Department of Physics

The Department of Physics has been a national resource since the beginning of the last century. It was at the center of the 20th-century revolution in understanding the nature of matter and energy and the dynamics of the cosmos. Our faculty—four 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 number of SB degrees awarded to students majoring in physics was higher than we have seen since the 1980s and more than twice the number in 2000. Physics faculty continue to win prizes for research and teaching, and we attract the best physicists in the field at all levels of seniority to the department.

Honors and Awards

Following are a few of the many honors and awards conferred on Physics faculty during the 2005 academic year. Frank Wilczek, the Herman Feshbach professor of physics, won the Nobel Prize, our first laureate for contributions to theoretical physics. This was the fifth faculty Nobel in our department since 1990, an amazing record. A few months later we learned that Frank had also won the King Faisal Prize and received his third Best American Science Writing Prize. He was also elected a member of the American Physical Society along with colleagues Krishna Rajagopal and Jackie Hewitt. Claude Canizares, associate provost, was elected to the American Academy of Arts and Sciences. Samuel Ting was made an honorary fellow of the Tata Institute of Fundamental Research, Mumbai, India. Alan H. Guth, the Victor F. Weisskopf professor of physics, was cowinner of the 2004 Cosmology Prize of the Peter Gruber Foundation. Hale Bradt won the Advisor of the Year Award.

Our faculty in atomic and optical physics had an outstanding year. Dan Kleppner won the Wolf Prize. Dan is our third Wolf winner, along with Vicki Weisskopf and Bruno Rossi. Wolfgang Ketterle, our 2001 Nobel laureate, received MIT's James R. Killian Jr. Faculty Achievement Award. David E. Pritchard, Cecil and Ida Green professor of physics and associate director, Research Laboratory of Electronics, was the 2004 recipient of the Optical Society of America's Max Born Award, while Erich Ippen received the Optical Society of America's Charles Hard Townes Award. The Optical Society of America also awarded the Adolph Lomb Medal to Marin Soljacic.

Three faculty members were named chairs. John Belcher was named the Class of 1922 professor. Eric Hudson was named the Class of 1958 career development chair; and Xiao-Gang Wen was named the Cecil and Ida Green professor of physics.

This academic year was also a busy and successful year for faculty promotions and appointments. Krishna Rajagopal was promoted to full professor and Max Tegmark was granted tenure. The department added seven new faculty members, including two members of the physics community, Marin Soljacic and Jan Edgedal-Pedersen, who will join the department's faculty this fall. Marin, a former Pappalardo fellow, will continue his research in optics. Jan will continue his work on plasma physics in the Plasma Science and Fusion Center. Two high-energy physicists will also join in the fall: Steve

Nahn and Joseph Formaggio. Steve will work on high-energy physics on the Compact Muon Spectrometer at the Large Hadron Collider. Joe will continue his work on neutrino physics. In January 2006, two astronomers, Joshua Winn and Enectali (Tali) Figueroa-Feliciano, will join the department. Josh is currently a Hubble fellow at Harvard and will move his optical astronomy research to MIT. Tali will move from the NASA Goddard Space Flight Center and continue to build imaging bolometers for X-ray astronomy. A third astronomer, Rob Simcoe, currently a Pappalardo fellow, will join the faculty in September 2006. Rob will continue to use optical and infrared astronomy to study the early universe.

Education

We continued the integration of the Technology Enabled Active Learning (TEAL) format into first-year physics at MIT. This was the third 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. For the second year, a trial version of 8.01 Physics in the TEAL format was offered as an option during the fall term. Some 144 students chose this over the traditional lecture/recitation format. As part of the TEAL transition, 8.01X was no longer offered. Now that a second TEAL room is available in the Stata Center, 8.02X will be discontinued as well. 8.01L will continue to be offered for students with weak backgrounds, but will be restructured to include some of the TEAL modules. 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 experiment assignments that were traditionally offered in a laboratory.

The 78 SB degrees awarded this year in physics continued the steady growth of the past five years, increasing from a low of 35 in 2000. Current enrollments at the sophomore and junior levels indicate that the number of undergraduate degrees in physics should hold steady for the next few years. The 8-B degree, an option that continues its popularity, was awarded to 68 percent of our undergraduates. Some 49 percent of our undergraduate degree recipients received two degrees.

The graduate program continues to thrive. We awarded seven SM and 36 PhD degrees. However, budget constraints in the federal support of science limited the number of new students we could admit. The number of graduate applications was 653, not significantly different from last year. Seventeen of these students will come to the department with fellowship support, mostly from MIT sources. This is consistent with the number in this category last year. Due to fewer RA positions open this year, only eight nonfellowship students will be enrolling, just 35 percent of last year's figure of 23.

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 tracked 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.

Our percentage of women graduate students is higher than for most institutions but 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; for example, they host a reception during Open House for female candidates and telephone individual female candidates. They annually organize a dinner, open to all undergraduates, to discuss graduate studies in physics, physics research at MIT, and career choices in general. Last year they began 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 their website, 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 are given consideration across all of the divisions. Our system is effective, as one of our incoming faculty members is an underrepresented minority.

The American Physics Society (APS) recently conducted a study, "Women in Physics and Astronomy, 2005" (available on the web at http://www.aip.org/statistics/trends/reports/women05.pdf), and concluded that the representation of female women in physics and astronomy at all levels continues to increase. During 2003, women earned 22% of bachelor's degrees and 18% of the PhDs in physics; this is a record high. The representation rates in astronomy were 46% and 26%, respectively. They found that although the number of women is increasing, physics is not attracting women at the same rate as other fields. As a result, APS concluded that the low representations of women are at about the levels one would expect, based on degree production in the past. However, they also found that women tended to leave physics during their undergraduate years. Contrary to the APS findings, we've actually increased the number of women in our undergraduate programs. In fact, the total number of women majors has increased by a factor of three since 2001, much more rapidly than for the men. Indeed, the number of women who earned MIT physics degrees last year is larger than the total number of physics majors at many great research universities, such as Princeton, Columbia, and Stanford.

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 physics 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 10 members of the program’s Executive Committee, which encompasses a nine-member Faculty Committee and one staff administrator who directly manages the program. Each division of the department is represented on the committee by senior faculty members in both theory and experiment, whose primary responsibilities are the careful review and evaluation of the fellowship candidates in their respective area of physics, as well as selecting and interviewing each year’s 18–20 finalists during the two-day on-campus “marathon” of panel-style interviews.

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 13 of its fellows, program founder Neil Pappalardo pledged renewal funding for an additional five years.

Research Highlights

Cosmic Dawn: Hunting for the First Stars in the Universe

The stars have been celebrated throughout art and literature for their constancy, and rightly so, for not much happens to a star during the ~100 years that we are around to witness it. Yet over 13.7 billion years of cosmic history, many generations of stars have come and gone—being born in astonishing variety and sometimes exploding in spectacular, violent deaths. Since the universe has a finite age, at some point in the past there must have been a “first star.” So, one might ask: How long after the Big Bang did stars first begin to shine? What kinds of environments were conducive to their early formation? And what physical processes governed their assembly? These problems define an exciting research frontier in theoretical and observational astrophysics. Using telescopes with unprecedented clarity and light-gathering power, we can now peer deep into the past, hunting for the fingerprints left behind by stellar relics from the early universe. (From “Cosmic Dawn: Hunting for the First Stars in the Universe,” Robert Simcoe, Pappalardo fellow in physics, MIT, physics@mit, fall 2005.)

Generating Single Photons on Demand

In optical signal transmission, binary signals are encoded in pulses of light traveling along optical fibers. An undesirable consequence is that if somebody taps into the system and splits off a small portion of the light pulse, he has complete access to the signal while remaining virtually unobservable.

The quantum nature of light—that is, the fact that light consists of individual photons—prevents, however, the extraction of a small fraction of a weak pulse. If each bit of information is encoded (e.g., via the light polarization in a pulse that consists of exactly one photon), then the eavesdropper must divert the whole pulse, which is easily detected at the receiving end. Neither can the intruder copy the state of the photon into his own photon and measure the polarization state of the replica. The latter approach is prevented by the so-called no-cloning theorem of quantum mechanics: It is impossible to copy the unknown polarization state of a single photon without modifying the original in a noticeable way. The impossibility to both measure and preserve a quantum state is the principle behind quantum encryption—encryption protected by the laws of quantum mechanics. (From “Generating Single Photons on Demand,” Vladan Vuletic, associate professor of physics, MIT, physics@mit, fall 2005.)

Marc Kastner
Department Head
Donner Professor of Science

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