DOE Princeton Plasma Physics Laboratory

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PPPL NEWS

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MINDS Licensing Agreement Signed

Nuclear Detection Technology Developed by PPPL Could Boost Homeland Security

Princeton University and InSitech, Inc. have signed a licensing agreement for InSitech to commercialize an anti-terrorism device developed by the U.S. Department of Energy's Princeton Plasma Physics Laboratory (PPPL). The device, the Miniature Integrated Nuclear Detection System (MINDS), would have applications in transportation and site security.

Scan for Specific Nuclear Signatures

MINDS would be used to scan moving vehicles, luggage, cargo vessels, and the like for specific nuclear signatures associated with materials employed in radiological weapons. The system could be employed at workplace entrances, post offices, tollbooths, airports, and commercial shipping ports, as well as in police cruisers, to detect the transportation of unauthorized nuclear materials.

"We are very pleased that technology we have developed through our fusion research at PPPL can also make an important contribution to Homeland Security. This is a very good example of the kind of cooperation that can be most effective for the nation," said PPPL Director Rob Goldston.

A team of PPPL researchers led by Charles Gentile designed a prototype system and InSitech, through the licensing agreement signed March 28, has certain rights to the commercial development, manufacture, use, and sale of the product.

InSitech is a not-for-profit organization working for the U.S. Army to bring government-developed technology to market. InSitech's Chief Executive Officer Timothy N. Teen

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MRI Experiment May Shed Light on Star and Planet Formation

by Anthony DeMeo

The formation process of stars and planets remains one of the big questions in astrophysical science. Presently, scientists do not understand the required conditions and the accretion, or matter collection process, involved in this formation. The Magnetorotational Instability (MRI) experiment at PPPL, however, may shed light on this mystery.

"The Earth must have sufficient angular momentum so that it does not fall into the Sun under the influence of gravity," said PPPL physicist Hantao Ji, who is the project's Principal Investigator. Angular momentum is the impetus of a body to keep rotating. "We also know that galaxies and solar systems have a preferred direction of rotation. Consequently, matter forming these systems must also have had net angular momentum, which must have been overcome by gravity for the matter to coalesce."

Ji explained that the angular momentum prevents matter from falling into the star directly, so an accretion disk

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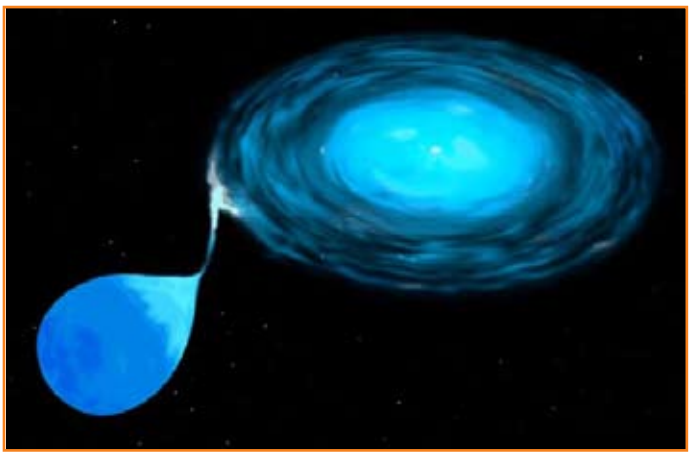

Accretion occurs in a binary star system when one star is paired with a sufficiently compact star such as a white dwarf, a neutron star, or a black hole. An accretion disk may form as the stellar envelop of the first star is captured by the denser star. (Space Telescope Science Institute, NASA)

MINDS

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said, "We enjoy our relationship with the Princeton-PPPL team and are proud of our involvement with MINDS. This agreement typifies InSitech's initiative to transfer federally funded technology into the commercial sector."

MINDS, which combines many off-the-shelf components with specific nuclear detection software, is capable of detecting X-rays, soft gammas, gammas, and neutrons. The system is specifically designed to identify, in real-time, gamma emitting radionuclides at levels slightly above background and in radiologically noisy environments. Radionuclides can be recognized and differentiated from one another since each has a distinctive energy signature or "fingerprint."

MINDS compares the energy spectrum of the detected radionuclide with the spectra of particular radiological materials that might be used in weapons.While InSitech proceeds with commercialization of the product, PPPL will continue to develop the library for MINDS, collecting data for radionuclides.

Three Different Radiation Detectors

The MINDS system is configured to employ a lap-top computer and can also be used with other types of processors for the storage of radionuclide databases. The unit uses proprietary detection software, and three different radiation detectors, or heads, to cover a wide gamut of nuclear signatures. It would typically be able to detect radiation — dependent on source quantity — from several feet away and would identify the type of radiation, but not specifically the quantity. System hardware could be configured with one, two, or more heads to suit the needs of law enforcement and Homeland Security officials. For instance, airport officials might be interested in detecting materials such as cobalt or cesium that could be used in a "dirty" bomb.

At tollbooths or in police cruisers, the system would be tuned to recognize but not sound an alarm for radioactive materials with legal uses such as medical radioisotopes. It will be programmed to respond only to signatures of threat-specific radionuclides, greatly minimizing false positive alarms. MINDS also would be able to detect some shielded materials since shielding often results in the generation of X-rays of certain energies.

At a recent meeting at PPPL to discuss upcoming MINDS deployments for homeland security applications are, from left, PPPL's Lewis Meixler; Picatinny Arsenal's Tom McWilliams; PPPL's Kenny Silber, Bill Davis, Steve Langish, and Charlie Gentile; Advanced Logic Systems' Kaydon Stanzione and Michael Fisher; and InSitech's Roger Adams.

"The MINDS system is a sophisticated solution that can identify — not just detect — in real time, one-one-billionth of the material required in a dirty bomb, yet it is cost effective, easy to use, and can be deployed as a stand-alone device or as part of a larger system. MINDS has achieved successful results in field trials, and we have recently secured extended demonstrations, and full-scale deployments, with customers and government agencies to further validate this compelling breakthrough," said Teen.

Once a unit is in place, law enforcement agencies would incorporate it into an alerting system. For example, it could be set up at a tollbooth so that when a suspicious vehicle is detected, a picture would be taken, and an e-mail or wireless alert would be sent to authorities. The vehicle could then be stopped a short distance beyond the tollbooth.

For more information about MINDS, go to www.pppl.gov, select publications, and then go to PPPL Digests and choose, "PPPL Researchers Develop Anti-terrorism Device."

The MINDS team from PPPL includes Bill Davis, Charlie Gentile, Steve Langish, Dana Mastrovito, Lewis Meixler, and Kenny Silber. ●

PPPL NEWS

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MRI

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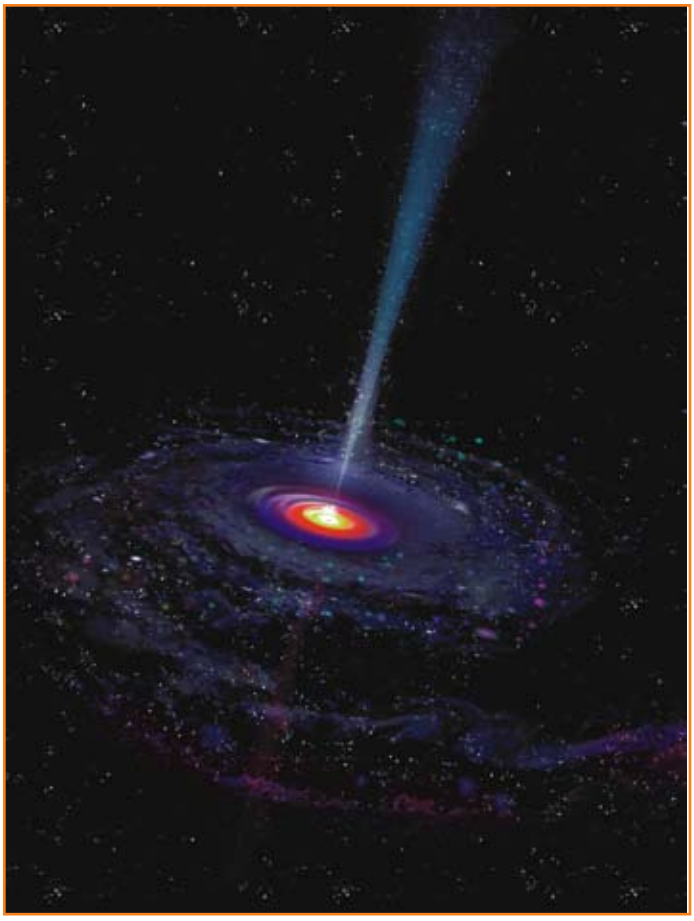
is formed, which consists of matter losing its angular momentum and swirling into the core of the star. "For example, when our Sun was formed, the accretion process was very efficient in casting off angular momentum because most of the material comprising our solar system ended up in the Sun," he said.

Since angular momentum must be conserved, the lost amounts must be efficiently transported elsewhere. But how does this happen, and where does the angular momentum go?

Unique PPPL Apparatus

Star formation occurs in deep space and therefore is not directly observable, so the accretion process has been described only in theoretical models and in their resulting computer simulations. The unique PPPL apparatus will be the first anywhere to attempt a direct test of this widely postulated physical process in accretion disks.

The project's primary mission is to test the plausibility of a 1991 theory that indicates magnetorotational instability (MRI), a disruptive plasma process, plays a major role in accretion. Unlike most PPPL experiments, MRI will not use an actual plasma. Ji and Princeton University Professor Jeremy Goodman, the principal collaborator for theory and astrophysics on the project, came up with a way to physically simulate an accretion disk with material "standing in" for the plasma, dust, and other materials.



Above is a rendering of an accretion disk around a massive black hole often thought to exist in the center of many galaxies. (NASA)

The system they have built consists of two concentric cylinders, each 28 centimeters in length, free to rotate independently about a common axis. The inner cylinder has a radius of 7 centimeters and is made of steel, and the outer cylinder has a radius of 20.3 centimeters and is of made of plastic to allow visual inspection.

During a typical experiment, the space between the cylinders will be filled with a liquid metal, chosen because it is easy to maintain and interacts with the magnetic field in ways similar to plasma. The researchers have chosen a mixture of 67 percent gallium, 20.5 percent indium and 12.5 percent tin. The inner and outer cylinders will rotate independently in the same direction, but at significantly different speeds, 4,000 rpm and 533 rpm, respectively. The project is a significant engineering challenge since it requires two rotating disks at each end of the cylinders. The disks must be driven at different speeds by separate motors through six concentric pipes.

Experiments will be conducted with and without a magnetic field parallel to the axis of the cylinders. Researchers will measure the differences in the torque on the cylinders between both conditions. The magnetorotational instability, when it occurs in the liquid metal, will cause angular momentum to be transferred from the inner cylinder toward the outer cylinder, resulting in an increase in torque couplings between cylinders. This is equivalent to the transfer of angular momentum outward in an accretion disk, allowing matter to fall toward its center, forming a star. This result would support the hypothesis that MRI is responsible for the transport of angular momentum.

Better Understand Phenomena

Accretion disks also form around massive black holes in the center of many galaxies and in binary star systems. Results from the PPPL experiments will help astrophysicists better understand these phenomena. Understanding transport phenomena in plasmas is important for basic plasma physics in general, and also for fusion plasmas in particular.

Staffing the MRI project are Ji, postdoc Michael Burin, and graduate students Ethan Schatman and Wei Liu, with technical and engineering support from PPPL's Robert Cutler, Steve Raftopoulos, Phil Heitzenroeder, Chang Jun, and Lew Morris. The team is working in collaboration with Professor Goodman of the Princeton University Observatory. The work is being funded jointly by the Department of Energy, the National Science Foundation, and NASA. ●

PPPL-Led Team Completes Work on JET Alpha Detector

by Anthony DeMeo

At left is the JET Alpha Detector built at PPPL with (clockwise from left front) Dave Miller, Bob Ellis, Doug Darrow, and Joe Frangipani.

Studying the behavior of alpha particles produced in fusion plasmas is of paramount importance for ITER and other advanced fusion devices in which these particles are expected to be the predominant source of plasma heating. An international team led by PPPL physicist Doug Darrow recently completed work at PPPL on the construction of diagnostic equipment that will be used to measure alpha particles and other energetic particles ejected from the plasma in the Joint European Torus (JET) in Culham, England. The alpha detector was shipped to JET this spring.

Neutrons and alpha particles are produced when deuterium (D) and tritium (T) ions fuse. The neutrons carry away about 80 percent of the fusion energy produced, the alphas the rest. The positively charged alpha particles (helium-4 nuclei) can impart energy to the plasma, heating it. "PPPL did a good bit of work on alpha detection for the deuterium-tritium experiments on TFTR [Tokamak Fusion Test Reactor]. A lot of good results came out of that work, and that's what sold JET on getting into this in earnest," noted Darrow, who was involved in the TFTR measurements.

Built at PPPL

The diagnostic equipment, built at PPPL, is one of two different kinds of JET alpha particle detectors being supplied under a collaboration among researchers from the UKAEA, the Max Planck Institute for Plasma Physics (IPP) in Greifswald, Germany, and the Colorado School of Mines in the U.S. PPPL's effort began in early 2002. Since then, the Laboratory has received about $1.5 million from the Department of Energy for the design and fabrication of one of the two detectors. In addition, the IPP has invested roughly $1 million for the design and fabrication of the second detector at Greifswald.

The collaboration's primary interest is the measurement of alpha particles that exit the plasma before having a chance to heat it. "Alphas and other energetic particles can drive instabilities in the plasma that cause the alphas to be ejected. Studies on JET using these lost alpha diagnostics will provide new insights into the causes and nature of instabilities driven by alpha particles and other energetic particles," said Darrow. ●

NASA Talk Highlights Annual Safety Forum

Sheila Widnall (at right) delivered the keynote talk, "Lessons Learned from the Columbia Accident Investigation and How They Apply to the R&D Environment," at PPPL's Fourth Annual Safety Forum on February 18. Widnall is a professor of aeronautics and astronautics at the Massachusetts Institute of Technology. The ES&H and Infrastructure Support Department hosted the forum, which included a series of presentations aimed at improving workplace safety.

PPPL "Artists" Win Art of Science Competition

Above, Andrew Post-Zwicker (left) and Elle Starkman with their collaborative art, "Plasma Table." At right is the first-place winning photo, which features a dust cloud of silica microspheres suspended in a plasma and illuminated by laser light.

PPPL's Elle Starkman and Andrew Post-Zwicker won the first-place prize May 3 for their photographic submission, "Plasma Table," in the "Art of Science" Competition at Princeton University. The winning piece, for which the artists received a $250 prize, is displayed at the Friend's Center for Engineering Education, along with many of the other top submissions out of more than 200 received. Starkman is PPPL's staff photographer and Post-Zwicker is the Head of PPPL's Science Education.

The competition was launched by students and faculty from a number of departments seeking entries of images that came directly from research in science and engineering or works by artists incorporating tools and concepts from science. Images were submitted by students, faculty, and staff from 16 departments across campus. The contest and exhibition were created to get people at Princeton who use imagery as part of their research more involved in the visual arts program and in the arts in general. ●

Female Students Flock to PPPL for Conference

Nearly 200 female eighth through 12th graders came to PPPL on March 11 for the fourth "Expand Your Horizons Mini-conference for Young Women in Science, Mathematics, and Technology."

"It's a great opportunity to encourage science and engineering careers for young women," said Christine Ritter, PPPL Science Education Program Administrator and organizer of the event. The conference included talks by women in the sciences and exhibits. Exhibitors were from the FMC Corporation, Mercer County Community College, the N.J. Department of Environmental Protection's Division of Watershed Management, NJIT, Princeton University, and PPPL. Speakers were from the Fashion Institute of Technology, Johnson & Johnson, the N.J. Department of Environmental Protection, New York University, and the U.S. Army Corps of Engineers. ●

At left, West Windsor-Plainsboro High School South student Sumona Bhattacharya (right) watches Becky Barak, of the Princeton Environmental Institute at Princeton University, make "clouds in a bottle" to demonstrate that cloud formation is based upon changes in temperature and pressure.

Redi Receives DOE Mentoring Award

PPPL Principal Research Physicist Martha Redi recently received the Outstanding Mentor Award from the Department of Energy's Office of Science. The citation, which honors Redi for her mentoring efforts in 2004, reads, "In recognition of your dedication as a mentor, to share knowledge and to inspire and instill confidence in the next generation of scientists and engineers by setting high expectations, seeking for creative solutions, and immersing inquisitive minds in the world of science." Redi is the only PPPL recipient of the 2004 award, which is given through the Office of Science Undergraduate Research Program.

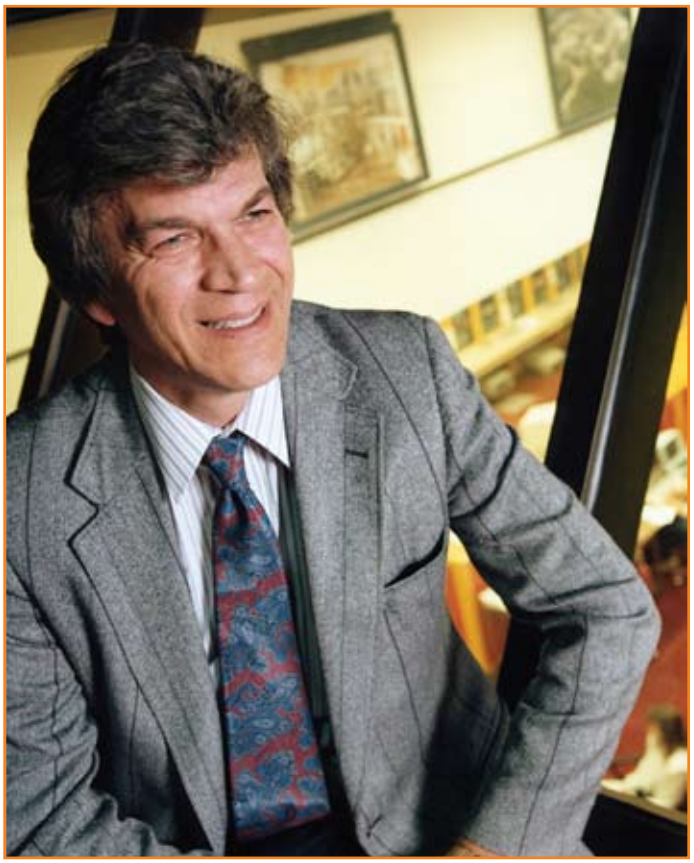
At right, PPPL Director Rob Goldston (left) and PPPL Deputy Director Rich Hawryluk (right) congratulate Redi on receiving the award. ●

PPPL Garners Small Business Administration Award

At the award ceremony are (from left) Small Business Administration's Allison Randolph, Princeton University's Michelle Christy, PPPL's Arlene White, Small Business Administration's William Manger, PPPL's Rodney Templon and Rob Goldston, Small Business Administration's Larry Hansen and Janette Fasano, PPPL's Ed Winkler, and U.S. Department of Energy's Greg Pitonak. The award is on display in the Director's Office lobby.

On May 19, Representatives of the U.S. Small Business Administration (SBA) presented PPPL Director Rob Goldston with an "Award of Distinction" in recognition of the Laboratory's "Outstanding Public Service" in providing subcontracting opportunities and assistance to small business. This is the second time the Laboratory has received the award. Less than two percent of SBA's portfolio of large contractors are active recipients of this award. Denise Benjamin, SBA's Acting Associate Director for Government Contracting, said in a letter to Goldston, "I especially wish to commend Arlene White, Small Business Liaison Officer [at PPPL]. She shows exceptionally strong support of the company's small business program and plays a significant role in promoting opportunities for small businesses." ●

IEEE Honors Davidson for Beam Physics Work



Ronald C. Davidson

In recognition of his important contributions to beam physics, PPPL's Ronald C. Davidson has been selected to receive the Particle Accelerator Science and Technology (PAST) Award for 2005.

Davidson is being honored for "*pioneering contributions to the theory of charged particle beams with intense self fields, including fundamental studies of nonlinear dynamics and collective processes.*" Davidson received the award on May 18 during the biennial Particle Accelerator Conference in Knoxville, Tenn. The PAST Technical Committee of the IEEE [Institute of Electrical and Electronics Engineers] Nuclear and Plasma Sciences Society sponsors the award.

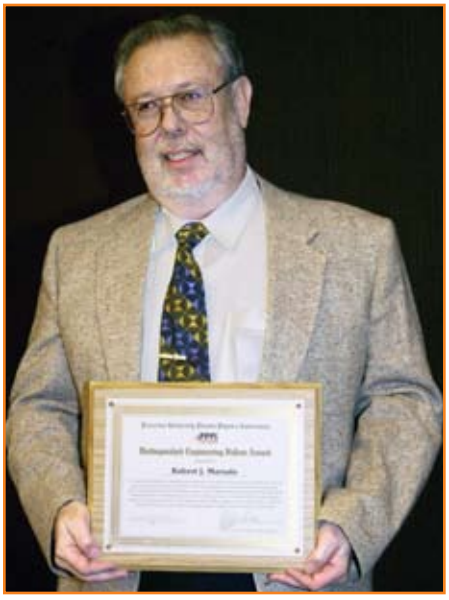
The PAST Award nomination letter noted Davidson's seminal research in the physics of intense charged particle beams and one-component nonneutral plasmas, as well as his important contributions to graduate education and the training of research scientists, and his enthusiastic community service and scientific management skills.

Davidson is a professor of Astrophysical Sciences at Princeton University and the Deputy Director of the Virtual National Laboratory (VNL) for Heavy Ion Fusion, a collaborative effort among PPPL, Lawrence Berkeley National Laboratory, and Lawrence Livermore National Laboratory. At PPPL, he is Deputy Head of the Theory Department and Head of the Beam Dynamics and Nonneutral Plasma Division. ●

Princeton Awards Cylinder

In March, PPPL's Dave Cylinder was among five Princeton University staff members to receive the 2004 President's Achievement Award in recognition for their exceptional performance. Above is Princeton President Shirley Tilghman (left) with Cylinder.

PPPL Honors Marsala



PPPL engineer Robert Marsala (at right) received the PPPL Distinguished Engineering Fellow Award in November. The Lab honored Marsala for significant contributions to the advancement of plasma science and electrical engineering technology. Marsala was cited for his technical ability, creativity, and resourcefulness, as well as for a long history of innovative contributions in the design, fabrication, operation, and maintenance of electronic systems that have proven critical to the high performance, safe, and reliable operation of many fusion experiments at PPPL.

American Association for the Advancement of Science Names Meade and Sauthoff Fellows

In recognition of their exceptional research contributions to and leadership in magnetic confinement fusion science, PPPL's Dale Meade and Ned Sauthoff have been elected Fellows of the American Association for the Advancement of Science (AAAS). New Fellows were honored in February in Washington, D.C., at the AAAS Fellows Forum, a part of the association's annual meeting.

PPPL Director Rob Goldston said, "We are very pleased that the AAAS has chosen to honor two of the leaders of our Laboratory. Dale and Ned both have long records of scientific accomplishment and leadership, and this award is very well deserved."

Dale Meade

Meade is Program Head of the PPPL Off-Site Research Department and leads the Next Step Options Division at the Laboratory. He came to PPPL in 1973 after serving as a professor of physics at the University of Wisconsin and was Deputy Director of the Laboratory from 1991 to 1997. From 1986 to 1991, he was Head of the Tokamak Fusion Test Reactor project and of Experimental Physics in the Research Department, and prior to that headed many experiments.

Ned Sauthoff

Sauthoff is a Principal Research Physicist at PPPL and a leader in the coordination of international fusion research activities. He was recently named U.S. ITER Project Manager. Sauthoff has headed numerous departments at PPPL, including the Off-Site Research Department, Plasma Science and Technology Department, Physics Department, Experimental Projects Department, and Computer Division. ●

Cheng, Ji, and Wong Receive American Physical Society Honors

Frank Cheng

Hantao Ji

King-Lap Wong

The American Physical Society (APS) recently honored three scientists at PPPL. Chio Z. "Frank" Cheng and King-Lap Wong received the APS 2004 Award for Excellence in Plasma Physics Research and Hantao Ji was named an APS Fellow. APS officials announced the honorees during the society's Division of Plasma Physics annual meeting, held in Savannah, Georgia, in November.

Cheng and Wong were among five scientists to receive the Excellence in Plasma Physics Research Award in recognition "for the theoretical discovery and experimental identification of toroidicity induced alfven eigenmodes." This work relates to the confinement of energetic alpha particles, which is important to fusion energy research. The other recipients are William Heidbrink and Liu Chen, of the University of California, Irvine, and Edward Strait, of General Atomics in San Diego. The annual award consists of $5,000 to be divided equally among recipients, and includes a certificate citing the contributions made.

Ji received the lifetime appointment of Fellow in recognition of his contributions to the field of plasma physics. The APS rules limit the maximum number of Fellows selected each year to be no more than half of one percent of the Division membership. ●