free configurations. They further investigated the steady-state (such as linewidth narrowing and broadening, optical bistability and multistability, and Rabi splitting) and dynamical (such as instability, chaos, stochastic resonance, and all-optical switching) in systems with such EIT atoms inside an optical ring cavity. They also demonstrated interesting spatial and temporal interference effects between four-wave mixing (third-order nonlinearity) and six-wave mixing (fifth-order nonlinearity) processes in multi-level EIT atomic systems. Another direction of research in Xiao's laboratory is to perform ultrafast optical spectroscopic studies on colloidal and MBE-grown semiconductor micro/nanostructures and investigations of strongly correlated material systems.

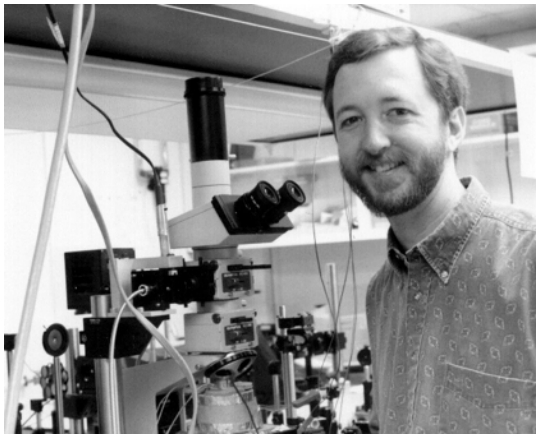


Figure 22: Professor William F. Oliver III in his laboratory. *Photo by Rajendra Gupta, circa 1999.*

William F. Oliver III 1992–

PhD, University of Colorado Boulder, 1988
Postdoc, Arizona State University, 1988–1992[6]

Positions Held at the University of Arkansas

Assistant Professor, 1992–1998
Associate Professor, 1998–
Vice-Chair of the Physics Department, 1999–2002, 2015–2017
Chair of the Physics Department, 2002–2005, 2017–
Director of the Arkansas Center for Space and Planetary Sciences, 2010–2015

Visiting Positions

Exxon Corporate Research Laboratories, summer 1993, summer 1994

Honors

National Science Foundation CAREER Award, 1996
Exxon Education Foundation Award, 1994, 1995

Oliver's research (1992–2008) was focused on two areas, both involving transitions between different states of condensed matter. One area involved light-scattering studies of thermal and chemical denaturation processes in small globular proteins, with an emphasis on the presence and stability of intermediate states and the effect of point mutations on these states. A major area of focus concentrated on dynamic and thermodynamic studies of glass-forming systems under extreme conditions. Brillouin light-scattering, photon correlation spectroscopy, and fluorescence microscopy

[6] Oliver held positions in both the Department of Physics and Astronomy and the Department of Chemistry.

were used to study systems over wide temperature ranges and at pressures up to 10 GPa, that is, nearly an order of magnitude higher than almost all previous studies. Both the pressure dependence of the glass transition and molecular dynamics were probed. These studies enabled him to begin sorting thermal effects from volume effects in these systems, and to better elucidate the mechanics underlying the fundamentally and technologically important glass transition.

Gay B. Stewart 1994–2014

PhD, University of Illinois at Urbana-Champaign, 1994

Positions Held at the University of Arkansas

Assistant Professor–Professor, 1994–2011
Professor, 2011–2014

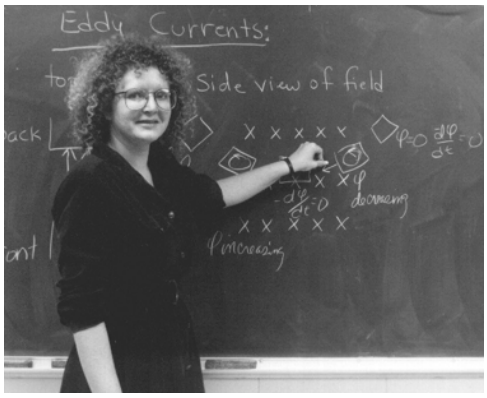


Figure 23: Professor Gay B. Stewart. ***Photo by Rajendra Gupta, circa 1999.***

Honors

Fellow of the American Physical Society, elected 2009
Council for Advancement and Support of Education Arkansas Professor of the Year, 2002
President, American Association of Physics Teachers (AAPT), 2013
AAPT Executive Board: Vice President, 2011; President Elect, 2012; President, 2013; Past President, 2014
APS Board of Directors, 2014–2016[7]
APS Council Steering Committee, 2014–2016
APS Executive Board, 2011–2012
APS Councilor, 2009–2014
APS Council of Representatives, 2014–2016
APS Forum on Education Executive Committee, 1999–2006, 2009–2016[8]
AIP Governing Board, 2011–2014
Chaired the College Board's Science Academic Advisory Committee
Cochaired the AP Physics Redesign Commission (NSF Appointment)
University of Arkansas Alumni Association 2007 Teacher of the Year

Stewart has described her education research as follows:

> Three interrelated issues driving educational improvement are introductory courses, physics majors' preparation for many career options, and future faculty preparation, both high school and professoriate. To study these (NSF supported 1995–2015) we needed to model and measure the features in an introductory class. We built a functioning class and then stabilized it so the impact of course policy and information presented could be controlled; University Physics II. Physics saw a 10-fold increase in

[7] The year 2014 marks the board's inception.
[8] Stewart served as AAPT liaison, then Vice-Chair and Chair of numerous subcommittees, including the Fellowship Committee.

graduates and was one of six initial PhysTEC institutions. The integral TA program became one of four NSF/AAPT "Shaping the Preparation of Future Science Faculty" sites. As co-PI of an NSF-GK-12, we recognized the importance of middle school mathematics and science teachers collaborating. Supporting high school mathematics and physics teachers' collaboration was central to our $7.3M NSF-MSP. Noyce grants supported preservice, and master physics, teachers and research to understand program components that recruited and better prepared them.

She is currently Eberly Professor of STEM Education at West Virginia University.



Figure 24: Professor Paul M. Thibado in his laboratory. *Photo by Rajendra Gupta, 2019.*

Paul M. Thibado 1996–

PhD, University of Pennsylvania, 1994
National Research Council Post-Doctoral Fellow, US Naval Research Laboratory, 1994–1996

Positions Held at the University of Arkansas

Assistant Professor–Professor, 1996–2004
Professor, 2004–

Visiting Positions

Visiting Researcher, Centre national de la recherche scientifique, 2002–2003, 2009–2010

Honors

National Science Foundation CAREER Award, 1998
Awarded five patents by USPTO

Thibado built a combined molecular-beam epitaxy and scanning tunneling microscopy facility with two new developments: a non-contact optical delivery system for measuring the substrate temperature, and enabling in situ atomic-scale characterization of epitaxial surfaces. He used this facility to discover the correct atomic structural model for the technologically important surface of gallium arsenide (GaAs). Hs also discovered that the surface of GaAs spontaneously roughens and precisely follows the predictions of the two-dimensional lattice-gas Ising model. He discovered that electrons with a particular spin orientation can tunnel into GaAs without disrupting the spin orientation. This discovery resulted in the department's first paper published in the journal *Science*. He published the first paper quantifying the benefits of using a classroom response system (CRS) to monitor student learning and mandate participation. This work led to a widespread use of CRS.

Kenneth G. Vickers 1998–2014

MS, University of Arkansas, 1978

Positions Held at the University of Arkansas

Research Professor, 1998–2014

Director of Microelectronics-Photonics Interdisciplinary Graduate Program, 1998–2014

Positions Held Prior to Joining the University of Arkansas

Engineering Manager, Integrated Circuit Wafer Fabrication, Texas Instruments, 1991–1998
Engineering Section Manager, Integrated Circuit Wafer Fabrication, Texas Instruments, 1980–1991
Process Engineer, Integrated Circuit Wafer Fabrication, Texas Instruments, 1977–1980

Honors

Member of Texas Instruments Group Technical Staff, 1987
Senior Member of Texas Instruments Group Technical Staff, 1989
Technical Manager of Texas Instruments Group Technical Staff, 1991
Recipient of the Graduate School Collis R. Geren Award, 2014
Awarded three NSF grants as PI ($1.3 million) and seven NSF grants as Co-PI ($6.6 million)



Figure 25: Professor Kenneth G. Vickers. ***Photo archived in the Physics Department. Undated.***

Vickers held several managerial and company-wide special project leader positions at Texas Instruments over his twenty-year career there and was the recipient of thirty-one patents (fourteen sole inventor, four principle inventor, and thirteen contributing inventor). He came to the University of Arkansas in 1998 as the founding director of the microelectronics-photonics (μEP) interdisciplinary science-engineering graduate program, oversaw the successful creation and implementation of this program, and guided it through its formative years to maturity. He developed and taught the program's core classes in research commercialization, engineering ethics, operations management, and proposal writing. He was instrumental to the successful construction of the Nanoscale Material Science and Engineering Building that was dedicated in 2011 and served as its building executive until his retirement in 2014. During his tenure as director of the μEP program, over 110 MS degrees and over forty-five PhD degrees were awarded. Details of the μEP program are given in appendix VII.



Figure 26: Professor Laurent Bellaiche. ***Photo archived in the Physics Department. Undated.***

Laurent Bellaiche 1999–

PhD, University of Paris VI (now part of Sorbonne Université), 1994
Research Associate, University of Paris XI, 1994–1995
Postdoctoral Associate, National Renewable Energy Laboratory, 1995–1997
Research Associate, Rutgers University, 1997–1998

Positions Held at the University of Arkansas:
Assistant Professor–Professor, 1999–2006
Professor–Distinguished Professor, 2006–2013
Distinguished Professor, 2013–
Twenty-First Century Endowed Professor in Optics, Nanoscience, and Science Education, 2006–

Visiting Positions:
Visiting Faculty Professor, École Centrale, 2003–
Visiting Faculty Professor, Xi'an Jiaotong University, 2011–2013
Visiting Faculty Professor, Luxembourg Institute of Science and Technology, 2015–

Honors:
Fellow of the American Physical Society, 2010
Alumni Association Faculty Distinguished Achievement Award in Research, 2009
National Science Foundation CAREER award, 2000

Bellaiche has described his research as follows: "We are carrying out research in the field of computational condensed matter physics. Our current interests mainly lie in developing and/or using direct first-principles methods, first-principles-based techniques and semiempirical approaches to calculate properties of ferroelectrics, magnetic compounds, multiferroics, semiconductors, nanostructures and graphene." Bellaiche is one of eleven members of the multi-institutional Center for Dielectrics and Piezoelectrics, sponsored by the Office of Naval Research, and a member of a working group on ferroelectric systems involving scientists at MIT; the National Institute of Standards and Technology (NIST); Yale University; Harvard University; Sandia National Laboratories; University of California, Santa Barbara; and University of Texas at Austin.

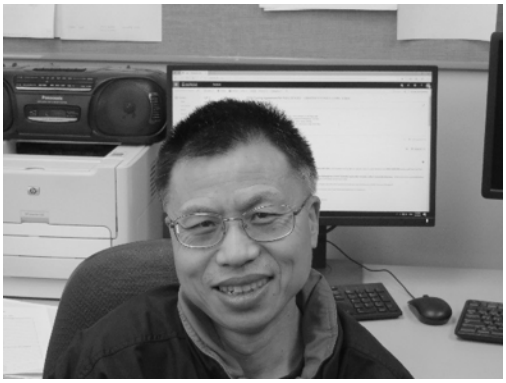


Figure 27: Professor Huaxiang Fu in his office, 2019. *Photo by Rajendra Gupta.*

Huaxiang Fu 2002–
PhD, Fudan University, 1994
Postdoc, National Renewable Energy Laboratory, 1995–1998
Postdoc, Carnegie Institution for Science , 1999–2000

Positions Held at the University of Arkansas:
Assistant Professor–Professor, 2002–2014
Professor, 2014–

Positions Held Prior to Joining the University of Arkansas
Assistant Professor, Rutgers University–Camden, 2000–2002

Fu's research largely focuses on theoretical modeling and understanding, by first-principles density-functional methods and other ab initio derived methods, of real materials with considerable

fundamental and technological relevance. First-principles theories use very basic and minimum input such as atomic charge to predict the electronic, optical, mechanical, and electrical properties of materials.

Jiali Li 2002–

PhD, City University of New York, 1999
Postdoc, Harvard University, 1999–2002

Positions Held at the University of Arkansas:

Assistant Professor–Professor, 2002–2016
Professor, 2016–

Visiting Positions:

Visiting Professor, Harvard University, July 1 to December 31, 2011

Honors:

Holder of five patents in association with coworkers at Harvard



Figure 28: Professor Jiali Li in her office, 2019. ***Photo by Rajendra Gupta.***

Since August 2002, Li's research group has successfully built a nationally competitive nanopore fabrication and nanopore single-biomolecule analysis research lab. She successfully built a feedback controlled ion beam sculpting system that makes 1–50 nm solid-state nanopores, and using the ion beam sculpting system, she and her students discovered that low energy ions from all noble gases can be used to fabricate nanopores and make nanopores of different thickness. Li and her students also designed and constructed a solid-state nanopore-based single biomolecule sensing system, with which they observed double stranded DNA melting to single strand. They determined DNA conformation and base number simultaneously, slowed DNA translocation in a solid-state nanopore by increasing solution viscosity, and demonstrated that single protein molecules can be characterized electrically by a solid-state nanopore. Her research activities have generated new discoveries, and results have led to publication in journals including *Nature Materials, Nano letters*, *Electrophoresis,* and *Applied Physics Letters.*



Figure 29: Professor Jaques Tchakhalian.

Jacques Tchakhalian 2006–2016

PhD, University of British Columbia, 2002
Postdoc, Max-Planck-Institut

Positions Held at the University of Arkansas:

Assistant Professor–Professor, 2006–2013
Professor, 2013–2016
Charles and Claudine Scharlau Endowed Chair, 2010–2016

Honors

National Science Foundation CAREER Award, 2008

Tchakhalian's research at the University of Arkansas involved fabricating and characterizing oxide interfaces, which are important in the understanding of strongly correlated systems



Figure 30: Professor Julia Kennefick. ***Photo from the University of Arkansas Department of Physics website.***

Julia Kennefick2007–

PhD, California Institute of Technology, 1995
Postdoc, Ohio State University, 1995–1997
Postdoc, Oxford University, 1997–2000

Positions Held at the University of Arkansas:

Visiting Assistant Professor, 2003–2007
Assistant Professor–Associate Professor, 2007–2014
Associate Professor, 2014–
Vice-Chair of the Physics Department, 2017–

Honors

The National Science Foundation ADVANCE Fellowship, 2004–2007

Kennefick's research interests are in active galaxies, the quasar luminosity function, the black hole mass function, disk galaxy structure, and most recently, exoplanet atmospheres.

12.

Administration and Support Services

In this chapter we describe how the department has been administered and what kind of support has been available to it to fulfill its academic mission. Section A lists departmental heads, chairs, and vice-chairs; section B discusses financial resources that have been available; section C describes administrative support available to the department; section D discusses the technical support (machine shop, electronics shop, etc.) and finally, in section E we discuss the Physics Library and its evolution over the years into a full-fledged departmental library.

A. Department Heads, Chairs, and Vice-Chairs

Department Heads and Chairs

1908–1940: Giles Ripley, first department head.
1940–1957: Lloyd Ham, second department head.
1957–1969: Paul Sharrah, first chairman.
1969–1975: Stephen Day, second chairman.
1975–1978: Charles Richardson, third chairman.
1978–1983: Donald Pederson, fourth chairman.
1983–1986: Michael Lieber, fifth chairman.
1986–1989: Allen Hermann, sixth chairman.
1989–1995: Rajendra Gupta, seventh chair.
1995–2002: Surendra Singh, eighth chair.
2002–2005: William Oliver III, ninth chair.
2005–2011: Surendra Singh, tenth chair.

Vice-Chairs

The department did not have a permanent position of vice-chair until 1992. However, we were able to find three instances when the department had vice-chairs for limited periods of time. In 1968, when Paul Sharrah was the chairman, the department decided to take over the teaching of astronomy from the Mathematics Department (see chapter 10). Sharrah retreated to his faculty office to devote time to develop astronomy courses and observational laboratories for them and appointed Steve Day as vice-chair to handle the administrative duties of the department. Day became the chairman in 1969. He appointed Rich Anderson as his vice-chair from 1973 to 1975. Anderson's job description is not available. Then, in 1988, the dean made some funds available on a temporary basis to Allen Hermann to appoint Reeta Vyas as assistant chairperson during the period of summer 1988 to spring 1989 to help him with scheduling of classes and so on. This was so that Hermann could spend more time on his research on high-temperature superconductivity. The position disappeared when Hermann stepped down as chair in 1989. The vice-chair position was allotted to the department by the dean in 1992 as an incentive for Gupta to accept a second term as the chair of the department. Gupta's understanding was that it was a permanent position, but Singh, who succeeded Gupta as chair in 1995, had to reargue the value of the position to the dean, and it ultimately became permanent at that time. Gupta appointed Michael Lieber as the first vice-chair in the newly created position. The vice-chair's duties could be anything that the chair assigned. Lieber was assigned to supervise instructional aspects of the



Figure 1: Current and former chairs gathered on September 9, 1994 to celebrate the Grand Reopening of the Physics Building. From left to right: Paul Sharrah (1st Chair), Charles Richardson (3rd Chair), Donald Pederson (4th Chair), Michael Lieber (5th Chair), Allen Hermann (6th Chair), and Rajendra Gupta (7th Chair). ***Photo archived in the Physics Department.***

department's mission, that is, teaching assignments and class scheduling, and so on. Essentially the same duties have been assumed by the subsequent vice-chairs. A list of the vice-chairs follows:

1968–1969: Stephen Day
1973–1975: Richard Anderson
1988–1989: Reeta Vyas
1992–1998: Michael Lieber
1998–2002: William Oliver III
2002–2006: Gay Stewart
2006–2015: Claud Lacy

B. Departmental Budgets

The department, indeed the whole university, has worked with very meager resources over the years. The earliest information on the department's budget that is available is for the 1927–28 academic year. For proper perspective, the reader is reminded that the department had a faculty of three and taught a total of 371 students across both semesters. The department was allocated $2,000 from the College of Arts and Sciences, and it realized an additional $800 or so from laboratory fees. Thus the department had about $2,800 for the 1927–28 academic year (this would have had the purchasing power of about $35,000 in 2008). Students enrolling in courses with a laboratory component had to pay a rather hefty laboratory fee, which could be as much as six dollars for a laboratory-intensive course such as x-rays. All of the department's expenses had to be paid out of these funds, such as laboratory equipment acquisition, fabrication and maintenance, student labor (shop work, laboratory setup and tear down, clerical work, etc.), Physics Library (book acquisition, journal subscriptions, journal binding, etc.), and travel. The category that made the largest demand upon the department's financial resources was laboratory equipment, and rightly so. Further details are shown in chapter 2. It should be emphasized that there was no support staff (secretary, machinist, etc.) and that all of these chores were done by student assistants on hourly pay. The Physics Library was maintained wholly by the department (see section E).

The departmental budget remained essentially

constant over the next decade or more, with a sharp decrease in the post-Depression era, followed by full restoration. By the 1937–38 academic year, the budget had been restored to $3,100 ($2,100 maintenance plus $1,000 from laboratory fees).

We do not have much information about the budgets again until 1949–50, when the budget was about $6,000 (the equivalent of about $56,000 in 2008). There is no mention of laboratory fees either in the departmental reports or the university catalog. For a full perspective in relation to the previous periods, it should be noted that at this time the department was teaching a much larger number of students (both regular students and veterans) compared to the 1930s and had to employ a large number of student assistants to provide the support services mentioned above. In addition, the department had a robust physics major program, several master's students, and was trying to prepare for a PhD program (see chapter 3). It should also be noted that there were special allocations of additional funds here and there for the purchase of research equipment to help the department develop its research infrastructure. Further details about the department's finances during the 1927–1949 period can be found in chapters 2 and 3.

No information about the departmental budgets for the 1950s is available. However, the earliest available university budget reports are for the 1960s and 1970s and show that the department's maintenance budgets for the 1964–65, 1969–70, 1974–75 academic years were, respectively: $13,500 (faculty of eight); $17,300 (faculty of eleven); and $27,043 (faculty of thirteen). No breakdown as to how the funds were spent is available in the departmental files. However, in the early 1970s, Chairman Stephen Day complained to the dean that the department was not asked to submit an itemized request for its funding needs before maintenance funds were allocated. Therefore, the department had to continually make requests for supplemental funds for specific needs, which was frustrating. It appears that the instructional equipment was not being properly maintained and upgraded, because Chairman Day suggested that the laboratory fees should be reinstated.

The departmental maintenance budget in 1978–79 was just $37,000. Fortunately, details of how the funds were spent is also available. This was the only money for the management of the entire departmental operations such as office supplies, postage, copying, telephone charges, building maintenance (such as repair of window air conditioning units), hourly help, maintenance of instructional labs, teaching support, travel, colloquium speakers, and graduate recruitment. The department chairmen had to skillfully manage the budgets. When Professor Donald Pederson was the chairman in 1978, he even squeezed out about $7,000 to support faculty research. This was the age before desktop computers and emails, so about 25 percent of the budget was consumed by just postage, copying, and telephone charges. In 1982–83, the departmental budget went up to $51,700. This was a period of very high inflation.

The departmental budget remained essentially constant, and the department was consistently running into deficits. During negotiations to accept the position of chair of the department in 1989, Gupta asked for a boost of $10,000 to the department's budget. The dean agreed to his request, bringing the 1992–93 budget to $63,000. The department did not receive any significant increase in its maintenance budget in the subsequent years, and its budget in the Centennial Year (2007–2008) remained only $65,000.

In the early 1990s, however, two significant changes took place that changed the department's budgetary situation. First, the university imposed a new fee on students called

the Teaching Enhancement and Laboratory Equipment (TELE) fee in recognition of the general inadequate support of the classroom and laboratory instruction campus wide. The department has used these funds to successfully upgrade and properly maintain all instructional equipment. These funds were also used to introduce computers in laboratories in the 1990s. By 2008, the department was receiving about $50,000–$60,000 per year from TELE fees.

The second significant change was the university decision to return 25 percent of the indirect cost allowance (overhead) on research grants to the departments that generated it. The idea was to incentivize the departments to obtain more research grants. These funds were called Research Incentive Funds (RIF), and the department chairs could use them as they wished as long as it was in support of research. Initially the Physics Department used these funds exclusively for the start-up of new faculty. Later the department decided to return part of these funds to the principal investigators who received the grants and used the rest of the funds to support and promote research in a wider variety of ways. The principal investigators could use the money any way they liked as long as it was in support of research. By 2008, the department was receiving approximately $120,000–$130,000 in RIF per year. With these three funds together, the department found itself in a very comfortable position for the first time in a century.

C. Administrative Support

The department did not have a secretary until the 1950s. Prior to that, all the clerical work was done by student assistants paid on an hourly basis from the departmental budget. Wherever the list of student assistants is available, we note that female students were assigned clerical work, whereas males were assigned the technical work — a discriminatory practice not surprising in the context of its time.

In 1946, Dr. Ham requested a half-time clerk. The department experienced a huge upsurge in student enrollment in the postwar period — both regular students and returning GIs. A large amount of paperwork was associated with GIs alone. There is no evidence that Dr. Ham's request was granted.

It appears that the first professional secretary was hired in 1952, coinciding with the move of the department to the Dickson Street building. At that time the Physics Library was established as a branch of the main library (see section E), and the library administration agreed to pay half the salary of a library clerk. The College of Arts and Sciences agreed to provide the other half of the salary, and a secretary was hired. Her duties included, besides the regular secretarial work for the department, shelving and checking library books in and out. The main library continued to provide half-time support until the position was transferred entirely to the college, perhaps in the late 1960s. The secretary's duties, however, continued to include the Physics Library's clerical work. Her desk was in the Physics Library (room 102).[1]



Figure 2: S. Jean Eaton served the department for thirty-three years and was the first office manager. ***Photo archived in the Physics Department, circa 1995.***

[1] The room numbers refer to those in the Dickson Street building as they were numbered when the department

The first expansion of the administrative staff took place in the 1965–66 academic year, during Paul Sharrah's tenure as chairman. The university's budget report lists one full-time and one part-time secretary (listed as clerk-stenographer and clerk-typist) that year, and both became full-time the following year. In 1972, the Physics Office and the chairman's office were moved into rooms 104 and 103, respectively, to make room for the library expansion. Ms. Shirley Jean Eaton was hired as a secretary in 1975 and staffed the Physics Department office. She became the longest-serving administrative staff member in the department and later the first office manager. The Physics Library was staffed by the department's second secretary. Her duties included library clerical work and technical typing of papers and proposals using an IBM Selectric typewriter (on display in the Physics Lobby). Jean retired in the spring of 2007.

Starting in the late 1970s, the need for a third secretary became apparent. We see this being mentioned in the annual reports starting in 1978–79 and repeated almost every year. As new faculty were hired, the need became more and more acute. Note that between 1978 and 1988, ten new faculty were hired: Gupta, Lacy, Milonni, Singh, Carmichael, Merkle, Harter, Hermann, Sheng, and Oseguera. However, new secretarial positions were very hard to get.

Finally, in 1989, the dean of the college agreed to authorize a third secretarial position to the department as part of Gupta's "start-up package" as chair of the department. The dean also provided funds to renovate room 105 to become the new Physics Office with room 106 as the new chair's office. The new Physics Office had space for two secretaries: one whose duties included reception and typing, and Eaton, who became the office manager. Her duties included, in addition to the management of the office, purchase orders, appointment forms, and travel requests. The third secretary continued to fulfill departmental duties as well as library duties as described earlier. In 2001 the main library decided to take over the staffing of the Physics Library (see section E), and at this point, the entire administrative staff (all three members) was consolidated in the Physics Office. Donna Johnson succeeded Eaton as the office manager after her retirement in 2007.

D. Technical Support

Technical support personnel consisted of a laboratory equipment curator for repair, maintenance, and setup of all teaching equipment, both for instructional laboratories and lecture demonstrations; a machinist to fabricate instructional and research equipment; an electronics technician to repair and construct electronic instrumentation; and a scientific glassblower to construct glass equipment. In the following section, we will individually describe the first three positions in some detail.

1. Laboratory Equipment Curator

The need for such a position has existed ever since the department started teaching a substantial number of courses with laboratory components. As far back as the earliest records in 1927, laboratory and demonstration equipment was maintained and repaired by student assistants. All of these assistants were most probably engineering students, until at least the late 1940s when there were a substantial number of physics majors.

A short exception to this occurred during the WWII period, when the supply of students had dwindled and the department was teaching a very large number of cadets (see chapter 3, section B). During this period, Mr. Bruce Keller was employed to fill this position. However, his

moved into this facility (refer to map in chapter 5, section G).

duties also included machine shop work and teaching. He was released upon the conclusion of the war in 1945.

Professor Ham made many requests to the dean to establish such a position in the department, using the phrase "laboratory custodian." The first of these was in 1946. However, Ham wanted this person to be a machinist as well and fill in to teach laboratories when necessary. The position was not granted. Eventually Mr. George Lingelbach was hired in 1947 as an instructor to teach laboratories and manage equipment. It was anticipated that when the postwar instructor shortage was over (see chapter 3), Mr. Lingelbach would take over as the laboratory custodian, but instead he continued to teach lecture courses and coordinate instructional labs until his retirement in 1966. The department continued to ask for the position of laboratory custodian, and the *1954–55 Annual Report* lists this as one of the most important needs of the department.

The requests for an equipment custodian (or equipment curator) continued year after year with the phrase "desperate need" used in 1969. In 1973, during the tenure of Stephen Day as chairman, the department finally received a position and hired Larry Albert. His primary task was that of laboratory equipment custodian, but he did some machining as well. The position was formally listed in the university budgets as a research associate. Albert quit in 1978, and he was succeeded by Kenneth Hagar. Hagar also quit after just three years, in 1981. Chairman Pederson hired Atha Pigg in this position as an electronics technician and engineer to take care of the department's critical needs in this area. Pigg was a graduate student in the department at that time and was very skilled with electronics. A teaching assistant helped by managing the instructional lab equipment. Two years later, in 1983, Pederson used this same position to hire the first professional machinist in the department (see section 2). That is, the department had just one position allotted to it, called research associate, and it used the same position for multiple jobs. Meanwhile, requests to the dean for a laboratory equipment curator position continued in 1981 and onward.

The department continued to rely on a teaching assistant for setting up laboratories, but maintenance and certainly development of new experiments was seriously lacking. When Gupta became chair in 1989, he tried to negotiate for a laboratory curator as part of his "start-up" package, but it was denied by the dean for lack of funds. He continued to ask the dean in almost every meeting he had with him, until finally the dean relented and the position was granted in the summer of 1992. The availability of funds was extremely scarce during that period, as the underfunded College of Arts and Sciences was continually running into deficits. The position had to be cobbled together by using one teaching assistant position and funds from the newly established Teaching Equipment and Laboratory Enhancement (TELE) fees. The university rules prohibited using TELE fees for salaries and required the chancellor's approval to make this exception. Gradually, over the following years, the curator's salary was shifted to the regular payroll budget, and the teaching assistant position was restored. The position was formally listed as "instructor" in the university's budget reports.

After a national search, the first dedicated laboratory equipment curator, J. Brad Shue, was hired in the summer of 1992. Shue had recently graduated with a BS degree in physics from Appalachian State University in Boone, North Carolina. He had extensive knowledge of, and interest in, laboratory and demonstration equipment. Shue left the university in the summer of 1999. Stephen Skinner, a fresh University of Arkansas graduate with an MA degree in physics education, was hired to replace

him in January 2000. Prior to that, Skinner had worked part time as Shue's assistant on an hourly basis.

2. Machine Shop

From the earliest annual reports, it is clear that the Physics Department had its own shop where instructional equipment was being built and repaired. The shop was staffed by student assistants, most probably engineering students. In the departmental reports such a person has been referred to as the "shop man." At times, more than one student assistant had to have worked in the shop because there was a high volume of equipment being built in and beyond the 1920s. Professor Ham made repeated requests in the 1940s for a person who could manage laboratory equipment as well as do machining but had no success. In a 1950 proposal to start a PhD program in physics, he requested a full-fledged machinist, but the proposal was not accepted.

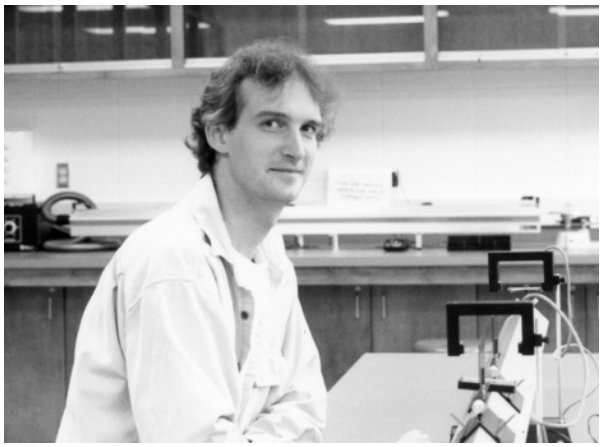


Figure 3: J. Brad Shue, the first laboratory equipment curator (1992–99). ***Photo by Rajendra Gupta, 1999.***

As the department's research grew, so did the need for a professional machinist. In the 1950s the department started using the services of the university's central machine shop staffed by a professional machinist. The central shop was run by an organization called Research Services that also ran electronics, glass, and carpentry shops. These shops were available for use by any department in the university, but users had to pay for the services out of departmental funds or research grants. We do not know when these shops began to operate.[2] The machine shop and the carpentry shop were moved to the Physics Building in 1952 when the department moved there. The machine and carpentry shops were located in rooms 15 and 14 and staffed by George Kirsch and Leonard Gabbard, respectively. Gabbard gradually built all the cabinets in the instructional and research laboratories as well as large bookshelves for the faculty offices. George did all the machine work for physics research from the 1950s until the department hired its own machinist in 1983. All of the early researchers in the department much admired his skill, cooperative attitude, willingness to try even the most challenging jobs, and friendly demeanor. In 1960, the machine and carpentry shops were moved to the Old Fair



Figure 4: Stephen Skinner, the second laboratory equipment curator (2000–present). ***Photo archived in the Physics Department, undated.***

[2] Professor Zinke has suggested in his communications with us that a machine shop had to have existed in 1946 or shortly thereafter to support the work of ORDARK, ARNO, and IST (see chapter 9).

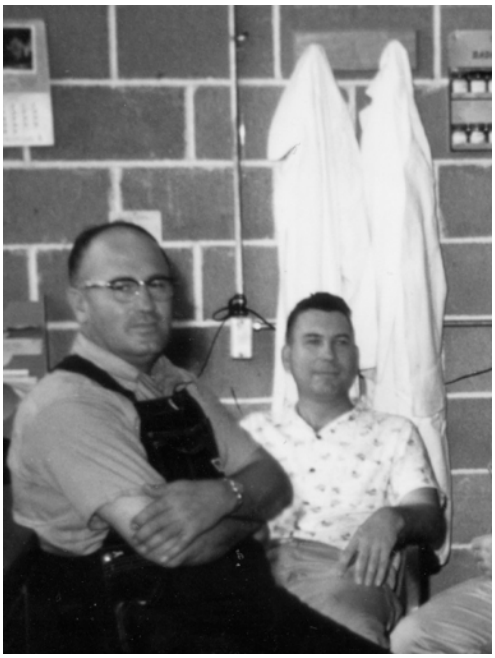


Figure 5: Leonard Gabbard, the carpenter (left) and George Kirsch, the machinist (right), in the Research Services machine shop in the Physics Building. *Photo archived in the Physics Department, undated.*

Grounds, just north of where Printing Services is now located. Rooms 14 and 15 were then used to house the university's first mainframe computer.

Meanwhile the department continued to maintain its own small shop with basic equipment (a lathe, milling machine, band saw, etc.) and without a professional machinist. It was called the Student Shop, and it was used extensively by the graduate students and faculty. It was first located in room 23 and later moved to room 15 when the computer center moved out of the building in 1964. When it could find a suitable candidate, the department often employed a work-study student to do some of the necessary machining. [3] This was not a satisfactory situation, particularly in the summer — the busiest time for research — when such help was typically not available. Additionally, there were often long waiting periods in the Research Services shop, which greatly impeded the department's research. The department consistently continued to ask for a full-time professional machinist of its own until such a position was filled.

The department's shop was finally staffed by a full-time professional machinist in 1983, when Frank P. Sperandeo III was hired. Room 15 then doubled as professional and student shop — not an entirely satisfactory situation. As mentioned in section 1 above, the funding for the machinist position was realized by converting the position of laboratory curator, last held by Ken Hagar until 1981, into the machinist position. Instructional laboratory equipment continued to be managed by teaching assistants until 1992.

When the renovation of the Physics Building started in 1992, the main shop was moved to room 29 and the student shop to room 30 (see chapter 5, section G). However, these two rooms were renovated to accommodate the MBE laboratory in circa 1997, and the machine and student shops were moved down to the basement of the Phase I expansion. Sperandeo



Figure 6: Frank P. Sperandeo (1983–1999), the first departmental machinist. *Photo archived in the Physics Department, undated.*

[3] As mentioned above in section 1, during the period of 1973–78 the laboratory curator, Larry Albert, provided some of the machining services.

left the university in 1999, and Brandon Rogers was hired as the second machinist.

3. Electronics Shop

The Physics Department probably had some sort of student electronic shop of its own back into the 1920s. There are references to electronic equipment being built by students, such as one in the 1928–29 academic year to a student-built harmonic synthesizer. Professor Ham requested for an electronics expert to be hired in the 1940s and again in the 1950 PhD proposal. It was suggested that this person would teach courses in electronics, as well as take care of the repair and fabrication of electronic equipment. Nothing came of these requests. At some point a central electronic shop was established by the university and run by Research Services. [4] It was a university-wide facility staffed by a professional electronics technician and maintained a modest stock of electronic components that one could draw from. The Physics Department used this facility, mostly to obtain electronic components, but the available expertise was not quite adequate for the needs of the department.

The department needed an electronics technician of its own and made multiple requests for the position, but it was a lower priority than the need for a laboratory curator and a machinist. Therefore it was after these two positions were filled that the department focused on acquiring an electronics technician.[5]

Finally, circa 2001, Chair Singh was able to convince the dean that the department desperately needed an electronics technician, and the dean agreed to grant the position. The first electronics technician hired was Edward Townsend circa 2002. The technician's responsibilities included construction and repair of electronic equipment, as well as teaching students how to diagnose problems, do minor repairs, and construct and assemble new equipment. Townsend left the department circa 2004, and Steven Kelly was hired to replace him. Unfortunately, Kelly passed away in circa 2007. Richard Penhallegon took the position in May 2008.[6]

4. Glass Shop

The department never had enough need to warrant own glass shop, but it did need access to one. Most probably, a glass shop existed on the campus in some form as early as the 1920s because Professor Roberds built several x-ray tubes of his own design (see chapter 2). One



Figure 7: Brandon Rogers (1999–present), the second departmental machinist. *Photo by Rajendra Gupta, 1999.*

[4] No information is available as to when this facility was established, but we know from Leflar's centennial history of the university [Ref. 3] that it predated 1971.

[5] As mentioned in section 1 above, the department did employ a graduate student, Atha Pigg, as an electronics technician and engineer temporarily in the 1981–83 period.

[6] The information in this paragraph is derived from university budget records, which represent the latest information at the time of printing of the budget reports. Thus, the dates indicated as *circa* could lag by one year behind the actual dates.



Figure 8: Wray Wilkes, first director of the computing center with the IBM-7040 computer in Science Engineering Hall about 1966. This was the second IBM used by the university. *Photo archived in the Physics Department.*



Figure 9: Part of the Physics Library collection in circa 1949. This shelf held the unbound journals. This shelf, and another one shown in figure 10, were kept in Professor Schwartz's office. *Photo archived in the Physics Department.*

suspects that that shop was probably located in the engineering college. Eventually, a university-wide central glass shop staffed by a professional scientific glassblower was established and run by Research Services. We do not know when this shop was established but it had to be fairly early.[7] The Physics Department used this facility at least as far back as the 1950s, and perhaps earlier.

5. Computer Center

The university's computer center was established in room 15 of the Physics Building in 1960, when the Research Services machine shop was moved out of that room. The IBM-650 was the first mainframe computer, and, as was customary, this was the central facility for university-wide use. In 1964 the computer center was moved out to Science Engineering Hall across the street, where the IBM-7040 was installed as the university's second mainframe. The Physics Department continued to have a remote terminal in the Physics Building, and it is now on display in the Physics Lobby.

The department has continued to use the services of the computer center, even though the nature of these services has changed over time (see appendix V).

E. Physics Library

The Physics Department had its own library back in the very early days, well before it had a master's degree program, and even before it had any physics majors (the first bachelor's degree in physics was awarded in 1928 and the second in 1931). The earliest departmental report that is available to us is for the 1926–27 academic year, and at that time the Physics Library had recently been moved into Physics Hall, which housed the department. The 1926–27 report states, "The Physics Library has been moved back into this

[7] This is because a glass shop was essential to the Chemistry Department, and that department was generally able to get what it needed, according to communications from Professor Zinke to us.

building." It is not clear where it moved back from. The same report also states that in that year, "Forty-six volumes of periodicals have been bound, and 25 books purchased, in addition to the periodicals to which we subscribe."

The Physics Library was completely independent of the university's main library. The acquisition of books and periodicals was achieved from the department's own budget. There was no staffing, and since the collection was small and building space scarce, presumably this collection was kept in the Physics Office or in one of the faculty offices, as we know was the case later on when the department moved into University Hall. The department was making every effort to build the collection subject to the usual budgetary constraints. In 1927–28, the department subscribed to six periodicals, bought thirty-eight books, added forty-two back volumes of journals, and spent $30 on periodicals and $125 on books. By the 1929–30 academic year, it subscribed to twelve periodicals. Funds had to be requested by the department every year from the dean of the College of Arts and Sciences, and the amount allocated varied substantially from year to year, sometimes putting constraints on the subscriptions to journals and physics-related magazines. In the 1937–38 academic year, the budgetary pressure was so high that even the subscription to *Scientific American* was on the chopping block, even though Professor Roberds frequently referred his students to articles in this magazine on x-rays and other topics.

When the department moved into University Hall in 1936, the Physics Library moved with it. We are fortunate to have two photographs of the Physics Library collection circa 1949. These shelves were located in Professor Schwartz's (and earlier in Sharrah's) office in the southeast corner of the University Hall basement and stored physics books and unbound journals. The bound journals as well as some additional physics books were stored in the main library in Vol Walker Hall due to the lack of space in Physics Department. Among the journals subscribed to by the department in 1949 were the *Physical Review, Journal of the American Association of Physics Teachers*, *Journal of the Acoustical Society of America*, *Reviews of Modern Physics*, and the *Review of Scientific Instruments*.



Figure 10: The Physics Library's book collection was also kept in Professor Schwartz's office in Old Main. Additional physics books were in the main library. *Photo archived in the Physics Department, circa 1949.*

The Physics Department's collection of books, magazines, and journals was not considered a branch library by the main library because, we suppose, it was neither funded nor staffed by them. But when the Physics Department along with its library moved into the new Physics Building on Dickson Street in 1952, it was decided that the main library would provide half of the salary of a secretary to take care of the



Figure 11: One of the first pictures of the Physics Library in the Dickson Street building. This view is looking west. The library clerk's desk is in the left corner. The door to the office of the head of the department can be seen in the center. *Photo archived in the Physics Department, undated.*



Figure 12: Physics Library looking east. *Photo archived in the Physics Department, undated.*

Physics Library. The other half of her salary would come from the College of Arts and Sciences. She was placed in this newly established Physics Library and had combined duties of departmental secretary and library clerk. It is assumed that at this time the main library took over the funding for acquisition of books and journals as well.



Figure 13: As the library collection grew, space needs became acute. Shelves were built up to the ceiling and a tall ladder used by faculty and students to access the journals. *Photo archived in the Physics Department, undated.*

A clear account of the establishment of the Physics Library was provided by Grace Upchurch, who was head of the Circulation Department and responsible for overseeing the collection's move from Old Main to the Physics Building as well as setting up guidelines for its operation. She writes:

> [The] Physics Library was established in September 1952, when the new Physics Building was occupied. Since the library was to be supervised by a secretary who had no library training, the Circulation Librarian had to see to arrangement of books on the shelves, to devise and set up a set of records and a charging system, and even to write a manual for operation of library. In 1961 this librarian wrote a complete, detailed manual giving not only information on charging and discharging books, but also checking in magazines, ordering replacements, and collection of fines and handling of over dues.[8]

[8] *The University of Arkansas Library*, *1929–1970,* by Grace Upchurch. She served as the Circulation Librarian from



Figure 14: The "new" Physics Library in the renovated space, looking west showing journal stacks. ***Photo by Rajendra Gupta, 1994.***

From all indications, bound volumes of the physics journals as well as some of the physics books were transferred from the main library to the Physics Library in 1952. This resulted in a fairly sizeable collection of books and periodicals, sufficient for the department's needs.

Upchurch goes on to say:

> The Physics Library was supposed to be strictly a research collection and was to remain small. There was room for only about 2,000 volumes on the shelves. The arrangement with the Physics Department faculty was that nothing primarily for undergraduate use was to go to that library, but was to remain in the General Library where it would be more generally available and for longer hours. Physics Department would continue to order materials for their undergraduate classes to be kept in the General Library. Somewhere along the way, and several years after the Library was established and policies set up, all agreements were forgotten, and all books bought by Physics began to be sent over to that Library, with the result that shelves were overcrowded and undergraduates could not find the material they needed. This is a bad situation.

The Physics Library occupied 714 square feet of space in the Physics Building (room 102; see chapter 5, section G). With journal collections growing fast, the library soon ran out of space. In 1972 the Physics Library expanded into the office of the head of the department (room 101), which added an additional 272 square feet for a

1929 to 1968. This report is available in the library.



Figure 15: Physics Library looking east. The librarian's office is behind the glass enclosure on the right and library assistant's desk is in the center. The door on the left leads to the book room where monographs were kept. Photo by Rajendra Gupta, 1994.

total of 986 square feet. But even this was not enough, and the library soon ran out of space again.

There is documentation to suggest that circa 1969, the department received federal funds for the acquisition of material.[9]

The Physics Library's status as a branch of the main library was somewhat ambiguous until 2001 — nearly half a century after it was established. In the late 1960s, the main library withdrew its support of the library clerk, and the position of the physics secretary was fully funded by the College of Arts and Sciences. However, she continued to provide clerical services in the library.

When the junior author of this history joined the department in 1978, the acquisition of new books and journal subscriptions was fully funded by the main library (within budgetary constraints), but the clerical services were provided by the physics secretary. She checked books in and out, shelved books, prepared unbound journals for binding, entered books and current issues of journals into Cardex, and so on. No reference services were available in the Physics Library.

In 1981 the first physical sciences librarian, Mary Fran Bustian, was appointed. She was based in the main library, and served for two years as the liaison librarian for both the physics and chemistry departments and as the physical sciences reference librarian.

In 1985 Usha Gupta was appointed as the physical science librarian based in the main library. Her responsibilities were split: one half included general reference in the main library and liaison to the physics and chemistry departments, and the other half included working as coordinator of science collection development. This included all sciences: physical, biological, and geosciences. She started providing online searching of physics databases to faculty and students as such databases became available.

Statistics available for 1987 show that the library had 12,529 bound volumes and subscribed to 149 journals[10]. This perhaps represents the peak number of journal subscriptions, as budgetary pressures in the following years forced a number of subscriptions to journal titles that were not often used to be cancelled. The collection was prioritized by the physical sciences librarian into the following categories based on faculty research in the department: exhaustive, comprehensive, research, undergraduate, and minimal.

By 1990, the space shortage problem had become acute. Shelving reached the ceiling. There was almost no seating space as more and more space was taken up by shelves. Many journals had to be stored in boxes due to the lack of shelving space. Then in 1994 the entire Physics Building was renovated. At that time, the

[9] Annual reports of the department from 1968–69 and 1979–70.
[10] *Self-Study Report of the Physics Department.*

Physics Library was moved across the hall (room 221 of the renovated building; see chapter 5, section H). It provided 1,500 square feet of pleasant space with large windows and a high ceiling. It also had office space for a professional librarian.

In 2001, finally, the library administration (under the leadership of the dean of libraries, Carolyn Henderson Allen) accorded the Physics Library the full privileges of a branch library. The main library took complete control of the operation of the Physics Library. Usha Gupta was appointed the first head of the Physics Library and moved her office into that space. Staffing was provided in the form of one full-time technical assistant and a couple of student assistants. Gupta's duties included general supervision of the library's operation, physics collection development, bibliographic instruction to students, and reference services to faculty and students. Her tenure saw significant developments in journal access. The transition to online journals began in 2003. By 2005, 85 percent of physics journals were available online and by 2007 that had risen to 98 percent, of which 40 percent were available from volume one to the present. The prestigious APS journal *Physical Review* had an online archive reaching all the way back to its first volume in 1893. Online access to INSPEC, COMPENDEX, RefWorks, Science Citation Index, the *Handbook of Chemistry and Physics*, full-text access to the IEEE, and many more databases became available. As a result, in 2007 most of the old bound volumes of journals were transferred to the main library or storage, and space was created for more computer stations and seating.



Figure 16: Usha Gupta, the first full-time physics librarian and the first head of the Physics Library (2001–2009), in her office. *Photo by Rajendra Gupta, 2009.*



Figure 17: The Physics Library in 2008. hosting a reception during the department's centennial celebrations. *Photo by Russell Cothren, 2008.*

13.

Other Academic Pursuits

Military Training, Summer Institutes, and Teacher Training

A. The 1940s to 1970s — A First-Hand Account by Sharrah[1]

I. Military Training, World War II

Beginning in 1942 and for the next three years, World War II greatly affected the university. Student enrollment dropped by approximately 30 percent, so the regular civilian student body numbered as low as 1,792 in 1945, and over one-half of these were women [Ref. 1, 159]. Many of the young men had volunteered or been drafted for military service.

In 1943, 1944, and 1945, the Army Air Corps and Army Specialized Training Programs came to the campus. As many as 3,500 students in uniform may have been trained here [Ref. 1, 215]. The Physics Department had some early experience teaching physics to students of the Civilian Pilot Training Program in special night classes. Then the young Army Air Corp volunteers arrived in 1943. The first three groups were Squadrons A, B, and C with 150 members each. Ham, Sharrah and Dr. Charles H. Cross, a physics instructor from Peabody High School in the College of Education, gave the daily lectures in physics to these three groups. The lectures were in the Engineering Auditorium in the old engineering building on the southeast corner of the campus. The text was *College Physics* by O. M. Stewart of the University of Missouri.

These students also performed rather classical physics laboratory work and attended drills. Ham organized all of this, and a large number of faculty members from the other departments and colleges came in to do this work. The advanced laboratories downstairs in Old Main were converted to elementary laboratories. Dr. R. K. Bent of education helped to arrange the equipment storage. Some new items were purchased with military funds. If you see some ancient pieces around the Physics Department with an "A" roughly painted on them, they were purchased by the Army then.

Harold Clark held weekly discussion sessions attended by all the faculty brought in from the other departments for the Army Air Corps Program and later for the Army Specialized Training Program. He described the experiments, went through most of them, and worked selected problems from the Stewart text and answered questions. All of this was well organized by Ham, and most of the activities went smoothly. Many of the staff members brought in from the other departments spent long night hours studying physics again.

When these Army Air Corps cadets reported to their classes, they were usually brought by one of the lieutenants and later by the group leaders. A Lieutenant Montgomery sat in on most of the lecture sessions for one squadron. At first, the cadets would stand at attention until the physics instructor would tell the officer in charge to seat them. This military formality didn't last very long,

[1] This section was written by Paul Sharrah and has been reproduced from History1 with only minor editorial changes.



Figure 1: Students of the Army Specialized Training Program in front of the Chemistry Building, circa 1944. *Photo from History1.*

and they soon became much more relaxed. But the groups did come and leave in formation, often singing "nothing can stop the US Air Force." Sometimes one would hear, "the WACS and WAVES[2] will win the war, so what the hell are we fighting for — ?"

There was a feeling at times that the army was using us to hold these Army Air Corps volunteers until they had planes and training space for them. Most of these volunteers were very young, and, while they were bright and eager, they had much to learn. We did them some good, I hope. Someone, somewhere in the United States should have made the young navigator of the Lady Be Good[3] study a little harder.

Then, in 1943, when we had just about figured out how to teach young Army Air Corps volunteers, here came the Army Specialized Training Program (ASTP). Then we heard a new song, "Those Caissons Go Rolling Along." It appeared now that the army expected a long war, and they were becoming concerned about the lack of personnel with mathematics and engineering training.

It was obvious that the ASTP students had been selected very carefully as to academic background and potential. We taught them a course more typical of engineering physics with a text authored by Robson and chosen with this in mind. The work was more mathematical than the course taught for the Army Air Corps cadets.

Most of the ASTP students took to this work very well. It was clear that if they didn't make it they would be out of the program soon. Some did leave. I remember the face of one very bright ASTP student who was quite literary and artistic. He said that he really didn't want to learn the slide rule and trigonometry and physics, but he was smart, and he did. It was reported later that many of these trainees made the difference at the Battle of the Bulge.

Fifteen credit hours was considered the normal teaching load for several years, but a twelve-hour load was a well-established norm by the middle of the 1950s. When the members of the physics faculty were teaching very heavy loads above twenty hours during WWII, the university (through the army) paid all of them a 50 percent increase in pay. The extra load came about because of the Army Air Corps and Army Specialized Training programs. But it was very

[2] WAC stands for Women's Army Corps, who were mainly nurses and other auxiliary members of the army. The Navy equivalent were called WAVES.
[3] A 1941 musical film.

hard work, and one of the physics teachers came down with pneumonia that was probably brought on by fatigue.

II. Summer School

One day in late 1952 or early 1953, Dr. Henry Kronenberg, dean of education and director of the summer session, walked into the Physics Office on Dickson Street and reported to Dr. L. B. Ham that he wanted college physics to be offered again during the summer session. He preferred to walk to the various offices to do business rather than use the telephone or send memos.

For some unknown reason, physics had not been taught for one or two summers. Dr. Sharrah was quick to agree that this should be renewed but complained about how hot the rooms were in the summer in the Dickson Street building without air conditioning.

Dean V. W. Adkisson had something to do with this question and said that we did not really need air conditioning here in the cool Ozarks. His office was a nice southeast corner room in Old Main with many windows. Physics was down in a hot hole south of Dickson Street where there was very little breeze. The summer school offerings have included not only College Physics but University Physics, astronomy, physical science, and Physics and Human Affairs. Details of the offerings have changed from year to year, but physics has been a part of the summer school since Kronenberg got us together again in the 1950s.

But Sharrah went to the Oak Ridge National Laboratory for several summers, and Ham liked his long summer vacations, seeking a place where Mrs. Ham's health might improve. As a result, some very fine teachers were brought in from other institutions to teach College Physics in the summer school. Among these were Dr. Joe G. Robbins and Lamont Woodruff of Hendrix College, Dr. Wallace A. Hilton and Dr. Roger Crawford of William Jewell College, Dr. Moody Coffman of Oklahoma City University, and Dr. Roger Hanson of Carleton College.

The department continued to bring in outside teachers for the elementary physics courses even through the 1960s because it became involved in summer science institutes taught by some of its key faculty. Dr. Paul Sharrah, Dr. Charles Jones, and Dr. Charles Richardson contributed to these institutes in the 1960s, and Dr. Richard Anderson and James Wisman of Chemistry worked with institutes for high school students during the 1970s (see below).

III. Institute Teachers

Not only were outside teachers brought in during the 1960s and 1970s to teach the principal offerings of the summer school, but teachers from other schools were employed to assist with the science institutes (see below). Wallace Hilton was the backbone of the optics laboratory work taught as a part of the institutes sponsored jointly by the Atomic Energy Commission (AEC) and the National Science Foundation (NSF). These jointly sponsored institutes were in operation from 1963 to 1971 and were for high school teachers of chemistry and physics.

Noel Rowbotham of the College of the Ozarks helped develop laboratory experiments. Moody Coffman of Oklahoma City University helped one summer with the junior high school science teachers in addition to teaching in the regular summer session. JoAnne Rife of Harrison High School assisted in the AEC–NSF institutes, and Sallylee Hines of the College of Education assisted in the institute for junior high school science teachers.

One year, special Saturday morning lectures for the junior high school science teachers were conducted at five University of Arkansas campuses around the state. Moody Coffman came from Oklahoma City to Fort Smith, and Professor Powers came from Monroe Louisiana

to Monticello, and three other teachers whose files have been lost taught on Saturday mornings at Little Rock, Fayetteville, and Arkansas State University in Jonesboro.

Several physics graduate students and some undergraduate students were employed to assist in various parts of the institute work. Some of the students recalled were John Gray, Charles Thorne, Carl Rutledge, Onis Cogburn, Charles Head, Martha Moore, Mordecai Schwartz, Sam Donaldson, Robert Hilton, and Thomas Atwood.

IV. Summer Institutes

The first NSF institute on campus was an excellent program directed first by Dr. Lowell Bailey and later by Dr. Leo Paulissen of the Department of Botany and Bacteriology. This institute was in operation for ten consecutive summers, beginning in 1956. Dr. Bailey had been assisted and encouraged by Dr. Arthur Fry of the Department of Chemistry in initiating this program.

This institute brought in approximately fifty high school science teachers for six weeks. They had courses in all the basic sciences and all took a three-credit-hour course in demonstrations in physics. Glenn Bray of Grosse Point High School was brought in specifically to assist Paul Sharrah with this course. Several high school students and college students assisted in the development of these demonstrations.

All of the offerings were designed to meet the needs of the high school teachers and were offered for graduate credit. In addition to the physics demonstrations course, an eight-credit-hour course was offered entitled Principles of Physics. This was an algebra-trigonometry-based general physics course.

Of course some complained that we were giving graduate credit for such courses, but they were indeed designed to meet a need and were definitely challenging.

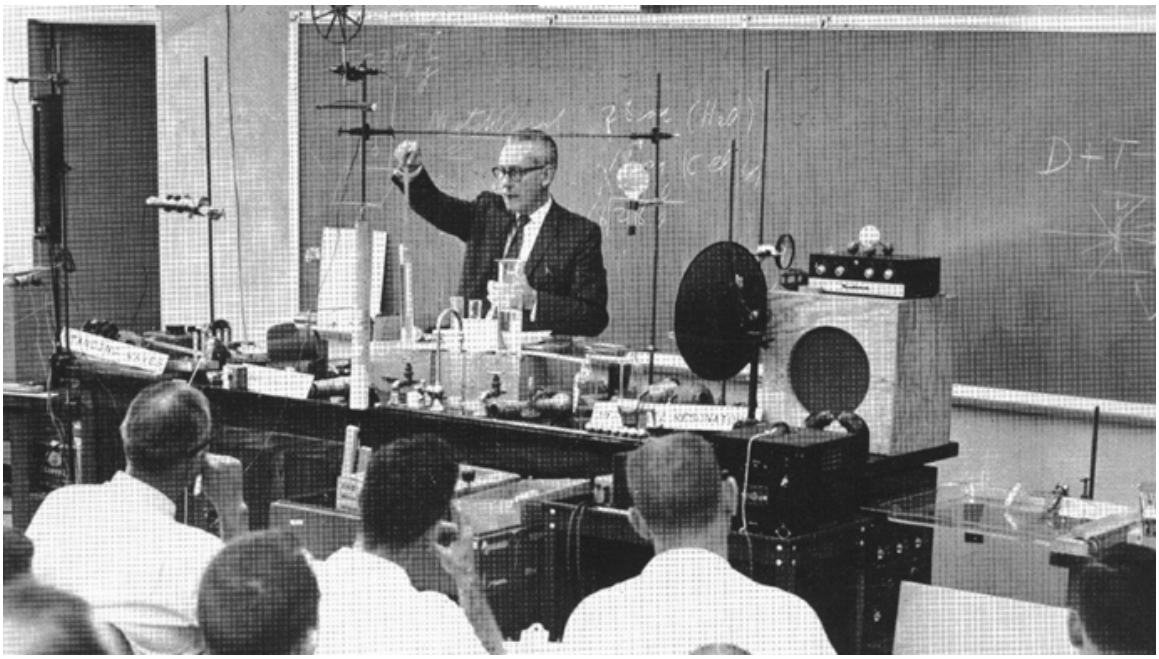


Figure 2: Professor Sharrah performing physics demonstrations. ***Photo archived in the Physics Department, undated.***

V. MS in Natural Science

It was about 1960 when Dr. Bailey took the lead in developing a graduate program resulting in the master of science degree in natural science. It again was a program designed to broadly train the recipient in the sciences and mathematics. A number of these degrees were awarded to high school teachers in the 1960s and 1970s, and several of the students with a physics emphasis have had outstanding careers.

Someone in the Physics Department is always saying that each decade has its challenge and its opportunity. We met the challenges of these decades with the institutes and the master of science in natural science. This degree was later phased out when it was felt that it had served its purpose.

VI. Modern Physics Institute

In 1963, the Department of Physics operated an institute funded jointly by the Atomic Energy Commission and the National Science Foundation entitled "Atomic and Nuclear Physics for High School Teachers of Chemistry and Physics" for the first time. The initial proposal for this institute was written by Paul Sharrah and Glen Clayton, and Sharrah directed these institutes from 1963 to 1971. The principal teachers in these institutes were Charles Jones, Charles Richardson, and Wallace Hilton. The publicity for this institute was sent out nationwide, so a few of the participants each year came some distance. The NSF provided the participant stipends, and the AEC provided the instructors' salaries and other essential funding.

This institute was limited to approximately twenty participants because one half of the work was a serious laboratory course emphasizing atomic and nuclear physics, including classical optics and spectroscopy. The other half was a lecture course on atomic and nuclear physics. This lecture course was effective, taught first by Charles Jones and in the institute's final year of 1971 by Paul Sharrah. Charles Richardson, Lamont Woodruff, Wallace Hilton, Carl Rutledge, and JoAnne Rife of Harrison High School were key persons in the laboratory work.

The laboratory had been enriched by an AEC equipment grant, including a subcritical assembly, received earlier to fortify the nuclear physics offering. This subcritical assembly was presented later to the nuclear program in mechanical engineering under the direction of Dr. Leon West, a former physics major at the university.

Another significant part of the AEC–NSF institute program was an equipment grant from the AEC to each participant completing the course. This was a desktop radiation detecting system using a Geiger counter and scaling circuit, an ionization radiation detector of simple design, several sources and filters and other accessories. It was stimulating on the last day to see the participants coming to the back door of the Physics Building in their cars to load up this equipment they had been using during the six-week course. Some equipment had to be shipped. Two of the participants were so impressed by Arkansas that one came to work in chemistry and one later retired to Beaver Lake.

We were very successful in obtaining AEC and NSF funding for summer institutes. Glen Clayton assisted materially in writing proposals and contributing ideas. We were so successful that Moody Coffman of Oklahoma City University wanted to know more about our proposals. Part of our success was a result of the desire on the part of the National Science Foundation to have institutes widely distributed across the country, and we were ready and willing candidates. The recent AEC equipment grant obtained by Dr. O. H. Zinke was also a factor in obtaining the joint AEC–NSF institute grants.

The director of the NSF institutes program, a former chemistry professor at Illinois, was an alert and imaginative person. More than once he

called, usually in the late afternoon, with a specific pertinent question about our program and made inquiries about our work. He must have been reasonably well impressed with our work because, after Sharrah returned from teaching in India in 1967, the NSF institutes director corresponded with him concerning the possibility of an appointment with the NSF to work with the AID and India programs. Approximately twenty years later, Dr. Richard J. Anderson did go to Washington with another type of NSF program.

VII. Institute Directors

A very important feature of the NSF institute program was the meeting for institute directors. All of the directors from the different colleges or universities in a broad geographical region convened sometime in the late winter or early spring for detailed information on institute management and participant selection. It was one long day, and all the directors went home with practical management information and increased confidence.

There were fewer of the AEC–NSF sponsored institutes, approximately twenty, and most were directed by biology teachers, with the remainder from chemistry and physics departments. In addition to the NSF directors training sessions, all of these directors were brought together in one place, sometimes Atlanta, or Albuquerque, or San Juan, or New Orleans. About half of the day again was given over to management considerations, but the other half was spent in much needed scientific and technical discussions. This included detailed information on the nuclear laboratory equipment that was to be delivered for the participants to use in the institute and to take back to their high schools.

Some interesting nearby nuclear facility was visited. Sometimes this was a hospital and at other times it was a university research laboratory, as at the University of Puerto Rico Medical Center.

VIII. Junior High School Teachers

Mentioned earlier was an institute funded in 1965 by the NSF entitled Physics for Junior High School Science Teachers. It consisted of a three-week summer session followed by an in-service course offered throughout the next year at five different centers in Arkansas.

The summer portion was a laboratory course and a demonstration lecture each day, emphasizing physics principles and phenomena. The demonstrations were essentially the ones used during the years of the NSF institute directed by Lowell Bailey and Leo Paulissen. The laboratory work leaned heavily on the department's existing general physical science offerings.

Then, during the following school year, several of the teachers continued their studies in the in-service course taught at five locations. This in-service course was a lecture course emphasizing physics principles and phenomena. Two textbooks were used: one a recently published junior high school text emphasizing physics, the other a brief general physics text (Beiser). The five centers where these in-service courses were taught were the Arkansas State University in Jonesboro and the University of Arkansas campuses in Fort Smith, Monticello, Little Rock, and Fayetteville. The institute director (Paul Sharrah) or associate director (Glen Clayton) visited each of these five sites at least once during the school year.

This program for junior high school teachers of science, while considered to be a success, was not proposed again the next year primarily because of the great amount of time required to initiate and manage it.

IX. Students and Teachers

An excellent series of institutes and summer science camps were in operation by Dr. Richard

Anderson from 1971 to 1977 and are best described in his own words from a December 1992 memo:

> During the periods of the 1970s the physics faculty continued their involvement with teacher education and expanded their efforts to include summer programs for high-ability students from small rural school systems within Arkansas. Professor Richard Anderson's first effort in teacher training was as a staff member on an NSF-funded project directed by Dr. Sallylee Hines of the College of Education.
>
> This 1971 project provided a six-week summer workshop for twenty-four junior high school teachers from the Northwest Arkansas area. The participants were introduced to the Introductory Physical Science Curriculum (IPS), a ninth-grade course that emphasized the "discovery" approach. The participating schools agreed to purchase the necessary equipment for all the teachers to implement the curriculum during the following school year. Follow-up meetings were held during the academic year to ensure that the participants were successful in their efforts.
>
> This program was significant in several ways. First, it marked a significant commitment on the part of the school system to implement the curriculum training received by the teachers (e.g., equipment purchase and academic year follow-up meetings).
>
> Second, teachers actually "took" the course that they were to teach while university faculty "played" the role of the junior high teacher.
>
> Third, it introduced the physics faculty to a curriculum that was essentially the sole purview of the college of education. This last point was especially significant because it led directly to the development of the Department's highly successful Physical Science Course for prospective elementary school teachers by Dr. Glen T. Clayton. Clayton's course utilized the IPS materials and "discovery" approach, but added several enrichment experiments and displayed significant physical principles in a way that was "fun" for the teachers (e.g., making ice cream as a freezing-melting point experiment). The increase in volume of popcorn was studied! This provided another example of how the Department's summer educational programs impacted the Department's regular academic year offerings.

In 1973–74 Anderson received NSF support for curriculum implementation programs involving high school physics teachers from across the state. The programs were designed to assist school systems, including Fayetteville, Fort Smith, and Pulaski County, to introduce the Harvard Project Physics Curriculum into their senior high classrooms. Anderson was assisted by a high school teacher from Little Rock's Hall High School, Mr. A. T. Bell. Bell received training at a workshop conducted by Harvard University before joining the program. These summer programs were also characterized by supplementary academic year meetings; a requirement that the school district purchase the necessary texts and laboratory equipment; and a "hands on" classroom approach to the summer training period.

Perhaps one of the most interesting outcomes of the summer Harvard Project Physics workshops occurred in 1974 when Anderson and James Wisman, Lecturer in the Department of Chemistry, obtained an NSF grant and solicited private donations to conduct a Student Science Training Program (SSTP) for 24 high-ability students from small rural school systems. The six-week SSTP was timed to "overlap" by one week with the teacher workshop so that the twenty-four teachers, participating in the workshop, could try out their new-found techniques on the students. The result was a "one-on-one" learning experience that few other students would ever experience.

The SSTP "summer science camp" concept

that Anderson and Wisman initiated was repeated each year during the four-year period 1974–77. The programs varied in length from six to four weeks, but the format, sans high school teachers, remained the same. Each week students were introduced to topics in astronomy, environmental chemistry, computer literacy and physics (e.g., optics, atomic and nuclear, sound and electronics). The emphasis was placed on student projects that provided innovative "hands-on" experience. For example, one of the sessions included a visually-impaired student from the Arkansas School for the Blind (Little Rock); an opportunity to examine new approaches to teaching a "visual" subject such as observational astronomy to a student who could not observe. The SSTP staff and participants accepted the challenge and working together developed various activities that all of the students could participate in.

One such activity of note involved using the microwave transmitters and receivers from the Sargent-Welch microwave optics apparatus to set up an experiment in Radio Astronomy. Several microwave sources were set up around the room, one on a rotating turntable. The participants were given microwave receivers with audio signal capability and with the exception of the visually impaired student, each student was blindfolded before entering the room. Teams of students were placed around the room and each asked to "map" the "universe" that they "discovered" based upon their analysis of the observed microwave signals. The experiment yielded surprisingly good results, but most importantly the visually impaired student became a valuable contributor to the project.

The SSTP experiences were extremely gratifying to the faculty and graduate students involved as counselors and teachers. Especially satisfying were the follow-up academic year visits to the schools. Wisman and Anderson would rent a trailer, load it with laboratory demonstrations and travel to select schools for Saturday science sessions with the participants and their classmates. Both of us learned a great deal about the status of science education in the smaller rural schools in the state.

The Student Science Training Program was discontinued after four years of operation due to several factors including: an increased emphasis upon research within the College of Arts and Sciences; decreasing NSF support for the national program; and to a certain degree staff burnout (handling 24 high-spirited high school juniors for 24 hours per day, seven days per week was not an easy task). In spite of continued student interest at the time of its termination, neither Anderson nor Wisman could interest any of their faculty colleagues to pick up the "torch" and continue the program.

X. Summary of the Institutes

We continue to quote from the December 1992 memo from Dr. Richard Anderson.

> Many of the SSTP alumni went on to earn college and advanced degrees and one, Dr. Ramona Bates, became a physics honor graduate. It is interesting to note that the NSF recently reinstituted this most successful program on an expanded scale as a summer science camp initiative.
>
> The legacy of the teacher training and SSTP programs shaped the Department's relationship with many of the state's school systems, their teachers and students for many years afterward.

The above paragraphs are quoted with only small editorial changes from material submitted by Richard Anderson in December 1992.

The work with the participants in the institutes was certainly one of the most rewarding experiences anyone interesting in teaching could have. Let us never cease to sharpen our tools as teachers. There is always plenty of room for

improvement. Always!

The summer science institutes were certainly a major thrust, but the regular summer school program continued to serve the needs of the students. Introductory courses were being taught and astronomy and physical science courses were popular.

A few intermediate and advanced courses have also been offered, and research is certainly a major activity for the graduate students and the faculty in the summer. The research grants assisted with the support of the graduate students in the summer and also the faculty frequently had part or all of their salary paid by the grant.

In conclusion, it is estimated that in the neighborhood of eight hundred teachers may have been involved in all of the above institutes from 1956 to 1977. Approximately one hundred high school students also profited from the summer science camps.

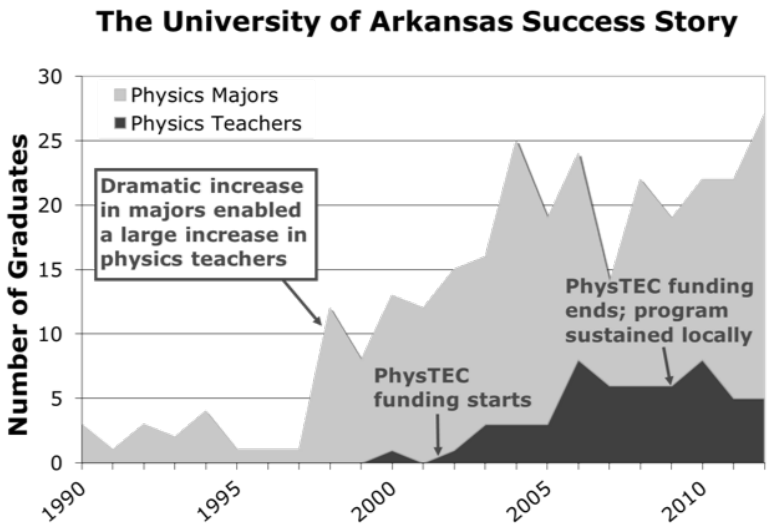
Also, while the summer institutes were originally conceived as a way to be of assistance to the science teachers, the good relations established with the teachers, the schools, and the principals definitely assisted the Physics Department to obtain many good physics majors. The high school student or college freshman merely came by to see us and said, "I want to major in physics!" Frequently they would mention the name of the teacher who recommended that they come to see us.

B. PhysTEC (Physics Teacher Education Coalition) Program[4]

There is a strong desire nationally to increase the number of students preparing to teach in the Science, Technology, Engineering and Mathematics (STEM) areas. The University of Arkansas (UA) Physics Department has been significantly engaged in the preparation of preservice teachers since 2001, building on major efforts to reform their undergraduate program, which began with NSF support in 1995. UA has seen a dramatic increase in both the number of physics majors and the number of physics teachers produced, as shown in the following figure, distributed by the American Physical Society as an exemplar of both the new Doubling Initiative and PhysTEC (Physics Teacher Education Coalition). UA's PhysTEC philosophy is that there are reasons you want teachers to teach in certain ways, so you should model this pedagogy for all students, improving their learning, and providing future teachers with good models of instruction. Not only will this have a significant effect on the number of future teachers, but on student success at the university, particularly in STEM fields. Physics classes are typically the gatekeeper courses for other STEM majors. By reforming the physics courses into experiences that not only provide significant student learning, but also develop skills necessary for success in subsequent STEM courses, graduation rates for engineering have also gone up markedly. Physics is the most successful course in the new freshman engineering program, built at UA to enhance the retention of engineering majors.

We did not, of course, go directly to PhysTEC. Our first step was reforming University Physics II starting in 1994. This earned NSF support in 1995, Implementing Interactive Laboratory-Based Learning Techniques in Second-Semester Introductory Physics, and resulted not only in a factor-of-four increase in the number of physics majors and significant improvement in learning gains (well above the national average on standard assessments) but also higher graduation rates in disciplines requiring the introductory physics courses, distribution of the materials through several vetted NSDL projects, involvement of physics graduate and

[4] This section was contributed by Gay Stewart. She was the director of this program at the University of Arkansas.



undergraduate students in physics education research or apprenticeships to improve their future teaching, better preparation of future high school physics teachers, development of a TA preparation program and a Preparing Future Physics Faculty program, part of Shaping the Preparation of Future Science and Mathematics Faculty. With this effort, an apprentice teaching program to better prepare graduate students, which had been introduced to support the reforms in University Physics II, was more thoroughly developed. Some of our undergraduates asked for permission to take the course, so they would be prepared to teach when they went to graduate school. The quality of instruction and the growth of the undergraduate program allowed physics to be competitive for one of the initial six primary program institutions in PhysTEC. As part of PhysTEC, a second faculty member with a specialty in physics education research was hired, and the reforms from University Physics II were adapted to the other two courses in the sequence. The apprentice teaching course was easily modified to support preservice high school teacher preparation. With these changes, the number of graduates has continued to rise, and while these students are competitive for physics graduate programs, 10 percent or more choose to go into 7–12 physics and physical science teaching. Arkansas had seen a decade where only one highly qualified physics teacher was produced statewide. Now, about 2 percent of the national production of physics-prepared high school physics teachers occurs on the UA campus.

The Physics Department's MA in physics teaching, originally developed to prepare faculty for two-year or small four-year colleges, was carefully adjusted over a decade to become a degree that serves teachers well. Working with Education on the licensure paths available to our students, we realized we would need funding to help students with the fifth-year Master of Arts in Teaching requirement. In 2007, an NSF-sponsored Robert Noyce scholarship program to support future STEM teachers was secured in the Physics Department. PhysTEC had allowed us to build much stronger relationships with our College of Education and Health Professions, as well as area teachers and schools through program components such as the teacher in residence and the teacher advisory group. To better support our graduates and to help other teachers as well, the department continued to reach out to area teachers by building partnerships with teachers and schools through Department of Education and NSF funded programs. Our work with in-service teachers, and our unusual success in the preparation of physics teachers, drew state and national attention to Arkansas and allowed us to successfully compete to bring a four-year model path to licensure to our campus, in collaboration with our colleagues in Education.

14.

Faculty Reminiscences

In this chapter we present reminiscences by a few faculty members. This is one way to learn what the department was like, from the first-person accounts of those who actually taught and did research here at various periods during the past century. The first date in each heading refers to when that faculty member joined the department, and the second date is when they either retired or resigned. Some of the statements have been edited for brevity.

Otto Zinke (1959–1988)

Professor Zinke offers a valuable reflection on what the department was like near the midpoint of its century:

> I arrived here in the Fall, 1959, the year that the PhD program started. Glenn Clayton had joined the department a year before. Ray Hughes had been here for several years and was instrumental in starting the PhD program. The department operated on a shoestring in those days. Paul Sharrah was in constant trouble for overspending his budget. In fact, while he was interviewing me, he received a telephone call from the dean who so loudly abraded Paul for overspending that I could hear both sides of the conversation across the desk. Paul just smiled through it. Later, I found out that the dean was universally known for his evenness of temper.
>
> There were no startup funds for research. There were no funds delegated specifically for the support of the PhD program. Recently, I found out why. Apparently, the University had just put in several PhD programs, and could only fund one. So, to avoid the appearance of favoritism, it didn't fund any.
>
> There was plenty of lab space, but there was almost no equipment. The building had leaky windows and virtually no insulation. We sweltered in the summer and were uncomfortably cold in the winter. I recently ran across a note in one of my lab books which registered a temperature change in the lab of 12 degrees C on one mild April day. Imagine what it was like in the summer. We were doing some experiments which required controlling temperature to within a few tenths of a degree. It wasn't easy.
>
> When I arrived, the immediate shortage was of furniture. Glen and I shagged a large truck from Buildings and Grounds and drove to North Little Rock. At a government surplus center there, we loaded up desks and chairs left over from World War II, which had ended some 15 years before. Some of the furniture was broken and had to be repaired. George Kirsch and Len Gabbard were able to fix most of it. I used one of those chairs for 28 more years before it collapsed. That furniture served until the physics department was massively remodeled.
>
> All that said, we did have a plentiful supply of good graduate students; the majority of the early ones were educated at William Jewell College, a small liberal arts college in western Missouri which Paul Sharrah had attended.
>
> During those early years, Glen and I had teaching schedules of 13 or more hours, and during several semesters I also had an additional six hours of supported research. We were pretty busy.
>
> In the next several years, Charlie Jones came in off and on and gave us some relief. Then, Steve

Day, Art Hobson, Charles Richardson, Rich Anderson drifted in, and teaching loads became much lighter and we could devote more time to research.

Early on, we made some good decisions. We beefed up the undergraduate curriculum with excellent texts: Symon in mechanics, Corson and Lorraine in E and M, and Leighton in modern physics. We didn't graduate many physics majors, but those we did graduate, we could send to any graduate school in the country and we did. They inevitably performed well, and I think that served our reputation.

We tightened up the requirements for Master's theses and orals. We held the qualifying exam and the candidacy exams to very high standards. In the process we lost some graduate students with whom we had become very good friends. An occasional faculty member was antagonized when a student was lost. However, I think those early decisions are responsible for where this department is today.

I gradually built up several research projects and acquired graduate students and a little money here and there. My students were a very cohesive and very hard-working lot. They were frequently in the labs at 2:00 a.m. They worked 7 days a week. A group of them knocked the experimental underpinnings from under the Thomson-Onsager-Callen theory of non-equilibrium thermodynamics. Another group used a technique developed in our laboratory for analyses of pulsed plasmas and analyzed the production of plasmas in the kilo- to mega-degree range. We did some interesting pulsed-heat transfer work.

My students were also given to hilarious pranks. I constantly groused that referees probably thought that we didn't have indoor plumbing at the University of Arkansas. So, I came in one day, opened my office door (Room 113), and found myself staring into a complete, weathered privy, roof and all. It was a two-holer with coffee grounds substituted for the usual contents. We had a visitor from Texas coming the next day, and Steve Day made the students take it down. I am not sure that I have ever forgiven Steve for that.

Stephen Day (1961–83)

Professor Day's reminiscences provide a glimpse into the environment here at that time:

> My first experience with Arkansas came the night I flew into the Fayetteville Airport in the spring of 1961. As we were approaching the airport, the plane, a DC-3, started bouncing around and the flight attendant appeared to get very upset, even crying. As it turned out a violent storm was passing through Northwest Arkansas and a tornado was hitting Winslow that night. If I remember correctly, the lights had gone out on the runway. This was an interesting introduction to Arkansas.
>
> The next morning Professor Zinke picked me up at the motel on the corner of College and Dickson for the start of my interview visit. Instead of taking me straightaway to the Physics Department, we went for a drive out in the country to look at good fishing places. We had chatted earlier and shared our common interest in fishing. I immediately realized Fayetteville was the kind of town I wanted to live in. This was especially true after living in the city of Houston for four years and I had four children.
>
> Paul Sharrah had telephoned the Chairman of the Physics Department at Rice and asked him when he was going to recommend one of his graduates [to] apply for a position at the University of Arkansas. As it turned out I had that same day talked to Professor Tom Bonner, the Chair, about academic positions in the southwest. I had already turned down offers from the University of North Carolina and the University of Texas and I wanted his advice about other schools. Professor Bonner called me back

in his office and encouraged me to consider Arkansas which I did for a number of good reasons.

Steve Day offers a valuable account of how the department grew in its formative years as a research-oriented department:

> Paul Sharrah was a very gracious man while at the same time he did a great sales job on the bright future of the U of A Physics Department with the newly approved PhD program. I enthusiastically accepted a position as Assistant Professor and started my appointment on May 1st 1961. I was given $500 for startup funds for research, a nice laboratory room with window air conditioning but no equipment, two graduate students, one an NSF Fellow, and a great undergraduate research student. I was given a twelve-month appointment with no summer teaching duties so I immediately went to work writing research grant proposals and building electronics equipment for my research. I was very fortunate to get an NSF grant within the first year and two more students joined me in the laboratory. From the very beginning the faculty in the department were committed to building a very strong high-quality research program. At times our expectations for our students may have been too demanding but the morale remained very high.

Arthur Hobson (1964–1999)

> When I arrived in 1964, we had eight tenured or tenure-track faculty members. Classes had 30 or 40 students at most, and each of us taught two or three classes per semester. That changed during the late 1960s, so that by about 1968 only one section of the University Physics and College Physics courses was offered each semester and there were 100 or 200 students in one section of many introductory classes. This allowed us to reduce teaching loads to one or two courses per semester and meant that large introductory courses had to be taught in large auditoriums outside the physics department. This might have been a bad idea pedagogically, but it did give the faculty more time for research.
>
> I'm proud to note that ours is a talented department. That was true in 1964 and it's even more true today. The department has become more and more talented, partly because of our hiring policy. We have always tried to hire the very best people we could find, even when the new people were better researchers than those already here. We didn't fear competition but instead welcomed the stimulation of good new people. It seems to me that some university departments don't operate this way, and that these less ambitious departments become boring and unproductive. It's fun to be around talented people!
>
> The undergraduate physics majors program has undergone some ups and downs. During the 1950s, we graduated 4 or 5 physics majors per year. Then Russia's Sputnik space capsule orbited in 1957 and the Sputnik boom began. National support for science lurched into high gear. This boom partly influenced my decision, in early 1958, to go back to school as a physics major, after obtaining a music degree three years earlier. This decision panned out pretty well, as the boom was in full swing in 1964 when I finished my PhD, which meant that I had no shortage of faculty job offers from college physics departments. Among other reasons, I chose Arkansas because the department was more congenial than other places I'd interviewed, and because of Fayetteville's beautiful environment.
>
> The Sputnik boom continued during 1963–1982, during which we graduated seven to nine physics majors per year. But the cold war with the Soviet Union, and public interest, died down in the 1980s and the number of graduates declined to only one, two, or three per year during 1983–1994. I wondered if the undergraduate program

would survive.

In about 1993, the department decided to hire a physics education specialist to lift our undergraduate program out of the doldrums. The result was that Gay Stewart came on board in 1994, devoting her attention to teaching the introductory course for scientists and engineers, mentoring the undergraduate majors, and conducting physics education research — a new and developing field of physics-related research. The American Physical Society dubbed the next several years The University of Arkansas Success Story, but I consider it to be the Gay Stewart boom. By 1998 we were graduating about 10 physics majors per year, by 2003 it was 15 per year, and it's averaged 20 per year since then. Among others who helped with this effort to build undergraduate physics, John Stewart (Gay's husband) joined the faculty as Visiting Professor in 2001 and then as Assistant Professor in 2008. By paying attention to mentoring the physics majors, and by emphasizing inquiry-based teaching methods in the introductory courses, Gay and John and others demonstrated that even programs bearing the often-dreaded titled "physics" can thrive if you get the right people to shepherd them.

Richard Anderson (1966–1989)

In 1966 the departmental leadership was in the capable hands of Paul Sharrah who served as Chair from 1957 to 1969. He was committed to expanding the department's graduate program that was instituted in 1959. Joining me in 1966 as members of the department were Charles Richardson, an experimentalist, and Bill Plummer, a computational theoretician. The hiring of three new faculty members in a single year was viewed as a "coup d'etat" within the College of Arts and Science. Paul was followed as chairman by a series of capable individuals who possessed his commitment to the growth of graduate education. Stephen Day (1969–75), Charles Richardson (1975–78), Donald Pederson (1978–83), Michael Lieber (1983–86), and Allen Herman (1986–89) not only provided leadership in this important area, but also supported significant improvements in the department's undergraduate and service offerings. They expected the members of the physics faculty to excel and attempted to create an environment in which they could. Thus, the common advice given to a young faculty member seeking tenure was that typical faculty responsibilities included 50% teaching, 50% research, and 50% service. There was minimal tolerance for average performance. In fact, when it was noticed that students and faculty were heading for home a little too early on Friday afternoons, the day and time of the "required" Physics Colloquium was changed from early Tuesday afternoon to 4:00 pm on Friday afternoons. The departmental leadership also worked with the faculty to ensure that teaching loads would be appropriate for a department seeking to expand its research capabilities. For example, prior to the arrival of a new Dean of the College of Arts and Sciences, Robbin Anderson from the University of Texas, introductory physics courses were of limited size with a faculty member teaching two or more sections of the same course. Dean Anderson employed the statistic — "student semester credit hours per full-time faculty equivalent" — as a measure of a department's effectiveness. Thus, the department moved to the current system of fewer sections of significantly larger class size not only to meet the Dean's criteria, but also to allow faculty adequate time for graduate research and study.

Rajendra Gupta (1978–2010)

I joined the University of Arkansas in August 1978. I had been an Assistant Professor at Columbia University for four years (I had spent

the 1977–78 academic year on assignment from Columbia jointly at the Air Force Institute of Technology as a Visiting Professor and the Aero Propulsion Laboratory as a Visiting Scientist, both located at the Wright-Patterson Air Force Base). With no prospect of tenure at Columbia, I was looking for a new faculty position. I applied here after noticing an advertisement in *Physics Today*, which was among perhaps only about half-a-dozen academic positions advertised. I did not know anything about the State of Arkansas at that time, or about the University of Arkansas (this was the pre-Internet age), having spent all my time in this country only on the East Coast. One day I received a call from Professor Charles Richardson, who was the Chair at that time, inviting me for an interview. I learned a little bit about Arkansas from my associates at Air Force, which gave me serious doubts about moving to Arkansas, and I wondered whether I should even come here for the interview. I consulted with my mentor at Columbia, Professor William Happer, by telephone. He told me that I should never turn down a place without first looking at it. I came here for the interview. The department was very small, much like Boston University, where I had received my PhD. I really liked the camaraderie among the faculty. It was the month of April, and the spring flowers were in full bloom. Professor Richardson gave me a tour of the city, and I really liked the city. Having lived in large cities only (Boston and New York), I had never learned to drive until I came to Wright-Patterson AFB a year before. But driving was still an issue, and I felt that I could easily drive in this small town. My wife was reluctant to move away from the East Coast, the only area she had known, but she agreed, and I accepted the offer here. Even though I had not realized the challenges I would face here, some of which I have outlined below, I have never regretted moving here. In the following I will reflect on what the department was like at that time.

The Physics Department had thirteen faculty members at that time, a number that had been stable for a while. I was hired due to the vacancy created by the retirement of Professor Herman Schwartz. The Department had made a decision to build a group in the area of lasers and optics, a newly developing field at that time. I was the second person to be hired in this area, the first being Greg Salamo. Charles Richardson, who had hired me, had just stepped down as the Chair of the Department, and Donald Pederson had taken over as the Chair.

The University operated on what I would consider a shoe-string budget. But I was given a princely sum of $14K for start-up, which, I was told, was unprecedented, and had been secured only after Professors Richardson and Pederson visited with the President of the University and made a direct appeal to him! These funds served a dual purpose: I used them as a matching for a Research Corporation grant as well (Research Corporation requires institutional matching).

The department had about 15 graduate students but could use a lot more. This was one of the challenges that the department faced. There were just two secretaries, one of whom also served as library clerk in the Physics Library, since the library was under the department's administrative control. The entire department had just two telephone lines, and the telephone rang in the physics office and in the upper floor hallways. The secretary in the office answered the phone and forwarded the call to the appropriate faculty member. The research labs had no phones, and neither did the graduate students. In the evenings and the weekends, when the department office was not open, the telephone rang in the hallways, and whoever answered the phone had to physically go looking for whoever the call was for. Those who worked in the labs in the evenings and weekends were inaccessible to family members unless some faculty member was in his office to answer the phone and fetch the

person! This was a particular problem for me because my wife did not drive at that time, and we had two toddlers.

The department's operating budget was about $40K. Except for the external research grants, which were few, this was the only money the department had. TELE and RIF were to come later. I was absolutely amazed how, by prudent management, the chair was able to keep the department functioning on such a meager budget. We had to record every long-distance call we made and submit the log to the chairman.

The department shared the building with the geology department, and the physics department was extremely short of space. All of the department's functions, faculty and administrative offices, graduate student desks, research labs, instructional labs, and all of the classroom teaching, except those of the large introductory classes, had to be accommodated in this space. The building also had the Physics Library and a small planetarium. The large introductory classes were taught in various auditoria around the campus. The building had no central air conditioning, although some rooms had window air conditioners. The floors were bare concrete, the ceilings were exposed to fiberglass insulation creating unsafe conditions, and the windows were painted blue, factory-like, in order to keep the sun out as there were no window blinds or curtains. I was given a small room (the size of a faculty office), graciously vacated by Professor Zinke, for my lab. It had no water supply for cooling equipment, no 220V power, and inadequate 110V power. This was simply because the department was extremely short of space, and any upgrade of facilities was not possible given the limited operating budget of the department. Professor Hughes then graciously vacated one of his large laboratory rooms for my use. A concerted effort of the department chair, Don Pederson, resulted in the renovation of this room almost two years later. The room was equipped with all the lab amenities and optical tables. Initially I shared this space with Greg Salamo and Rich Anderson.

The research infrastructure was barely adequate. The department did not have a machinist or an electronics technician, although there was a student/faculty machine shop with a few basic machines. However, there were adequate central facilities for university-wide use. These included a machine shop, an electronics shop, and a glass-blowing shop. Each was staffed by a single professional technician. The machinist, George Kirsch, was very competent and extremely cooperative, which made it possible to get my research started. Because I had only $14K to get started, we had to design and fabricate all of our equipment ourselves, and I do not know what I would have done without George Kirsch or someone like him. Even though the University lacked a research infrastructure, my colleagues and my Chair, Don Pederson, had a strong desire for me to succeed. In addition, I was very fortunate to have had a group of very talented graduate students, Mahmood Soltanolkotabi, Chao-Chia Wu, Kevin Tennal, David Pyrum, and Allen Rose, who helped me build my lab and launch my career.

Min Xiao (1990–present)

I came to the University of Arkansas in August 1990 after completing a two-year Postdoctoral Fellowship position at MIT. Because several faculty members had just left in the late '80s due to various reasons, the department was in a "rebuilding" mode and had chosen "quantum optics" as the core area to develop at that time, so both Julio Gea-Banacloche (arrived in January 1990) and I were basically hired in the same year. However, due to the budget deficit in the Fulbright College, the college could not provide any startup fund for an experimentalist like me. Professor Raj Gupta, the Department Chair, had

made a lot of effort and scrabbled $40K from the limited departmental funds, and the Graduate School matched another $35K, for me for the first two years as my startup package. Since that amount of startup fund was not enough to build the experimental setup for studying cold atoms (I worked on the experiment of slowing and trapping Na atoms when I was at MIT), especially when the "new" atomic trapping technique with high-power diode lasers and vapor cell had not been invented and developed yet at that time, I had to find a simpler and low-cost experimental project to start. After careful consideration, we decided to work with hot rubidium atoms in vapor cell and use home-built low-power diode laser systems. We had to design and build the electronic circuits for temperature and current stabilizations of the diode lasers, as well as the mounts for housing the diode lasers, which had taken lots of our time at the beginning. We even designed and made our own mirror mounts and various other mounts for holding optical elements in the department machine shop to save money. At the same time, I worked on some theoretical problems in quantum optics and had published several theoretical papers between 1991 and 1994. Luckily, my first research proposal sent to NSF was funded in 1992 which was against all odds. Also, I received the NSF Young Investigator Award in 1994. Those early NSF grants had helped my career greatly.

When I came to Fayetteville from Boston in August 1990, we had one young child with a second one on the way, so it was a difficult time for us. The department and several senior faculty members were very helpful for our settling down in the new environment. I learned most of the things about the department/university and on how to be an effective professor from various members of the physics lunch group at the Union. The regular members in the early '90s included Mike Lieber, Raj Gupta, Suren Singh, Julio Gea-Banacloche, and later joined by several different new faculty members including Laurent Bellaiche, Huaxiang Fu, Jiali Li, and Jak Tchakhalian. This tradition of some physics faculty eating lunch together at the Union has been kept for so many years, now several people from other departments on campus even recognize and refer me as a member of the physics lunch group. I really liked the friendly atmosphere of the department when I just came, since it was strikingly different from the attitude of faculty members in some of the "big schools" (such as MIT where I had just come from). The department usually had an annual party at the Department Chair's house and people frequently joined each other for family activities.

The biggest event for the department in the early '90s (1991–1993) was the renovation of the laboratory spaces and extension Phase I of the Physics Building. As the department chair, Raj worked hard to get the necessary funding and took charge of the detail design and implementation of the renovation project. Raj constantly worried about the details of the building renovation, and his hair got much grayer during that short period of time. Since the renovation, the department has much more laboratory space and a few nice lecture rooms, so some of the physics classes could be taught in our own building. Also, putting all faculty offices in the second floor next to each other could enhance interactions between the faculty members.

The atmosphere of the department in the 1990s and 2000s was very good and very active. As a young faculty member, I normally always met and went to dinners with visitors for department colloquiums in any research areas and learned many things in different areas of physics. Many distinguished scientists, including several Nobel Laureates in atomic physics and optics, such as Norman Ramsey, Nicolaas Bloembergen, Carl Wieman, William Phillips, Steve Chu, and Wolfgang Ketterle, came to deliver our Maurer

Lectures and department colloquiums. We were more involved in departmental services/events such as serving on various departmental committees and duties. I was assigned to be in charge of organizing the department's written PhD candidacy exams in 1991 and 1992. Without much experience, I must have chosen problems that were too hard since more than half of the students failed the exams, I was then released of that duty. The written PhD qualifying exam must have been one of the most discussed issues in the department over the years, and, after many attempts to modify it, it was finally abolished 2016 and replaced with an oral exam mainly involving research presentation.

Huaxiang Fu (2002–present)

From the moment I joined the physics department, the warm-hearted, hard-working, and dedicated faculty left on me an enduring memory that never faded away. It is a privilege to be part of it.

One day in March 2002, I was in New Jersey, starting to prepare for a trip to Fayetteville, Arkansas, for a job interview. I was embarrassed by not knowing which airport I should fly to, and the Internet was of no help. I was hesitating to ask anybody in the UA physics department, since, by revealing how little I knew about Fayetteville, I may disqualify myself for the job. With no apparent solution, I reluctantly picked up phone and called Greg (who was the Chair of faculty search committee). To my relief, Greg was not offended a bit by my ignorance and explained patiently which airport I should fly to and how to be on campus. I was grateful. On the trip day, I did not expect anything different in Fayetteville than in many other cities. However, as the airplane was descending and preparing for landing, suddenly I saw a herd of cows feeding on vast, green grassland. I sensed that Fayetteville was going to be different. The next day, Laurent volunteered to drive me to tour the town and Lake Fayetteville. That evening, Min took me to Shanghai restaurant for dinner, telling me about the nice things in the department. All of these may sound trivial, but they made a difference. I had been on different interview trips, the trip to the physics department of UA was special, because of the warm-hearted nature of the physics faculty and genuine welcome from the department. I started to think that UA and the physics department are unlike others.

Several months after I joined the department in 2002, it was plenty clear to me that the department was made of faculty members of strong integrity and dedication, forming the cornerstone of the department; to name a few, Raj (Gupta), Suren (Singh), Greg (Salamo), Min (Xiao), among many others.

The departmental faculty had a strong sense of responsibility about educating graduate and undergraduate students. To ensure the success of graduate students, the Graduate Affair Committee (GAC) and Raj (as the Chair of GAC) made rigorous curriculum and comprehensive policies, which were documented in the graduate student handbook, serving as the foundation of our graduate education. Nowadays the graduate handbook remains the most important guideline for all graduate students. It highlights the strong dedication of Raj to the education of our graduate students. It is special. Another tradition which I feel important is the annual evaluation of each and every one of our graduate students, making achievable goals for each year and aiming at eventual success for each student. Furthermore, after evaluation, there was a faculty meeting devoted exclusively to the graduate student annual review, identifying the slow-progressing students and finding solutions for improvement. Under the diligent supervision of GAC and the faculty, the success of our graduate education was no wonder. The undergraduate education was spectacular and became nationally known, thanks

to Gay and John (Stewart), Lin (Oliver), Raj, Reeta (Vyas), and many others, attracting a large number of undergraduates each year. The commitment of Reeta to training undergraduates in research was highly respectable.

There was a period of time when the graduate written candidacy exam became a heated issue. The whole department was heavily involved, different points of views were debated, and a task force committee was formed. It was a healthy debate, and eventually a majority of faculty members felt strongly that one of our key missions is to educate quality graduate students who are to educate others, and a solid foundation of basic knowledge is critical for teaching in small colleges. The written candidacy exam continued, although it did not survive long

In addition to teaching and research, Suren's dedication and unparalleled skills in serving the department as Chair were outstanding. Not only serving as the chair (which was daunting and challenging), Suren simultaneously supervised graduates, managed his labs, published papers, and wrote a book. How extraordinary! In a similar fashion, I was impressed by Raj's dedication and integrity in serving the department, as the GAC chair (handling graduate affairs and communicating with graduate students on a daily basis), a graduate-student recruiter, a heavy-duty graduate-student advisor, a dedicated teacher, and a good mentor, at the same time.

Our graduate students worked hard. Many stayed late in the Physics building, studying, conducting experiments, and preparing for candidacy exams. After graduation, many of them became good scientists on their own, such as Xiaoyong Wang, Haibin Wu, etc. Many undergraduates went on and were admitted to prestigious graduate schools. It proved that our department can make outstanding graduates.

I cherished the faculty lunch group, Michael (Lieber) and Raj as the leaders.

15.

Alumni Profiles

With Contributions by Surendra Singh and Michael Lieber

The department's alumni have made valuable contributions to society in many diverse professions, including as educators and academic researchers, industrial scientists, military scientists, inventors and entrepreneurs, and researchers at national laboratories. They have served on the faculty of institutions such as the University of Illinois at Urbana-Champaign and the University of Texas at Austin, and have been scientists and leaders in industrial and federal labs such as Texas Instruments, Northrup Grumman, NASA, and NIST. Their achievements have been recognized by the highest awards in their professions, such as the Oersted Medal of the American Association of Physics Teachers (the highest national honor bestowed upon a physics teacher); the National Medal of Technology (the highest honor accorded by the President of the United States for a technological achievement) and the Fritz London Memorial Award in Condensed Matter Physics by the American Physical Society. By 2008, a century after the physics major was first established, about 140 doctoral, 270 master's, and 510 bachelor's degrees had been awarded. There is no way that we can profile even all those who may have attained the highest achievements in their chosen professions. In the following, we present the profiles of just a very few to illustrate some of the areas where alumni have made contributions.



Figure 1: Robert Maurer, undated. ***Photo courtesy of Corning Incorporated. All rights reserved.***

Robert Maurer[1]

Industrial Scientist

"Robert D. Maurer is truly the father of the optical fiber," said Roland W. Schmitt, president of the Industrial Research Institute on the occasion of presenting Maurer with the institute's Achievement Award for 1986. Dr. Maurer, a native of Arkadelphia, received his BS degree in physics, with high honors, from the University of Arkansas in 1948. From there he

[1] Robert Maurer is the charter member of the University of Arkansas chapter of the Sigma Pi Sigma Society — a physics honors society — and served as its secretary. His reminiscences of the time he was an undergraduate here appear in chapter 16.

went to graduate school at MIT and received his PhD in physics three years later.

During his early years at Corning Labs, Maurer studied lasing phenomena in glasses and carried out comprehensive fundamental studies of scattering and absorption in glasses. This early scientific research on optical properties of glasses later proved invaluable when the suggestion of using optical fibers for telecommunications arose in the 1960s. Maurer's work on optical attenuation not only helped in choosing and creating the right materials for fibers but also provided a fundamental limit on attenuation, which is still used in evaluating fiber performance. Maurer also displayed an unusual ability to analyze phenomena and design experiments to discover the mechanisms behind them. Accordingly, he was the ideal person to undertake the task of inventing a glass fiber waveguide, and in 1970 he led a team (with Donald Keck and Peter Schultz) at Corning that designed and produced the first low loss fiber-optic cable made of fused silica. More than 90 percent of the fiber optic network in the United States is based on this technology. The National Academy of Engineering credits fiber optic communications as one of the most outstanding engineering achievements of the twentieth century.

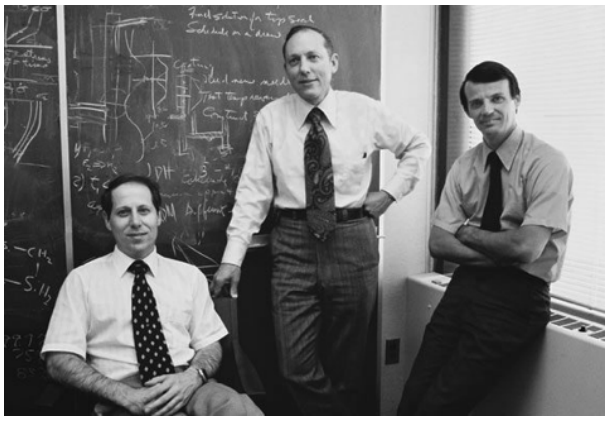


Figure 2: From left to right: Donald Keck, Robert Maurer, and Peter Schultz. Undated. ***Photo courtesy of Corning Incorporated. All rights reserved.***

Maurer has published more than fifty technical papers and holds sixteen patents, including the optical waveguide technology patent. With S. E. Miller of Bell Labs, he founded the Optical Fiber Communication Conference as a forum for technical advances in the field. Today the conference draws several thousand technologists. Maurer is a member of the NAE (National Academy of Engineering) and a fellow of the AcerS (American Ceramic Society), IEEE (Institute of Electrical and Electronic Engineers), and APS (American Physical Society).

Maurer's contributions to technology and, through fiber optic telecommunications, to society have been recognized by numerous awards and honors from technical as well as public institutions around the world, including the L. M. Ericsson International Prize for Telecommunications (Swedish Academy of Engineering); the George Morey Award (AcerS); the Morris N. Liebmann Award (IEEE); the International Prize for New Materials (APS); the American Innovator Award (US Department of Commerce); induction into the National Inventors Hall of Fame (1993); the John Tyndall Award for Industrial Applications of Physics (American Institute of Physics), of which he was the first recipient; the 1999 Draper Prize (NAE); and the US National Medal of Technology, the highest honor the president of the United States bestows upon America's leading innovators in technology. In 1980, the University of Arkansas awarded Maurer an honorary LLD degree, and a Distinguished Alumnus Citation in 1994. Although numerous honors have come his way, Maurer says he values his honorary LLD from the University of Arkansas most highly of all.

William McMillan

Academic Researcher and Educator

William McMillan was recognized as one of the world's leading experts on the behavior of matter at extremely low temperatures.

McMillan, a native of Little Rock, studied electrical engineering as an undergraduate at the University of Arkansas. After receiving his BSEE in 1958, McMillan switched his interests to physics and earned his MS from the University of Arkansas in 1961. He continued his education at the University of Illinois at Urbana-Champaign and received his doctorate in physics in 1964. He then joined the theoretical physics research staff at the prestigious Bell Laboratories, where he worked on a variety of problems in liquid helium, superconductivity and liquid crystals. During a year at the Cavendish Laboratory of Cambridge University, McMillan wrote a paper that has become a classic in low temperature theory. He joined the faculty of the University of Illinois at Urbana-Champaign in 1972. In 1977 he received a Guggenheim Fellowship for study and research at the University of Paris. The next year, he returned to receive the highest prize awarded for research in low-temperature physics: the Fritz London Memorial Prize. This award, named after a pioneer in low temperature physics, is awarded every three years. McMillan was cited in recognition of "his outstanding theoretical contributions to the fundamental knowledge of superconductivity."

At its 1979 Spring Commencement, the University of Arkansas bestowed upon McMillan an honorary Doctor of Laws degree. Tragically, McMillan was killed in 1984 near Champaign-Urbana, when a bicycle he was riding was struck by an automobile. Bill was only forty-eight at the time, with more than a dozen papers in progress.



Figure 3: William McMillan (left) with Donald Pederson, chair of the Physics Department, in 1979 on the occasion of McMillan receiving the honorary LLD degree at the University of Arkansas. *Photo archived in the Physics Department.*

The University of Illinois at Urbana-Champaign organized a scientific meeting in McMillan's honor on October 17, 1984 on the campus of the university. We reproduce below a few comments made by his peers that give insight into McMillan as a scientist and as a person.

John Bardeen [2] (University of Illinois at Urbana-Champaign) said:

> Bill McMillan was a truly unique individual with an amazing array of talent. He was an outstanding theoretical physicist with an excellent taste for what is important. He had the ability to do difficult experiments when required. He had a

[2] Nobel Prize in Physics, 1956 and 1972. The only person to have received two Nobel Prizes in physics.

deep understanding of computers and what they can do. Although he had great confidence in his own abilities, he was modest and unassuming. Bill was liked by all who knew him. He cared little about convention but followed his own inclinations and did what pleased him.

Philip W. Anderson[3] (Princeton University) said:

I think that everyone who knew Bill McMillan must have felt that there was something very special indeed about him. By this I don't just mean his predilection for doing the things a little more outrageously than anyone else — like his beard which grew longer or shorter according to some inner dynamic of its owner, or his celebrating his award of the London Prize in a tee-shirt with "Where the hell is Urbana" on it — nor the fact that he seemed to be able to do anything well that he set his mind to — music, art, science. He picked up the guitar for instance. In a year or two at Bell he was very good at it and just recently many of us received a Christmas card designed by Bill McMillan which showed that he was well on his way to becoming a real competent artist. But there was also the fact that to go with this he had a certain calm, a rock-like patience and steadiness, and an integrity on which you instinctively felt that you could lean.

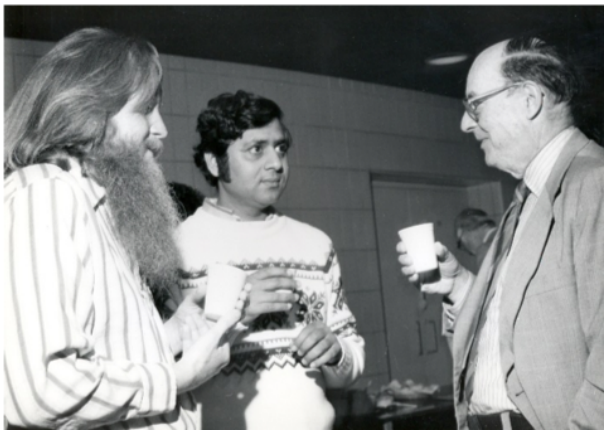


Figure 4: From left to right: William McMillan, Vijay Pandharipande and John Bardeen discussing physics at the weekly precolloquium coffee hour at the University of Illinois at Urbana-Champaign circa 1977. *Photo courtesy of Department of Physics, University of Illinois at Urbana-Champaign.*

Jack B. Swift

Academic Researcher and Educator

Jack B. Swift was a professor of physics at the University of Texas (Austin) until his retirement in 2008. His research activity was in the field of theoretical condensed matter physics with emphasis on phase transitions, liquid crystals, nonlinear dynamics, and granular media.

Jack was awarded a BS in physics by the University of Arkansas (1963) and an MS (1965) and PhD (1968) by the University of Illinois at Urbana-Champaign. He was an NSF postdoctoral fellow at the Max Planck Institute for Physics and Astrophysics (1968–69) and did postdoctoral research at Harvard University (1969–71) as well. He was appointed assistant professor in the Physics Department at the University of Texas at Austin in 1971, promoted to associate professor in 1975, and to professor in 1981. He was an Alfred P. Sloan Foundation



Figure 5: Jack Swift, undated. *Photo from the University of Texas website.*

[3] Nobel Prize in Physics, 1977.

fellow, 1973–75. He was also a visitor at the prestigious Bell Laboratories (1974).

He became a fellow of the American Physical Society in 1994, and in 2004 he received the University of Texas Outstanding Graduate Teaching Award. He mentored fourteen PhD students during his time at the University of Texas at Austin. He is also associated with the Center for Non-Linear Dynamics at the University of Texas.

In his early work, Swift used the mode-mode coupling formalism to investigate dynamical critical phenomena. His work resulted in the first quantitative predictions of the singular behavior of the thermal conductivity and diffusion constant near critical points. In a long-term effort, he and collaborators then studied the thermodynamic, structural, viscous, and hydrodynamic properties of numerous phases of liquid crystals. Swift's research then focused on the theoretical investigation of instabilities, pattern formation, and chaos in nonequilibrium, nonlinear systems.

Wallace Hilton

Academic Scientist and Educator

Wallace Hilton, known to everyone (except his students) as Wally, was one of America's finest teachers of physics. In 1978 the American Association of Physics Teachers (AAPT) recognized his accomplishments by awarding him their highest honor, the Oersted Medal (named for a nineteenth-century Danish physicist who emphasized the importance of teaching).

Hilton was born in Hardin, Missouri, in 1911. He received his BA in physics from William Jewell College near Kansas City and, after three years teaching in a tiny high school, went to graduate school. He earned an MA and then an EdD in Science Education from the University of Missouri–Columbia, the latter in 1941. While in graduate school he also taught at the University Training High School and nearby Hickman High.

During World War II Hilton served as a captain in the US Army Air Corps teaching meteorology. After the end of the war, Hilton came to the University of Arkansas where he earned his MS in physics in 1948, working primarily with Professor Ham, but also with Professors Sharrah and Hughes. While still working on his master's he joined the faculty of his alma mater where he remained for the rest of his professional career, serving as professor and chairman for thirty-four years. Over the next two decades, he worked to strengthen the Physics Department at William Jewell until it developed an outstanding reputation for a small liberal arts college, with the number of physics majors increasing more than fivefold to well over 200 graduates. He published over 160 papers, many with undergraduate students as coauthors, for

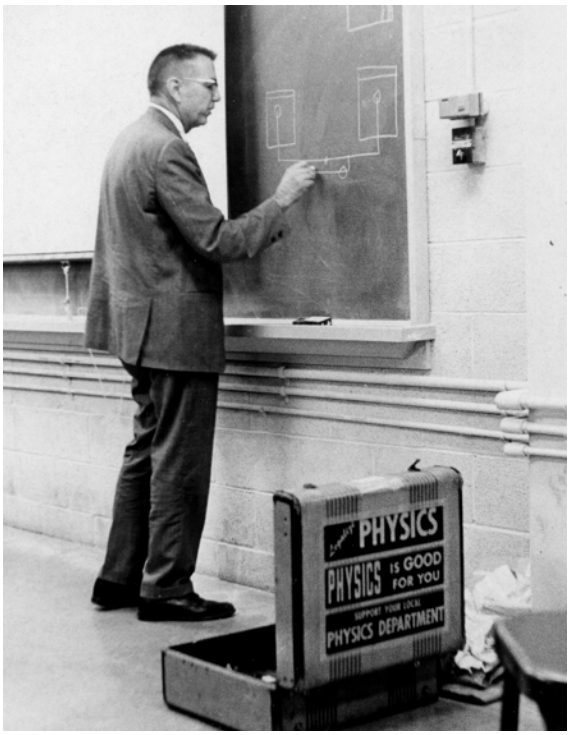


Figure 6: Wally Hilton presenting a lecture and demonstrations to high school students. *Photo courtesy of Paul Sharrah. Undated.*



Figure 7: Richard Fitts circa 2008. ***Photo courtesy of Mr. Fitts.***

Hilton encouraged his students to be involved in research as an essential component of their education. An enthusiast of lecture demonstrations, he collected and developed so many that the AAPT published his book, *Physics Demonstrations at William Jewell College*, which became a standard reference. He also published two other books.

Hilton was honored for his contribution to teaching physics in 1969 by being awarded the first Outstanding Teacher Award given by the Missouri Science Teachers Association. Elected a fellow of the Optical Society of America in 1976, Hilton also in that year became national president of Sigma Pi Sigma, the national physics honor society. In that same year the AAPT gave him their Distinguished Service Citation. The honors culminated with the Oersted Medal of the AAPT in 1978. Hilton was cited for "his long and effective service in teaching, writing, and research," and for "his contributions to the teaching of physics, the design of laboratory experiments, and the production of demonstrations." Hilton passed away in 1991.

Richard N. Fitts

Government Scientist

Rick Fitts received a BA in physics in 1970 and a MSEE in 1972, both at the University of Arkansas. This was followed by a long and a distinguished career at NASA. In 2009, he was featured in the Physics Department newsletter, *Reflections* (Summer 2009). An edited version of that article follows. Comments within quote marks are attributable to Fitts.

Fitts's career with NASA began in March 1971, while he was still in graduate school and working toward his master's degree in electrical engineering. Fitts recalls, "I was amazed to be interviewed and hired over the phone, but I later learned that's the way it was done in those days. I told the HR woman that I would not graduate for another nine months, but they said my physics degree qualified me just fine."

He set off to Houston and started as a NASA flight controller, one of the engineers who worked in Mission Control monitoring. He was assigned as a Guidance, Navigation and Control (GNC) officer and began his training during the Apollo 15 mission. Controllers work either in the "Front Room" (often featured in media depictions) or in the "Back Room." For each person in the Front Room, there is team of controllers in the Back Room. Fitts trained in the Back Room for Apollo 15, in the Front Room for Apollo 16, and expected to be assigned to work on Apollo 17 (the last lunar landing). Instead he was given the opportunity to move straight to the Front Room for the Skylab program.

Skylab was the first US space station and lasted at least a full year. Three different crews of three astronauts each manned it for varying lengths of time. The final crew spent eighty-four days on board, which was the human space-flight record at that time. Fitts was in charge of his own team of controllers watching the station's GNC systems. Not only did he monitor and analyze

data, but he also commanded Skylab to perform maneuvers and updated navigation parameters. The teams faced many challenges, but they met them all.

When the Skylab mission ended in 1974, Fitts was assigned to the Space Shuttle program, again as a GNC officer. He started training in 1977, but because of the delays in the Space Shuttle program, the first launch did not take place until 1981, which gave him the opportunity to participate in 1000 simulated launches. He was at the control for the Challenger disaster and helped his employees survive the loss of Columbia. From there he moved into management and spent his last years at NASA as the division chief for systems with responsibility for almost 500 Shuttle and Station flight controllers.

After thirty-three years at NASA, in 2004 he started a second career in industry. He served at SPACEHAB, Inc. from 2004 to 2008, first as director of the Exploration Systems Division and then as vice president of the SPACEHAB Government Services. In 2008 he moved to MacDonald, Dettwiler and Associates (MDA), where he served as the vice president of Houston Operations until his retirement in 2011.



Figure 8: A young Richard Fitts at his console at NASA. ***Photo courtesy of Richard Fitts. Undated.***

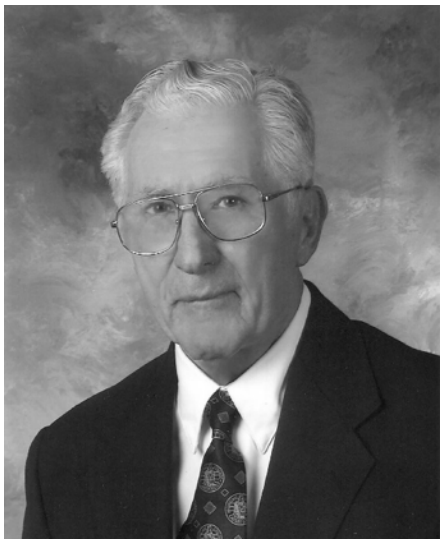


Figure 9: Walter Keller. ***Photo courtesy of Mr. Keller, circa 2008.***

J. Walter Keller

Inventor

Walter Keller received a BSEE degree in 1946 and a double MS in math and physics in 1948, all from the University of Arkansas. What followed was a career as diverse as his academic interests. Although best known for his work on the design of biomedical devices, his career included the design of instruments involved in nuclear testing and control systems for hydrofoil crafts. Over his long career he held many positions, which are listed below:

1947–51: US Naval Research Laboratory: Worked on developing many electronic devices involved in nuclear testing.

1951–56: US National Bureau of Standards, Harry Diamond Laboratories: Project leader for developing a system for fusing guided missiles carrying "special" weapons. Project leader on transistor ground-to-air guided missile fuses. Member of a team of twenty scientists evaluating a secret Russian defense system.

1956–59: Graduate School Bureau of

Standards: Instructor of semiconductor electronics and physics.

1956–59: Miami Shipbuilding Company: Research Director and designer of automatic control systems for hydrofoil craft. He pioneered a transistorized control system for stabilized flight of two submerged foil hydrofoil crafts.

1959–69: Cordis Corporation: Staff Physicist. Originator (systems and electronic designer) of a pacemaking program from the P-synchronous pacer through the conception of the implantable remotely programmable digital pacemaker system, Atricor, Ventricor, Stanicor, Ectocor and Omnicor. Atricor was the first prosthetic device to automatically control a physiologic parameter.

1969–72: Miami Heart Institute: Organized the Biomedical Engineering Department.

1972–74: ESB-Medcor: Vice President, pacer systems follow-up and design.

1974–79: STIMTECH (J & J Company): Consultant, pacer systems design and transcutaneous neuro stimulators for pain relief and updated version of a remote programmable pacer system. One of the Transcutaneous Electrical Nerve Stimulation (TENS) designs employed alternating polarity outputs



Figure 10: This picture was published in National Geographic in 1981 with the following caption: "Ringside seats for the "bomb" were a hot ticket in 1951, when military and civilian VIPs (above) watched from the officers club on Enewetak, just 12.5 miles from ground zero." Keller provided us this and more pictures with the following description: "Two of these pictures were made via light from a nuclear burst on Enewetok in 1951. The shutter speed was 1/1,000,000 of a second. I'm the second from far end, front row. This was published in National Geographic in 1981." Enewetak (also spelled Enewetok) Atoll is large coral atoll in the Pacific used for nuclear testing during the Cold War.

that eliminated formation of caustic ions at the electrodes.

1979–85: Wallace Labs (Carter-Wallace): Consultant, Biotronik, Intermedics, Pacesetters.

1958–1995: University of Miami: Adjunct Associate Professor. Designed a control system for a proposed artificial heart.

We elaborate below on his most important contributions in biomedical engineering.

In 1961, Keller designed the first implantable synchronous pacer. This was the first human prosthesis for the control of a bodily function. It sensed the required physiological heart rate and restored the correct ventricular beat, adjusting for exercise and emotion, and it restored the sinus rate. This innovation dramatically altered life for the hundreds of thousands of patients who would ultimately benefit from Keller's implantable device and its technological descendants. He continued to design improvements and devices for pacemakers, such as a rate-voltage dependent warning system for pacemaker battery depletion in 1963.

In 1962, he designed a demand heart pump control circuit for the Cleveland Clinic. It drove an artificial heart pump in the absence of spontaneous heartbeats.

He participated in more than one thousand pacemaker surgical procedures at hospitals throughout the United States and Europe. The list of cardiologists that he has worked with includes such pioneers as Dr. Michael DeBakey and Dr. Cooley of the Baylor School of Medicine.

He received many honors, among them the University of Arkansas Distinguished Alumnus Award (1991), and is the 2008 inductee into the University of Arkansas College of Engineering Hall of Fame.

Paul Sharrah in History1 tells an interesting story:

> NAUGHTY GIRL — One graduate student slipped into the final rough draft of his master's thesis an 8 × 10 photograph of his best friend's girlfriend dressed only in a bathing suit. She was sitting on and admiring the x-ray machine used in his research. It really wasn't indecent but when the professor didn't get to the thesis for two or three days this student got very nervous. He thought the ax was going to fall and he was going to fail or be thrown out of school! He couldn't stand it any longer and confessed! No harm done!

Sharrah did not identify either the student or the professor. In 2009, Keller sent Gupta a picture of the x-ray machine that he had used to do research for his MS thesis with a young lady in a bathing suit sitting on top of it (with the caption: Some horseplay with my MS thesis equipment). This revealed the identity of both the student and the professor. Departmental records show that Keller was indeed Sharrah's student.

Keller passed away on October 12, 2016.

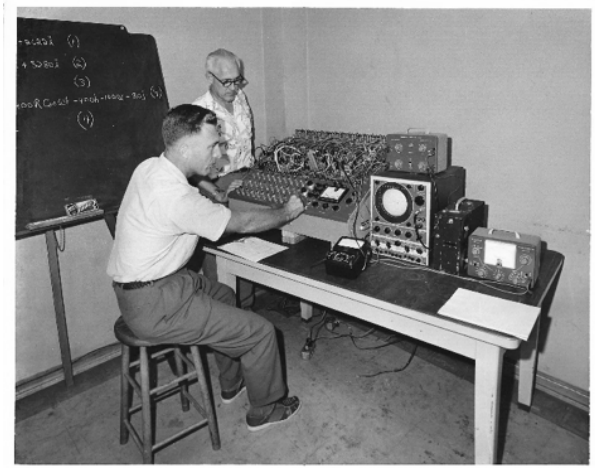


Figure 11: Keller working on a $1,000 Radio Shack analogue computer in 1959. Six simultaneous second order differential equations simulating the dynamic flight of a hydrofoil craft [were solved]. ***Photo and caption provided by Mr. Keller.***



Figure 12: Colleen Wilson Hodge in front of Fermi Gamma Ray Telescope in 2007. *Photo courtesy of Dr. Wilson-Hodge.*

Colleen Wilson-Hodge

NASA Research Scientist

Colleen Wilson Hodge received her BS degrees in physics, magna cum laude, and math in 1992 at the University of Arkansas. With her interests in astrophysics (having written her honors thesis in astronomy), she went to the University of Alabama at Huntsville for her graduate degree. She received a PhD in 1999. While a graduate student in 1992, she started working as a computer engineer and research assistant at the nearby NASA Marshall Space Flight Center's Astrophysics Branch. Since her graduation in 1999, she has held the position of astrophysicist with the Space Science Department of the Center.

Wilson-Hodge's research interests have been, and currently are, in the various areas of gamma ray astronomy. She has numerous research publications and has been honored with several internal NASA awards.

The above picture shows Wilson-Hodge at General Dynamics in Gilbert, Arizona, standing in front of the GLAST (Gamma Ray Large Area Space Telescope) satellite in November 2007, when her group had just finished an end-to-end test of the satellite. The satellite was later renamed the Fermi Gamma Ray Space Telescope. She states that the GLAST integration and testing was a lot of fun, as she normally does not get to do instrumentation work but spends most of her time at a desk like everyone else.

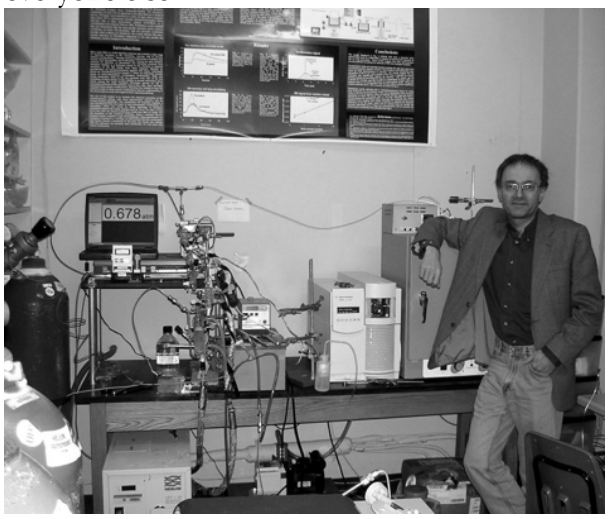


Figure 13: Juan Rodriguez in his research laboratory at Centenary College. *Photo courtesy of Dr. Rodriguez, circa 2008.*

Juan Rodriguez

Academic Researcher and Educator

Juan Rodriguez came to the University of Arkansas as a graduate student in 1980 after receiving a BS in physics from Centenary College in Louisiana. He received a PhD in physics in 1986. After a postdoc at Washington University

in St. Louis (1986–90), he returned to his alma mater, Centenary College, as a faculty member. Here he held a named chair, the Keen Professorship in Physics, until leaving for the St. Louis College of Pharmacy in 2014.

Rodriguez has done extensive work in the area of physics education, and his research interests are mostly in the area of biophysics. He has been the recipient of many grants and has published extensively in research journals.



Figure 14: Daniel Erenso in his research laboratory. ***Photo courtesy of Dr. Erenso, circa 2008.***

Daniel Erenso

Academic Researcher and Educator

Daniel Erenso received a BS degree in physics in 1990 and an MS in physics in 1997 from Addis Ababa University, Ethiopia. He received an Advanced Diploma in Condensed Matter Physics in September 1999 from Abdus Salam International Center for Theoretical Physics (ASICTP), Trieste, Italy. He entered the University of Arkansas in 1999 as a graduate student and received a PhD in 2003.

In 2003 Erenso joined the faculty of the Physics Department at the Middle Tennessee State University in Murfreesboro, where he is currently a professor. His research interests span a wide range of topics, including:

Quantum Information: E Quantum teleportation for faithful information transmission using fully entangled (spectrally, spatially, and polarization) produced by parametric down conversion.

Synthetic Photonics Crystals: The design and building of synthetic photonic band-gap crystals with new optical properties and electrical properties using laser tweezers.

Experimental Biophysics: Biophysical techniques as an alternative method for the measurement of the efficacy of gene therapy for hemoglobin disorders.

Computational Biophysics: Simulations and free energy calculations on the membrane binding of lipidated peptides.

Alan C. Tribble

Industrial Scientist

Alan Tribble obtained his BS degrees in physics and math from the University of Arkansas in 1983. He went to graduate school at the University of Iowa, where he obtained MS and PhD degrees.

Tribble is an expert in the field of space environmental effects. He has worked at Rockwell Collins, Inc. of Cedar Rapids, Iowa, since 1996, where he has held many different positions. Currently he is the principal program manager of the Precision Weapons Division and is responsible for the NavStorm+ product line of GPS receivers. From 1988 to 1996 he worked at Boeing Space Systems Division in California.

In his spare time Tribble likes to write books, and has published the following titles:

The Space Environment: Implications for Spacecraft Design, 2nd edition (Princeton University Press, Princeton, NJ, 2003).

A Tribble's Guide to Space (Princeton University Press, Princeton, NJ, 2000).

Fundamentals of Contamination Control (SPIE Press, Bellingham, WA, 2000).

Princeton Guide to Advanced Physics (Princeton

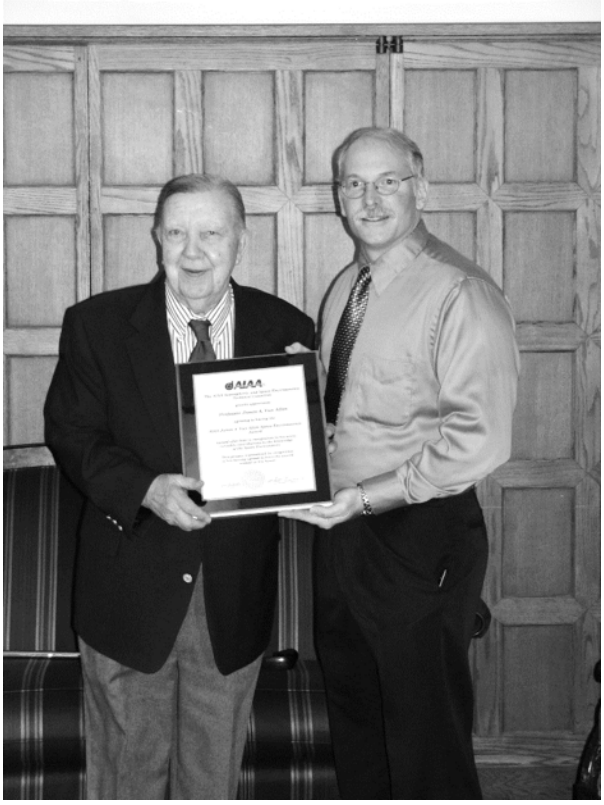


Figure 15: Professor James Van Allen (left) and Alan Tribble with commemorative plaque discussed in the text. *Photo courtesy of Dr. Tribble.*

University Press, Princeton, NJ, 1996).

The photograph shows Tribble presenting James A. Van Allen[4] with a plaque on behalf of the AIAA to commemorate the establishment of the James A. Van Allen Award[5] in 2006. Tibble himself was the recipient of this award in 2008, by which time Professor Van Allen had passed away. The citation reads:

> For outstanding leadership, research, and scholarship in the emerging field of space environments and effects and their influence on spacecraft design and engineering in the tradition of James Van Allen.

Astronaut Buzz Aldrin has stated: "Alan Tribble has captured the spirit that inspired us to explore."[6]

[4] James A. Van Allen is credited with the discovery of what are now known as Van Allen Radiation Belts. These are giant, donut-shaped regions in the Earth's upper atmosphere consisting of highly energetic charged particles trapped by the Earth's magnetic field. Most of the particles are thought to come from the solar wind. Van Allen discovered these belts after the launch of the Explorer 1 satellite in 1958. For a history of this discovery, see D. Baker and M. Panasyuk, *Physics Today*, 70, 47–51 (December 2017).

[5] The James A. Van Allen Space Environments Award is presented by the American Institute of Aeronautics and Astronautics (AIAA) to recognize outstanding contributions to space and planetary environment knowledge and interactions as applied to the advancement of aeronautics and astronautics. The award honors the late James A. Van Allen, Regent Distinguished Professor of Physics at the University of Iowa.

[6] http://alantribble.com/books-and-courses/books/a-tribbles-guide-to-space, 2018

16.

Alumni Reminiscences

In this chapter we present reminiscences by a few alumni. This is one way to learn what the department was like from the first-person accounts of those who were actually here during those periods. Many of the reminiscences have been edited for brevity.

Franklin Wintker (BS, 1931)

Wintker was the second graduate of this department, the first being Roy Sullivan who received his degree in 1928. Both authors of this History had extensive correspondence with Wintker in the mid-nineties. He was in very poor health at that time. Still, he made the effort to correspond with us. The following excerpts have been taken from a long letter he wrote to Sharrah on July 8, 1995:

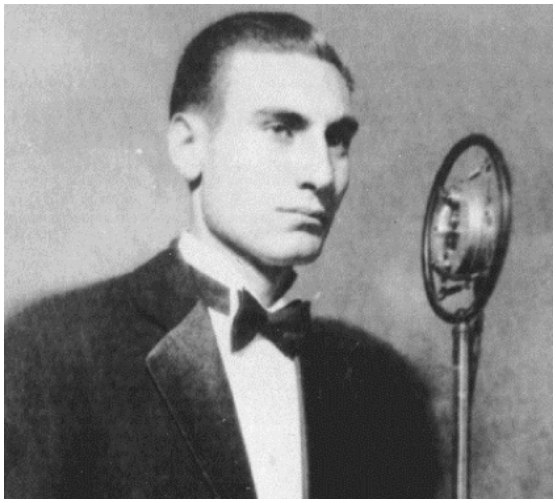


Figure 1: Franklin Wintker, circa 1930 at the KUOA radio station. ***Photo courtesy of Wintker.***

> My time at U of A was 1926–31. Most of 1929 was spent with WLS in Chicago, and on return to Fayetteville I elected to change from EE to Physics/Chemistry, to gain more subjects pertinent to radio, which mistakenly had my interest at that time. Also I was strongly attracted to U of A by a red headed young lady from Wynn, Ark., and I finally won her. By that time my job with Mitchell's Orchestra had been replaced, and I made it through on KUOA earnings (meager) and debt. There were no Government loans then!
>
> A noon hour of KUOA resulted in the only unpleasantry between Dr. Parsons and me. He was using the noon hour to make measurements on high voltage line corona losses. Naturally the radiation from our antenna (not more than 1000 yards by air away) interfered. He walked to the studio and demanded that I shut the radio down so that he could continue. I carefully explained the ramifications of that, particularly since KLRA in Little Rock was filling for our time. He was somewhat upset, but left without comment. The matter was never mentioned again, and his attitude toward me did not change.

He goes on talk about Dr. Parsons:

> He could do more with slide rule than I could possibly understand, and annually gave a slide rule use lecture to all students, filling our lecture hall with Engineers, etc.
>
> It is interesting that you specialized in diffraction studies of liquids. I recall that Dr. Roberds was more interested in research (diffraction) than in medical use. Of course, I became more interested in after marketing designed for that use. I think that interest in X-radiation at U of A came from early work by the

then head of the Engineering College (name escapes me). I recall his primitive set-up (gas tubes, no filaments), and that he had multiple hand sores from excessive radiation. We were conscious of danger from direct radiation, but gave little thought to secondary radiation.

Robert Maurer (BS, 1948)

Maurer is a distinguished alumnus of this department, and his profile appears in chapter 15. While a student here, he was the first secretary of the Sigma Pi Sigma honor society. In a letter to Gupta in August 2009 he wrote:

I couldn't think of anything from my stay at the University that would be helpful in your task. I remembered isolated incidents (I don't know why these instead of others) that I will pass on. They are all about the students of the time but maybe this will suggest something more important that we can explore. The physics majors had a strong interest in the subject matter but were not a studious bunch compared to the best students today. Physics was one of the most difficult courses on campus but certainly a lot easier than it is today due to subsequent expansion of knowledge and grade pressure.

First, I recall very little about the establishment of Sigma Pi Sigma. I know I supported it but being the first secretary is news to me. There was a certain camaraderie among the small band of physics majors (~10) and I think all supported the idea. One whose name I don't see on the charter list was Bill Phillips (the name I remember anyway). His wife and I readied the restaurant site of the inaugural banquet. Someone decided to make the event one with invited dates. At that time the University was filled with ex-GI's and there were maybe four men for every woman on campus, many of whom were going steady. I got a blind date with help. The national office volunteered to send a speaker who spent maybe an hour with slides of various statistics. My date finished the night with some caustic comments about the evening and I don't recall ever seeing her again. Among other things, this was a good lesson in picking speakers for audiences of people with mixed interests.

Prof. Ham was department head and I had a job (75 cents per hour, I think) setting up for demonstrations for the general physics lectures. Occasionally he would complain that they didn't work but they were always working well when I left them. He taught a course on acoustics which was his specialty. One lab partner (Austin Chappelle) came to the exploratory section and had an inspiration. We got approval to go out and measure sound levels in the community. The decibel meter was powered by a heavy case of lead-acid batteries. Since it was a hot day, we drifted down hill, ending up in a beer garden. When we entered with our equipment, the waitress came over and asked if we were from the police. Taken aback, we said we were students, a cover for unusual behavior, and she left. We measured the sound levels of cars, a passing train, etc. but failed to detect the level for foaming beer. Sufficiently strengthened, we returned with a list of several sound levels that got us a commendation.

On the subject of beer, Bill Phillips invited all the physics students out to his house for a party with his homemade brew. In its preparation, some unknown variation resulted in a unique beverage. Every bottle had black sediment in the bottom and emitted a yellow vapor when opened. Nevertheless, it had only beneficial effects and a good time was had by all.

The x-ray lab had an ancient dental x-ray machine (wooden case) over in the corner. It had a mechanical voltage generator and an adjustable spark gap to measure the voltage. By increasing the voltage gap you could get arcing throughout the machine, which we enjoyed when Prof. Sharrah wasn't around. The manufacturer had seen fit to install a plaque "using this machine for

pyrotechnics is extremely hazardous," which is my main memory of X-Ray lab even though it was my PhD minor at MIT.

None of the above is very academic and I even have a blank spot for my courses at MIT [University of Arkansas]. I remember the teachers. The only advanced physics courses I recall were acoustics and theory with Ham, x-rays with Sharrah and optics with Camus. There must at least have been a course on electricity and magnetism.

One of my best courses was freshman English under Dean Jordan. He picked 10–15 students who had top scores on some test we took before entering (I don't remember SAT's at that time — it must have been something else). He was a great teacher and I enjoyed association with the students. After the war, Adkinson taught me Fourier Theory and Differential Equations and I took number theory with Dean Nichols. It seems all the Deans taught advanced courses at the time and, naturally, were good teachers.

However, MIT was like being hit by a train but McKeehan and I had no more trouble with our preparation than most of the other PhD candidates. Of course, there were others entering with us that made the rest look mediocre. Murray Gell Mann[1] and the undergraduates from MIT (they only kept their best students) were examples that seemed to coast along. Most of us took courses the first year that the MIT grads had already taken. I got through with a so-so academic record but very good experimental work thanks to guidance from my thesis advisor.

Carolyn Cloud Stanley (BA, 1959)

The following are selected paragraphs from her long memoir.

> The fall of 1957 started much like any other year at the University of Arkansas — that was the year the Ford Motor Co. rolled out its infamous Edsel sedan; the world was in the midst of an escalating Cold War and the Soviet Union launched the first man-made satellite, Sputnik, into orbit in October. At the University students selected their courses and went through the fall registration process thinking that all was as it should be — they would spend many hours studying (some more than others) and most hoped they would spend many hours at whatever leisure activity best suited their personalities. Some would be so wrapped up in the football games that just attending the games on the weekend was not enough; they would discuss the previous game and the upcoming game during the entire week. Others planned to attend many movies and a few intended to use fake identification cards, if necessary, to be able to "get a few beers." Some even planned to attend "cultural events" such as the plays and operas staged by the Drama and Music students.
>
> What follows in this article is a personal



Figure 2: Carolyn Cloud receiving her degree in 1959. *Photo courtesy of Ms. Cloud.*

[1] Nobel Prize in Physics, 1969

memoir to try to explain some of the workings of the physics department at the time and to add a bit of insight into two major events of college life at the University in the late 1950s.

I was transferring to the University that fall after completing 2 years at Arkansas A&M in Monticello and was using the 4-year plan for the Chemical Engineering program at the University in effect when I began college in 1955. However, I was hit with a problem when I arrived in Fayetteville — changes were being made in the program which applied to all incoming students (including those transferring from ANY two-year program) which would mean that it would take me another 3 years to get my degree and my family (and I) could only afford 2 more years (my younger brother was to enter college in 1959 and in those years educating boys was definitely a priority over "wasting money" educating girls). I then learned that I could complete a BA in Physics (and take several extra courses in English) in those two years.

It was the policy of the Physics Department at the time that any student majoring in Physics (including Juniors and Seniors) who wanted the job would be allowed/encouraged to teach one or more 1-hour sessions of the Lab course for the first-year Introductory Physics course required of all Engineering students. Dr. Ham was in charge of this effort, which I believe consisted of about 20 or so separate lab sessions; each of us "Lab Assistants" was to be totally responsible for the way our own session was taught, with the stipulation that a certain percentage of the course grade was to be based on a "final exam" provided by Dr. Ham.

One of my favorite memories of my life was my first day teaching that course. I arrived early for the class and heard many muttered comments like "oooh — we're going to have a girl in this class" or "ugh — there's going to be a girl in this class" (with most of them implying this was NOT a good thing). Naturally, I was very nervous. Thus, I had written and memorized a five-minute introductory speech. When the tardy bell for the class rang, I walked to the front of the room, wrote my name on the chalk board, turned to the class and began my speech: "Good afternoon, Gentlemen. My name is Miss Cloud and I will be your instructor for this class." I continued with more of the speech (which basically told them that I would not be teaching them any physics in the class, but would be teaching them how to write reports detailing the results of their experiments in the lab (like I anticipated that their future bosses would require). I soon realized I was wasting my effort — no one had heard a word after "I'll be your instructor."

At the end of that first semester, I gave most of the students C's, with a few students getting B's, and one or two meriting/getting an A. Many of the students getting those B's and C's were outraged and some made "official requests" to try to get their grade raised (the prevailing notion on the campus was that you got an A in the course if you attended most of the class sessions). I was relieved when Dr. Ham backed me totally and not one grade was changed. The good part came during the next couple of semesters when many of those same students came to me to thank me for what I had taught them — they were now getting A's in their 3-hour Lab courses while most of their peers were getting C's, based on how well they could write those "engineering reports."

That 1957–58 school-year was barely started when the first of two major life-changing events occurred for many: the state National Guard troops were called to assist with trying to maintain order during the integration of the "Little Rock Nine." Within days of arriving at Little Rock, the Arkansas National Guard was nationalized by President Eisenhower and many of the young men spent so many weeks in Little Rock that they had to either quit their plans entirely for getting a degree or somehow manage

to "come back next year" and resume. (It may be that this only seemed to me to affect the entire school because so many of my friends (mainly from the engineering department) *were* called and I never saw them again.) This was especially disheartening because the University had been successfully integrated in 1947 (with the admission of one student into the Law School) and I had several classmates/friends who were obviously of African American descent, but whose minds were sharp and whose desires for an education were the overriding force in their lives. I noticed that most of the entire student body accepted a person based on his/her actions and no longer cared about her/his color/size/sex/whatever — I'm sure there were underlying prejudices; but they were not evident among my peers.

William Pendleton (PhD, 1964)

Pendleton was the first student to receive a PhD in physics from the University of Arkansas, receiving the degree in 1964. He went on to become a professor of physics at Utah State University. Here he recalls his graduate education in the newly established PhD program in physics during the 1959–64 period.

In the autumn of 1959, the graduate faculty in the department was small with only four active members. Initially the core graduate-level classes [Classical Mechanics (Schiff)] were taught by Professor H. M. Schwartz, the sole theoretician. A two-semester course in intermediate level (senior/first-year graduate) Modern Physics (text by Leighton) was taken in preparation for the quantum mechanics course and for many of the specialty classes and research seminars. (Professor O. H. Zinke was the first faculty member to teach this new offering.)

In my particular program, the specialty classes included Solid-State Physics (Kittel) and a summer-school offering on the mathematical theory of vibrating systems (taught by Dr. Joe Robbins of Hendrix College). Not surprisingly, the latter course emphasized solving the wave equation for various vibrating systems subject to specified boundary and initial conditions. Research seminars in my area were conducted by professor R. H. Hughes who led us through Material on Atomic Structure and Spectra (monograph by Herzberg and text by Condon and Shortley) and on Molecular Structure and Spectra (Herzberg's classic phenomenology-based text on diatomics). The total program also included several classes in mathematics at the intermediate and graduate level, e.g., intermediate differential equations, vector analysis, operational mathematics, advanced applied mathematics, theory of matrices.

A "qualifying examination," which emphasized undergraduate-level questions/problems, was administered relatively early in the program. A "PhD-level pass" provided the option of working directly toward the terminal degree, thus bypassing the MS degree which was a research degree at that juncture. It appears that at least four of the early PhD-bound students (C. Head, M. Head, W. Pendleton, D. Ross) exercised this option. Following PhD-level qualification and the completion of core (and supporting) classes, a two-part (written and oral) preliminary or candidacy examination was taken. A pass on this examination elevated the student to the full status of candidacy and provided the "green light" for full-time effort on the research problem and on the preparation of the dissertation. A critical last step in meeting degree requirements was the traditional "dissertation defense" or final oral examination which was scheduled following approval of the study by the research advisor.

During this early period of the program, a library-based literature search was a necessary part of determining the potential of a proposed dissertation topic for original work. The modern computer-assisted, web-based searches have, of

course, obviated the need for the tedious methods of yesteryear. Additionally, preparations for research activities included a modest level of training in the following: (1) machine-shop usage (mainly metal lathe and band saw), (2) soldering and brazing, and (3) glass blowing. Although limited in scope, this training proved invaluable to the timely completion of research since valuable time was not wasted waiting for technical assistance.

It should be mentioned that early requirements for the PhD degree included satisfactory reading skills in two foreign languages, usually German and French or Russian. The candidate selected scientific materials, e.g., textbooks of "other [languages]," submitted to the language department for approval, and scheduled the examination. The examination consisted of translating (with the use of an appropriate dictionary) and transcribing passages of material selected, seemingly at random, by the examiner. Typically the required rate of translation and transcription was about one line per minute of about 120 lines during the two-hour examination. (Presumably the required rate was chosen to make excessive use of the dictionary a detriment to passing the examination.) The quantity and fidelity of the translated material had to satisfy the unclear subjective standards set by the examiner.

Bruce Schulte (BS, 1975)

My fine memories of our Physics Department begin in that vintage era of the early 70's. The conclusion was spring of 1975 — completing my BS under Stephen Day (my advisor and department chair).

I arrived in Arkansas in '71 from southern California with two goals, succeeding in math and physics, and the same in cross country. The cross country went well with freshman records until an Achilles injury had me bearing down on the physics. I tried running again for John McDonnell in his first year (fall of '72) then reinjured that Achilles.

So my life was "all about physics" as for all amongst that sophomore class. We strengthened our SPS club in the fall of '72. I was honored with a sophomore Sigma Pi Sigma award — I keep this membership active today — with gratitude to my peers and professors.

In about December of '72, a "rich kid" showed off his new calculator (the first in history!) which was an HP 35. $350 for this technological wonder when students rented 2 bedroom houses on Wedington for $75 a month . . . Our jaws were dropping as he showed it off, and I'll never forget his exact words, "this thing does so much, the guys who designed it *don't even know what all it will do*." Well, the slide rule era had ended.

Then later that school year (or was it next?) we constructed the Physics Department's first hologram; literally in a sandbox to dampen Dickson street vibrations in the basement (in the old acoustics room). We simply imaged points of light, under Dr. Richard Anderson's direction.

Computer facilities for the entire campus were the IBM-370 "across the way;" running on decks of punch cards, which generated the most awesome of confetti for the many practical jokes we did in those days. The Physics Department did have a couple of Altairs, programmed (if I remember correctly) with toggle switches on the front. The SPS was strong socially, and [carried out] several notable pranks (which I won't go into, ha!).

Dr. Pederson conducted the department's first "solid state physics" course, and I remember turning in homework literally on brown paper bags (we were the "back to the earth generation" right?) and acing his class. This junior year had me taking harder courses, including electromagnetics which were to play a huge role in my "not realized yet" career as a radar systems engineer in southern California. That school year concluded with me receiving the George

Lingelbach Scholarship, the grapevine telling me later that professors such as Dr. Richardson had a role in my selection and for which I will always be extremely grateful. My senior year had the department's first elementary particles course under Dr. Lieber. After a Phys. Rev. B article on strings, I wrote a class paper on these in spring of '75.

Aerospace then started where I led many efforts at Hughes and Northrop, in tactical fighter radar concepts and design. That U of A physics background held me in good stead, to the extent of supervising PhDs from USC and UCLA. I always kept up with the department on summer vacations, running across Dr. Anderson a couple times after his NSF appointment and Dr. Pederson "up on the hill."

A defense downturn led me back to the department in '91, hoping to work on that neutrino telescope no matter Congress's rejection of supercollider funding. Clinton's presidential election sealed the fate of the neutrino telescope; Dr. Lieber's chair of a multinational effort notwithstanding — some aversion to "pork barreling" getting mentioned. Grad school developed very close ties with Claud Lacy in astronomy, Lin Oliver in high pressure research, and Gay Stewart in education research. We saw the basement getting a ceiling, a wondrous change as the entire building got remodeled under Dr. Gupta's great direction. I hosted the last of the planetarium's ages-old shows with Jeff Sabby, as it was replaced with the new library.

These wonderful ties all continue quite strongly today! My path has me in Little Rock at Pulaski Tech as "instructor of physics and chemistry" and which has a similarly collegial atmosphere as our Physics Department's. Pulaski Tech students are accessing the department's nanotechnology programs and laboratories — just as groundbreaking now as that HP 35 was, way back when.

The best way to describe my 38-year-old ties in Fayetteville's physics is simply the smiles, hellos, technical excellence and encouragement. Staff and students, all. It is certain my ties to the Physics department continually increase; as I treasure the memories, the present days, and the future possibilities. All will no doubt exceed our imagination.

Ken Vickers (BS, 1976; MS, 1978)

After receiving his MS, Ken Vickers joined Texas Instruments, where he had a successful career. He returned to the University of Arkansas in 1998 to establish an interdisciplinary graduate program in Microelectronics-Photonics. He recalls his time at the University of Arkansas as follows:

> While I visited Michigan State in my senior year, there was never any real question about whether or not I would go to the UA. Fayetteville was 200 miles from my home, Batesville, far enough to assure myself that I would be fully independent (but no so far away that I couldn't yell for help if I got myself into bad trouble). I was valedictorian of the 1972 graduating class of Batesville High School with the top awards in physics and math, so during UA orientation I identified myself as a chemistry/physics major and signed up for the entry level classes in chemistry, physics, and calculus (yes, those were the days when AP did not exist and calculus was not taught in the schools the size of Batesville).
>
> That first year was eventful. I became involved in campus politics; became the reigning chess champion of the sixth floor of Yocum Hall and then was trounced when I played chess with real chess players at the UA chess club (teaching me my first real lesson of big fish in small ponds versus small fish in big ponds); and worked hard to overcome my assumptions that the same level of work in high school would result in the same academic results at the college level. My first semester I finished with a 4.0 GPA, but then

went down from there (never to a catastrophic level, but I did have a few academic bruises along the way from over-confidence and under-preparation).

My first strong memory of interaction with the department was during advising for my second semester (spring 1973). I went to the Chemistry

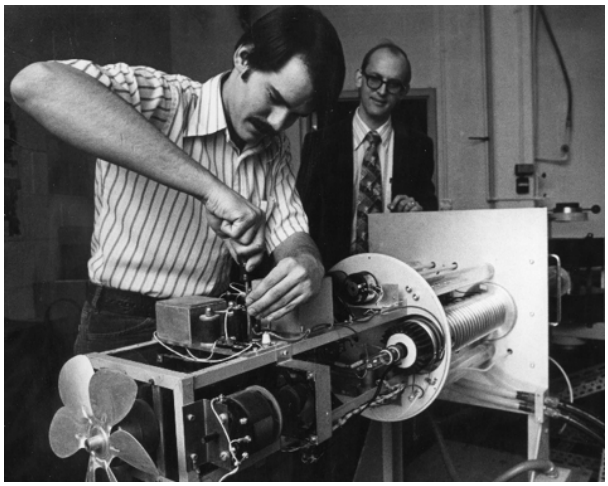


Figure 3: Ken Vickers (student) and Don Pederson (wise major professor) begin work on a 150 KeV accelerator donated by Reynolds Metals. The accelerator was originally part of a Texas Nuclear Neutron Generator system creating a deuterium beam but was used at the University of Arkansas to create a simple proton beam to use in channeling-enhanced backscatter investigations of impurity locations in single crystal structures. *Picture and caption courtesy of Ken Vickers.*

Department looking for my advising packet and they did not have it. So I went to the Physics Department and Steve Day (who was then Chair) invited me in to his office with the observation "We wondered who you were." He asked me about my first semester and I told him I enjoyed the physics class much more than the chemistry class. At that point he nodded his head wisely, noted that he thought I looked like a physics major, and scratched off chemistry from my forms while leaving physics as my only major. In hindsight, this was one of the best advising sessions I ever had.

"I don't remember my freshman and sophomore classes too much, but I do remember impressions around some of my other undergraduate classes from random odd things. I remember always being three minutes late to Otto Zinke's Thermodynamics class because I had to wait until the 8 a.m. movie ended at 9:28 before I could run down the hill from Yocum Hall to the Physics Building for that 9:30 class. He seemed to tolerate my high-speed entrances to his class, but perhaps my approach to educational prioritization contributed to the fact that I did not set the curve for grades that semester.

In my junior year F. T. Chan's Classical Mechanics classes gave me good data indicating that professors were just possibly people, too. F. T. had a teaching style that was dead serious during the class or when meeting with him out of class, but we saw it break the day there was a car having trouble from ice in the parking lot outside the classroom window. He saw the driver's problem, led us out of the building at a run, and as we hit the cold air his face broke into the big grin of a kid on a snowy day. We moved the car out of its parking spot through muscle power, he led us back at a run into the building, and as we entered the classroom his grin disappeared and the "real" Dr. Chan reappeared. To say we were amazed at the transformation would be a serious understatement.

As I went through my undergraduate years I began to balance many other aspects of my life with my academic pursuits. My involvement with politics ended my junior year, but I replaced it with becoming engaged and getting married before my senior year. During that same year I started working part time at the Holsum commercial bakery on Dickson Street, and after getting married Anna and I also started managing a small apartment complex across Maple Street from the Graduate Education Building.

During this part of my education I could have easily crashed and burned, but I received a lot of encouragement from faculty and had a very good study group of good friends that provided us all with help when it was needed. Our method was to work the problems before meeting, compare results and figure what happened when our answers were not the same, and then to play Risk for about three hours after each study session. The first two elements of our study group technique were very beneficial, and I guess we survived the third element.

In the second half of my junior year I went knocking on doors in the department looking for an undergraduate research project. I was lucky and found a fairly new professor (Don Pederson) that was willing to turn me loose on a back-burner project that was not at all related to his major research effort. Don's real research group was upstairs about where the lunch room is now located, while I was installed by myself in the basement in what is now part of Jiali Li's lab to bring up a small proton accelerator that had been donated to the department.

I believe this was the most valuable part of my undergraduate education, being given the loosely guided project to turn what was first a part of a neutron generator system into a proton beam probe of crystal structures. Don gave me exactly the right mix to encourage "learning by doing" while still making sure I arrived at the point that I could collect real results in time to complete my undergraduate research thesis — just enough financial resources to purchase what I could not create, sufficient authority to work with outside folks in our support shops, and maximum encouragement to work through the problems of creating a new experimental system.

We had a few momentous events along the way. One was when I discovered our original room was too small, which resulted in the accelerator arcing to the cement block wall at about 100 kV. A second event was when I replaced a three-quarter inch thick Plexiglas cover on an eight inch diameter experimental vacuum chamber with a plate of quarter inch thick glass given to me by the glass shop technicians for that specific purpose. It was only by pure luck that I had walked away from the chamber only seconds before the glass broke during pump down and the chamber became an effective eight inch bore shotgun. As a result of that and other experiences since then, I firmly believe that graduate students are watched over by the same power that watches over drunks and fools.

The department also supported a plan I developed in my senior year to do a rapid MS degree by expanding my undergraduate research apparatus to accommodate more complex experimentation and by letting me take graduate level courses my last semester as a BS student.

Summarizing my experiences as a student here is possible only if I keep it to the most general level — that the department through classes, student activities (and student lounges), faculty support and interactions, and a strong emphasis on hands-on learning at all levels provided me with the skills, knowledge, and confidence to launch into a professional career that has been both professionally and personally rewarding. Part of my decision to return here as a professor to set up a new kind of interdisciplinary graduate program was based on my wish to return that support I received as a student to a next generation of Arkansas students through my own efforts. With eleven years of professorship now behind me I can only hope that I have been half as supporting to my students as this department was to me.

17.

The Centennial Celebrations

The Physics Department celebrated its centennial during the 2007–2008 academic year [Refs. 9, 10]. To provide a context to this period for the future reader, let us take a quick look at what was happening at that time, just as we did with the 1907 period in chapter 1. The state of Arkansas had a population of about 2.85 million, and the city of Fayetteville had grown to over seventy-two thousand. While 1907 Fayetteville was connected to the nation by a relatively new passenger rail service, it was now connected to the world by jet airlines; passenger rail service having been abolished decades ago. Fayetteville was served by Northwest Arkansas Regional Airport in Bentonville, about twenty-five miles northwest of Fayetteville.

In 2007, the university had grown to a student body of 18,648 and was in a steep growth pattern. Among the student body were 3,287 graduate students, 413 law students and 958 international students from 103 countries. It had nine colleges, sixty-five departments, six interdisciplinary programs and an instructional faculty of 929. Among them were twenty-four distinguished professors and twenty-six university professors. [1] What was a "mere hope" in 1871 when the university was established, described in Prologue I, was indeed transformed into a major public institution of higher learning with a sprawling campus by 2007.

The latest technological advance was the introduction in 2007 of the first smart phone by Apple, Inc. called the iPhone. It provided a person, in the palm of their hand, with a mobile phone, a device to store music, a watch, a GPS navigator, and capability to use email, text messaging, and to search the World Wide Web for information, among many other useful features. It had an easy-to-use touchscreen. Future applications of this device exploded and, arguably, made a profound impact on our culture.

What was happening in physics? The recent (within the last fifteen years) discoveries consisted of the formation of Bose-Einstein condensate in the laboratory (1995), acceleration

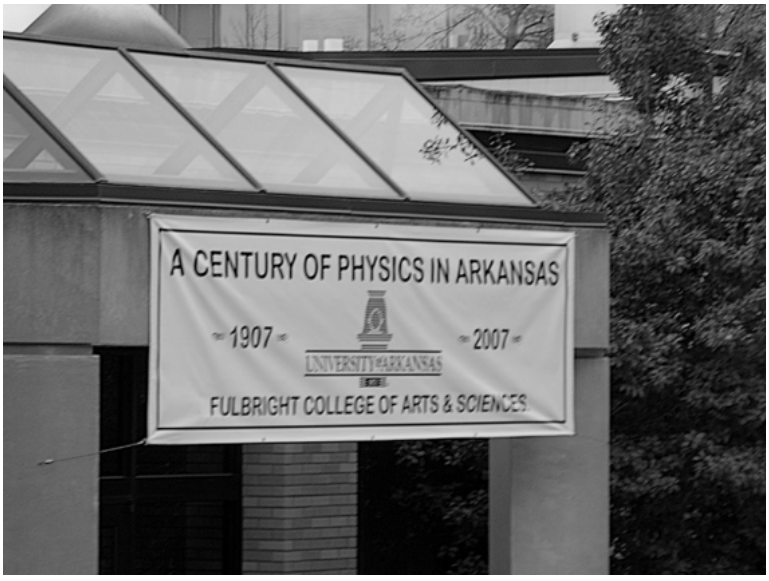


Figure 1: A banner announcing the Physics Department's centennial on the front entrance of the Physics Building. *Photo courtesy of Alumnus Ken Osborne, April 4, 2008.*

[1] All data for this paragraph were provided by the Office of Institutional Research, courtesy of Gary Gunderman.

of the expansion of the universe (1997), and experimental evidence that neutrinos have mass. Higgs boson was yet to be discovered at CERN, and gravitational waves were yet to be observed at the LIGO observatories.

The Physics Department had a tenured and tenure-track faculty of eighteen and had approximately fifteen postdoctoral research associates and research professors (all three ranks). The department was supported by a staff of six (three members of the administrative staff and three technical staff). There were about thirty-five graduate students and eighty-five physics majors. The 2007–08 catalog listed about fifty undergraduate and about thirty graduate courses in physics and astronomy. The departmental faculty and students had published about 150 papers over the previous three-year period, which had resulted in approximately three thousand citations up to that point in time. The research expenditures for the financial year of 2005–06 were $4.64 million.

The faculty consisted of five fellows of the American Physical Society (seven including emeriti), two fellows of the Optical Society of America, three endowed professors and two distinguished professors. One emeritus faculty member was awarded the Millikan Medal for physics education by the American Association of Physics Teachers.

Alumni were recipients of the Oersted Medal of the American Association of Physics Teachers, the Fritz London Award for research in condensed matter physics by the American Physical Society, the National Medal of Technology presented by President Clinton, and one was inducted into the National Inventors Hall of Fame. Two of the alumni were awarded honorary LLD degrees by the University of Arkansas.

The year-long centennial celebrations consisted of four Centennial Lectures by distinguished physicists spread out over the entire 2007–08 academic year, culminating in a three-day main event in April 2008. The celebration was organized by a committee consisting of Rajendra Gupta (chair), Surendra Singh (department chair), Greg Salamo, Min Xiao, and Michael Lieber.

The Centennial Lectures consisted of, "Ask Not What Physics Can Do For Biology; Ask What Biology Can Do For Physics" by Professor Robert H. Austin, Princeton University (October 18, 2007); "Rainbows, Visible and Invisible" by Professor Robert Greenler, University of Wisconsin (November 8, 2007); "Einstein's Biggest Blunder: A Cosmic Mystery Story" by Professor Lawrence M. Krause, Case Western Reserve University (February 7, 2008); and "Collected Papers of Albert Einstein", by Professor Diana Buchwald, director of the Einstein Papers Project, California Institute for Technology (March 13, 2008).

The Centennial's main events were celebrated from Thursday through Saturday, April 3–5, 2008. One hundred and twenty alumni and their guests, totaling some two hundred from around the country and abroad, returned to Arkansas to attend. They were joined by almost all former and emeritus faculty, current physics faculty, department staff, students, campus officials, and other guests.

Wolfgang Ketterle, a 2001 Physics Nobel laureate, kicked off the events with the Maurer Distinguished Centennial Lecture on the evening of Thursday, April 3. The Maurer lecture series is endowed by Robert Maurer, a 1948 graduate of the Physics Department who is coinventor of the telecommunications-grade optical fiber. Each spring, the department brings an eminent physicist (many have been Nobel laureates) to campus for a public talk as part of this lecture series.

Ketterle joined the physics faculty at MIT in 1993, where he was the John D. MacArthur Professor of Physics and director of the MIT–

Harvard Center for Ultracold Atoms in 2008. He was doing experimental research in atomic physics and laser spectroscopy and focused mainly on Bose-Einstein condensation in dilute atomic gases. He was among the first scientists to observe this phenomenon in 1995 and realized the first atom laser in 1997. His earlier research was in molecular spectroscopy and combustion diagnostics.

His awards include a David and Lucile Packard Fellowship (1996), the Rabi Prize of the American Physical Society (1997), the Gustav-Hertz Prize of the German Physical Society (1997), the Discover Magazine Award for Technological Innovation (1998), the Fritz London Prize in Low Temperature Physics (1999), the Dannie Heineman Prize from the Göttingen Academy of Sciences (1999), the Benjamin Franklin Medal in Physics (2000), and the Nobel Prize in Physics (2001, together with E. A. Cornell and C. E. Wieman).

The Friday morning session began with a talk on the history of the department given by Rajendra Gupta. A few physics faculty members also spoke, highlighting some of the research being done in the department. The Friday afternoon program consisted of Provost Bob Smith unveiling a George Rhoads audiokinetic sculpture and a Faculty Roll of Honor, the opening of the A Century of Physics poster exhibit, and dedicating a display of historical equipment. The Physics Library hosted a reception, and an open house of the physics research laboratories followed.

That evening, a gala banquet was held at the Fayetteville Town Center. It was attended by about four hundred guests, including prominent university officials.

The Saturday morning session on April 5, 2008 was a reunion of alumni and former, emeritus, and current faculty in Giffels Auditorium, Old Main. Centennial Medallions were presented to former and emeritus faculty for their service to the department. Faculty and alumni reminisced about their times together and told anecdotes, followed by group photographs on the steps of Old Main.



Figure 2: Professor Ketterle delivering the Centennial Maurer Distinguished Lecture titled "New Forms of Quantum Matter Near Absolute Zero Temperature" on the evening of Thursday, April 3, 2008 in Giffels Auditorium,

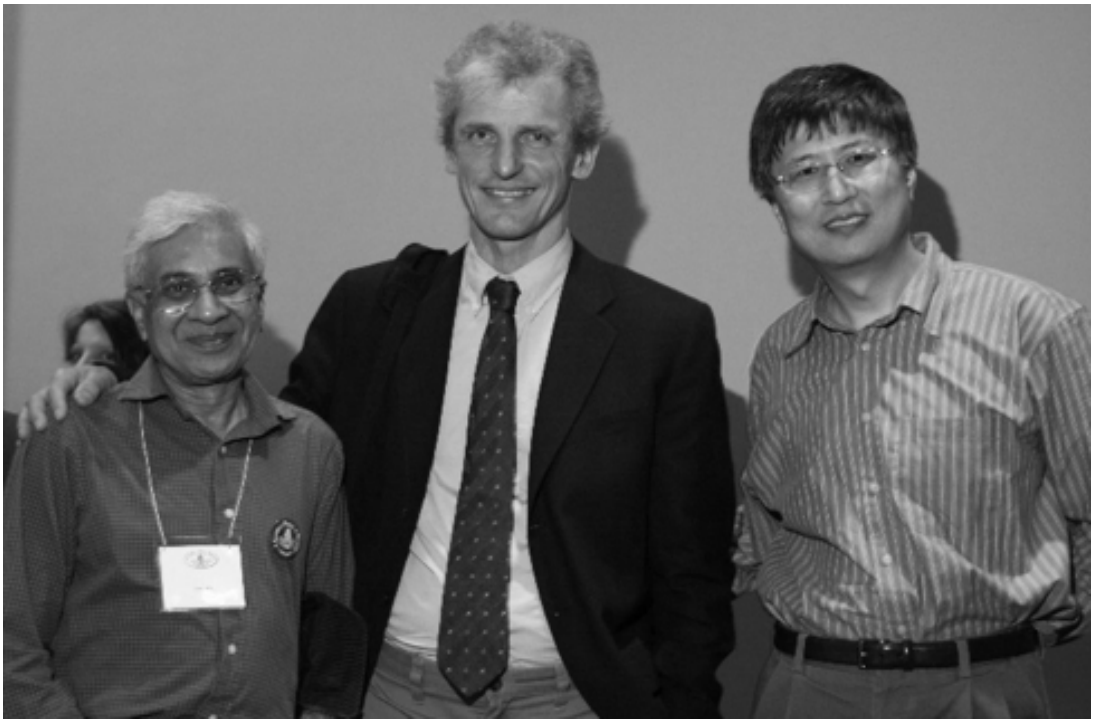


Figure 3: Ketterle (Center) with Rajendra Gupta (left) and Min Xiao. Gupta was the chair of the Centennial Organizing Committee and Xiao was responsible for hosting Ketterle in Fayetteville.



Figure 4: Distinguished Alumnus Robert Maurer (left) with Chair Surendra Singh. Maurer, after whom the lecture series is named, traveled to Fayetteville to participate in the celebrations.



Figure 5: Min Xiao (left) and Ketterle (right) chatting with Collis Geren, dean of graduate school and vice provost for research after the lecture.



Figure 6: Emeritus Professor Ray Hughes (right) talking with Ketterle. Usha Gupta (partially hidden), head of the Physics Library, looks on.



Figure 7: Provost Bob Smith admires the George Rhoads's audiokinetic sculpture, "Odyssey of the Spheres," after unveiling it in the Physics Lobby. *Courtesy of Russell Cothren, University Relations.*



Figure 8: The audiokinetic sculpture "Odyssey of the Spheres" by George Rhoads, illustrating the principles of physics, was commissioned by the Physics Department for the Centennial and is now on permanent display at the Dickson Street entrance of the Physics Building. Rhoads's other works are on display at many leading museums around the world, including the Museum of Modern Art (New York), the Art Institute of Chicago, and Boston Museum of Science. *Photo courtesy of Russell Cothren, University Relations.*



Figure 9: A poster exhibit in the Physics Lobby celebrating a century of physics (1907–2007) in Arkansas was inaugurated by Provost Smith. The exhibit consists of nineteen posters, fifteen of which were produced the American Physical Society tracing the development of physics from 1890 to 1990. Four posters were produced by the department, and depict the birth of the department in 1907, where the department was in 2007, and accomplishments of the alumni. *Photo courtesy of Russell Cothren, University Relations.*

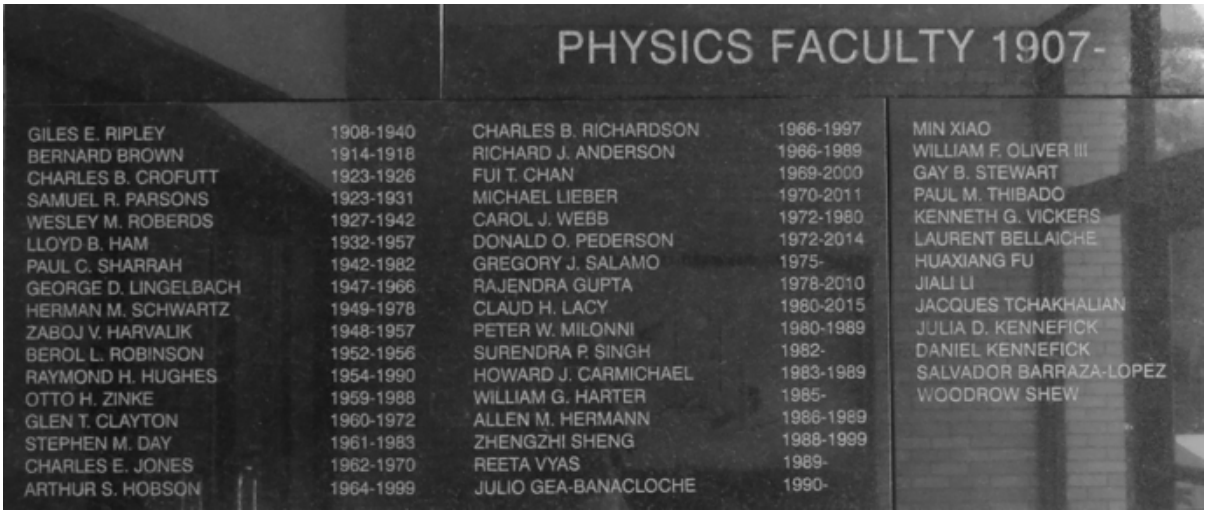


Figure 10: Faculty Honor Roll, engraved with the names of all faculty members who have made significant contributions to the department since 1907. This is installed at the Dickson Street entrance to the Physics Building. *Photo by Rajendra Gupta, 2019.*



Figure 11: An exhibit of historical physics equipment was formally inaugurated by Provost Smith. This is on permanent display in the ground floor lobby of the physics building Phase 1 expansion. Some of the equipment dates back to the early twentieth century.



Figure 12: The afternoon's activities concluded with a reception in the Physics Library and an open house of all research laboratories. Shown above are (clockwise starting from left): Keith Andrew, Jim Spann, Paul Breaux, David Ramer, Charles Kurtz, and Allen Rose (back to the camera). All were graduate students in the 1980s. *Photo courtesy of Allen Rose.*



Figure 13: Banquet at the Fayetteville Town Center on the evening of Friday, April 4, 2008. The event was attended by about four hundred guests which included alumni and their guests (totaling about two hundred, several from across the country and even abroad), former and current faculty, students, staff, Chancellor-designate David Gearhart, Provost Bob Smith, Vice-Chancellor for Finance and Administration Don Pederson, Dean of the Fulbright College of Arts and Sciences Donald Bobbitt, and their guests. Entertainment was provided by Allen Hermann, former chair and professor of physics and a world-renowned jazz trombonist, and his accompanists.



Figure 14: Professor Greg Salamo and Pam Salamo (center) with alumni (left to right) Kevin Tennal, David Ramer, Paul Breaux, Tarlok Aurora, and guests.



Figure 15: Chancellor-Designate David Gearhart (right) greets Barbara Maurer and Robert Maurer (extreme left) while Chair Surendra Singh (partially hidden) looks on.



Figure 16: Chair of the Physics Department Surendra Singh welcomed the guests.

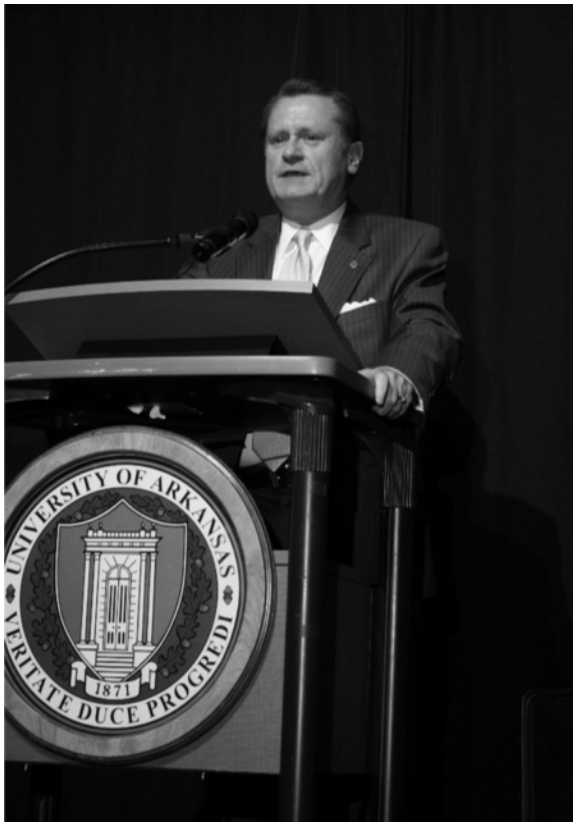


Figure 17: Chancellor-Designate David Gearhart addressed the gathering.



FAYETTEVILLE

Physics alumni mark 100 years of UA program

BY TRACIE DUNGAN
ARKANSAS DEMOCRAT-GAZETTE

FAYETTEVILLE — Two years into his engineering studies at the University of Arkansas, David Norris switched his major to physics, earned his bachelor of science and kept going.

"I enjoyed how the teachers in physics encouraged us to ask questions about the things we were studying," said Norris, a 1998 graduate of Parkview High School in Little Rock.

He preferred exploring ideas to focusing on scientific applications, he said. He is seeking a doctorate in physics at the University of Maryland after graduating from UA in 2003.

Norris is among the nearly 200 alumni of UA's physics department — there are only 700 in all — who reunited on campus this week to celebrate the program's centennial.

As a crowd of alumni, faculty and students gathered in the Physics Building lobby Friday afternoon to remember those changes, Provost Bob Smith unveiled a fun, physics-based audiokinetic sculpture for the occasion — an electric-powered contraption sandwiched between two panes of glass.

Reminiscent of the 1960s-era board game Mouse Trap, only more vertical, the sculpture's

See PHYSICS, Page 6B

Arkansas Democrat-Gazette/JASON IVESTER

A crowd gathers Friday at the physics department of the University of Arkansas at Fayetteville for the unveiling of the sculpture "Odyssey of the Spheres." The audiokinetic work by artist George Rhoads has been installed there to honor the department's centennial.

Figure 18: The event received a widespread media coverage. Above is from the April 5, 2008 issue of the *Arkansas Democrat-Gazette*.



Figure 19: On behalf of the department, Emeritus Professor Charles Richardson presented Centennial Medallions to the former and emeritus faculty and staff for their service to the university. Those visible in this picture are (left to right): George Lingelbach's son accepting on behalf of his father (who is now deceased), former office manager S. Jean Eaton, Professors Stephen Day, Howard Carmichael, Otto Zinke, Arthur Hobson, Raymond Hughes, Allen Hermann, and Richard Anderson. *Photo courtesy of Ken Osborne.*



Figure 20: The audience in the auditorium. ***Photo courtesy of Ken Osborne.***

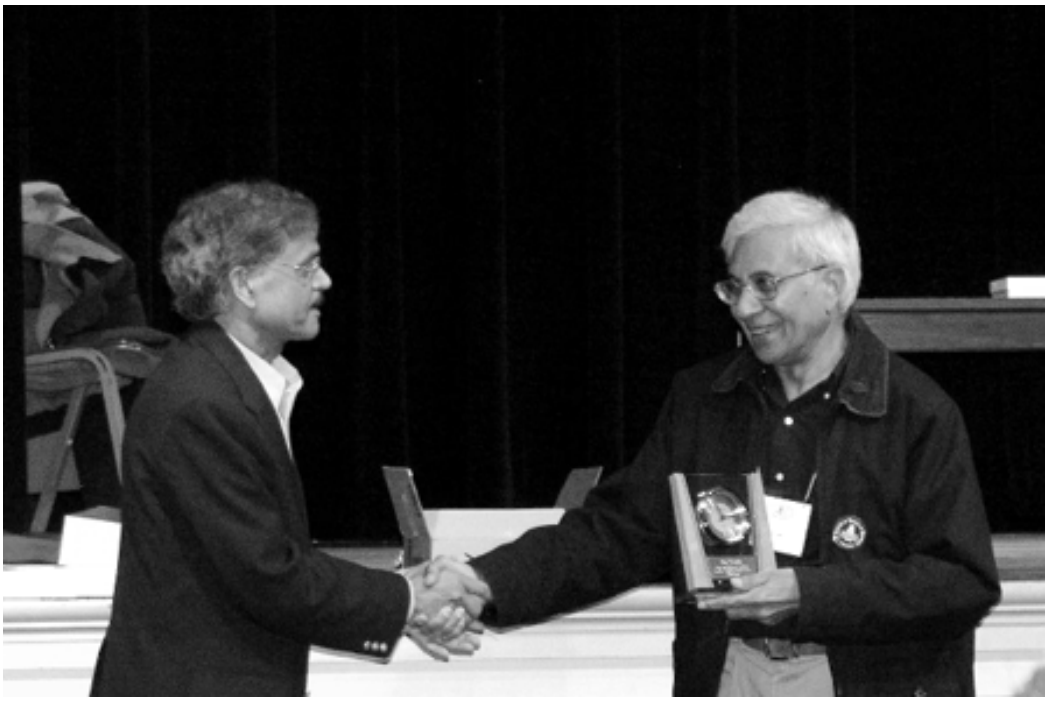


Figure 21: Department Chair Surendra Singh presenting an award on behalf of the department to Rajendra Gupta, chair of the Organizing Committee for his efforts. Gupta accepted the award on behalf of the committee. ***Photo courtesy of Ken Osborne***



Figure 22: Current, former, and emeritus faculty on the steps of east entrance to Old Main, April 5, 2008.

First row (left to right): Huaxiang Fu, Howard Carmichael, Allen Hermann, Raymond Hughes, Rajendra Gupta, Julio Gea-Banacloche, Reeta Vyas. Second row: Arthur Hobson, Otto Zinke, Julia Kennefick, Jiali Li, Tamara Snyder, Richard Anderson. Third row: Charles Richardson, Jacques Tchakhalian, Laurent Bellaiche, Kenneth Vickers, Surendra Singh, Stephen Skinner. Fourth row: William Oliver, Claud Lacy, Michael Lieber, Stephen Day, Gregory Salamo. Fifth row: William Harter, Paul Thibado, Min Xiao, John Stewart. Sixth row: Eitan Gross, Donald Pederson, Gay Stewart.



Figure 23: A group photograph of the alumni, and current, former, and emeritus faculty on the steps of the east entrance of Old Main on Saturday, April 5, 2008.

Epilogue

Important Developments

2009–2018[1]

Faculty Hired

In 2018 the department had a tenured and tenure-track faculty of twenty-one, up from nineteen in 2008. During this period, Rajendra Gupta, Michael Lieber, Claud Lacy, Donald Pederson, and Kenneth Vickers retired, and Jacques Tchakhalian and Gay Stewart resigned. New faculty hired between 2009 and 2018 are as follows:

Daniel Kennefick, assistant professor 2009–2015, associate professor 2015–present.
PhD, California Institute of Technology, 2004
Research Interests: History of physics, Einstein papers, and gravitational waves.

Salvador Barraza-Lopez, assistant professor 2011–2017, associate professor 2017–present.
Awarded a five-year DOE Early CAREER Award in July 2016.
PhD, University of Illinois at Urbana-Champaign, 2006.
Research Interests: Theory of two-dimensional materials.

Woodrow Shew, assistant professor 2012–2017, associate professor 2017–present.
PhD, University of Maryland, 2004
Research Interests: Statistical and nonlinear physics of the brain.

Pradeep Kumar, assistant professor 2013–2019, associate professor 2019–present.
PhD, Boston University, 2008
Research Interests: Biophysics, life in extreme conditions, soft matter physics.

Hugh Churchill, assistant professor 2015–present. Awarded AFOSR Young Investigator Award in fall 2016, NSF CAREER Award in December 2018, and PECASE Award in July 2019.
PhD, Harvard University, 2012
Research Interests: Material properties, physics and quantum device applications of low-dimensional (0D, 1D, and 2D) quantum materials.

Bret Lehmer, assistant professor 2015–present.
PhD, Pennsylvania State University, 2007
Research Interests: Variety of topics in high-energy astrophysics, including the observational studies of black holes and neutron stars in binary stars and the evolution of galaxies through cosmic time.

Yong Wang, assistant professor 2016–present.
PhD, University of California at Los Angeles, 2011
Research Interests: Super-resolution fluorescence microscopy, single-molecule fluorescence techniques, mechanics of biological systems, molecular diffusion in living systems, and antimicrobial mechanism of metal nanostructures.

Jin Hu, assistant professor 2017–present.
PhD, Tulane University in New Orleans, 2013
Research Interests: Materials that display exotic properties due to collective quantum phenomena of electrons such as superconductors, topological quantum materials, and functional 2D materials.

Rick Wise, director of the Interdisciplinary MicroElectronics Photonics Graduate Program 2014–present.
PhD Southern Methodist University in Dallas, Texas, 2000; Elected Texas Instruments Fellow, 1998.
Research Interests: Epitaxial growth of group IV and III-V materials, studies of epitaxial growth defects, and Cz-grown silicon crystal properties.

Chairs of the Department

Surendra P. Singh, 2002–2011
Julio Gea Banacloche, 2011–2017
William F. Oliver III, 2017–present

Research

Number of papers published by faculty and students with 2018 publication dates: Eighty-nine refereed papers and three books or book chapters. Five of these papers appeared in *Physical Review Letters*, seven in *Nature* journals, two in *Nano Letters*, and one each in *Advanced Functional Materials* and *Advanced Materials*. Two papers were chosen as cover articles.

Number and total amount of new grants awarded in the 2018–19 academic year: Four major federal grants totaling $2,153,000, in addition to several smaller grants totaling several hundred thousand dollars.

Total citation of faculty publications in the 2018 calendar year[2]: The number of citations in 2018 to papers published (at any time) by the tenured and tenure-track faculty employed by the university in 2018, and based on work done at the University of Arkansas (as determined by institutional affiliation shown in the publication as University of Arkansas, Physics Department) was 3,616. If the faculty is expanded to include former faculty as well (but still limited to publications based on work done at the University of Arkansas), the number of citations in 2018 was 4,502.

Important Developments in the Graduate Program[3]

In 2013 the graduate program in physics was named for Raymond Hughes, professor emeritus of physics who founded the physics PhD program. His wife and their four children honored his memory with a $500,000 endowed gift to name the Raymond H. Hughes Graduate Program in Physics. The returns support two semester-long research assistantships and professional development activities for faculty and graduate students.

In 2017, the course-based written PhD qualifying examination was replaced by a PhD qualifying examination based on a research-based written proposal and oral presentation. Three new concentrations in astrophysics, biophysics and neuroscience were added to the physics program and core course requirements were changed. The MA degree for in-service high school teachers was dropped.

Important Developments in the Undergraduate Program[4]

Professors Gay and John Stewart left the University in 2014 and the whole faculty began taking on the role of teaching UPI and UPII by rotation. Also, the undergraduate advising program was redesigned to pick up the advising that Stewarts had been doing.

A second semester of undergraduate quantum mechanics course, Advanced Quantum Mechanics, was added to the course offerings.

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[1] Based on information provided by William Oliver III, chair of the department, and by others as noted below.

[2] Citation data provided by Stephanie Pierce, head of the Physics Library.

[3] Information provided by Surendra Singh, chair of the Graduate Affairs Committee.

[4] Information provided by Salvador Barraza-Lopez, chair of the Undergraduate Affairs Committee.

Appendix I

Chronology of Significant Events

1862–2008

Compiled by Martha Moore Head and Paul C. Sharrah in December 1960, and revised by Paul Sharrah in 1981, 1991, 1993, and 1995. Supplemented by Rajendra Gupta in 2019 with the significant events of 1996–2008. The original, that is, with events up to 1995, was published in History1 (Ref. 7) and is reproduced here with a few corrections.

1862 Land-Grant Act made law, providing for "donation of public lands to the several states and territories and colleges for the benefit of agricultural and mechanical arts."

1866 Land-Grant Act amended giving states five years from 1866 to establish colleges.

1867 Arkansas Legislature passed an act establishing an Industrial University. Little was accomplished under this act.

1871 Arkansas Legislature passed An Act for the Location, Organization, and Maintenance of the Arkansas Industrial University with Normal Department Therein. Bids were to be accepted for location of the university. $50,000 appropriated to purchase site and buildings. Land between 160 and 650 acres was to be purchased. N. P. Gates was made President.

1871 Fayetteville selected as location for university November 15, 1871. William McIlroy homestead of 160 acres purchased at a cost of $12,000.

1872 First group of students enrolled January 1872. William J. Waggener enrolled in the university March 1872.

1873 Physics was taken during the junior or senior year "in order that the students may have the light of the higher mathematics in investigating some of the problems presented."

1875 University Hall (Old Main) completed. N. P. Gates was President from 1875 to 1877.

1876 June 10, first graduating class of nine. W. J. Waggener awarded a bachelor of arts degree. Received an MA in 1885. Mr. Waggener served as professor of physics at the University of Colorado for thirteen years, retiring in 1898 (*Arkansas Alumnus*, April 1938).

1877 D. H. Hill was president of the university until 1884. He showed interest in increasing equipment of scientific courses. Students petitioned to remove the physics teacher; standards too high.

1879 Cuthpert Power Conrad was made professor of chemistry and natural science. He devoted himself to raising the standards of the university. He started a mineral collection with the cooperation of newspapers and superintended the Arkansas exhibits at the 1883 Louisville and 1884–85 New Orleans Expositions. A campus plan was displayed at the New Orleans exhibit.

1893 Chemistry and physics taught in a two-story brick building south of University Hall (later condemned and torn down, about 1904 or 1905).

1899 Name changed from Arkansas Industrial University to University of Arkansas.

1902 Anthony Muckenfuss was in charge of chemistry and physics from 1902 to 1904. Thirty-three faculty members; 606 students.

1904 Engineering Hall built. Used by engineering until 1926, and then by business and ROTC. Physics was taught in the Department of Electrical Engineering by Professor William N. Gladson and Instructor H. Schapper. Razed on 1991.

1905 New chemistry building constructed directly north of University Hall. It was used by chemistry until 1935.

1907 Physics became a separate department lead by electrical engineering Assistant Professor Schapper. A small frame building (forty by fifty feet) consisting of two large rooms was built for the physical laboratories. The Physics Department continued to hold classes in Engineering Hall and laboratories in the small frame physical laboratories building.

1908 Professor Giles Emmet Ripley became the first full-time professor in physics and head of the department. He had graduated from Purdue University and taught physics and chemistry before coming to the University of Arkansas. S. A. Rowland was listed as his assistant in the 1908–1909 catalog. BS degree program in physics introduced. 149 students enrolled in physics. Building requested of the Legislature.

1909 Fire destroyed the 1907 physical laboratory and all the equipment. Physics continued in Engineering Hall until 1918.

1910 Summer session introduced.

1913 Dr. John C. Futrall was acting president from 1913 to 1914 and president from 1914 to 1939. His strong leadership is credited with establishing a broader base for the university program.

1914 W. D. Gladson is credited with having operated the first x-ray machine and the first wireless in Arkansas. He was the physics instructor for a time and became the dean of engineering.

1915 First dean of arts and sciences appointed. Small (six-inch) refractor telescope bought. Used by A. M. Harding, D. P. Richardson, and others. Acquired a new lens 1993.

1918 Another frame building was built for the Physics Department at approximately the present south end of Campus Drive. This two-story wooden building with dimensions of approximately forty by sixty feet was used by the department until 1936.

1921 One thousand students enrolled in the university.

1922 Fiftieth Anniversary Celebration of the university. During the first fifty years, 2814 graduates.

1923 Dr. Samuel R. Parsons became a member of the physics faculty and served until his death in 1931.

1924 University becomes member of the North Central Association of Colleges and Secondary Schools.

1927 Wesley Milton Roberds was employed and stayed until he resigned in 1942 to work with industry. Dr. John Clark Jordan became first graduate school dean.

1928 Roy R. Sullivan was the first student to graduate from the University of Arkansas with a

major in physics. Earned PhD from the University of Minnesota.

1931 Chapter of Phi Beta Kappa installed.

1932 Dr. L. B. Ham came to the Department of Physics from New York University having received his PhD in physics from the University of Illinois at Urbana-Champaign. For the first time a 400-level course, Introduction to Theoretical Physics, was introduced.

1933 An attempt to remove certain faculty members.

1935 Wesley M. Roberds (1927–1942) on leave for part of the school year to complete his PhD in physics at the University of Kansas.

1936 The Department of Physics moved to the basement and first floor in the south wing of University Hall, into approximately eleven thousand square feet of space vacated by the library when it went to Vol Walker Hall.

1939 J. William Fulbright was president of the university until 1941. Two hundred students enrolled in all physics courses.

1940 First MS degree granted in physics. Dr. L. B. Ham became the second head of the Physics Department.

1941 Dr. A. M. Harding was president from 1941 to 1947.

1942 Harold Clark from the University of Illinois at Urbana-Champaign and Dr. Paul C. Sharrah from the University of Missouri joined the physics faculty.

1943 Civilian enrollment in all parts of the university dropped, and several civilian and military programs came to the university, including Civilian Pilot Training, Army Air Corps Cadets, Army Specialized Training Program.

1946 Army Ordnance-Arkansas (ORDARK) project began, with Wladimir W. Griegorieff as director. Arkansas-Naval Ordnance (ARNO) project began.

1947 Dr. Lewis Webster Jones was president from 1947 to 1951. A new fine arts center and other extensions of classrooms and housing were obtained in the next few years. Institute of Science and Technology (IST) established with Dr. Wladimir W. Griegorieff as director. Instructor was paid $2,400 for twelve-month appointment. By 1947 university graduates number 8,492. There are 575 students enrolled in all physics courses. G. D. Lingelbach joined the department.

1948 A chapter of the national physics honors society, Sigma Pi Sigma, was established with twelve charter members. Dr. Marsh W. White of Pennsylvania State University, national secretary of Sigma Pi Sigma, presided over the installation. Dr. Willard C. Bennett, the discoverer of the plasma pinch effect, joined the IST and the department. Initiated large research grant with Dr. Maurice Testerman. Institute of Science and Technology obtained several research contracts. By 1952, budget was $532,200. Dr. Z. V. Harvalik joined the IST and the department. The Physics Department received their first research equipment grant. General Education Program instituted in College of Arts and Sciences. Physical Science course developed, three versions for a few years.

1949 Dr. H. M. Schwartz joined the Department of Physics, having recently been employed by the Brookhaven National Laboratory and the Bartol Foundation in Philadelphia. Salary for professors is $5,000. Chapter of Sigma Xi installed. High level decision to develop doctoral programs. V. W. Adkisson, the new dean of the graduate school, traveled and consulted with many graduate schools.

1950 First doctoral programs approved. Dickson Street physics building planned.

1951 Research Cooperation grant received by Schwartz and Sharrah to study neutrons produced by cosmic rays.

1952 Dr. John T. Caldwell was president from 1952 to 1959. Department of Physics moved into new structure on the south side of Dickson Street with floor space of more than twenty thousand square feet devoted to teaching and research. Building cost $300,000. Physics was assigned approximately 13,600 square feet of this space initially. Dr. Berol L. Robinson joined the department. Helium ground state calculations, H. M. Schwartz and Ms. Veronica Fink, radiation correlating studies, Berol Robinson, all Atomic Energy Commission funding through chemistry.

1953 A study of the possibility of expanding to the PhD program was made by the Department of Physics. It was decided about this time to start requiring a thesis for the Master of Science in Physics. The Physics Library was being expanded.

1954 Dr. R. H. Hughes joined the Department of Physics and obtained in 1956 an Air Force grant for the study of isotope shifts in atomic spectra. Dr. Brent Stearns joined the Department of Physics. Academic year salary $5,500. Paul C. Sharrah on leave, at the Oak Ridge National Laboratory, 1954–55.

1955 Provost Rohrbaugh served as research coordinator; then research coordinator duties assigned to graduate school dean V. W. Adkisson and Assistant Research Coordinator Dr. Aubry E. Harvey.

1956 First National Science Foundation Summer Science Institute was put into operation on the campus under the direction of Dr. Lowell F. Bailey of the Department of Botany and Bacteriology. Bent and ground crystal "theta-theta" x-ray monochromator for diffraction studies of liquids, P. C. Sharrah, R. F. Kruh from chemistry and Glen T. Clayton. H. M. Schwartz on leave at the University of Tel Aviv for two years.

1957 Dr. L. B. Ham retired. A summer course in physics demonstrations was introduced and continued for some time to be an important portion of the institute for high school teachers. Dr. Paul Sharrah became the first chairman of the Department of Physics. Graduate Institute of Technology started in Little Rock. Department supplied some of the advisory committee leadership.

1958 Dr. Glen T. Clayton joined the Department of Physics having recently completed his thesis work at the Argonne National Laboratory for his PhD from the University of Missouri. Act 10 (Ref. 3).

1959 PhD program instituted in the Department of Physics. Dr. Otto H. Zinke joined the Department of Physics, having recently been employed by the University of Missouri and by Linde PLC. Plasma studies on exploding wires. Introduced two-semester senior-graduate course in modern physics using Leighton. Zinke taught it the first time. Twelve-month salary $10,000.

1960 Dr. David Mullins became the fourteenth president of the University of Arkansas. The Undergraduate Colloquium was put into operation. IBM-650 computer installed in the physics building. Low energy proton acceleration, R. H. Hughes and T. S. Walton. First class in Modern Physics for Engineers ("UP III") was taught about this time.

1961 Dr. S. M. Day joined the department. Nuclear Magnetic Resonance research.

1962 Charles E. Jones joined the department, completed doctoral degree at Texas A&M in a few months.

1964 Dr. A. S. Hobson joined the Department of Physics. First Physics PhD granted. IBM-7040 computer installed in Science Engineering Building.

1965 Physics department active in organizing regional section of the American Association of Physics Teachers, AOK (Arkansas-Oklahoma-Kansas).

1966 Dr. Richard J. Anderson joined the department. Atomic physics. Dr. Charles B. Richardson joined the department. Atomic physics and physics of microparticles.

1967 Dr. Sharrah taught in a National Science Foundation and Agency for International Development–sponsored six-week summer institute for high school physics teachers at Sarder Patel University in Anand, Gujarat, India. S. M. Day on leave 1967–68 at University of Nottingham, England.

1968 The national Society of Physics Students (SPS) was organized, and local SPS chapter installed. Physics students Carl T. Rutledge, Leroy Humphries, and Richard Schurtz attend organizational meeting at Purdue University. R. H. Hughes designated fellow of the American Physical Society.

1969 Dr. F. T. Chan joined the department. Dr. S. M. Day became second chairman of the department.

1970 Dr. Michael Lieber joined the department. Hand-held calculators are here! Hewlett Packard, followed soon by Texas Instruments and Radio Shack etc. Several kinds were programable and some used small magnetic cards to store programs. First of several regional meetings of the Society of Physics Students (1970, 1971, 1972, 1973, 1974). Several were joint meetings with the Arkansas-Oklahoma-Kansas section of the American Association of Physics Teachers. As many as two hundred participants from twenty-six schools in five states. S. M. Day, D. O. Pederson, and Richard J. Anderson planned these conventions.

1971 Paul C. Sharrah was on off-campus duty assignment fall semester 1971 studying physics and astronomy at the University of Arizona in Tucson.

1972 First astronomer, Carol Webb, joined the department. Spitz A-1 planetarium installed in excellent renovated space in the Physics Building.

1973 O. H. Zinke was on leave for nearly two years 1973–74 and served the Office of the Governor (Dale Bumpers) of the State of Arkansas, working in Little Rock, Fayetteville, and in Washington, DC. Among other assignments, he chaired the Governor's Energy Conference of businessmen and government officials, funded by a grant from the Ford Foundation.

1975 Dr. Gregory J. Salamo joined the department. Dr. Charles B. Richardson became third chairman of the department.

1976 Laser research initiated.

1977 Microcomputers are here! PET, Apple, Radio Shack, etc.

1978 Dr. Rajendra Gupta joined the department. Laser spectroscopy. Droke observatory receives sixteen-inch telescope. Dr. Robert D. Maurer was first UA physics graduate to receive Distinguished Alumnus Citation. UA Physics graduate, Dr. Wallace A. Hilton, received the AAPT Oersted Medal. Dr. Donald O. Pederson became fourth chairman of

the department. Dr. H. M. Schwartz retired. F. T. Chan was on an off-campus duty assignment in 1978–79 working with Professor J. Eichler on atomic collision at the Hahn-Meitner Institut in Berlin, Germany.

1979 R. H. Hughes on sabbatical working at the Oak Ridge National Laboratory on a laser-generated ion source

1980 Second astronomer, Dr. Claud H. Lacy, joined the department. Dr. Peter W. Milonni joined the department. Dr. William L. McMillan received Distinguished Alumnus Citation.

1981 Frank P. Sperandeo III joined the department as research associate in charge of production and development of research devices.

1982 Dr. Paul C. Sharrah retired. Dr. Surendra P. Singh joined the department. Quantum optics. Physics is now using approximately eighteen thousand square feet of the Dickson Street building it moved into in 1952.

1983 Dr. Larry S. Merkle joined the department. Dr. Howard J. Carmichael joined the department. Dr. Michael Lieber became the fifth chairman of the department. Dr. Richard J. Anderson became director of the Fulbright College Honors Program (1983–89). Raymond H. Hughes on leave calendar year 1983, working at the Air Force Weapons Laboratory at Kirkland Air Force Base, Albuquerque, New Mexico, on the interaction of high intensity electron beams on the atmosphere.

1984 Charles B. Richardson was on off-campus duty assignment, June–December 1984, working with Ignatius Tang at the Brookhaven National Laboratory.

1985 Dr. William M. Harter joined the department. Computer modeling and molecular spectroscopy. Art Hobson was on an off-campus duty assignment January–May 1995 working at the Stockholm International Peace Research Institute in Sweden. Richard J. Anderson was on assignment for the academic year 1985–86 at the National Science Foundation on an Intergovernmental Personnel Act Appointment.

1986 Dr. Allen Hermann joined the department as sixth chairman.

1987 Superconductor research developed. Dr. Z. Z. Sheng joined the department as a research associate. Hermann and Sheng develop at that time the world's record high temperature superconductor. Gregory Salamo was on off campus duty assignment 1987–88 and leave 1988–89, working with Dr. Edward Sharp at the Night Vision Electro-optics Laboratory in Fort Belvoir, Virginia.

1988 Dr. Urbano Oseguera joined the department and was given the responsibility of directing the elementary laboratories. Dr. O. H. Zinke retired and went into private consulting. Michael Lieber was on off-campus duty assignment spring 1988, at the Institute for Theoretical Physics at the University of California at Santa Barbara.

1989 Dr. Reeta Vyas joined the Physics Department as a tenure-track faculty member in quantum optics. Department hosted AOK regional meeting. Rajendra Gupta became seventh chairman of the department. Surendra Singh was on off-campus duty assignment 1989–90, working with John Hall, Joint Institute for Laboratory Astrophysics (JILA), University of Colorado, and the National Institute of Standards and Technology (NIST).

1990 Dr. Julio Gea-Banacloche and Dr. Min Xiao joined the department. Quantum optics. Dr.

R. H. Hughes retired.

1991 University of Arkansas–Fayetteville grants 100,000th degree. September 21, 1991 rededication of Old Main. University Hall officially named Old Main. Physics Department receives grant for renovation and expansion. Total cost of project $3.9 million. Art Hobson was on a duty assignment on campus from August 1991 to May 1992 for the purpose of writing a first draft of a physics textbook.

1992 Dr. William F. Oliver III joined the department as experimental condensed matter physicist. James B. Shue joins the department as instructor and equipment curator. Dr. Michael Lieber began serving as vice-chairman. Physics is now using all of the approximately 21,320 square feet of space in the Dickson Street building it first moved into in 1952. Building renovation begins and five thousand square feet additional teaching space being built (Phase I). Phase II awaiting funding and is expected to include a modern planetarium. A. S. Hobson designated fellow of the American Physical Society.

1993 February 14, eight-inch snow closed the university for two days. Dr. William G. Harter was on an off-campus duty assignment 1993–94 working at Harvard University. Fall 1993, department started using some of the renovated offices. Department moved laboratories out of east wing for final phase of renovation work. December 3, surprise party for Professor Rajendra Gupta to recognize his work in implementing the renovation and Phase I construction.

1994 Remodeled and enlarged Physics Building officially dedicated September 9. Professor Rajendra Gupta served as master of ceremonies at the banquet celebrating the event at the Hilton Hotel in Fayetteville. Richard J. Anderson, Donald O. Pederson, and Paul C. Sharrah were on the program. Sharrah gave a brief review of the history of the physics buildings, with slides. Departmental Secretary Sandra Johnsen surprised everyone by presenting a plaque to Professor Gupta. Dr. Mark E. Filipkowski and Dr. Gay Stewart join the physics faculty. Professor Min Xiao, NSF Young Investigator Award; up to $500,000 over three years.

1995 William G. Harter designated fellow of the American Physical Society. UA group salary averages for spring 1995 (AAUP Report as printed in the *Arkansas Traveler* March 10, 1995): full professors $58,160, associate professors $44,949, assistant professors $39,323. Professor Surendra Singh becomes eighth chairman of physics as of July 1. Dr. Michael Henry joins faculty. It has become the normal practice in recent years to provide initial funds to assist new faculty to set up their research laboratory. Rajendra Gupta on research assignment for the university, fall 1995.

1996 Emeritus Professor Paul C. Sharrah passed way. Dr. Paul Thibado joined the department and starts the assembly of Molecular Beam Epitaxy facility at the University of Arkansas.

1998 Ken Vickers joined the department to start, with Greg Salamo, a new interdisciplinary program called Microelectronics-Photonics Graduate Program. Vickers became the director of this program. Professor Donald O. Pederson became the vice-chancellor for finance and administration. Rajendra Gupta went to Princeton University on sabbatical and was elected a fellow of the American Physical Society. Paul Thibado received an NSF CARREER Award.

1999 Dr. Laurent Bellaiche joined the department and he started a research program in

computational condensed matter physics. Professor Zhengzhi Sheng resigned, ending the effort to find a higher-temperature superconducting material at the University of Arkansas.

2000 Dr. Julio Gea-Banacloche appointed an Associate Editor of Physical Review A, with responsibility for the section on Quantum Information. Laurent Bellaiche received an NSF CAREER Award. Greg Salamo elected a fellow of the Optical Society of America.

2002 Dr. Huaxiang Fu joined the department to expand the research effort in computational condensed matter physics. Dr. Jiali Li joined the department to start research in experimental biophysics. Surendra Singh stepped down as chair and William Oliver appointed the new chair of the department.

2003 Dr. Surendra Singh elected a fellow of American Physical Society.

2004 Dr. Julio Gea-Banacloche elected a fellow of the American Physical Society. Min Xiao appointed as a distinguished professor and elected a fellow of the American Physical Society and a fellow of the Optical Society of America. Greg Salamo appointed as a distinguished professor.

2005 William Oliver stepped down as the chair and Surendra Singh appointed as the chair of the department for the second time. Greg Salamo appointed to a Joe N. Basore Professorship.

2006 Dr. Jacques Tchakhalian joined the department. Research in experimental condensed matter physics. Fourth new faculty member to be hired in condensed matter and nanoscience. Min Xiao appointed to the Twenty-First Century Endowed Chair in Nanotechnology. Laurent Bellaiche appointed to the Twenty-First Century Endowed Chair in Optics, Nanoscience and Education.

2007 Dr. Julia Kennefick joined the department to expand the research program in astronomy.

2008 Jacques Tchakhalian received an NSF CAREER Award. The department celebrated its centennial. It was a grand affair. It consisted of, among other things, the Centennial Maurer Distinguished Lecture by Wolfgang Ketterle, a John D. MacArthur Professor of physics at MIT and 2001 Nobel Laureate; installation of a George Rhoads's audiokinetic sculpture; inauguration of a poster exhibit and a display of historical physics equipment; an evening banquet attended by four hundred people; and a reunion of alumni, former-, emeritus-, and current-faculty. About two hundred alumni and their guests, plus almost all former faculty, returned to the campus to participate in these celebrations.

Appendix II

The Early Teachers of Physics

1871–1907[1]

The following information has been derived from Prologue II where the primary sources are given, except for that regarding the 1872–77 period, which is obtained from Ref.5.

1872–1877: Professors Thompson, F. L. Harvey, and perhaps others (temporary building and University Hall)

1877–1878: Professor J. B. Gordon, CE, BS; civil and mechanical engineering and mathematics (University Hall)

1878–1880: Professor C. P. Conrad, AM and Professor F. L. Harvey; natural philosophy and chemistry (University Hall)

1880–1884: Professor C. P. Conrad, AM; physics and chemistry (University Hall)

1884–1886: Professor J. M. Whitham, MA, CE, ME; applied mathematics and commandant of the cadets (University Hall)

1886–1887: Professor F. W. Simonds; biology and geology (University Hall)

1887–1889: Professor J. M. Whitham, MA, CE, ME and Adjunct Professor W. E. Anderson; mechanical arts and engineering (University Hall)

1889–1904: Professor A. E. Menke, PhD and at different periods Adjunct Professor W. B. Bentley, PhD, Associate Professor P. H. Walker, Professor A. M. Muckenfuss, PhD, and Professor L. H. Rose; chemistry and physics (University Hall and Science Hall)

1904–1907: Instructor H. Schapper and Professor W. N. Gladson, PhD; electrical engineering and physics (Engineering Hall)

1907–1908: Adjunct Professor Heinrich Schapper (Engineering Hall and small wooden building (1907–09) for laboratory work)

[1] When more than one name is shown, the first listed is considered to have been the primary physics teacher during the period indicated. The first full-time teacher of physics was employed in 1908 (see appendix IV).

Appendix III

Early Teachers of Astronomy

1875–2011

Until 1972, all the teachers of Astronomy were primarily teachers in other disciplines. This appendix lists the primary disciplines and leadership positions of the part-time astronomy teachers. The list is taken from History1 (Ref. 7).

O. C. Gray: (1875–1895) Mathematics, logic
E. H. Murfree: (1887–1894) Mathematics, logic; president
G. W. Droke: (1880–1925) Preparatory, mathematics; dean of arts and sciences
A. M. Harding: (1905–1947) Preparatory, mathematics; director of general extension, president
J. C. Hughes: (1918–1930) Mathematics
D. P. Richardson: (1927–1967) Mathematics; head mathematics, planetarium director (1954–1967)
P. C. Sharrah: (1942–1982) Physics; department chairman, planetarium director (1967–1982)
C. B. Richardson: (1966–1997) Physics; department chairman, astronomy teaching laboratory
M. L. Lieber: (1970–2011) Physics; department chairman

The first professionally trained astronomer was employed in 1972 (see appendix IV).

Appendix IV

Physics Faculty Hired

1908–2008

This appendix presents the names of physics and astronomy faculty who we were hired between 1908 and 2008. All initial appointments were in one of the professorial ranks (generally assistant professor), except where indicated. Only those faculty who were tenured at the university or stayed for a significant length of time are included in the list. Names of other shorter-term faculty, where they could be identified, are given below the list. All available information has been used to determine the appointment dates, including the departmental records, catalogs, and personal recollections of the faculty. In several cases catalog information was the only source of information. It should be kept in mind that the catalog information could lag behind the actual appointment date by a year or so. Department heads and chairmen are indicated by boldface letters.

1908–1940 **Giles E. Ripley**, MS, Purdue University; First full-time teacher and department head 1908–1940; Dean of Men 1923–1937; Deceased January 31, 1943

1914–1919 Bernard Brown, MS, University of Chicago; Instructor 1914–17; Assistant Professor 1918–19

1923–1926 Charles B. Crofutt, PhD, University of Iowa; Instructor

1923–1931 Samuel R. Parsons, PhD, University of Michigan

1927–1942 Wesley M. Roberds, PhD, University of Kansas
left for Industrial Research

1932–1957 **Lloyd B. Ham**, PhD, University of Illinois at Urbana-Champaign; Second Department Head 1940–1957; Retired in 1957; Deceased

1942–1982 **Paul C. Sharrah**, PhD, University of Missouri; First Department Chairman 1957–1969; Planetarium Director 1967–1982; Retired in 1982; Deceased 1996

1947–1966 George D. Lingelbach, BSEE, Kansas State University; Laboratory Coordinator and Instructor; Retired in 1966

1949–1978 Herman M. Schwartz, PhD, University of Pennsylvania; Retired in 1978

1948–1957 Zaboj V. Harvalik, ScD, University of Prague; Went to Ft. Belvoir Army Corps of Engineers 1957.

1952–1956 Berol L. Robinson, PhD, Johns Hopkins; Went to Case Western Reserve and UNESCO in Paris

1954–1990 Raymond H. Hughes, PhD, University of Wisconsin; First in the department to receive a major external research grant, to direct a PhD candidate, to be elected Fellow of the American Physical Society, to be appointed a University Professor, and to receive UA Alumni Research Award; Retired in 1990; Deceased October 3, 2010

1959–1988 Otto H. Zinke, PhD, Washington University; Retired in 1988

1958–1972 Glen T. Clayton, PhD, University of Missouri; went to Stephen F. Austin University as Dean of Science and Mathematics and Graduate Dean

1961–1983 **Stephen M. Day**, PhD, Rice University; Second Department Chairman 1969–1975; Associate Dean of Arts and Sciences 1979–1983; went to Miami University in Ohio as Dean of Arts and Sciences

1962–1970 Charles E. Jones, PhD, Texas A&M; Went to East Texas State University as Head of Physics Department

1964–1999 Arthur S. Hobson, PhD, Kansas State University; Editor, American Physical Society Science and Society Newsletter; Fellow American Physical Society 1992. Robert A. Millikan Medal of the American Association of Physics Techers 2006; Retired in 1999.

1966–1997 **Charles B. Richardson**, PhD, University of Pittsburgh; Third Department Chairman 1975–1978; Retired in 1997

1966–1989 Richard J. Anderson, PhD, University of Oklahoma; Director, Fulbright College Honors Program 1982–1989; Went to National Science Foundation in 1989

1969–2000 Fui T. Chan, PhD, University of California San Diego; Retired in 2000

1970–2011 **Michael Lieber**, PhD, Harvard University; Fifth Department Chairman 1983–1986; Vice-chairman 1992–1998; Retired in 2011

1972–1980 Carol J. Webb, Astronomy, University of Texas; First Equipment grant in Astronomy

1972–2014 **Donald O. Pederson**, PhD, Rice University; Fourth Department Chairman 1978–1983; Associate Dean of Arts and Sciences 1983–85; Vice-Chancellor for Academic Affairs 1986–98; Vice-Chancellor for Finance and Administration 1998–2014; Retired in 2014

1975–Present Gregory J. Salamo, PhD, City University of New York; Director of Fulbright Honors Program 1985–1986; Fellow of the Optical Society of America 2000; Fellow of the American Physical Society 2016; Joe N. Basore Distinguished Professor 2005–Present

1978–2010 **Rajendra Gupta**, PhD, Boston University; Seventh Department Chairman 1989–1995; Fellow of the American Physical Society 1998; Retired in 2010

1980–2015 Claud H. Lacy, PhD (Astronomy), University of Texas; First Research grant in Astronomy

1980–1989 Peter W. Milonni, PhD, University of Rochester; Went to Los Alamos National Laboratory in 1989

1982–Present **Surendra P. Singh**, PhD, University of Rochester; Eighth and Tenth Chair of the Department 1995–2002 and 2005–2011; Fellow of the American Physical Society 2003; University Professor 2016–Present

1983–1989 Howard J. Carmichael, PhD, University of Waikato, New Zealand; Went to University of Oregon

1985–Present William G. Harter, PhD, University of California Irvine; Elected Fellow of the American Physical Society 1995

1986–1989 **Allen M. Hermann**, PhD, Texas A.&M.; Sixth Department Chairman 1986–1989; Distinguished Professor of Physics; Fellow of the American Physical Society 1984; Went

to University of Colorado

1989–1999 Zhengzhi Sheng, PhD (Chemistry), University of Arkansas; Research Professor

1989–Present Reeta Vyas, PhD, State University of New York at Buffalo

1990–Present **Julio Gea-Banacloche**, PhD, University of New Mexico; Fellow of the American Physical Society 2004; Associate Editor, *Physical Review A* (section: Quantum Information) 2000–2012; Eleventh Chair of the Department 2011–2017

1990–Present Min Xiao, PhD, University of Texas; National Science Foundation Young Investigator Award 1994; Fellow of the American Physical Society 2004; Fellow of the Optical Society of America 2004; Distinguished Professor 2004–Present; Twenty-First Century Endowed Chair in Nanotechnology 2006–Present

1992–Present **William F. Oliver III**, PhD, University of Colorado; National Science Foundation CAREER Award 1996; Vice-Chair of the Department 1999–2002 and 2015–2017; Ninth and Twelfth Chair of the Department 2002–2005 and 2017–Present; Director of the Arkansas Center for Space and Planetary Science 2010–2015

1994–2014 Gay B. Stewart, PhD, University of Illinois at Urbana-Champaign; Fellow of the American Physical Society 2009; President, American Association of Physics Teachers 2013; Went to West Virginia University in 2014

1996–Present Paul M. Thibado, PhD, University of Pennsylvania; National Science Foundation CAREER Award 1998

1998–2014 Kenneth G. Vickers, MS, University of Arkansas, Founding Director of Microelectronics-Photonics Interdisciplinary Program 1998–2014; Retired in 2014

1999–Present Laurent Bellaiche, PhD, University of Paris VI; National Science Foundation CAREER Award 2000; Fellow of the American Physical Society 2010; Distinguished Professor 2013–Present; Twenty-First Century Endowed Professor in Optics, Nanoscience and Education 2006–Present

2002–Present Huaxiang Fu, PhD, Fudan University

2002–Present Jiali Li, PhD, City University of New York

2006–2016 Jacques Tchakhalian, PhD, University of British Columbia; National Science Foundation CAREER Award 2008; Charles and Claudine Scharlau Endowed Chair 2010–2016; Resigned in 2016 to accept a position at Rutgers University

2007–Present Julia Kennefick, PhD, Caltech; The National Science Foundation ADVANCE Fellowship 2004–2007; Vice Chair of the Department 2017–Present

After 1911 attempts were made to add another faculty member to the department, but none of the people hired stayed for a very long time. The following names, in addition to Ripley, appear in the catalogs: Instructor A. J. Thomas, 1911–12; Associate Professor Jacob Kemp (PhD, University of Illinois at Urbana-Champaign), 1912–14; Assistant Professor Oswald Blackwood, (BA, Boston University), 1919–20; Assistant Professor Paul Bayley (AM, University of Illinois at Urbana-Champaign), 1920–21; Assistant professor Charles Hill (PhD, University of Illinois at Urbana-Champaign), 1921–23. It appears that it was not easy to find and retain qualified physicists at that time.

Another forty-five or more faculty members can be identified as serving in the Physics Department in the 1940s and 1960s for short periods of time or on a limited joint appointment. Among those

brought in from other colleges were Moody Coffman of Oklahoma City University, Roger Crawford of William Jewell College, William E. Gran of the University of Arkansas at Little Rock, Roger Hanson of Grinnell College, Wallace A. Hilton of William Jewell College, Joe G. Robbins of Hendrix College, and Carl T. Rutledge of Southern Arkansas University. Several faculty members were principally employed in research by the Institute of Science and Technology during the late 1940s and early 1950s and taught physics part time. This list includes Willard C. Bennett, J. E. Crites, Paul Damon, Jack A. Doughty, Matti Nurmia, Raymond Raible, Albert Sauer, James Scobie, and Maurice Testerman. Another group of twenty-five or thirty faculty members from other departments on campus taught physics and physics laboratories to US Army and Army Air Corps groups during WWII.

More recently, faculty who stayed for less than seven years include Larry Merkle (1983–1988), Urbano Oseguera (1988–1993), Mark Filipkowsky (1994–ca. 2002), Michael Henry (1995–ca. 2002), Yuji Ding (ca. 1999–2002), and Eitan Gross (2006–2011).

Appendix V

Use of Desktop Computers

The first desktop computers (also known as personal computers or PCs) to be used in the department were Commodore PET computers. In the following section we give a historical context to their introduction and use. In 1977 Donald O. Pederson took over the instruction of a laboratory course on electronics, and purchased self-paced instructional materials and equipment for six learning modules from Heathkit with support from an NSF LOCI (Local Course Improvement for Undergraduate Science Education) grant.[1] The modules consisted of DC Electronics, AC Electronics, Semiconductor Devices, Integrated Circuits, Digital Techniques, and Microprocessors (Motorola 6800 based). In the last module, the students learned machine-language programming. In 1978, he purchased the world's first single-board computers, KIM-1 (Keyboard Input Monitor), for use in this lab. KIM-1 had a MOS 6502 processor, 1K RAM, built-in ROM, hex keypad, seven-character LED display, input/output ports, and a cassette interface for storage, all on a nine-by-ten-inch board. Students were to use these for learning machine-language programming, but no self-paced module was developed as the advent of fully functional personal computers soon outpaced the value of the boards. Soon, another use for these boards was found (see below).

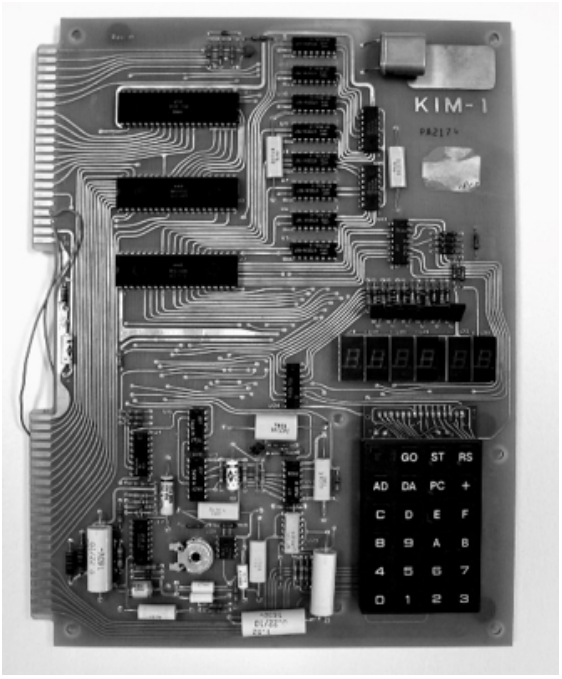


Figure 1: The KIM-1 circuit board purchased for the Electronics Lab in 1977. On display in the Physics Lobby.

Rajendra Gupta Joined the department in 1978 and was planning, in collaboration with Greg Salamo, to start an experiment on photoacoustic spectroscopy in flames. They needed to capture transient signals from a microphone with a capability for signal averaging. In an informal discussion, Pederson suggested using a Commodore PET computer for signal storage and averaging. PET computers were introduced in 1977 and were the first fully functional personal computers. Pederson had experience with these computers since he had bought one from his personal funds in 1978. At that time the PET Model 2001-8 sold for $795 each, but in 1979 there was a promotion where one could purchase three computers for the price of two. It was decided to purchase three computers: one

[1] This information is derived from a document prepared by Donald O. Pederson for Rajendra Gupta on the early use of personal computers in the department.



Figure 2: A PET 2001 computer used for the photoacoustic experiment. On display in the Physics Lobby.

for the electronics lab, one for the photoacoustics experiment, and we are not quite sure where the third was used.

The PET 2001 computer was based on a MOS 6502 microprocessor, but unlike the KIM-1 board, the PET 2001 was a complete unit; it had a keyboard, a monochrome monitor, and a cassette tape recorder for data storage. It had 8K of RAM and was programmed in BASIC, which was preloaded on ROM.

One of these computers was wired and programmed to interface with a LeCroy transient digitizer by graduate students Kevin Tennal, David Pyrum, and Allen Rose so that it could accept, average, and store data from the transient digitizer for the photoacoustic experiment. This PET computer was the first personal computer to be used in the department for data acquisition. Pederson was chair of the department at that time and did not get the time to integrate the computer in the electronics lab. Additional PET computers were purchased by Gupta and other faculty members subsequently. One of these was rewired and programmed to work as a multi-channel pulse-height analyzer by graduate student Atha Pigg and used by graduate student Chao Chia Wu for a laser spectroscopy experiment. According to Pederson, one of these PET computers was used by Ray Hughes, his students, and collaborators to acquire and store data from the LOIS (Laser Operated Ion Source) experiments. Pederson and students on the LOIS project developed a program with Commodore BASIC to plot data from the experiments for quick visualization.

Claud Lacy joined the department in 1980. With funding from Research Corporation, he decided to automate the sixteen-inch reflecting telescope at the Droke Observatory (see chapter 8). The KIM-1 circuit board originally purchased by Pederson for the electronics lab, in conjunction with an Apple II Plus personal computer, was used for this purpose. Introduced in 1979, Apple II Plus computer was the first personal computer made by Apple (Apple I was only available in the form of a circuit board). This telescope was one of the first automated telescopes in the world. Thus, Apple II Plus was the first personal computer used in the department (circa 1981) for equipment automation.

Surendra Singh joined the department in 1982. In August of that year, Commodore Business Machines (the same company that manufactured the PET 2001) released a new computer named Commodore 64. The number 64 signified its 64 KB of RAM. Singh purchased a Commodore 64 for his experiments in the field of quantum optics, and graduate student Marvin Young interfaced this computer to a photon counter for data acquisition and processing.

In 1981 IBM entered the personal computer market. Its first computer was Model 5150, which was based on the Intel 8088 microprocessor operating at 4.77 MHz and had a Microsoft Disk Operating System (MS-DOS). Three such computers were purchased by the department circa 1982–83: one by Gupta on an Air Force grant and two by F. T. Chan and Michael Lieber on a Department of Energy

grant. While Chan and Lieber used their computers for their research, Gupta's computer was never used.

The IBM computer and the Apple computer had different operating systems and different architecture. The IBM model was soon cloned by other manufacturers who offered more attractive prices than IBM. This line of computers came to be referred to as PCs, while the Apple computers came to be known as Macs (after Apple's highly successful Macintosh line).

Subsequent use of the PCs and Macs in this department is perhaps no different than in any other physics department. However, for completeness we are including the following brief description. We will classify them into three categories: laboratory automation, data acquisition and processing, and computation. In the following paragraphs, a few examples of each are listed.

The automation of the Droke telescope using an Apple II Plus computer was the first use of a desktop computer for laboratory automation in our department, as mentioned above. In the mid-2000s LabVIEW*,* a commercial software sold by National Instruments, became popular and was widely used for instrument control and data acquisition in the department. In all likelihood, there were many computer-controlled experiments performed in the department in the two-decade-long period between the automation of the telescope and the wide use of LabVIEW.

In the category of data acquisition and processing, we have already mentioned the first use of PET computers above. Starting in in the early 1980s PCs with what is referred to as open architecture became available. One could insert circuit boards into open slots in the computer to make it perform various functions such as lock-in detection, multi-channel pulse-height analysis, and spectral analysis, to name just a few. In addition, commercial software became available to aid in the acquisition and analysis of data. Perhaps the first software in this category was a plotting software. Origin, an interactive graphical data analysis program, rose to popularity in the 1990s and allowed one to fit data to desired functions, do statistical analyses, make publication-quality plots, and much more.

In the category of computing, the first use of PCs was as terminals for the mainframe computer. In the early 1980s, punch cards were replaced by remote terminals connected to the mainframe by telephone lines. These terminals were just terminals, not computers. To distinguish them from PCs, they are sometimes referred to as dumb terminals. The department had several of these in one designated room for use by faculty and students. By the mid-1980s they were replaced by PCs serving as terminals. They connected to the mainframe by telephone lines until the Physics Building was wired with high-speed Internet connections during the building's renovation, which was completed in 1994.



Figure 3: The Apple II Plus computer used by Dr. Lacy to automate the Droke Telescope. On display in the Physics Lobby.

About the same time, commercial computational software was becoming available. One of the first to be popular in the department was MathCad, introduced in 1986. While MathCad turned out to be very useful for many types of calculations, it could not replace the mainframe computer for higher-level mathematics. During

the 1990s Mathematica was used in the department quite extensively. The capabilities of Mathematica coupled with the higher memory and speed of PCs made it possible for PCs to gradually replace the use of the mainframe altogether. Other computational software such as MATLAB and Maple also became available, and currently all three are used in the department.

As people stopped using the mainframe computer, the university's Computer Center changed its name and mission. It is now known as IT (Information Technology) Services and maintains campus-wide resources including computer laboratories, Internet and email services, Wi-Fi, and all university-owned computers, to name just a very few. It also makes various software available to the campus community, such as antivirus programs, Microsoft Office, Mathematica, MATLAB, and SigmaPlot. Besides maintaining servers for administrative use (such as student records and payroll), it operates the Arkansas High Performance Computing Center to provide high-performance hardware, storage, and support for computationally intensive research on the campus. In the Physics Department, Professors Laurent Bellaiche and Huaxiang Fu, their students, and collaborators use these facilities for research in the field of computational condensed matter physics.



Figure 4: IBM Model 5150. On display in the Physics Lobby.

Appendix VI

Discovery of High-Temperature Superconductors at the University of Arkansas[1]

Donald O. Pederson

Prior to 1987, there was no published superconductivity research in the Department of Physics at the University of Arkansas. It is remarkable that in a department in which there was no research going on in superconductivity, an event as momentous as the discovery of the thallium high-temperature superconductor (HTS) could occur. There was, however, one important though little known connection prior to 1987 that linked the department to the superconductivity community.

A bright electrical engineering student at the University of Arkansas, William L. McMillan, joined the Department of Physics after his BSEE to work on a Master of Science degree in theoretical physics that he received in 1961 under Professor H. M. Schwartz. McMillan then went to the University of Illinois at Urbana-Champaign where he completed a doctorate in 1964 under Nobel Laureate John Bardeen. McMillan is widely known for his development of an approximation known as the McMillan formula that enables one to predict the transition temperature of strong-coupled superconductors [W. L. McMillan, Phys. Rev. 167, 331, (1968)]. His approximation complements the description of weak-coupled superconductors by the Bardeen-Cooper-Schrieffer (BCS) theory. McMillan joined Bell Laboratories in late 1963 where he continued to make contributions to the understanding of superconductivity before he returned in 1972 to the University of Illinois at Urbana-Champaign as professor of physics.

McMillan achieved recognition for his accomplishments in the field of superconductivity when he and two other researchers from Bell Laboratories received the tenth Fritz London Prize that the research community awards biennially at an International Low Temperature Conference. The University of Arkansas recognized McMillan for his accomplishments in 1979 with an honorary doctorate. McMillan met an untimely death in a bicycle accident near Urbana in 1984. [*Physics Today,* September 1985, 92]. It can only be a matter of speculation what McMillan might have contributed to the understanding of high-temperature superconductors that continues to elude the best minds in physics.

[1] The above very informative and complete report on the Sheng and Hermann discoveries was prepared for Physics Department Chairman Rajendra Gupta by Donald O. Pederson in May of 1993 and corrected in May of 1995 and in April of 2019. Dr. Pederson was formerly chairman of physics and was then serving the university in his capacity as vice chancellor for academic affairs. The complete version of the 1993 report is housed in the special collections of the University of Arkansas Libraries.

It was only in September of 1986 that IBM Zurich physicists Karl Alex Müller and Johannes Georg Bednorz announced signs of superconductivity at near 30 K (−405°F) in lanthanum barium copper oxide (La-Ba-Cu-O). By January of 1987, Paul C. W. Chu at the University of Houston had confirmed these results and Bertram Batlogg and Robert Cava at Bell Laboratories announced that lanthanum strontium copper oxide (La-Sr-Cu-O) became a superconductor at 36 K (−395°F).

By March of 1987, Chu and his coworkers had replaced the lanthanum in the IBM compound with yttrium and had seen the resistance of the yttrium barium copper oxide (Y-Ba-Cu-O) drop sharply at 93 K (−292°F). These developments led to an explosion of research and publications in the field of high-temperature superconductors.

During the spring of 1987, Allen Hermann was teaching introductory physics and discussed these new discoveries in his class. In his class happened to be a young student whose father, Zhengzhi Sheng, had just received his PhD from the University of Arkansas in nuclear chemistry. Upon hearing of the new discoveries, Zhengzhi Sheng decided to work in the area of high-temperature superconductivity. Sheng discussed the possibility of carrying out some of his ideas with two physics faculty members, Professors F. T. Chan and Allen M. Hermann, who was also chair of the department.

Sheng's background in inorganic chemistry and experience with rare earth elements enabled him to make yttrium barium copper oxide (Y-Ba-Cu-O) samples following the discovery by Chu. By the end of the spring of 1987 Sheng felt some urgency to begin high-temperature superconductivity research full-time.

Hermann, whose research previous to his 1986 appointment at the University of Arkansas included experiments on low-temperature superconductors, tested some of the samples Sheng had made. The samples were as good as any samples in the country at the time, according to Hermann. After discussions between Hermann and Donald O. Pederson, a member of the physics faculty who was then vice-chancellor for academic affairs, in the Physics Building hallway in May of 1987, university funds were made available from the graduate school. These funds provided for the appointment of Sheng as a research associate in the Department of Physics to pursue his ideas.

In August of 1987, Sheng and Hermann announced a new process for creating high-temperature superconductors that could be shaped, molded, or formed into wires, which had previously not been possible. Their new process also improved Chu's material to become superconducting at 95 K (−288°F), a slight improvement in the world record. Following this work the Arkansas Energy Office of the Arkansas Industrial Development Commission awarded Hermann and Sheng $140,000 beginning February 1, 1988 to continue work in high-temperature superconductors. These funds required approval of the Joint Committee on Energy of the Arkansas General Assembly and Governor Bill Clinton as authorized under Act 7 of 1981.

One year after the initial 1986 discovery, Bednorz and Müller were awarded the Nobel Prize. In January of 1988, Sheng and Hermann announced the first rare-earth-free superconductor, thallium barium copper oxide (Tl-Ba-Cu-O), with a super-conducting transition beginning at 91 K (−296°F) which is above the temperature of liquid nitrogen at 77 K (−321°F). On the same day, a Japanese group also announced a rare-earth-free superconductor using bismuth instead of thallium.

On February 15, 1988, Sheng and Hermann announced a new record high of superconductivity at 122 K (−238°F) in thallium barium calcium copper oxide (Tl-Ba-Ca-Cu-O). [Z. Z. Sheng and A. M. Hermann, Nature 332, 138 (1988)]. On February 2 the details of the discovery were presented as a poster session paper at the World Congress on Superconductivity in Houston. By March 3, 1988,

scientists at IBM Almaden had taken the Arkansas material and the Arkansas discovery and had coaxed it to become superconducting at 125 K (−235°F).

Thus in early 1988, researchers at the University of Arkansas and the Department of Physics led the world in the search for higher-temperature superconductors. As of May 1993, the record still stood. Sheng and Hermann have been widely recognized for their discovery.

The discovery at Arkansas came about in part because of the involvement of undergraduates in the research. When the undergraduates did some of the preparation work slightly differently, it led Sheng to try a different preparation technique that resulted in the thallium compound.

This discovery put Sheng and Hermann, the Department of Physics, and the University of Arkansas on the national scientific map, with articles about their work in the *Wall Street Journal*, the *New York Times, National Geographic,* the *Chronicle of Higher Education, Superconductor Week, Newsweek, Science News, Business Week, Research & Development, Physics Today,* and *Science*. One *Wall Street Journal* headline was "His Was the Little Laboratory That Could" [*Wall Street Journal*, 31 March 1988 page 1]. The early work was done in the south end of a row of apartments shared with the university's National Public Radio station, KUAF, on the north end. This apartment building owned by the university was formerly situated where there is now a parking lot between Duncan Avenue and the Nanoscale Material Science and Engineering Building. The early work in rooms not outfitted to be laboratories caused Herman to refer to it as "research on a loading dock."

Governor Clinton announced on June 15, 1988 an Arkansas Energy Office award, under Act 7 in 1981, that was the largest grant from the state in support of a particular research project. The amount of the grant was for $1,007,796 beginning July 1, 1988 and was to continue high-temperature superconductivity research. The grant followed a demonstration of superconductivity levitation before the Committee on Energy and Governor Clinton.

While IBM received the first patent for a thallium-compound superconductor as reported in October of 1989 [Robert Pool, *Science* 246, 320, (1989)], it was only for a process of making the compound and not for the compound itself. Sixteen patents had been issued by April of 1993 based on the high-temperature superconductivity research at the University of Arkansas. The primary patents on the 122 K thallium compound were licensed to Superconductor Technologies Incorporated (STI) with headquarters in Santa Barbara, California, on April 10, 1992. The university and the inventors received over $1 million in license fees and 400,000 shares of Class D stock of the company. STI went public on March 9, 1993, at ten dollars per share and in the week ending April 23, 1993, was trading in the NASDAQ national market (as SupTech) at a low of 6½ and a high of 8¾ on a volume of just over 200,000 shares.

During the period of collaboration between Sheng and Hermann, the publications on their research in refereed journals numbered three in 1987, fifteen in 1988, thirteen in 1989, and one in 1990, including three in *Nature* and two in *Physical Review Letters*. Hermann left the University of Arkansas in January of 1990 for a position at the University of Colorado. Sheng has continued to carry out research on new high-temperature superconducting materials primarily by elemental substitution and has published forty-seven additional refereed articles over the period 1990–1996.

Professor William G. Harter became interested in the levitation effects of the high-temperature superconductors in 1988. [William G. Harter, A. M. Hermann, and Z. Z. Sheng, *Applied Physics Letters* 53, 1119 (1988)] This led to the development of one of the earliest high-temperature superconductor magnetic bearings by his doctoral student, David E. Weeks, who reported on the work in five

publications. A patent was obtained based on this work.

Pederson began looking for additional funding for the high-temperature superconductivity effort in late 1990. In early 1991 a group of faculty from physics and engineering submitted a proposal for a thin film center to the National Science Foundation. This proposal was not successful but formed the basis for discussions with the Defense Advanced Research Projects Agency (DARPA) during the spring of 1991. These discussions occurred during a time when DARPA was reducing their support for various superconductivity consortia. DARPA was moving their support to teaming arrangements doing more mission-oriented research and development that might take advantage of the advances in not only high-temperature superconductivity but also in the development of crystalline diamond thin films. The university benefited tremendously from the guidance of Dr. Al Joseph, formerly with the Rockwell Science Center, and Bruce MacDonald in Senator Dale Bumpers's office in discussions with DARPA and in developing cooperative arrangements with industry.

The proposed work evolved into projects focused on advanced multichip modules (MCM) with the support from E-Systems of Dallas, Texas, and Norton Diamond Film of Northborough, Massachusetts. These modules are substrates upon which the bare semiconducting chips are attached and interconnected using printed circuit techniques, incorporating high-temperature superconducting interconnects and thin film substrates. While the advances in high-temperature superconductivity gave the University of Arkansas credibility in any project concerned with high-temperature superconductivity and certainly opened the door to this additional funding, the goals of both companies and DARPA emphasized the application of high-temperature superconductors to improving multichip modules rather than basic material research being carried out by Sheng.

The High Density Electronic Center (HiDEC) was created at the University of Arkansas to establish the University's presence in the MCM arena. An MCM facility valued at over $1 million was built at the Engineering Research Center to enable MCM research and development to be carried out on campus. The high-temperature superconducting thin film development of Chan, Salamo, Sheng, and coworkers (supported by the bulk high-temperature superconductor work of Sheng) fit very well into the HiDEC work initially. But as the HiDEC project addressed specific goals of companies and agencies, it moved to more mission-directed research and away from curiosity-driven research. Chan and Salamo continued to pursue research in laser ablation of thallium thin film superconducting materials using some of Sheng's techniques and provided the closest link between the Physics Department and HiDEC in the arena of superconductivity. The HiDEC work with the thallium compound was last published in 1997. Work on other superconductors by Chan and Salamo was last published in 2000.

The discovery of Sheng and Hermann of a world record, high-temperature superconductor was eventually surpassed by other materials. Sheng continued to pursue new materials looking for higher-temperature superconductors until 1997. As noted above, the University of Arkansas licensed its thallium patent to an entrepreneurial company, Superconductor Technologies Incorporated (SCON on the NASDEQ Exchange in 2019). STI did not bring any thallium superconducting devices to the marketplace.

While much basic and applied work in high-temperature superconductivity continues to be done worldwide, the Physics Department's role in these developments has faded. Nonetheless, the University of Arkansas, the Department of Physics, and Sheng and Hermann will remain a significant footnote in the annals of important discoveries.

Appendix VII

Microelectronics-Photonics Graduate Program

Rick Wise[1]

The Microelectronics-Photonics (μEP) Graduate Program at the University of Arkansas was initiated by Professor Greg Salamo through his 1997 National Science Foundation (NSF) funded proposal for the Arkansas Center for Electronic-photonic Materials Interactions (ACEMI) with matching UA funds. Professor Ken Vickers was hired and started at the UA in April 1998 and led the program as director for its first sixteen years. The Arkansas Department of Higher Education approved the MS μEP degree on July 23, 1999 for fall semester 1999 implementation, and, following a successful NSF Integrative Graduate Education and Research Traineeship (IGERT) proposal, the PhD μEP degree was approved on July 26, 2000 for implementation in the Fall 2000 semester. The program offices were located in the Physics building until 2011, when they moved to the new Nanoscale Material Science and Engineering Building.

The Microelectronics-Photonics Program is an interdisciplinary graduate program designed to expand a student's knowledge beyond the boundaries of traditional departmental based graduate programs. Students in the Microelectronics-Photonics Program participate in cross-departmental research, take applications-intensive classes from multiple engineering and science departments, and develop workplace productivity skills in a simulated industrial environment. The outcome of the students' graduate education in this interdisciplinary environment is a better understanding of: micro- and nanoscale materials and processing that result in high-performance, miniaturized devices; the combination of these materials and devices into electronic, photonic, and chemical/biological systems; and the economics that affect successful introduction of these devices and systems into industry and the community.

The Microelectronics-Photonics Program offers graduate degrees through an interdisciplinary assembly of faculty from two colleges and ten academic departments, all of whom are appointed to traditional academic departments but chose to join the microelectronics-photonics faculty because of their shared interests in, and needs when, working at the micro- to nanoscale.

Additional value has been created for μEP students through a partnership with the Walton College of Business, through which Graduate Certificates in Entrepreneurship and Business may be incorporated into the student's degree plan. Several students who have taken advantage of this have launched successful entrepreneurial ventures in the local area.

The Microelectronics-Photonics Program reports directly to dean of the graduate school, but closely

[1] Rick Wise is the Director of MicroElectronics Photonics Program.

aligns its policies with those of both the Fulbright College of Arts and Sciences and the College of Engineering. The program is also reviewed annually with an Industrial Advisory Board comprised of professionals from industries producing or enabling products at the micro- to nanoscale. Professor Rick Wise became the second director of the program in 2014 following a thirty-one–year career at Texas Instruments.

There are currently over sixty faculty members affiliated with the program from the departments of Biological and Agricultural Engineering, Biomedical Engineering, Chemical Engineering, Chemistry and Biochemistry, Civil Engineering, Computer Science and Computer Engineering, Electrical Engineering, Industrial Engineering, Mechanical Engineering, and Physics. As of spring 2018, the Microelectronics-Photonics Program had granted a total of 159 MS and 71 PhD degrees.

Appendix VIII

Arkansas Center for Space and Planetary Sciences

William Oliver III[1]

In December of 2000, a small interdisciplinary group of scientists and engineers formally founded what is now called the Arkansas Center for Space and Planetary Sciences, or the Space Center for short. Originally this was a joint interdisciplinary research center with like-minded faculty at Oklahoma State University. Soon after the Space Center was established, instabilities at the OSU campus led to the departure of a significant number of faculty there, including several who were members of the Space Center, and this soon led to the departure of OSU from the Space Center. Founding UA faculty members included:

- Professor Derek Sears, a cosmo-chemist in the Department of Chemistry and Biochemistry and an expert in meteorites
- Professor Claud Lacy, an astronomer in the Department of Physics with expertise in binary star systems
- Professor Tim Kral, an astrobiologist in the Department of Biological Sciences whose research focused on the study of methanogens in Mars-like conditions
- Professor Larry Roe, an expert of propulsion, fluid dynamics, and spacecraft systems in the Department of Mechanical Engineering

Each of these professors was essentially the only member of their respective department working in a space or planetary science related area of research. By coming together, they found a common ground that formed the initial core of the Space Center's research activity. Faculty members from the Department of Geosciences within Fulbright College and from both the Chemical Engineering and Electrical Engineering departments within the College of Engineering soon become involved in Space Center research and the mentoring of its graduate students.

Space Center faculty took the necessary steps to create graduate degree programs within the first half decade of the center's existence, and in anticipation of these new programs a listing of Space Science (SPAC) course descriptions first appeared in the 2004–2005 graduate catalog. Descriptions of the MS and PhD graduate degree programs with requirements for admission and fulfillment of both degrees first appeared in the 2005–2006 graduate catalog. These requirements remain substantially the

[1] William Oliver III is currently the chair of the Physics Department and was the director of the Arkansas Center for Space and Planetary Sciences during 2010–2015 when, largely due to his efforts, the center was able to move into its new renovated space. Improved laboratory space allowed faculty to effectively compete and obtain $1.2 million in new funding.

same since that time. In addition to a set of five core SPAC courses (Planetary Systems, Planetary Atmospheres, Planetary Geology, Astrobiology, and Astronautics), several other elective courses that already existed in the member departments were available for graduate students. One PhD student in chemistry switched to the new SPAC PhD program, and by 2008 the Space Center had graduated two students with MS degrees one PhD student.[1]

Shortly after the Space Center's formation, science and engineering faculty in the center built the large Andromeda Chamber for experimental simulations of Martian conditions. This chamber enabled faculty and students to conduct experiments in realistic Martian atmospheric conditions studying geochemical, thermodynamic and potential astrobiological processes on Mars. Later modifications to the Andromeda Chamber allow Space Center members to study the much colder and higher-pressure conditions of Saturn's moon Titan, enabling, for example, the study of the thermodynamics of hydrocarbon mixtures under these extreme conditions. The Space Center subsequently built other experimental simulation chambers for various planetary conditions, and this has become somewhat of a niche research area for the center and lead to several large NASA grants over the years. In addition to this emphasis on planetary science, by 2008 three astronomers and astrophysicists within the Physics Department and their students were conducting research on such topics as binary star systems, extra-solar planets, active galactic nuclei, and galaxy structure and evolution. This too led to very significant funding from NASA and NSF.

The Space Center also enriched the University of Arkansas's educational and outreach missions over its first decade. Most significantly, it built a planetarium and has used it for public outreach to area schoolchildren, teachers, and parents. In addition, Space Center graduate students have designed planetarium lab exercises for the large introductory *Survey of the Universe* course taught by the Physics Department, greatly enhancing the effectiveness of these labs and the enjoyment of many hundreds of students per year.

[1] By May 2010 the Space Center had produced seven PhD degrees in Space and Planetary Sciences, mentored by faculty in five different departments from two colleges.

Appendix IX

Institute for Nanoscience and Engineering

The Institute for Nanoscience and Engineering is an interdisciplinary research and education facility housed in its own building with state-of-the-art facilities. The institute currently operates under the leadership of its founding director and professor of physics, Gregory J. Salamo. Several members of the physics department use the facilities at the institute for research on quantum materials.

The interdisciplinary faculty, currently numbering twenty-four, is derived from the departments of physics, chemistry, biological sciences, mechanical engineering, electrical engineering, biological engineering, and others. It has a research staff of seven and a large number of graduate students.

The institute is housed in the Nanoscale Materials Science and Engineering Building, commonly known as the Nano Building, which was dedicated in 2012. The specialized needs of various experiments can be accommodated in this building. For example, it has a Class 100 clean room and rooms with vibration isolation, electromagnetic isolation, and ultra-sensitive temperature control.

Nine different laboratories and facilities are listed on their website: Materials Characterization Facility, Electrical Characterization Laboratory, Nano Mechanics and Tribology Laboratory, Materials and Manufacturing Research Laboratories, Optical Characterization Laboratory, Molecular Beam Epitaxy (MBE) Laboratory, Nanochemistry Laboratory, Protein Production/Protein Transportation Laboratory, and Nano/Bio Photonics Laboratory. Each of these facilities is equipped with specialized state-of-the-art equipment for use by faculty, students, and even by industries in the Northwest Arkansas area. Just to give a few examples: the Materials Characterization Facility has an FEI Titan 80-300 scanning transmission electron microscope, a Tecnai F20 Cryo-TEM, an FEI Nova Nanolab 200 Dualbeam Workstation, a PHI VersaProbe scanning x-ray monochromator XPS, a Philips PW1830 double system diffractometer, and a Vecco Dimension 3100 atomic force microscope; the MBE Laboratory has a nitride MBE, an oxide MBE, two arsenide III-V MBEs, a room temperature STM, and a low temperature STM; and the Optical Characterization Laboratory has facilities from UV to IR (250 nm–2000 nm) with temperatures from 4 K to 400 K, magneto-optical spectroscopy up to 10 Tesla, continuous-wave and pulsed lasers (fixed and tunable) from UV to IR, and time-resolved optical characterization from femtosecond to nanosecond resolution. To name just a few.

Appendix X

Alumni Relations and *Reflections*

Every department strives to maintain relationships with its alumni, but even at the best of times it is not an easy task, let alone when the department's staffing and resources are limited. The first documented effort to keep in touch with the alumni of the Physics Department was made by Professor Ham, head of the department from 1940 to 1957, in writing annual Christmas letters to former students [History1(Ref. 7)]. A few of these letters have survived, and we have quoted from them in chapter 5 to describe the contemporaneous view of the physics building when the department moved into its current quarters in 1952.

There is some evidence in the departmental files that later attempts were made by Professors Sharrah and Pederson to put together lists of alumni. By Pederson's time as the chair of the department (1978–1983), the task had become considerably more difficult as the number of alumni had grown into the hundreds.

The first successful, comprehensive directory of physics alumni was assembled in the early 1990s by Sandra Johnsen, a secretary in the Physics Department, and Rajendra Gupta, the then chair of the department. Records from the department and Alumni Association, as well records from the Fulbright College Dean's office, were pooled together to identify reported physics majors. This was not easy, as the records of the time were not always reliable and took a considerable effort to sort through. The alumni information consisting of alumni name, degree(s) obtained, home addresses, and work addresses were recorded in a *Quattro Pro* spreadsheet. The completed alumni directory consisted of approximately 400 alumni, and a paper copy, sorted by degrees and dates, and alphabetically by name, was printed and distributed to the faculty.

Chair Gupta decided to start an annual alumni newsletter to be sent to all known alumni, and Professor Surendra Singh volunteered to serve as editor. He named it *Reflections*, and the first issue was published in Spring 1991. This was among the very first, if not the first, newsletters by any department in the Fulbright College. Singh continued his work nurturing the newsletter as chair of the department after Gupta stepped down in 1995. Other editors include Professor Art Hobson and Office Manager Donna Johnson. *Reflections* has continued to be published by the department, with a few interruptions, until recently.

Not only has *Reflections* encouraged ongoing relationships with our past graduates, but it also serves as a contemporaneous record of the department's history. The newsletter has re-established contacts between the department and many alumni, including Franklin Wintker (BS, 1931), the second person to have received a Bachelor's degree from this department (see chapters 2 and 16). The back issues were an invaluable source of information while researching for this volume.

Alumni directories need to be updated from time to time. In 2007 such an effort was made by Donna Johnson and Rajendra Gupta. All records were again pulled together, including the 1993 alumni list, lists of all graduates from 1993 to 2007, Alumni Association records, and the Fulbright

College records. By this time, the latter two identified physics majors more reliably. This resulted in an expanded and updated directory of about 700 alumni.

Using this directory, personalized letters were written to all alumni inviting them to the Physics Department's Centennial Celebrations in April 2008. These letters were followed with personal contacts via email and telephone by individual faculty members and by Gupta as chair of the Centennial Committee. These efforts resulted in an attendance of about 200 alumni and their guests for a reunion on the occasion of the Centennial Celebrations (see chapter 17).

Appendix XI

Maurer Research Fund and the Robert D. Maurer Distinguished Lecture Series

Robert Maurer, an alumnus of our department and coinventor of the low-loss optical fiber, was awarded an honorary LLD degree by the University of Arkansas in 1980. While visiting Fayetteville to receive this degree, Maurer agreed to donate some personal funds to the department during informal conversations with Donald Pederson, then chair of the Physics Department. He planned to make these donations periodically, matched one-for-one by Corning Inc. The funds were to be used by the department to promote and support outstanding research.

Maurer's initial gift of $2,000 was received by the university on October 3, 1983 and matched by Corning Inc. Since then Dr. Maurer has continued to make additional gifts, often of significant amounts. These gifts were matched by Corning Inc., often one-for-one, until 2003.

By the early 1990s, the accumulated funds were generating an annual income that was enough that it could be put to some use. Rajendra Gupta was then chair of the department and decided to start a lecture series named after Robert D. Maurer. The idea was to bring a distinguished and engaging speaker to campus to give a public lecture each year. The lecture would be of general interest and given at a level comprehensible even to nonscience students. Attempts were to be made to attract wide audiences from across the university. Gupta presented this idea to Dr. Maurer and the faculty, and in 1994 the fund was turned into the endowment for the Robert D. Maurer Lecture Series. The first lecture was presented in December of 1994.

Surendra Singh became chair of the department in the summer of 1995. He made it his mission to invite particularly distinguished speakers, preferably with Nobel Prizes, to participate in the series, in order to attract wide audiences from across the campus. He succeeded. In view of the success in attracting such distinguished speakers, the series was retroactively renamed Robert D. Maurer Distinguished Lecture Series in 2008.

Singh has nurtured the department's relationship with Maurer, who prefers to communicate by handwritten letters. Surendra has maintained a correspondence with Maurer even after stepping down from the position of the chair of the department, informing him of the department's new developments. Thus, Maurer's ongoing relationship with the department through Singh, coupled with the success of the lecture series, has motivated him to continue to donate to the department, sometimes in large amounts. As of April 2019, the lecture series endowment stands at over $500,000, and the total amount in the Robert D. Maurer Physics Research Fund (including the endowment) is over $650,000.

Around the year 2000, Singh broadened the use of the Research Fund to include undergraduate research scholarships. Since then two to four Robert D. Maurer Research Fellowships of $1,000 are awarded annually to junior or senior physics majors based on scholastic achievements and

undergraduate research.

Robert D. Maurer Distinguished Lectures

First Lecture: "Revitalizing undergraduate science: Why Some Things Work and Most Don't." Sheila Tobias, a distinguished researcher in the field of science and mathematics education. December 1, 1994.

Second Lecture: "Breaking the Solitude: Explosions in the Night Sky." J. Craig Wheeler, Samuel T. and Fern Yanagisawa Regents Professor of Astronomy, University of Texas at Austin. February 15, 1996.

Third Lecture: "Life on Mars?" Richard N. Zare, Marguerite Blake Wilbur Professor of Chemistry, Stanford University. April 24, 1997.

Fourth Lecture: "Lasers: Physics Impacting Your Life." Nicolaas Bloembergen, Professor Emeritus, Harvard University; Nobel Prize in Physics, 1981. March/April 1998.

Fifth Lecture: "Time, Einstein, and the Coldest Stuff in the Universe." William D. Phillips, National Institute of Standards and Technology; Nobel Prize in Physics, 1997. March 4, 1999.

Sixth Lecture: "The Physics of Star Trek." Lawrence Krauss, Ambrose Swasey Professor, Case Western Reserve University. March 2, 2000.

Seventh Lecture: "Planets Galore Among the Stars: Facts and Forecast." Philip Morrison, Institute Professor Emeritus, Massachusetts Institute of Technology. March 29, 2001.

Eighth Lecture: "Laser Cooling and Trapping: From Atomic Clocks to Watching Biomolecules Move, One Molecule at a Time." Steven Chu, Professor of Physics, Stanford University; Nobel Prize, 1997. March 28, 2002

Ninth Lecture: "How Does the Universe Work?" Leon Lederman, Former Director, Fermi National Accelerator Facility; Nobel Prize in Physics, 1988. March 13, 2003.

Tenth Lecture: "The Dark Side of the Universe: Beyond Stars and the Starstuff We Are Made Of." Michael Turner, Rauner Distinguished Service Professor, University of Chicago; and Assistant Director of the National Science Foundation for Mathematical and Physical Sciences. April 1, 2004.

Eleventh Lecture: "Albert Einstein: The Man Behind the Myths." John Stachel, Emeritus Professor of Physics and Director of the Center for Einstein Studies, Boston University; Founding Editor and Director of the Einstein Papers Project. April 7, 2005.

Twelfth Lecture: "Bose-Einstein Condensate: Quantum Weirdness at the Lowest Temperature in the Universe." Carl Wieman, Distinguished Professor of Physics, University of Colorado; Nobel Prize, 2001. March 9, 2006.

Thirteenth Lecture: "Outdoing Maxwell's Demon: Taming Molecular Wildness" (a tele-lecture). Dudley R. Herschbach, Baird Professor of Science, Harvard University; Nobel Prize in Chemistry, 1986. April 6, 2007.

Centennial Lecture: "New Forms of Quantum Matter near Absolute Zero Temperature." Wolfgang Ketterle, John D. MacArthur Professor of Physics, Massachusetts Institute of Technology; Director, MIT-Harvard Center for Ultra Cold Atoms; Nobel Prize in Physics, 2001. April 3, 2008.

Fifteenth Lecture: "Binary Pulsars and Relativistic Gravity." Joseph Taylor, James S. McDonnell

Distinguished Professor of Physics, Emeritus, Princeton University; Nobel Prize in Physics, 1993. April 2, 2009.

Sixteenth Lecture: "Facing the Growing Threat of Bioterrorism." Steven M. Block, S. W. Ascherman Professor of Statistics, Department of Biology, Stanford University. March 18, 2010.

Seventeenth Lecture: "Testing Einstein's Assumptions about Space, Time and Speed of Light." John L. Hall, Joint Institute for Laboratory Astrophysics, University of Colorado and National Institute of Standards and Technology; Nobel Prize in Physics, 2005. March 17, 2011.

Eighteenth Lecture: "The Warped Side of Our Universe: From Big Bang to Black Holes and Gravitational Waves." Kip S. Thorne, Feynman Professor of Theoretical Physics, Emeritus, California Institute of Technology; Nobel Prize in Physics, 2017. April 3, 2012:

Nineteenth Lecture: "Fun with Ultracold Atoms." Deborah S. Jin, National Institute of Standards and Technology; Fellow of the Joint Institute for Laboratory Astrophysics; and Adjoint Professor of Physics, University of Colorado; MacArthur Fellow (popularly known as a Genius Grant). April 18, 2013.

Twentieth Lecture: "50 Years of Lasers: Meeting the Challenges of the 21st Century." Robert L. Byer, William R. Kenan, Jr. Professor of Applied Physics, Stanford University; Past President of American Physical Society and Optical Society of America. April 17, 2014.

Twenty First Lecture: "Origin of Life: From Geophysics to Biology." Albert J. Libchaber, Detlev W. Bronk Professor, Rockefeller University. April 2, 2015:

Twenty Second Lecture: "Watching the Earth Breathe: Measuring Atmospheric Carbon Dioxide with NASA's Orbing Carbon Observatory-2." David Crisp, Senior Research Scientist, Jet Propulsion Laboratory, California Institute of Technology. April 7, 2016.

Appendix XII

Fiftieth Anniversary of the PhD Program

The Physics Department celebrated the 50th anniversary of its PhD program on October 16, 2009 by organizing a symposium and banquet honoring its emeritus and former faculty members. Among those honored on this occasion were emeritus professors Raymond Hughes, Otto Zinke, Arthur Hobson, and Charles Richardson, as well as former professors Stephen Day and Richard Anderson. Professor Hughes was the primary author of the successful proposal for the PhD program, and he oversaw and nurtured it for over fifteen years. Other honorees, who joined the department between 1959 and 1966, helped lay the foundations for the development of the department's graduate program and continued growth of the undergraduate program. Some former faculty members came from as far as the East and West Coasts to participate in these celebrations.

The first PhD in physics was granted in 1964 to William Pendleton under the direction of Professor Hughes. Pendleton, now an emeritus professor of physics at Utah State University, traveled from Utah to join in the celebrations. Professors Pendleton, Hughes, Zinke, Day, Hobson, Richardson, and



Figure 1: Former Professor Stephen Day talks about his time at the University of Arkansas.

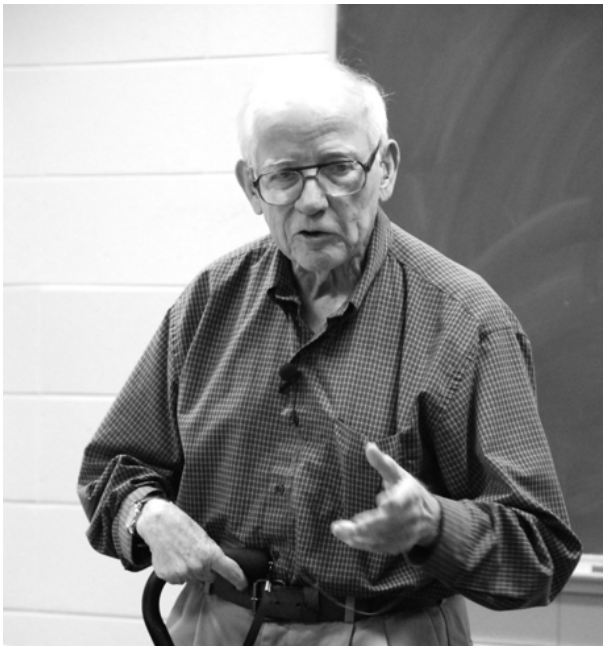


Figure 2: Emeritus Professor Raymond Hughes gives a talk at the symposium.



Figure 3: Emeritus Professor William Pendleton reminisces about his time as a graduate student at the University of Arkansas in the 1960s.



Figure 4: Emeritus Professor Otto Zinke tells the audience what it was like here when he joined the department.

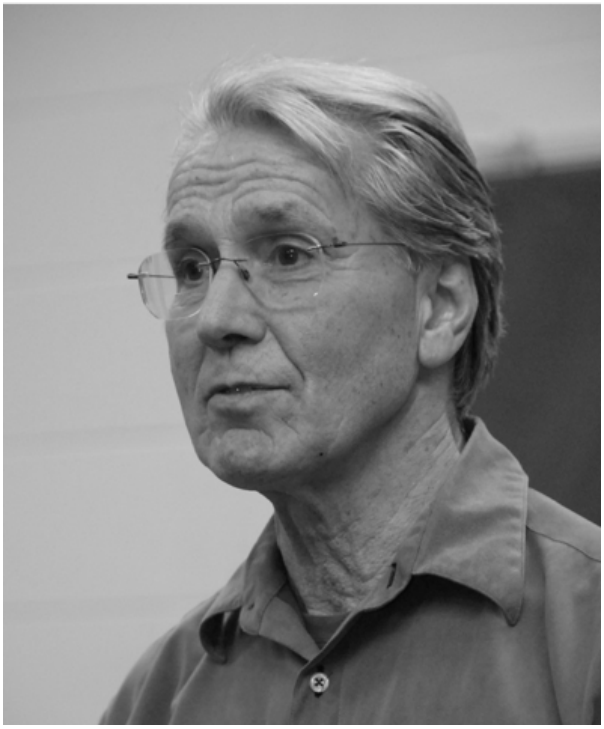


Figure 5: Emeritus Professor Art Hobson speaks at the symposium.

Anderson gave talks reminiscing about their time in Arkansas during the two-hour symposium. The symposium was attended by physics faculty and students, and the audience got a glimpse of the events that built the department into what it is today. In 2009, forty students were enrolled in the PhD program. The department offered over eighty courses and conducted research in lasers, quantum and nonlinear optics, quantum materials, biophysics, astronomy, and physics education.

The symposium was followed by a banquet in honor of the emeritus and former faculty, where they were individually recognized for their contributions to the department. Associate Dean Patricia Koski represented the graduate school and Associate Dean Jeannine Durdik represented Fulbright College of Arts and Sciences at the banquet. Donald Pederson, professor of physics and vice-chancellor for finance and administration, also participated in the events.

The event was organized by a committee consisting of Julia Kennefick, Jiali Li, and Ken Vickers, chaired by Rajendra Gupta. Pictures above are courtesy of Ken Vickers, except where noted otherwise.



Figure 6: Patricia Koski, associate dean of the graduate school (left), with Surendra Singh, chair of the Physics Department, at a reception preceding the banquet at University House. *Photo courtesy of Julia Kennefick.*



Figure 8: Donald Pederson, vice-chancellor for finance and administration (left), with former professors Stephen Day (center) and Richard Anderson.



Figure 7: Jeannine Durdik, associate dean of Fulbright College (left), with Professor William Harter at the reception.



Figure 9: Emeritus Professor Charles Richardson (left) shares a laugh with Former Professor Richard Anderson. Mrs. Jane Hughes is in the background.

Appendix XIII

Scholarships and Awards[1]

Charles B. Richardson Senior Fellowship. Two scholarships of $500 awarded annually to junior or senior physics majors for excellence in undergraduate research. Funded by a $20,000 gift from Professor Emeritus Charles B. Richardson in 1997.

Rear Admiral William C. Bryson Scholarship. One scholarship of $1,000 awarded annually to an outstanding physics major with demonstrated interest in astronomy.

George D. Lingelbach Award. One scholarship of $250 awarded annually for overall outstanding scholastic achievement in physics.

Robert D. Maurer Research Fellowship. Two to four fellowships of $1,000 awarded annually to physics juniors or seniors on the basis of scholastic achievements and undergraduate research. Funded from income from Robert D. Maurer Research Fund.

Paul C. Sharrah Scholarship. Two scholarships of $500 awarded annually to outstanding physics majors.

Steve Hildebrand Scholarship. Awarded annually to a female physics major. Funded by a gift from Hildebrand family.

Physics Faculty Fellowships. Eight fellowships of $500 awarded annually to physics majors for excellence in research. Funded from the sale of physics laboratory manuals.

Lloyd B. Ham Outstanding Teaching Assistant Award. One award of $500 annually to an outstanding physics teaching assistant.

Raymond H. Hughes Graduate Fellowship. One award of $1,000 given annually to a graduate student to support travel to scientific workshop, meeting, or conference to present a paper. Funded from income from a fund established by the family of Raymond H. Hughes, a late professor emeritus of physics.

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[1] Information for this appendix is derived from the 2002 departmental newsletter *Reflections* and private communication with Surendra Sigh, former chair of the department. Where a source of funds is not indicated, the scholarships are funded or augmented by contributions by alumni and friends.

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