Department of Nuclear Science and Engineering

The Department of Nuclear Science and Engineering (NSE) is centrally concerned with nuclear reactions and radiation, their applications, and their consequences. We generate, control, and use nuclear reactions and radiation for the benefit of society and the environment. The department is a leading contributor to the innovations needed for a major global expansion of nuclear energy and to the development of the next generation of leaders of the global nuclear energy enterprise. We are also laying the foundations for new applications of nuclear and radiation science and technology. As a leading academic department in the field, we have a responsibility to inform public debates on wise and humane uses of nuclear science and technology.

Increasing global energy needs and rising concerns over climate change, along with new technological advances, are placing renewed emphasis on the role of nuclear power around the world. There are many other potentially beneficial applications of nuclear science and technology. The Department of Nuclear Science and Engineering at MIT offers what is probably the widest spectrum of research activities of any nuclear department in the country. Our faculty and students develop nuclear reactors for diverse uses, including waste management and space propulsion They contribute to security by exploring ways to monitor nuclear materials and detect nuclear threats. They apply nuclear technologies to the physical and life sciences in areas ranging from neutron interferometry to radiation modeling and magnetic resonance imaging, and they work in direct support of the International Tokamak Experimental Reactor, a project aimed at demonstrating the scientific and technical feasibility of fusion power.

Faculty and Administratiion

In August 2009, Ian Hutchinson stepped down after a six-year tenure as department head and was succeeded by Richard Lester.

Two new assistant professors joined the department this year: Paola Cappellaro, a specialist in spin-based quantum information processing in the solid state, and Anne White, an experimentalist studying turbulence in thermonuclear plasmas. Felix Parra Diaz, a plasma theorist, accepted a position as an assistant professor in the department as part of our faculty search this year but has deferred his appointment until 2011.

Two faculty members were promoted this year. Jacopo Buongiorno was promoted to associate professor with tenure. Dennis Whyte was promoted to full professor.

Ronald Parker will retire on September 1, 2010. David Cory and Jacquelyn Yanch announced their resignations from the department this year. Professor of the practice Andrew Kadak took up a new position in industry.

Mujid Kazimi continues as director of the Center for Advanced Nuclear Energy Studies.

Jeff Freidberg continues as associate director of the Plasma Science and Fusion Center (PSFC).

Richard Lester continues as director of the MIT Industrial Performance Center. He also serves as faculty advisor to the President's Advisory Council on Regional Engagement.

Professor Kazimi succeeded Professor Yanch as chair of the NSE graduate committee and Professor Whyte continues as chair of the NSE undergraduate program. Peter Brenton is our administrative officer, and Clare Egan is our academic administrator.

The department notes with sadness the passing of former faculty member and department head Edward A. Mason.

Research Highlights

The department is playing a leading role in a major new Nuclear Energy Modeling and Simulation Energy Innovation Hub based at Oak Ridge National Laboratory. In addition to MIT, the Department of Energy (DOE)–funded Consortium for Advanced Simulation in Light Water Reactors includes partners from other universities and national laboratories as well as industry, and is expected to receive $122 million over five years. The MIT team is led by NSE professors Mujid Kazimi, Sidney Yip, and Jacopo Buongiorno, and includes professors Benoit Forget and Bilge Yildiz and research scientist Aydin Karahan of NSE, as well as professors Michael Demkowicz and Jeff Grossman of Materials Science and Engineering and professor John Williams of Civil and Environmental Engineering.

Fission energy research is mainly conducted through the department's Center for Advanced Nuclear Energy Studies. Research on advanced reactor designs, new fuel-cycle technologies, and advanced light water reactor technologies is carried out by professors Mujid Kazimi, George Apostolakis, Jacopo Buongiorno, Michael Driscoll, Benoit Forget, Michael Golay, Andrew Kadak, Neil Todreas, Bilge Yildiz, and Sidney Yip, and by Charles Forsberg (director of the Fuel Cycle Study) and research scientists Aydin Karahan and Tom McKrell. New research initiatives this year include a program to develop and validate advanced simulation methods and diagnostics for multiphase flow and heat transfer, led by Jacopo Buongiorno. Benoit Forget and Bilge Yildiz are contributing to fission energy research through their studies in reactor physics and the behavior of materials interfaces in extreme environments, respectively.

Paola Cappellaro has established the Quantum Engineering Group in the Research Laboratory for Electronics. She and her students are studying large quantum systems, comprising many nuclear spins, to explore coherence properties and noise reduction techniques. In parallel, they are studying small quantum systems with modular characteristics capable of scalable quantum computation as well as dedicated tasks such as quantum metrology.

Senior research scientist Richard Lanza is collaborating with Joseph Minervini and Timothy Antaya of PSFC in the development of compact superconducting cyclotrons; potential applications include medical isotope production, materials testing, proton therapy, and fundamental neutrino physics studies. Lanza is also collaborating with Raytheon on the development of new tools for long-range detection of radioisotopes, a capability useful in nuclear safeguards and nonproliferation applications.

Dennis Whyte began serving as director of the Plasma-Surface Interactions Science Center , a collaboration between MIT, the University of California at San Diego, and the University of California at Berkeley, and based at the PSFC. The center was launched following the award of a $7 million five-year grant by DOE's Office of Fusion Energy Sciences, and focuses on fundamental scientific studies of the plasma-surface interface. Jeff Freidberg and his students continue their investigations of plasma equilibria in toroidally axisymmetric magnetic confinement devices.

A special highlight of the year was the department's inaugural Doctoral Research Expo. Held in the Stata Center in March, this event brought together 39 doctoral students from all areas of the department to present posters and papers on their research. The event was marked by lively discussion among presenters and visitors from around the Institute.

Education

A total of 109 students pursued graduate degrees in nuclear science and engineering. Slightly more than half of them worked in the fission energy field, 28 percent in fusion and plasma physics, and 19 percent in other nuclear science and technology applications. The department awarded 23 SM degrees, 1 NE degree, and 15 PhD degrees—the largest number of PhDs granted by any nuclear engineering department in the country. Twenty-four students entered the graduate program in fall 2009.

Undergraduate enrollment continues above historical levels for the department. A total of 51 students were enrolled in the undergraduate program during the past year. This included 22 sophomores, 16 juniors, 13 seniors, and 2 fifth-year students. Ten students completed requirements for the bachelor's degree in nuclear science and engineering from September 2009 through June 2010.

The fall 2009 design course, taken mostly by undergraduates, focused on the design of a molten-salt-cooled power reactor to replace the current MIT research reactor within the same containment dome. Under Professor Kadak's direction, the students found that a molten-salt-cooled, pebble-bed-fueled power reactor, when coupled with a supercritical CO_2 power conversion system, could produce 20 megawatts of electricity and considerably reduce MIT's carbon footprint.

Professor Golay launched an undergraduate version of the department's long-running course on sustainable energy. Course 22.081J Introduction to Sustainable Energy is now a core subject in the Institute's undergraduate energy minor.

Faculty Awards, Honors, and Activities

Professor George Apostolakis was sworn in as a member of the Nuclear Regulatory Commission on April 1, 2010.

Professor Ronald Ballinger was appointed to an independent review panel of the Massachusetts Water Resources Authority that is examining the circumstances that led to a major failure along a section of the MetroWest Water Supply Tunnel.

Professor Benoit Forget received the Ruth and Joel Spira Award for Distinguished Teaching.

Professor Paola Cappellaro received the PAI Outstanding Teacher Award (presented by the MIT student chapter of the American Nuclear Society).

Professor Jacopo Buongiorno was program chair for the 2010 International Congress on Advances in Nuclear Power Plants. He also gave the keynote lecture, "Nanofluid Heat Transfer Enhancement for Nuclear Reactor Applications," at the Micro/Nanoscale Heat Transfer International Conference in Shanghai in December 2009.

Professor Mujid Kazimi received the Technical Achievement Award of the Thermal Hydraulic Division of the American Nuclear Society for 2009. He was elected as a member of the International Nuclear Energy Academy and became a member of the newly formed United Arab Emirates International Advisory Board on Nuclear Energy. He was also appointed chair of the Advisory Board of the Institute of Nuclear Energy Science and Technology at Idaho National Laboratory.

Professor Bilge Yildiz was appointed Norman C. Rasmussen Career Development Professor of Nuclear Science and Engineering, effective July 1, 2010.

Professor Richard Lester was appointed Japan Steel Industry Professor of Nuclear Science and Engineering, effective July 1, 2010.

Student Awards and Activities

Gary Eastwick received the Roy Axford Award for academic achievement by a senior in Nuclear Science and Engineering.

Michael Elliott received the Manson Benedict Award, presented to a nuclear science and engineering graduate student for excellence in academic performance and professional promise.

Bo Feng coauthored "Thermal Hydraulics of PWRs Transitioning to High Performance Annular Fuel," which won the ANS Thermal Hydraulics Division Paper of the Year Award for 2009.

Sara Sheldon received the Outstanding Teaching Assistant Award in recognition of exceptional contributions as a teaching assistant in Nuclear Science and Engineering.

Michael Short won Best Poster Award at the inaugural NSE Doctoral Research Expo in March 2010.

John Galle-Bishop, Christie Lin, and Geoff Olynyk were inducted into the Alpha Nu Sigma National Honor Society for Nuclear Science and Engineering.

Vladimir Sobes received the Irving Kaplan Award for academic achievement by a junior in Nuclear Science and Engineering. He was also inducted into the Alpha Nu Sigma National Honor Society.

Outstanding Undergraduate Research Opportunities Program Awards in Nuclear Science and Engineering were presented to Lauren Ayers, Sara Ferry, and Ruaridh MacDonald.

Outstanding Student Service Awards in recognition of exceptional service to students, the department, and the entire MIT community were presented to Joseph Hubley, Jacob DeWitt, and Stephanie Kempf.

Graduate students Mark Massie, Robert Petroski, and Jeremy Roberts were winners of the 2010 Innovations in Fuel Cycle Research Awards sponsored by the DOE. Petroski and Massie placed first and second respectively in the isotope transmutation category; Roberts placed second in the nuclear science and engineering category.

Richard K. Lester
Department Head
Japan Steel Industry Professor of Nuclear Science and Engineering

More information about the Department of Nuclear Science and Engineering can be found at http://web.mit.edu/nse/.