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The Physics Ph.D. Program, University of Arkansas, Semicentennial Celebration

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University of Arkansas
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Preface

The Physics Department celebrated the semicentennial of its PhD program on October 16, 2009. This booklet presents an archival record of the events.

The celebration was organized by a committee consisting of Professors Rajendra Gupta, Julia Kennefick, Jiali Li, and Kenneth Vickers, with Gupta serving as its chair. The event was held under the leadership of the department chair, Professor Surendra Singh.

Many thanks are due to Professors Kennefick and Vickers for the photographs.

Rajendra Gupta

Fayetteville, Arkansas

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I. Introduction

The Physics department celebrated the 50th anniversary of its PhD program on October 16, 2009 by organizing a symposium and a banquet honoring its emeritus and former faculty members. Those honored on this occasion were Emeritus Professors Raymond Hughes, Otto Zinke, Arthur Hobson, and Charles Richardson, and former Professors Stephen Day and Richard Anderson. Professor Raymond Hughes was the primary author of the successful proposal to start the PhD program in 1959, and then he oversaw and helped nurture it for over 15 years. Other honorees, who joined the department between 1959 and 1966, helped lay the foundations for the growth of the department's graduate 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 to William Pendleton in 1964 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 Anderson gave talks reminiscing about the early days of their tenure here in the two-hour symposium. The symposium was attended by the physics faculty and students and the audience got a glimpse of the past events that provided the building blocks for the development of the department's graduate program and research.

The symposium was followed by a reception and a banquet in honor of the emeritus/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.

This booklet presents an archival record of the celebrations. To provide a historical background and for completeness, a short history of the PhD program in physics is given in Sec. II below. Summaries of the symposium talks are reproduced in Sec. III. Photographs of the reception and the banquet are presented in Sections IV and V.

II. A Short History of the PhD Program[1]

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. 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.

Dean Adkisson and Dean Nichols of the College of Arts and Sciences held a meeting with all the

[1] Adapted from Chapter 7, Sec. C of *Acoustics to Quantum Materials: A Centennial History of the Department of Physics, University of Arkansas*, by Rajendra Gupta and Paul C. Sharrah, 2020.

department 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, minimum budgets for the Physics Library, maintenance, and equipment and additional faculty and technical Staff (machinist, electronics technician/instructor). The proposal was not approved.

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 with the hiring of Professor Herman Schwartz in 1949. Additional faculty members were appointed: 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.

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 used to say 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.

Paul Sharrah, Chairman of the department, successfully navigated the physics PhD proposal through the Graduate Council.

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.

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.

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 Sec. III below 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.

A rapid expansion in the number faculty took place after the PhD program was established. The following faculty were appointed: Stephen M. Day (1961), Arthur S. Hobson (1964), Charles B. Richardson (1966), Richard J. Anderson (1966), Fui T. Chan (1969), and Michael Lieber (1970). The numbers in the parentheses represent dates of appointment, and only those people are included in this list who served the University of Arkansas for a significant length of time.

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.

The growth of faculty led to the creation of a number of new graduate courses over time, including Goldstein-level Advanced Mechanics, two semesters of Jackson-level Electrodynamics, 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, 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).

By 2009, 40 students were enrolled in the Physics PhD program. The department offered over 80 courses and conducted internationally recognized research in lasers, quantum and nonlinear optics, quantum materials, biophysics, astronomy, and physics education. Research conducted in the department had appeared in prestigious journals such as *Science*, *Nature* and *Physical Review Letters*. During the three years preceding this anniversary, faculty, students, and postdocs had published more than 200 papers and books and accumulated over 3,000 citations to their work.

III. The Symposium[2]

Each speaker at the symposium was requested to provide a written summary of his talk. In this section we have reproduced those summaries.

The Symposium audience. Paul C. Sharrah Lecture Room, October 16, 2009.

[2] Abbreviated versions of a few of these reminiscences also appear in *Acoustics to Quantum Materials: A Centennial History of the Department of Physics, University of Arkansas*, by Rajendra Gupta and Paul C. Sharrah, 2020.

Raymond H. Hughes, 1954- 1990
University Professor Emeritus

I am a man of few words [and] as proof I offer this: In 1984 I was given the "Distinguished Award in Research" by Blue Key, Arkansas Alumni Association. During the ceremony, the fellow in front of me got the award for teaching. His acceptance speech went on and on. He apologized by saying after all he got the award for talking. In my turn I quoted him and pointed out that my award was not for talking and then I sat down. I got a lot of applause. The only time that has happened.

Right now I would like to pay tribute to Charlie Fan, C.Y. Fan, who passed away very recently at the U of Arizona. I would bet that he is an unknown to most of this audience, but he was a well-known auroral physicist that came here in the 1950's, only staying here a couple years before moving back to the U of Chicago. Charlie was interested in me because of my interest in spectra. He and I wrote a proposal to Cambridge Air Force Center to study proton impact on the atmospheric gases. My impact on the proposal was pretty minimal. Thanks to him it was funded, leading to the construction of the 1st accelerator in the Dept., a 120-KV machine was designed by Travis Watson [and] Research Services. (Travis was no relation to Wal-Mart as far as I know.) This was a source of several theses and later, doctoral dissertations. Later a 30-KV machine was built. My career, as a beamist, got a big boost, both in ion and electron beams. (For power, I would take the Giga Watts of electron beam power we had at Kirtland Air Force Base in Albuquerque, N.M.)


University Professor Emeritus Raymond Hughes speaking at the symposium.

These were far cry from the low power, hollow cathode discharge tubes that my students first started out with in 1954.

One of the later projects was LOIS which stands for Laser Operated Ion Source. It used high power Nd-Yag laser impact to form a plasma from which the ions were extracted. Rich Anderson came aboard as co-principal investigator. We were fortunate to attract a young laser type physicist from NY to join us. Rich and I could offer him summer employment from our NSF grant. He came running, his shoes never touched the ground, and never looked back. His name was Greg Salmo.

Rich and I wrote a chapter in "The Physics and Technology of Ion Sources," edited by Ian Brown. I always liked LOIS, after all she was Superman's girlfriend.

After Rich left, Don Pederson came aboard as co-principle investigator. We then studied ion impact on solid surfaces.

I retired in the spring of 1990. I earnestly hope that I left my mark on the physics Department of the U of A and my students. I did write the proposal for the Ph.D. Program for the U of A, modeled after the U of Wisconsin – my alma mater. Paul Sharrah, our chairman, defended it to the Graduate School. One of the requirements from the Graduate School was that we get NDEA Title IV Fellowships from the Federal Government. The proposal was rewritten. (The U.S. was in deep competition with Russia as I recall.) We submitted it and it was funded. We were on our way!

Bill Pendleton, my student, was our 1st Ph.D. Bill ended up at Utah State. Note: Pendleton, OR was my hometown.

Otto H. Zinke, 1959-1988
Professor Emeritus

I arrived here in the Fall, 1959, the year that the Ph.D. 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 Ph.D. 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 Ph.D. program. Recently, I found out why. Apparently, the University had just put in several Ph.D. 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

Professor Emeritus Otto Zinke reminisced about his early career at Arkansas.

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 am. They worked 7 days a week. A group of them knocked the experimental under-pinning's 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 M. Day, 1961-1983
Former Professor

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.

Former Professor Stephen Day recalled the early decisions by the faculty that shaped the department.

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 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.

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 of 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 a 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. 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 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' 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. The additional faculty also helped reduce our teaching loads. 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. Furthermore we had Mr. Lingelbach who taught four sections each semester and looked after the elementary laboratories. In addition several of our PhD candidates were teaching elementary lecture sections.

Dean at the time namely, Bob Kruh, from Chemistry promised an additional faculty position to us that was going to be filled in solid state physics. Unfortunately, the university started to experience a budget crunch and the new position didn't materialize. This was disappointing but we were not discouraged. The budget woes drove Dean Kruh away to Kansas State University as Graduate Dean.

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 we should offer the astronomy courses including observational laboratories. The transfer was made and we also got the planetarium which was used very effectively in attracting students to our rolls.

In 1967 I was invited to spend a year at the University of Nottingham in England working with Professor E. R. Andrew who was quite famous for his work in nuclear magnetic resonance. I accepted and took a sabbatical leave. Nottingham was the magnetism research center in Europe and it was a great experience for me. One of my close friends and research colleagues there, Peter Mansfield, ultimately won the Nobel Prize for his contributions to MRI in medicine.

When I returned in the summer of 1968, I learned Professor Sharrah had decided to step down as Chair of the Department at the end of the next academic year. The old issue of the balance of teaching and research rose again but research was felt to be our future. An election was conducted in the department and I was recommended to the Dean to be appointed Chair. In the meantime

Professor Sharrah asked me to serve as Vice Chairman and he moved out of the Chairman's Office to the office he occupied for the years up to his retirement. 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 and another theorist in Michael Lieber to broaden our research offering. Also during this time, we decided to appoint David Larsen from industry to develop an applied physics program. Dr. Larsen was from Gulf-General Atomic and had an interest in high power lasers. On his behalf we purchased a one kilowatt continuous CO_2 laser and started to prepare a space for it when he decided to leave the university and go back into industry in Georgia. At the time we didn't know where we could dump the beam because it was believed the laser could bring down airplanes flying over Fayetteville.

Glen Clayton and Charles Jones decided to move to non-PhD granting institutions in Texas. This led to a great opportunity to strengthen again the research direction of the department. We appointed two young experimentalists with excellent research credentials namely Donald Pederson and Gregory Salamo. In my judgment, I felt the department was on its way to being recognized as one of the strongest research departments in the University and was attracting attention from our colleagues in the physics community. However it didn't appear that our Dean was aware of this.

After a hiatus of two terms as Chair, I returned to the laboratory and classroom to get back to the research and teaching that I enjoyed. The seven years as Chairman and Vice Chairman took a heavy toll on my research. Even though grant money had become very scarce I started writing proposals in the energy storage area. I barely got started again in research when a new Dean was being appointed in the College and I was lured into the Dean's Office to serve as Associate Dean where I remained until leaving the University four years later to go to Miami University as Dean of Arts and Science. I was Dean for seven years then took a Sabbatical Leave for a year then taught for two years before retiring in 1993. As I look back on my years in the academic world, I remember very fondly my first six years as a young faculty member in this department when we were building the PhD program. These were my favorite years.

Arthur S. Hobson, 1964- 1999
Professor Emeritus

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!

Professor Emeritus Arthur Hobson talked about the undergraguate program at the University of Arkansas.

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.

Another physics department thread that I've followed closely is physics literacy for non-scientists. The first course that I taught when I arrived in the summer of 1964 was our old Physical Science course. I had about 10 Physical Science students that summer, and during 1964-75 this course was taught (usually by others) only once per school year plus once in the summer each year, to maybe 40 students per year. Neither I nor others were much interested in teaching this odd mix of geology, astronomy, and classical (Newtonian) mechanics. In 1975 my interests turned from research to physics-related social topics such as nuclear weapons, and to teaching. Beginning in 1976, the department allowed me to turn the Physical Science course into an entirely different course for non-science students, dubbed Physics and Human Affairs. It turned out to be surprisingly successful, beginning with an enrollment of 30 per year in 1976 and expanding to about 700 per year (330 each fall and spring, plus about 60 each summer) by 1995.

Physics and Human Affairs was a happy adventure for me. The large enrollments fulfilled my hope of teaching physics literacy to a large fraction of all the non-science graduates from the university. The course is non-mathematical or "conceptual," and emphasizes societal issues such as global warming along with a lot of modern physics including general relativity, big bang cosmology, quantum physics, and quantum field theory, while still presenting the major principles of classical physics. I've had the great pleasure of authoring a textbook for this course, *Physics: Concepts and Connections* (Addison-Wesley/Pearson, 5th edition to appear in 2010), that's used on over 130 campuses.

I retired from teaching in 1999, but the department was kind enough to let me keep an office in the department where I love to spend my days learning and writing about physics and its many connections to the world.

Richard J. Anderson, 1966- 1989
Former Professor

The history of “Physics at Arkansas” from 1872 to 1995 has been marvelously documented in a book published in 1995 by the late Paul C. Sharrah, former Chair of the Physics Department and Professor Emeritus. Therefore, the following paragraphs will not attempt to add to the department’s historical perspective, but rather will present some personal thoughts relating to my twenty-three years service as a member of the University of Arkansas Physics Department faculty (1966-89). This time represented the beginning and ongoing development of a career as a university professor, researcher, and administrator that ultimately led to service as a senior administrator and science advisor at the National Science Foundation (1989-2004). Although the observations presented here concerning the Arkansas physics community are purely personal, perhaps some might be of value to students who seek to pursue a similar professional path in science and technology.

Former Professor Richard Anderson reminiscing about his career at Arkansas.

Any discussion of a Physics career at the University of Arkansas would have to include the impact of the Department's administration, the influence of colleagues and the programs that served the many and varied students that I encountered.

In 1966 the departmental leadership was in the capable hands of Paul Sharrah who served as Chair from 1957 to1969. 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 "coupe de tat" 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.

Although Departmental leadership is necessary to create an environment that supports career development, colleagues also play an important role in forming one's approach to university teaching, research, and service. In this regard my perspective on teaching was initially influenced by my colleague Glen Clayton. Glen was a senior faculty member who proposed and initiated innovative approaches to meet the challenges faced by the department. For example, in the face of enrollment declines he developed a "hands on" laboratory course to serve the needs of large numbers of prospective elementary school teachers who were required to take a laboratory science. He also encouraged and worked with me to develop and promote a new approach to the existing B.A. physics degree program that increased the number of B.A. physics degree recipients from 7 in the period 1960-69 to 71 during 1970-89.

In the research area I was fortunate to have as a colleague and collaborator a nationally recognized research scientist, Ray Hughes. As a new faculty member I had the opportunity to work with Ray on several joint projects while I built-up my own laboratory and developed credentials sufficient to earn independent research support from the National Science Foundation. It was like having the "best of both worlds' – working with and learning from a top researcher and having the opportunity to independently develop my own research program.

The concept of university and community service was exemplified by Paul Sharrah. Whether it was serving on college- and university-wide committees or conducting community "star-gazing" sessions and planetarium shows Paul was always in the midst of things. Thus, it was not unusual that Paul volunteered me for service on the university-wide premedical advisory committee. It was an "eye-opening" experience for a faculty neophyte because it allowed one to work with colleagues from a wide variety of departments on both the Fayetteville and Medical Sciences campuses.

As the Physics Department grew in staff and capability existing faculty were able to develop collaborations in new areas of research and teaching. The addition of Greg Salamo to the Department faculty brought with it an introduction to state-of-the art Laser techniques. The development of a laser ion source with Ray Hughes and the application of new approaches to problems in atomic and molecular physics with Greg resulted from applications of these new techniques. The growing national interest in laser science led the Department to add faculty with expertise in allied fields and to increase emphasis on the development of new courses and laboratory experiences in laser related areas. The potential for service in support of the Physics graduate effort also presented itself through membership on a state-wide committee to develop a plan for participation in the Experimental Program to Stimulate Competitive Research (EPSCoR) conducted by the National Science Foundation. Participation in this effort ultimately led to major improvements within the department, such as the upgrading of the building's electrical system to support high-powered lasers.

As important as departmental leadership and the influence of colleagues were to making an Arkansas physics career memorable the students, whom one taught, advised and befriended, were even more important. Personal and professional growth was experienced not only through developing and teaching undergraduate physics courses and laboratories, but also through a variety of service and administrative activities involving students. Reinvigorating the Physics B.A. degree program, working with honor students, and serving as a faculty advisor to the Society of Physics Students/Sigma Pi Sigma and Alpha Epsilon Delta, the premedical honor society, allowed me to better relate to students with a wide variety of professional interests and goals. This broadened perspective produced some atypical undergraduate research projects such as a joint project with a local ophthalmologist in which the honor student monitored the impact of noise levels on peripheral vision. Working with students in the Physics graduate program, meanwhile, provided significant professional satisfaction. Attendance with graduate students at professional meetings of the

American Association of Physics Teachers and the American Physical Society produced many memorable adventures when the annual February winter meeting was held in New York City. Professional and social relationships were formed that have lasted throughout the years and have transitioned from "student-teacher" relationships to those of "colleague and friend."

If the current group of Physics students were to ask me what "lessons" I have "learned" from reflecting on my Arkansas tenure and subsequent professional experiences, I would have to refer them to a thought provided by my favorite philosopher – Lawrence Peter Berra, who said "*The Future Ain't What It Used To Be*." Yogi Berra was right. Each class of students will face new challenges and opportunities as they practice their chosen profession. These will be the experiences that will form the basis for their own colloquium talks some 40-plus years from now.

Charles Richardson[3], 1966- 1997
Professor Emeritus

A thread runs through the research I have done, put there mostly by chance. It is phase transitions. The principle of minimum free energy presented by J.W. Gibbs guides our understanding. This concept combines potential energy and entropy. But phase transitions are cooperative and therefore complex. They are often stymied leaving a system with excess free energy, or metastable; e.g. supercooled water.

My first effort, one end of the thread, came early - in my dissertation research. The probe was nuclear quadrupole resonance [nqr]. All nuclei with spin greater than 1/2 are nonspherical, have electric quadrupole or higher moments. The chlorine nucleus has spin 3/2 and is a prolate spheroid which is pulled into alignment with and precesses about the axis of a nonuniform electric field. Such a gradient field is formed by a carbon-chlorine chemical bond with lesser contributions from charges outside the bond. So crystalline structure and internal motion can be probed with nqr. Christopher Dean, my advisor at Pitt, had studied temperature dependencies of nqr and I set out on the same
path. Most of my effort was put on the molecule chloranil, $C_6Cl_4O_2$. Among the chlorinated benzene solids chloranil is unusual. It is very hard and has a high melting point, both evidence of strong intermolecular forces - due to the oxygens. For me the attraction was the nqr spectrum, a four line multiplet at 78K, a doublet at room temperature. Somewhere in that interval a phase transition occurs and I wanted to find and characterize it.

I built an rf spectrometer in which a single crystal could be cooled and rotated in a weak magnetic field. I found the transition but it was not as expected. It was not first order but began about 83K on warming and was not complete until about 110K. Three lines of the spectrum were washed out by motion over this range but one persisted. (Nature can be kind to graduate students). An order-disorder transition.

[3] Professor Richardson was unable to deliver his talk in person.

These molecules are planar in solids and stack with small tilt. Thermal motion is mostly in-plane oscillation at a frequency much higher than nuclear precession. The nuclei align along the average direction of the gradient. What I found monitoring bond directions at low temperatures was that moving down the crystalline c axis one molecule was rotated 3.5^{o} clockwise around its normal, the next 3.5^{o} counterclockwise, the next clockwise, etc. As the temperature rose oscillation grew until the double well was overridden. Disorder begins. By 110K neighbors move identically. The c axis of the cell is halved. The bond giving the persistent line could be tracked to about 0.1^{o} precision as it rotated through its 3.5^{o}.

Now ahead 20 years and the thread is picked up again at Arkansas in studies more or less related to atmospheric sciences. This work was done with Jim Spann, Chuck Kurtz, Atha Pigg, Roger Hightower, and Tamara Snyder. Single micron size particles were levitated in a quadrupole trap and phase changes in them were studied. I'll describe three results.

In our first study Jim and I picked ammonium sulfate. (This is one we breath[*sic*]). We wanted to study the solid-to-liquid transition and its reverse, the liquid being aqueous solution, with the particle initially a dry solid suspended in vacuum. Water vapor was slowly admitted through a precision leak valve and particle mass was monitored. Change of a few parts per thousand is detectable. As the vapor was admitted an adsorbed water layer of increasing thickness forms on all surfaces, the glass of the windows, the stainless steel of the trap and chamber walls, the teflon spacers, and the particle. Each layer thickness is different, depending on the interaction at the water-solid interface. (Edward Teller contributed to the theory of this). But each is the same at the water-vapor interface. The layer vapor pressures are equal.

At the salt surface the dynamic is that ions leave the solid to be surrounded by water dipoles. Though free energy is increased this is less than kT and short lived. The equilibrium at the vapor face is disturbed as the ions tie up water molecules, giving a net flux of water into the layer. Ions in one side water in the other then relaxing. Until a critical pressure is reached and there is runaway flux. This is the deliquescence point which is as sharp as a melting point. At 24^{o}C it occurs at 80.0% relative humidity where the solution droplet has 9.85±0.06 water molecules per sulfate ion.

If the vapor pressure is reduced the water content drops; the droplet becomes metastable. The liquid is not homogeneous. Tiny short lived crystallites (nanoparticles!) form and dissolve. As supersaturation grows with decreasing vapor pressure the crystallites grow larger and live longer until one acts like a seed for runaway crystallization. This is homogeneous nucleation. Jim found that the number of water molecules per sulfate ion had to be reduced to 1.54±0.03 before the probability of crstallization is unity.

Chuck studied solid-solid phase changes in a levitated particle. Common in nature are hydrated solids with water molecules stuck in the crystalline array. We chose lithium iodide from among these. It was known that at room temperature there are three hydrated forms. With the particle in water vapor below 4 mTorr pressure the solid is anhydrous. Chuck found that when the pressure rises to 4.4 mTorr the crystal changed to monohydrate. At such a low pressure the adsorbed layer on stainless steel or glass must be practically nonexistent. But if we keep our picture from the deliquescence, somehow the fluctuations at the crystal-adsorbed layer interface must produce enough LiI.H_2O crystal to nucleate the transition. It boggles my mind. And on up to the dihydrate at 238 and the trihydrate at 362 mTorr.

We got a pleasant surprise at 74 mTorr, a phase not previously seen, with 5/3 H_2O per LiI. So for each 6 LiI in the crystal it has structure with zero, 6, 10 12, and 18 H_2O, all of which we could lead it through in an afternoon in the lab. I think Gibbs might have enjoyed this.

Tamara used levitation to study heterogeneous nucleation, common in nature, e.g. fog forming with the aid of dust particles, but difficult to produce cleanly in the lab. The transition was aqueous solution to solid as in ammonium sulfate above but with a catalyst. The function of the catalyst is to help form the nucleus in the fluctuating liquid. The solid catalyst serves as a template. Tamara studied several solutions but a single example will do. The solution was common salt water, NaCl. Though uncommon in its purity. The catalyst was solid KCl. This pair was chosen because both solids are cubic close packed. The unit cell in NaCl is 5.63 Å, that in KCl is 6.29 Å. The first layer of ions layed on will look like a strained NaCl lattice, the second maybe less strained, etc., until a nice seed is produced. That was the hope.

So the first step is to study nucleation without the catalyst. When relative humidity reaches 75.3 % deliquescence occurs as above. There are 9.05 H_2O per NaCl then. Reducing humidity to 45.5 % where there are 3.25 H_2O per NaCl yields homogeneous nucleation to the solid. The next step is to produce a pure KCl catalyst in the solution. This is done by first trapping a mixed salt particle, dissolving it, then reducing humidity until KCl precipitates. It forms a pure core surrounded by the NaCl solution. Further reduction sends the solution back to solid NaCl, not at 45.5% RH but at 61.2%. The catalyst works.

Heterogeneous nucleation theory was developed long ago by B. Vonnegut (Kurt's father) and others. Their model is of a semispherical cap of NaCl formed on the surface of the catalyst. (This gives the nucleus minimum surface energy.) Applying it we found that the critical nucleus contains about 120 NaCl's, with a contact angle of 69^{o}.

And here ends the thread.

"Flipped spins, trapped things, taught, learned."

William Pendleton,
First physics PhD, University of Arkansas, 1964

In the autumn of 1959, the graduate faculty in the department was small with only four active members. Initially the core graduate-level classes 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.

William Pendleton, Professor Emeritus at Utah State University, described his graduate studies leading up to the first physics PhD at the University of Arkansas.

A "qualifying examination," which emphasized undergraduate-level questions / problems, was administered relatively early in the program. A "Ph.D.- level pass" provided the option of working directly toward the terminal degree, thus bypassing the M.S. degree which was a research degree at that juncture. It appears that at least four of the early Ph.D.-bound students (C. Head, M. Head, W. Pendleton, D. Ross) exercised this option. Following Ph.D.-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 the 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 Ph.D. 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.

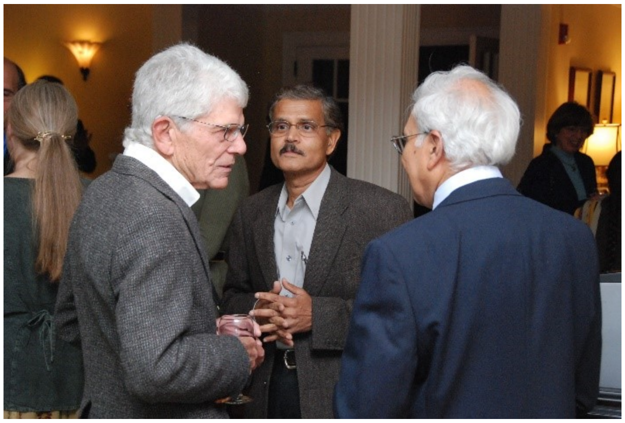
IV. Reception

Professor Arthur Hobson (standing) with Mrs. Jane Hughes and Professor Raymond Hughes.

Jeannine Durdik, Associate Dean of Fulbright College of Arts and Sciences, sharing a laugh with Professor William Harter.

L to R: Professors Donald Pederson, Vice-Chancellor for Finance and Administration, Stephen Day, and Richard Anderson.

Patricia Koski, Associate Dean of the Graduate School, with Professor Surendra Singh, Chair of the Physics Department.



L to R: Professors Charles Richardson, Surendra Singh, and Rajendra Gupta in conversation.

L to R: Professor Claud Lacy, Instructor Tamara Snyder, and Profedssor Gea-Banacloche.

V. Banquet and Individual Recognition of the Emeritus and Former Faculty

The reception was followed by a banquet where the honorees were individually recognized for their contributions to the department and each was presented with an award as a token of appreciation by selected members of the current faculty. The photographs below show the presentation of the awards and acceptance by the honorees.

The banquet held in the University Hall was attended by the physics faculty and guests.

Professor Rajendra Gupta recognized Professor Raymond Hughes for contributions to the department before presenting an award to him.

Professor Hughes expressed thanks for the award.

Professor Donald Pederson presenting the award to Professor Stephen Day.

Professor Day accepting the award.

Professor Julia Kennefick presented the award to Professor Otto Zinke.

Professor Zinke is seen here expressing thanks for the award.

Professor William Oliver III presented the award to Professor Arthur Hobson.

Professor Hobson expressed appreciation for the award.

Professor Surendra Singh Presenting the award to Professor Charles Richardson.

Professor Richardson accepting the award.

Professor Gregory Salamo presented the award to Professor Richard Anderson.

Professor Anderson accepting the award.