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ARKANSAS PHYSICS

Editor: Prof. Gay Stewart. Please contact me with comments and suggestions, Dept. of Physics, University of Arkansas, Fayetteville, AR 72701; call: (501) 575-2408, or e-mail: gstewart@comp.uark.edu.

Condensed Matter Under Extreme Conditions

Research an undergrad could get into! By William Oliver

Liquids and solids, as well as many other phases of matter such as liquid crystals and lipid membranes, are known to exist in many stable and metastable phases. It is endlessly fascinating to discover and explore these phases of matter, to understand the conditions under which they exist, their properties, and the ways in which they transform from one phase to another. Collectively we call all of these types of matter *condensed matter systems*. Most of the vast amount of research in condensed matter physics has probed material properties as functions of temperature, chemical composition, and electric and/or magnetic field. This has led to a well developed understanding of many materials, which in turn has often led to huge benefits for humankind.

In contrast, relatively little materials research to date has been done at pressures above atmospheric pressure (P = 1 bar) due to the relative difficulty of achieving high pressures in the laboratory. As a result, thousands of new phases or new materials with interesting and perhaps useful properties have yet to be explored and discovered. As an example, consider the beautiful and extremely useful form of carbon called diamond. Natural diamond is produced under **extreme conditions** of high temperature and pressure deep within the earth and yet it is very metastable and hence useful under ambient conditions. How many other remarkable and technologically important material phases might we discover as we explore the realm of high pressures?

In my laboratory we squeeze liquid or solid samples to very high pressures in what is called a diamond anvil cell while simultaneously controlling the temperature. Briefly, we drill a tiny 200 micron hole in a thin 100 micron thick piece of steel, place a tiny sample of material to be studied into this hole, and close off each side with anvils made of flawless gem quality diamond. We then squeeze the diamond anvils together to produce pressures as high as several hundred kilobars. The diamonds also act as windows through which we can view our sample and probe it with several types of laser light scattering and optical spectroscopy techniques. We measure the pressure *in situ* by placing tiny (5-10 micron) chips of ruby into the cell. When these chips are excited with blue or green laser light they fluoresce a beautiful red. This fluorescent light has spectral peaks the frequencies of which are pressure dependent and well calibrated.

With an arsenal of different optical and laser techniques we can probe thermodynamic properties of samples at high pressure, such as the basic pressure-volume-temperature relationship, as well as dynamic properties such as the frequencies or time scales on which the constituent atoms or molecules vibrate, rotate, or diffuse. We can measure these dynamical processes over time scales

from femto and pico seconds all the way to hundreds of seconds. The primary focus of our research is to study the static and dynamic properties of matter as temperature and pressure are varied so as to induce phase transitions between one phase and another. Many types of phase transitions are studied such as liquid to crystal, liquid to glass, crystal to crystal, etc.

In summary, we squeeze ruby impregnated samples between diamonds to achieve very high pressures and then do cool experiments as these samples undergo phase transitions using lasers, sophisticated optics, electronics, and computers.

Teacher Research Opportunity

The Oak Ridge Institute for Science and Education sponsors the ORISE Teacher Research Associates (TRAC) Program. Support is provided to junior and senior high school teachers for hands-on research participation in science and mathematics related areas, and workshops to package research experiences for use in the classrooms. Duration is eight weeks during the summer and includes a weekly stipend. Contact Peggy King, Program Manager, (615)576-5660.

HIGH SCHOOL PHYSICS DAY

The University of Arkansas Physics Department will host its annual High School Physics Day on **SATURDAY APRIL 27, 1996.** The day's events are open to all high school classes in Arkansas. The faculty and members of SPS invite students and teachers from your high school to participate. Note that a small registration fee is required, and that lunch will be provided by SPS, making the fee well worthwhile. Checks may be made payable to the Society of Physics Students.

We hope that this event will encourage the pursuit of physics as a career by providing an opportunity for detailed projects to be carried out in a light-hearted (and hopefully light-landing) manner. We also hope to give students and teachers from across the state an opportunity to get acquainted, better inform them about undergraduate physics at the U.of A., Fayetteville, and show that physics is fun. Art Hobson, who has been spearheading our new Physics B.A. program will be on hand for discussion with interested students.

SCHEDULE OF EVENTS AND RULES

8:30 - 9:00 Registration	12:30 - 1:30 Paper Tower Contest
9:00 - 9:15 Introduction and welcome	1:30 - 2:30 Physics Demonstrations Contest
9:15 - 10:00 Ping Pong Ball Launch	2:30 - 3:30 Egg Drop
10:00 - 11:30 Demonstrations, tours of research labs	3:30 - 4:00 Physics Study at U of A, Fayetteville
11:30 - 12:30 Lunch provided by SPS	4:00 - 4:30 Awards ceremony

EGG DROP RULES: No restraining devices or aerodynamic devices may be attached to the container. The container itself may not be an aerodynamic device. The maximum height of drop will be 60 to 80 feet. The winner is the container with the most eggs surviving both drops. In the event of a tie, the container with the least volume wins. Each container must hold **two** uncooked, unfrozen, untreated chicken eggs. Containers may be of any material but must fit into a cube 50 cm on each side. Containers which may chip the concrete or asphalt target will be disqualified. There will be two drops, and containers must be openable and reclosable to check the eggs between drops.

PHYSICS DEMONSTRATIONS: Design a demonstration that illustrates physical concepts or phenomena and enter it into the contest. The design must not have been presented or judged previously. It will be judged for originality and fidelity to the physical principles that are being illustrated.

POSTER: Entries should be made at home. They should deal with any thing related to physics, astronomy or mathematics. The posters should be turned in at registration time. The poster will be judged according to content and artwork. Entries are limited to one poster per person.

PAPER TOWER: You are to construct a free-standing tower of maximum height using a single sheet of 8.5" by 11" photocopier paper and one 50 cm strip of cellophane tape. No other materials may be used. Materials and construction aids will be provided. The paper may be folded into any shape, and the tape may be used to fasten parts of the tower together. The tower may not be attached to the floor or any other object. A tower shall be declared free-standing if it remains self-supporting for more than 10 seconds. Height is determined by measuring the perpendicular distance from the highest point on the tower to the supporting surface.

PING PONG BALL SHOOT: Students build an apparatus that will launch a ping pong ball the longest straight line distance from the point of launch to the point of first landing. The launcher must be built before the competition. 10 minutes will be allotted for set up. The best of three shots will be used. The launcher may be made from any material, but no combustible material may be used to launch the ping pong ball. A standard tournament ping pong ball will be provided for each team.

HOW TO PARTICIPATE: The previous schedule is tentative because of uncertainties in the amount of participation. Therefore it is very important that each school fills out the registration form below and sends it back by April 14 (sooner if possible). Awards will be given for first, second, and third place in the five competitions. Entries by individual high school students and by teams of two members are welcome. Provisions will be made so that each team member receives an award. Everyone is encouraged to participate but anyone can come to observe. The decision of the judge is final-in the event of a tie, the points will be split between the teams.

High School Physics Day Registration Form:

Teacher's Name_____

School _____

School Address _____

City/State/Zip/Phone_____

Preregistering ____ students at **$1.00 each for** a **total of $_____ payable to the SPS.**

Contests(check each your school will be competing in and give the number of teams competing in each):

__Ping Pong Ball Launch Number of Teams:___

__Egg Drop Number of Teams:___ __Bridge Building Number of Teams:___

__Physics Quiz Bowl Number of Teams:___

Mail all forms to Gay Stewart, Department of Physics, University of Arkansas, Fayetteville, AR 72701

NEWSLETTER
Department of Physics
University of Arkansas
Fayetteville, AR 72701