Tom Dickinson in his lab.

Dickinson Group Studies Fractures and Laser Etching

Tom Dickinson leads a research group whose work is catching the attention of scientists around the world. The group's activities center on applications of physics to materials science. The two major areas of interest include fracture of materials and the interaction of laser light with surfaces.

The fracture studies involve detection and characterization of particles—*e.g.,* electrons, ions, photons, and neutral species—accompanying crack propagation (fracto-emission). The goal of this research is to utilize these emissions to further understand the atomic processes responsible for material failure. New aspects of this work are relating the observed emission properties to chaotic processes associated with dynamic crack growth and also determining the resulting fractal dimension of the fracture surfaces. Recently, Dickinson and his students were able to show that the photon emission accompanying fracture of certain polymers, as well as single crystal magnesium oxide, exhibited chaotic fluctuations, which implies that the production of new surfaces during fracture is deterministic, as opposed to being a stochastic process.

To accomplish its research goals, Dickinson's group is using a scanning tunneling microscope and an atomic force microscope to characterize fracture surfaces of materials on much smaller spatial dimensions than previously possible. His team is particularly interested in the energetics of the formation of "rough surfaces" which are created during crack propagation. Furthermore, on the scale of nanometers to microns, the "roughness" on magnesium oxide cleavage surfaces exhibits fractal character, which again is a measure of the departure from the lowest energy, single-cleavage-plane fracture. Such issues relate to the physics and engineering of arresting cracks in brittle materials.

Another area of study involves the process known as "photo-ablation"—the removal or etching of surface material by intense excimer-laser bombardment. This process can also be a source of thin films of material deposited in high vacuum such as for the 1-2-3 superconductor. This research is also of interest to the microelectronics industry, which could use the ablation and deposition process to create large scale integrated circuits.

A focus of this work is determining a detailed understanding of the particle emission mechanisms and characterization of the species and energies of the ejected atoms and molecules. Current efforts center on examining the threshold behavior of the laser-induced emissions and determining the influence of laser bombardment on the surface composition and structure just prior to the onset of ablation.

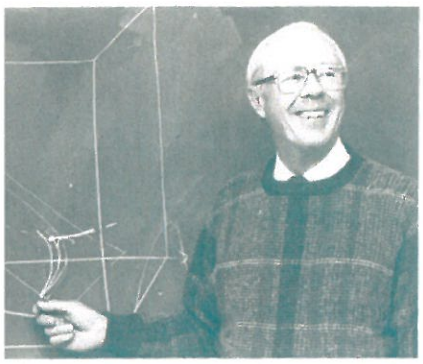
Dickinson's research is carried out under ultra-high vacuum conditions and employs a wide range of spectroscopies, including optical, mass, and electron. Because of its international reputation for pioneering work in fracto-emission, the Dickinson group is in constant demand for presentations to conferences and colloquia.

Department of Physics
Winter 1990

Physics matters

Washington State University

Greetings from the Chair



Professor Richard Fowles

With this edition of *Physics Matters* we are beginning a regular publication that we hope will keep you better informed of the current state of the physics department—our accomplishments, goals, and progress. We would like it to be a dialog and to include alumni news, so please write and tell us anything you would like to communicate to us or your colleagues.

There have been some major changes in the faculty the past few years. Sadly, **Paul Bender** died last summer. Many of you knew him as an outspoken advocate for the student, and we sorely miss him. A brief biographical sketch is included elsewhere in this issue.

Our most recent faculty addition is **Bradford Pate.** He comes to us from Stanford, where he was most recently a postdoc with the synchrotron facility. He is a surface physicist working primarily with **Tom Dickinson.** Further information about both of these faculty members is also to be found elsewhere in this issue.

Professors Edward Donaldson and **George Duvall** retired last year, but both are still active as emeritus professors, as is the ever-young **William Band. Peter Braunlich** is very busy with his new company, International Sensor Technology, and **James Park** is on half-time leave in order to explore the world. We are getting pretty thin at the senior level! Consequently, we are searching for two or three new faculty members to help us cope with our increasing enrollments. We now have 50 graduate students, for example, and our undergraduate enrollments are going up.

Professor Duvall and **Professor Philip Marston** received national honors this past year. Duvall was awarded the Shock Compression Science Prize of the American Physical Society, and Marston was elected a Fellow of the Acoustical Society of America. Marston also received a University Research Initiative grant for his research. We are proud of their accomplishments.

You will also find brief descriptions of current activities in two of our research areas, the shock dynamics lab and the surface physics group. We'll discuss other areas of research in later issues of *Physics Matters.* You might also note the increased activity in our development accounts, to which many of you have generously donated and for which we thank you very much.

I hope this finds you well and prosperous and that you will write, call, or visit us in the near future.

With best wishes,
G. Richard Fowles

Paul Bender Left Unusual Legacy

The Department of Physics lost a valuable and unique member of its faculty last July when **Professor Paul Bender,** 58, died of Marfan's syndrome. Many knew Bender through his direction of the teaching laboratories and as trainer of graduate teaching assistants. His dedication to the undergraduate physics program and laboratories will be deeply missed.

After receiving his doctorate from the University of Colorado, Bender went on to Drury College in Springfield, Missouri. In 1960 he and **Dian Bender** moved west to join the WSU community. Paul's research specialty was in geophysics, where he pioneered the use of electron spin resonance for characterizing igneous rocks. He taught optics, mechanics, and geophysics, and delighted in bringing dramatic and intriguing demonstrations of the way things work to the classroom and teaching laboratory.

As a result, Bender designed and built many hands-on physics displays. "In philosophy, kids don't have the opportunity to see how things work," Bender said in an interview shortly before his death. "People need to experience things in physics." The displays, which many consider

masterpieces of education and fun, are housed in the lobby of the Physical Sciences Building and were funded through gifts from alumni and friends of the department.

"Many of the exhibits evolved from demonstrations in the 101 and 102 labs," Bender said. One of the exhibits is a giant "guitar string" that extends about 20 yards down a hall in the building. The right touch administered to the string propagates various modes of vibration. It has also been observed since the exhibit was constructed that the tightness of the guitar string measures humidity in the air.

Another exhibit is an "infinity mirror." Through the use of two mirrors, the installation gives the impression of being a deep hole in the wall of the building; the front mirror is only partially coated with silver, which reflects much of the light between the mirrors. This type of mirror is used in psychology experiments and is commonly referred to as one-way glass. "These exhibits are interesting to those who haven't had physics," Bender said, "but they're instructive to those who have." Included in the exhibit is a corner mirror that allows you to see yourself as someone else sees you, a wave machine, and a large camera lens used in World War II to survey damage.

Paul Bender with physics 202 laboratotry experiment.

Bender felt that hands-on demonstrations are an important addition to the educational experience, not only at WSU, but everywhere. The hands-on exhibits were built during summer hours by **Wiley Wilson** and **Jim Berger,** educational technicians who maintain the laboratory equipment in the physics department. "It's Jim and Wiley's time," Bender said. "No state funds or any of my teaching time goes into these projects. Each exhibit is checked every morning by Wiley and Jim. If they need fixing, they fix them. They're always in operable condition. Some of these exhibits have been used quite a bit. The more they're used, the more we enjoy making them." Wilson and Berger are still completing projects designed by Bender.

An endowed scholarship to benefit undergraduate students in physics is being developed through gifts from Dian Bender and many individuals who knew and appreciated Bender. The scholarship is a tribute to the fine legacy left to us by Paul Bender.

Physics Scholarship Funds Increase

Over the past several years we have had the opportunity to establish several funds which benefit the programs and students of the department.

The Paul A. Anderson Prize is named to honor a long-time professor and former chair of the department. It is awarded to graduate students who excel in their classes and research projects. The most recent recipient, **Mark Conner,** earned his master's degree last year. Paul lives in active retirement in Carmel, California.

The Claire May Band Fellowship is designated for a female graduate student in physics. **Professor William Band** and his friends established this endowed fund as a memorial to Band's wife, **Claire,** who died December 1988. **Costantina Poga,** who is from Greece and is beginning her second year as a graduate student, became the first Claire May Band Fellow last summer.

The Harry Geoffry Hopkins Memorial was established through a bequest from the estate of **Geoffry Hopkins,** a former visiting professor from England. Income from the endowed fund will soon be large enough to award fellowships to graduate students in mathematical physics.

Students Tracy Long and Jon Mathison examine a superconductor they fabricated with other students as part of a special project under the direction of Professor Jim Walker.

The Physics Development Fund was the first fund established for the department and receives all gifts which are not specified for other funds. It is of great importance for supplementing our activities; only from this account can we supplement awards from special funds, cover the cost of bringing prospective graduate students and faculty members to campus, and provide emergency funds for teaching and research.

The Freshman Physics Scholarship. We have endeavored to increase our undergraduate enrollment by implementing this new scholarship for incoming freshmen. So far, we have awarded two scholarships for full tuition and fees for one semester. The funds for this award come from the Physics Development Fund, since there is no endowed fund for this purpose. This year the award went to **David Monk,** a freshman from Seattle.

Two new endowed funds were occasioned by the retirement of two veteran professors from the department:

The George Duvall Fellowship. Professor Duvall joined the department in 1964 and retired in May 1988. During his tenure he established the largest and best-known academic shock dynamics facility in the world. The work of that group is directed toward time-resolved chemical and physical changes in ruby, cadmium sulfite, calcite, and other materials and continues to be a strong asset to the department. This fellowship will be awarded to a graduate student whose interest is in the field of shock dynamics.

The Edward Donaldson Fellowship. Ed Donaldson joined the faculty in 1957 and retired in 1988. His work in the field of surface physics brought renown to WSU from all over the world. Remaining one of the most active research areas in the physics department, the surface physics group is concentrating in the areas of fracto-emission, the structure of diamond, and the emission of particles from surfaces under electron bombardment. This fellowship will be awarded to graduate students who are working in the field of surface physics.

Materials' Response to Shock Waves Studied

A Department of Physics laboratory which has achieved world class status is the Shock Dynamics Laboratory. The research efforts of this lab are focused on understanding the response of condensed materials to dynamic high pressures produced by shock waves. The areas of investigation include the study of optical, thermo-mechanical, chemical, and electrical effects on a sub-microsecond time scale. During the past several years methods to do time-resolved spectroscopy (with 10 ns resolution) have been developed in the lab. This permits investigations of the atomic and molecular mechanisms that govern shock-induced deformation and chemical reactions.

The touchstone of the basic research at the Shock Dynamics Laboratory is the attempt to link the disparate fields of continuum and quantum mechanics. In this vein during the past year, the laboratory has been able to relate the shock deformation in ruby crystals to changes in local site symmetry around the chromium ion; and evidence has been discovered for time-dependent molecular reorientation in shocked carbon disulfide. Problems under continuing investigation are

(1) luminescence and absorption measurements in shocked ruby crystals to relate the spectra to crystal deformation;

(2) absorption and Raman measurements to understand chemical reactions in shocked carbon disulfide;

(3) compression and shear wave experiments to study phase changes in shocked calcite;

Professor Emeritus George Duvall discusses a project with postdoctoral fellow Rick Gustaveson.

(4) the effect of crystal orientation on phase changes in shocked cadmium sulfide; and

(5) the specification of the stress tensor in shocked solids. In addition, there is a continuing interest in understanding the mechanisms that govern inelastic deformation in shocked crystals.

The laboratory was established in 1968 by **Professor George Duvall.** Under his able leadership and subsequently that of **Y.M. Gupta,** the current head, it has been developed into the premier academic shock facility in the world. Its equipment consists of two gas guns and diagnostic instruments consisting of several electronic streak cameras, detectors, and spectrometers for optical spectroscopy work. Wave profiles are measured using quartz gauges, piezoresistance transducers, electromagnetic gauges, and laser interferometry.

The laboratory research structure continues to emphasize the training of students in all the physical techniques necessary to carry out their research. In that training and the overall operation, **Paul Bellamy's** contributions continue to be essential.

The Shock Dynamics Laboratory continues to increase its international renown through invited addresses, preparation of top students, support of postdoctoral fellows, and the unique research that is accomplished there.

Bradford B. Pate

Diamond Impurities Are Brad Pate's Research Interest

Our newest faculty member is **Bradford B. Pate,** who was selected from a field of 80 applicants for a position in the area of experimental condensed-matter physics. His first few months have seen him preparing his laboratory to begin work on the microscopic and geometric properties of impurities in and on diamond. This reflects his Ph.D. thesis work, completed at Stanford University in 1984, on the nature of the diamond surface. At that time he predicted that hydrogen adsorption and desorption plays a key role in the hybridization stabilization of the surface during low pressure deposition. His subsequent work at the Stanford Synchrotron Radiation Laboratory involved him in a range of research topics from design and construction of soft X-ray monochromators to electronic structure measurements of heavy fermion systems, superconducting alloys, and carbon materials.

Professor Pate is a Texan, born in the windy city by the sea, Corpus Christi. After living in Denver, Colorado, and becoming an avid downhill skier, he returned to his native Texas to attend Rice University in Houston. He received undergraduate degrees in both physics and electrical engineering. While he was attending Rice he met his wife-to-be, another Rice student, **Toshiko Ichiye,** but they went their separate ways, she to Harvard, he to Stanford. They met again by chance while waiting for a table at a cafe in Berkeley in 1986 and were married in 1988. Ichiye is an assistant professor in the biochemistry-biophysics program at WSU.

Pate relates that while he is unsure when he decided to become a physicist, he does remember that in the third grade he wrote a report on careers and declared that he would be a physicist. "I'm not sure whether that was a cause or an effect," he said in a recent interview. "What fascinated me as a child is what it means when two objects 'touch.' What is the 'end' of a material in microscopic terms? I was asking that question before I even had a notion of an atomic view of things." Brad Pate continues to ask that question, only now he asks it in more sophisticated terms and armed with equipment that will help him formulate an explanation. We look forward to hearing some of his answers.

100=200?

More than 1,000 U.S. companies match their employees' gifts to educational institutions. The amount you contribute to WSU can be matched dollar for dollar, and in some cases by even more, if you work for one of these companies. Corporate personnel offices can usually provide information about such programs. Have you checked lately to see if your employer offers this benefit?

Last year Boeing Company alone matched employee contributions to higher education with about $500,000. Of this amount, $15,341 went to WSU—the third largest amount received from Boeing by any such institution. For 1989, Boeing has increased its gift-matching budget, allocating $1 million for education, arts, and cultural organizations.

Many other companies which employ WSU physics graduates have matching gift programs. Among these are Westinghouse, Tektronix, Hughes Aircraft, MITRE Corporation, GTE, Texaco, and perhaps your company as well.

Please consider a gift to the Department of Physics or the College of Sciences and Arts, and check to see if your gift can be matched. This year gifts to the Department of Physics are providing substantial scholarships to very worthy physics students. Your gift can make a real difference at WSU.

The Department of Physics Honor Roll of Donors

We are proud to report the names of the following individuals who contributed to the Department of Physics and the College of Sciences and Arts in the last year. Their generosity enables us to build programs of distinction and gives direct support to our students and faculty. We thank these supporters and encourage others to join them.

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