Department of Physics

The Department of Physics has been a national resource since the turn of the 20th century. It has been at the center of the revolution in understanding the nature of matter and energy and the dynamics of the cosmos. Our faculty—3 of whom hold Nobel Prizes and 23 of whom are members of the National Academy of Sciences—include leaders in nearly every major area of physics. The department is currently ranked number 1 for PhD programs by *US News & World Report.*

Honors and Awards

Many of the department's faculty received honors and awards during academic year 2004. Alan H. Guth, the Victor F. Weisskopf professor of physics, was the cowinner of the 2004 Cosmology Prize of the Peter Gruber Foundation. Guth and colleague Andrei Linde of Stanford University were awarded the prize for "their development of fundamental ideas of cosmic inflation, which has been one of the dominant themes of cosmology for more than two decades. The original concept of inflation and its many variations, including chaotic inflation, proposed and developed by Guth and Linde, have led to a revolution in our approach to studying cosmology and to understanding the history of the universe." The Cosmology Prize of the Peter Gruber Foundation is one of the premier international prizes in the field.

Bruno Coppi was named laurea honoris causa in physics, lectio magistralis, by the Università di Milano, 2003. Mildred Dresselhaus received the 2004 Founders Metal from the Institute of Electrical and Electronics Engineers and received honorary degrees from Northwestern University and the Weizmann Institute. Claude R. Canizares, the Bruno Rossi professor of physics and associate provost, was recently elected to the American Academy of Arts and Sciences. Roman Jackiw was elected a foreign member of the National Academy of Sciences, Ukraine. Paul Schechter was elected to the National Academy of Sciences. Lee Grodzins was the recipient of the R&D 100 Award from *R& D Magazine.* David Pritchard received the Max Born Award from the Optical Society of America and was named Selby lecturer, University of Western Australia. Samuel Ting was awarded the Distinguished Science and Technology Award by the Chinese Institute of Engineers, USA.

Frank Wilczek was awarded the Commemorative Medal of the Faculty of Mathematics and Physics, Charles University, Prague; the 2003 High Energy and Particle Physics Prize from the European Physical Society, 2003; and the American Physical Society Julius Edgar Lilienfeld Prize. His article, "The World's Numerical Recipe," was featured in *The Best American Science Writing 2003*.

Several junior faculty members had very successful years. Hong Liu and Iain Stewart were both named Sloan fellows. Stewart also won a Department of Energy Outstanding Junior Investigator Award. Nergis Mavalvala received the Cecil and Ida Green career development professorship. Eric Hudson was named the next holder of the Class of 1958 career development chair and Vladan Vuletic the next holder of the Lester Wolfe chair.

Several faculty members were recognized for their teaching or overall achievement at MIT. Thomas Greytak, David Pritchard, and John Belcher received the Dean's Educational and Student Advising Award. Young Lee won the William Buechner Teaching Prize. Walter Lewin received the Everett Baker Award for Excellence in Undergraduate Teaching. Wolfgang Ketterle was named MIT's James R. Killian Jr. Faculty Achievement Award winner for 2004–2005.

This academic year was also a very busy and successful year for faculty promotions and appointments. Deepto Chakrabarty, Christoph Paus, Gunther Roland, Alexander van Oudenaarden and Vladan Vuletic were promoted to associate professor and Ray Ashoori was promoted to full professor. Max Tegmark joins the faculty from the University of Pennsylvania in September 2004 and Adam Burgasser will join the department as an assistant professor in September 2005. Arlie Peters, a professor at Duke University, continued his appointment in the department as a Martin Luther King Jr. visiting professor.

Education

AY2004 was marked by the increased integration of the Technology Enabled Active Learning (TEAL) format into first-year physics at MIT. This was the second year in which 8.02 Physics II was offered on a large scale. Over 600 students enrolled in the subject during the fall and spring terms. The TEAL format was also utilized for the first time in 8.01 Physics during the fall term. Some 123 students chose this over the traditional lecture/recitation format. As part of the TEAL transition, the 8.01X/8.02X sequence began to be phased out as 8.01X was permanently removed from the *Bulletin.* When a second TEAL room is completed in the Stata Center, 8.02X will be discontinued. Subjects 8.012 and 8.022 continue to be offered to students who desire a more intensive study of Physics I and II. Although lecture/recitation will be retained as the teaching format in these subjects, TEAL is being incorporated into the curriculum via experimental assignments that were traditionally offered in a laboratory.

The number of SB degrees awarded this year in physics remained consistent with the previous year (65). Current enrollments at the sophomore and junior levels indicate that our degree statistics have leveled and should continue for the next few years. Forty-eight percent of our graduate students earned 8-B degrees, an option that continues its popularity. Forty-nine percent of our undergraduate degree recipients received two degrees.

The graduate program continues to thrive. Although the number of graduate applications declined (a trend experienced throughout the Institute), the department's yield increased. Forty-seven students graduated with SM and PhD degrees, while the department accepted 42 new students.

Diversity

The Department of Physics is in the forefront in producing minority PhDs. To recruit new minority graduate students, the department supports students' membership in the National Conference of Black Physics Students and the National Society of Black Physicists. The department also supports North American underrepresented scholars through the Physics Department Head Fellowships. The department funds all travel expenses for underrepresented North American candidates, as well as all North American female candidates. Professor Eric Hudson tracks all minority applications through the admissions process to assure that due diligence was considered in their candidacy. However, the pool of qualified minority candidates for graduate school remains extremely small, and the qualified students are aggressively recruited by the competition. Thus, in spite of our efforts, the percentage of minority graduate students has not increased. As a result, the department has retained the services of a minority, owned search firm specializing in the recruitment of underrepresented minorities in the sciences.

Our percentage of women graduate students is higher than for most institutions, but it is still quite small. We support the Women in Physics group, which consists of current female graduate students, by providing space and funding for biweekly dinners and other events. The group actively recruits female candidates to the program (i.e., they host a reception during Open House for female candidates and they telephone individual female candidates). They annually organize a dinner open to all undergraduates to discuss graduate school in physics, physics research at MIT, and career choices in general. This fall they initiated a mentoring program with the Undergraduate Women in Physics group for female undergraduate physics majors at MIT. The program was developed to foster a closer interaction between undergraduate and graduate physics students to benefit both groups of women. All these activities are listed on the following websites: http://web.mit.edu/physics/wphys/ and http://web.mit.edu/uwip/. This group also receives financial support from a generous alumna of our department.

Finally, the department continues to recognize the importance of recruiting and retaining underrepresented minorities and women to its faculty. Throughout the recruitment process, advertising is targeted to reach these groups through diversity and organizational job boards and publications. Applicant data is closely tracked and qualified women and minority candidates' applications given consideration across all of the divisions.

Pappalardo Fellowships in Physics

In 2000, Mr. A. Neil Pappalardo (EE '64) provided the funds to inaugurate and sustain a competitive postdoctoral fellowship program for the Physics Department named the Pappalardo Fellowships in Physics. He recognized that a distinguishing feature of the sciences in general—and physics in particular—is the invaluable contribution made by the accomplishments of outstanding individuals. With this in mind, the mission of the Pappalardo Fellowships in Physics was focused upon the creation of a preeminent postdoctoral program for the department that would identify, recruit, and support the most talented and promising young physicists at an early stage in their careers.

The program appoints three new fellows per academic year for a three, year fellowship term each. Fellows are selected by means of an annual competition, global in scope, for which candidates cannot apply directly but must be nominated by a faculty member or senior researcher from the international community of physics, astronomy, or related fields. Two notable features of the program are the fellows' complete freedom of choice in research direction (within the department) throughout their fellowship appointment and the active faculty mentoring of fellows, fostered by weekly luncheons and monthly dinners with the department's faculty throughout the academic year.

The department head appoints the eight members of the program's Executive Committee, which encompasses a seven, member Faculty Committee and one staff administrator who directly manages the program. Each division of the department is represented on the committee by a senior faculty member whose primary responsibility is the careful review and evaluation the fellowship candidates, as well as interviewing and selection of each year's finalists.

After successfully completing its first five, year funding cycle with a 150 percent increase in nominations, appreciable strengthening in the breadth and quality of candidates, uniformly enthusiastic support of the department's faculty, and the launching of faculty careers for seven of its fellows, program founder Neil Pappalardo pledged renewal funding for an additional five years.

Research Highlights

Joining the Foundations of Physics and Computer Science

Why should physics have anything to do with the ability to solve mathematical problems? Indeed, until recently, physics and computer science were divorced at their foundations by a fundamental thesis, that algorithms—procedures for solving mathematical problems—could be distinguished independent of the physical world. The thesis holds that problems are, among other things, either easy or hard to solve, and such distinctions persist no matter what the physical nature of the computational machinery is, be it mechanical, electrical, optical, or any other. Astonishingly, however, discoveries in the last decade showed this equivalence does not extend to information processors that utilize quantum physics. By utilizing nonclassical states of matter, quantum mechanical machines can easily solve certain problems that are hard for classical processors. Moreover, this capability can exist even in the presence of imperfections and noise. This reunion of the two fields has generated significant surprises for physics and computer science. In his pioneering research, Isaac Chuang describes the ideas underlying this new scientific area, and how current experiments are racing to develop access to this new realm, known as quantum information science (from "Quantum Information: Joining the Foundations of Physics and Computer Science," Isaac Chuang, associate professor of physics and associate professor of media arts and sciences, published in *physics@mit*, fall 2004).

From Vibrating Strings to a Unified Theory of All Interactions

For the last 20 years, physicists have investigated string theory rather vigorously. The theory has revealed an unusual depth. As a result, despite much progress in our understanding of its remarkable properties, basic features of the theory remain a mystery. This extended period of activity is, in fact, the second period of activity in string theory. When it was first discovered in the late 1960s, string theory attempted to describe strongly interacting particles. Along came quantum chromodynamics—a theory of quarks and gluons—and despite their early promise, strings faded away. This time string theory is a credible candidate for a theory of all interactions—a unified theory of all forces and matter. The greatest complication that frustrated the search for such a unified theory was the incompatibility between two pillars of 20th century physics: Einstein's general theory of relativity and the principles of quantum mechanics. String theory appears to be the long sought quantum mechanical theory of gravity and other interactions. It is almost certain that string theory is a consistent theory. It is less certain that it describes our real world. Nevertheless, intense work has demonstrated that string theory incorporates many features of the physical universe. It is reasonable to be very optimistic about the prospects of string theory.

New experimental input will help us determine if string theory describes our universe. The recent discovery of a nonzero positive cosmological constant has suggested new directions of investigation based on cosmological properties of strings. A discovery of supersymmetry would be a strong indication that string theory is correct because supersymmetry is generic in string theory—it is almost a prediction. The discovery of extra dimensions, perhaps surprisingly large ones, would also have dramatic implications. Most likely, finding out if string theory describes our universe will require a greater mastery of the theory. String theory is in fact an unfinished theory. Much has been learned, but there is no complete formulation of the theory and its conceptual foundation remains largely mysterious. String theory is an exciting research area because the central ideas remain to be found (from "From Vibrating Strings to a Unified Theory of All Interactions," Barton Zwiebach, professor of physics, published in *physics@mit*, fall 2004).

Marc Kastner
Department Head
Donner Professor of Science

More information on the Physics Department can be found on the web at http://web.mit.edu/physics/.