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MPA Materials Matter

INSIDE

In his laser lab, Hou-Tong Chen tests specially designed structures called metamaterials, which can be used to manipulate electromagnetic waves. Detectors capture the spectral response of the metamaterials and record the signals in graph form on a nearby computer screen.

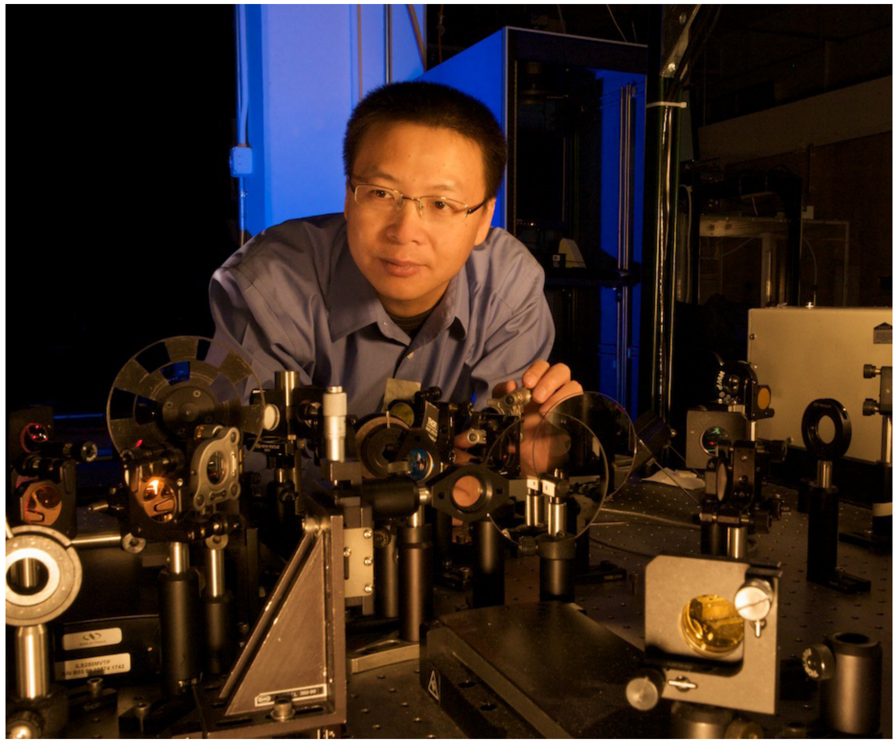

Photo by Robert Kramer

Hou-Tong Chen

Bringing the possibilities of metamaterials to light

By Diana Del Mauro, ADEPS Communications

For a decade, futuristic invisibility cloaks, bendable light, and superlenses defying diffraction limits have tantalized materials physicists who build tiny artificial structures called metamaterials, hoping to master their unnatural properties.

"Maybe after another 10 years, they'll find cloaking very useful for making things disappear, like airplanes, and freak everyone out!" said Hou-Tong Chen, a member of the nanophotonics and optical nanomaterials thrust at the Center for Integrated Nanotechnologies (CINT).

> *"We want to develop the individual components that are necessary to build a flat optics system for applications such as short-range communications and imaging."*

He's sticking with more tangible aspects of metamaterials—a set of properties that can manipulate electromagnetic polarization states and direct how light travels (think lenses, prisms) without the use of curved materials. His research keeps him running between his office, where he builds models on his computer; the CINT clean room, where he fabricates metamaterial samples; and his laser lab, where he tests his creations.

The lure is flat optics, which employ flat lenses made of metamaterials instead of conventional curved lenses. By them-

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From Mike's desk . . .

Change continues to be the watchword at Los Alamos National Laboratory, particularly so for division level leadership within the Principle Associate Directorate for Science, Technology, and Engineering. Doug Fulton retired from Los Alamos at the end of July after serving as Physics Division leader since the fall of 2008. His replacement, David Meyerhofer, comes to the Lab from the University of Rochester where he currently serves as both the deputy director of the Laboratory for Laser Energetics and professor of physics and mechanical engineering. Tony Redondo completed his tenure as Theoretical Division leader at the end of June, a post he held since the 2006 Los Alamos National Security contract transition; Jack Shlachter is acting division leader until a replacement is selected. Closer to home, Toni Taylor became the deputy associate director for the Chemistry, Life, and Earth Sciences directorate (ADCLES) early in June. As Materials Physics and Applications' (MPA) longest standing division leader Toni has been a dedicated and enthusiastic champion for all things MPA. Toni garners praise for her strong support of MPA's two user programs, the Center for Integrated Nanotechnologies (CINT) and the National High Magnetic Field Lab-Pulsed Field Facility (NHMFL-PFF). Toni provided effective leadership in her role as program manager for Los Alamos's Department of Energy-Basic Energy Sciences Materials Science and Engineering portfolio. In partnership with Materials Science and Technology Division leadership, Toni also led the Laboratory's materials community through no less than seven very successful Materials Capability Reviews and she showed steadfast leadership for the science that underlines the Lab's Materials Strategy. Our loss is ADCLES's gain, and all of MPA wishes Toni great success in her new assignment.

> *". . . MPA researchers continue to turn out noteworthy publications and receive awards that attest to the quality of our science."*

Mary Hockaday has asked me to take on the duties of acting MPA division leader until a permanent replacement is selected. Throughout my 27-year career at Los Alamos it has been my experience that change brings opportunity and facing the challenges underlying a new assignment are the surest path to personal and professional growth. My new role has given me an opportunity to become better acquainted with the impressive research being conducted in CINT and Materials Synthesis and Integrated Devices (MPA-11), to work closely with division and directorate level managers throughout the Associate Directorate for Experimental Physical Sciences, and to work with MPA group and division management to ensure the division's continued success during this time of management transition. Chuck Mielke is now serving as the acting group leader for Condensed Matter and Magnet Science (MPA-CMMS), while Ross McDonald and Leonardo Civale are serving as acting deputy group leaders, focusing on their group's TA-35 and Materials Science Complex operations, respectively. Chuck continues to be the director of the NHMFL-PFF, with Ross taking on deputy program director responsibilities. Vivien Zapf is now director of the NHMFL-PFF user program, with Jon Betts serving as director of NHMFL-PFF user operations and Doan Nguyen director of NHMFL-PFF magnet science and technology. Leadership for our NHMFL program is doubly important now because we are working closely with our Maglab colleagues at Florida State University and the University of Florida to develop a strong renewal proposal that is scheduled for submission in 2016.

Despite these changes, MPA researchers continue to turn out noteworthy publications and receive awards that attest to the quality of our science. MPA-11 Director's Postdoctoral Fellow Wanyi Nie has been selected for the Laboratory's Postdoc Publication Prize in "Clean Energy" for her work on solution-processed perovskite solar cells that was published in *Science* in January. For his work on fuel cells and electro-catalysis Piotr Zelenay of MPA-11 was awarded the national title of Professor in Chemistry by the President of Poland during a June ceremony held at the presidential palace in Warsaw (see page 7). Marc Janoschek of MPA-CMMS led an international research team that used inelastic neutron scattering to find the elusive signature of magnetism in plutonium (see page 6); this work was published in *Science Advances* in July and solves the plutonium "missing-magnetism" conundrum that has bedeviled actinide researchers for decades.

These accomplishments provide compelling evidence that at MPA we are successfully carrying out our mission to explore and exploit materials properties to address national security issues.

Acting MPA Division Leader Mike Hundley

From Chuck's desk . . .

The future of the Magnet Lab at Los Alamos

Recently the funding agent of the National High Magnetic Field Laboratory (NHMFL), the National Science Foundation (NSF), informed the NHMFL leadership that it intends to solicit a renewal for the funding of the NHMFL. Prior to that we were gearing up for a "re-competition." The news was welcome as probability of the NHMFL continuing in a similar structure as it is now is much more likely. The NHMFL is based on a collaboration between Florida State University, the University of Florida and Los Alamos National Laboratory. The three host institutions are responsible for operating a given branch of the NHMFL. At Los Alamos we operate the Pulsed Field Facility and our mission is to provide qualified users with access to the highest research quality magnetic fields available. What does "research quality" mean? The kinds of magnetic field environments that users require for (typically) condensed matter experiments is a field of long enough duration to measure a physical property of a material sample of dimensions of a millimeter on a side. Our magnetic field pulse durations last from a few microseconds to more than 3 seconds.

"The NHMFL-PFF at Los Alamos is unique because we have an amazing collection of experts who are truly exquisite in conducting experiments in extreme magnetic fields."

Another key aspect to delivering "research grade" magnetic fields to users is by providing users with advanced measurement methods. In the realms of condensed matter physics research there are a myriad of expert experimentalists on a very broad range of techniques for determining useful physical properties of a given sample. Around the world there is a relatively small number of experts of performing those measurements in transient magnetic fields. As the duration of the magnetic field is shortened, the measurement becomes more difficult for most methods of physically probing a material's properties. Additionally, there are several high magnetic field generating techniques that can produce very high fields in short (nanosecond to microsecond) times in small volumes (~1% field homogeneity in 0.1 mm^3). In some fields of physics those constraints are adequate for the experiment, but for materials research, macroscopic samples of the order of 1 mm^3 require a field homogeneity that tends to be somewhat better than 1% in order to avoid smearing out the signature of the physical property that is sought (for example detection of a magnetically induced phase transition). Another limiting factor to "research grade" magnetic field quality is the rise time of the pulse. The faster the rise time, the greater the induced electrical current into anything conductive in the field volume. Extreme magnetic field generation requires extreme electrical currents and usually voltages. This is where things start to get interesting and why there are so few places around the world generating extreme high magnetic fields for users. Your precious sample will act as a secondary coil in a transformer if it is metallic and will conduct a current within it proportional to the rise time and intensity of the applied magnetic field. Of course there will also be mechanical forces on the sample and anything electrically conductive in the field volume. So, not only does your sample want to jump to another position during the pulse, but the wires, the contact pads, even the cryostat, flanges, etcetera all interact. Designing an effective sample environment in a pulsed magnet has been done but is not rudimentary. There are many cases where the cryostat that houses the sample and probe jump violently out of the magnet and results in a poor experiment. In other cases, samples or probes have been observed to actually vaporize in some extreme magnet systems.

The NHMFL-PFF at Los Alamos is unique because we have an amazing collection of experts who are truly exquisite in conducting experiments in extreme magnetic fields. Los Alamos National Laboratory also brings to bear an extensive suite of pulsed power capabilities that is world unique in terms of the electrical energy that we can deliver in a given pulse. The future of the NHMFL at Los Alamos is bright and is now more likely to continue to provide researchers from around the world with state-of-the-art extreme magnetic fields.

Acting Condensed Matter and Magnet Science Group Leader Chuck Mielke

Chen cont.

selves, quantum dots and graphene don't interact strongly enough with light, severely limiting the functionality of optical devices. But, "if we can integrate those materials with metamaterials, we can engineer the response," Chen said. "Their performance can be enhanced dramatically and give us more opportunities to create multifunctional devices."

Instead of the intricate prisms and bulky geometric shapes found in conventional lenses, he said, pointing to his eyeglasses, metamaterials as flat as a single sheet of paper would focus light, alter polarization, and steer the light in different directions over a broad frequency range. Most importantly, since thin-layered metamaterials absorb little light, they would overcome the pitfall of bulk metamaterials, which absorb too much energy to be practical.

"We want to develop the individual components that are necessary to build a flat optics system for applications such as short-range communications and imaging," Chen said. "It can be done, that has been proven," he said—but will the imaging be sharp and fast enough for scientific instruments and satellites?

The U.S. Department of Defense lists metamaterials as a high priority research area, and the National Reconnaissance Office has funded Chen and his collaborators for a yearlong proof-of-principle study to determine how metamaterial-based thin films could be used in satellite antennae. The aim is lightweight, foldable satellites that would replace hefty satellite dishes.

"My entire career has been focused on metamaterials," said Chen as he opened boxes containing custom-designed gold and silver layered metamaterials he made the size of computer chips. When he entered the field after earning his PhD in physics from Rensselaer Polytechnic Institute in 2004, metamaterials were thought to be passive, with no on or off switch. As a CINT postdoctoral researcher at Los Alamos, he pioneered a control knob by which he could adjust how metamaterials respond to changes in voltage, light excitation, and temperature—thereby scoring his first *Nature* paper.

"I know him first through his pioneering paper in optical switching of THz metamaterials by using optical excited carriers in a semiconductor," said Lawrence Berkeley National Laboratory Materials Sciences Division Director Xiang Zhang. "This is a very clever idea, and basically opened the field of optically switchable metamaterials that is now a mainstream topic."

A terahertz beam can't focus tight like a microscope, a serious shortcoming, so Chen is pursuing the optical frequency range. In a $1.8 million-a-year Laboratory Directed Research and Development project, he leads a three-year quest for new meso-photonic materials that could control the functionality of light-matter interactions, benefitting solar cell energy harvesting as well as global security communications, imaging, and sensing. "I'm happy the Lab is supporting it because metamaterials are not commercialized yet, so funding sources are quite scarce," Chen said.

Hou-Tong Chen's favorite experiment

What: Observe the 90° polarization state rotation of the incident linearly polarized terahertz (THz) waves with high efficiency and over an ultra-broadband frequency range in our metamaterial samples

Why: Metamaterials have been known to enable exotic functionalities that are difficult or impossible to realize using naturally occurring materials. Metamaterials show promising potential in solving the so-called THz-gap caused by the lack of functional THz materials. This set of experiments validates one of our most clever design ideas— effectively controlling the polarization states of electromagnetic waves and, with further development, addressing critical issues toward a new class of high-efficiency flat optics.

When: 2012-2013

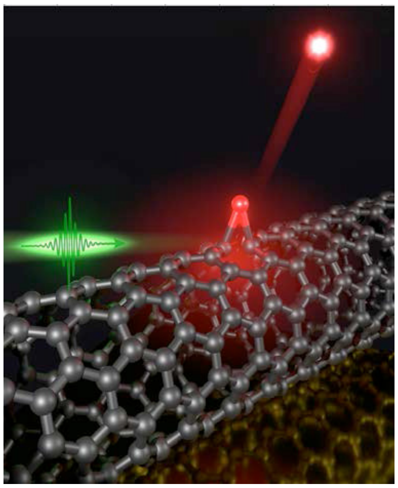
Where: Laboratory for Ultrafast Materials and Optical Science (LUMOS) at the Center for Integrated Nanotechnologies (Los Alamos) and CINT's core facility cleanroom (Sandia National Laboratories)

Who: Nathaniel Grady, Jane Heyes, Dibakar Chowdhury, Matthew Reiten, Abul Azad, Hou-Tong Chen (MPA-CINT); Toni Taylor (MPA-DO); Yong Zeng, Diego Dalvit (Physics of Condensed Matter and Complex Systems, T-4)

How: We fabricated the samples using clean room microfabrication techniques and based on our numerically validated metamaterial structure. We measured the properties using THz time-domain spectroscopy to observe the polarization state of the reflected and transmitted THz waves, as well as the frequency dependent transmission angle.

The "a-ha moment:" The a-ha moment was when we observed the broadband THz reflection or transmission with the polarization state completely orthogonal to the incident one. These measurements used metamaterial structures still on a substrate, well before the test of our final freestanding thin film metamaterials for publication.

Doped nanotubes open a new path toward quantum information technologies



A solitary oxygen dopant (red sphere) covalently attached to the sidewall of the carbon nanotube (gray) can generate single photons (red) at room temperature when excited by laser pulses (green).

In optical communication, critical information ranging from a credit card number to national security data is transmitted in streams of laser pulses. However, one can steal the information transmitted in this manner by splitting out a few photons of the laser pulse. This type of eavesdropping could be prevented by encoding bits of information on quantum mechanical states (e.g. polarization state) of single photons. Realization of such a quantum communication scheme would be a lot easier if the stream of single photons could be generated by simply making a reading lamp dimmer. However, photons emitted from lamps and lasers are distributed randomly in time; therefore “simultaneous” emission of two or more photons is always possible no matter how much they are attenuated.

True single photon generation requires an isolated quantum mechanical two-level system that can emit only one photon in one excitation-emission cycle. In the past decade, atomic-like quantum states of individual atoms, ions, and molecules as well as artificial nanoscale materials such as quantum dots, quantum wires, and nitrogen vacancy centers in diamonds have been explored for their potential in single photon generation. However, none of these systems has emerged as the ideal candidate meeting all technological requirements critical for implementation of quantum communication. These requirements include the ability to generate single photons in the 1.3-1.5 µm telecommunication wavelength range at room temperature, and compatibility with silicon microfabrication technology to enable electrical stimulation and integration of other electronic and photonic network components. Carbon nanotubes have the potential to meet all these needs. However, earlier studies revealed that nanotubes were capable of single photon emission only at cryogenic temperature, with inefficient emission also showing strong fluctuations and degradation. Therefore, researchers considered nanotubes to be less promising as materials for single photon generation.

In contrast to this belief, researchers led by Han Htoon and Stephen Doorn (Center for Integrated Nanotechnologies, MPA-CINT) reported in *Nature Nanotechnology* that incorporation of pristine carbon nanotubes into a silicon dioxide (SiO_2) matrix could lead to incorporation of solitary oxygen dopant states capable of fluctuation-free, room-temperature single photon emission in the 1100-1300 nm wavelength range. The team investigated the effects of temperature on photoluminescence emission efficiencies, fluctuations, and decay dynamics of the dopant states to determine the conditions most suitable for the observation of single photon emission. In principle, the emission could be tuned to 1500 nm via doping of smaller band-gap single-walled carbon nanotubes. This is a distinct advantage compared with diamond nitrogen vacancy centers, in which single photon emission is possible for a few discrete wavelengths shorter than 1 µm.

The oxygen-doped nanotubes can be encapsulated in a SiO_2 layer deposited on a Si wafer, presenting an opportunity to apply well-established micro-electronic fabrication technologies for the development of electrically driven single photon sources and integration of these sources into

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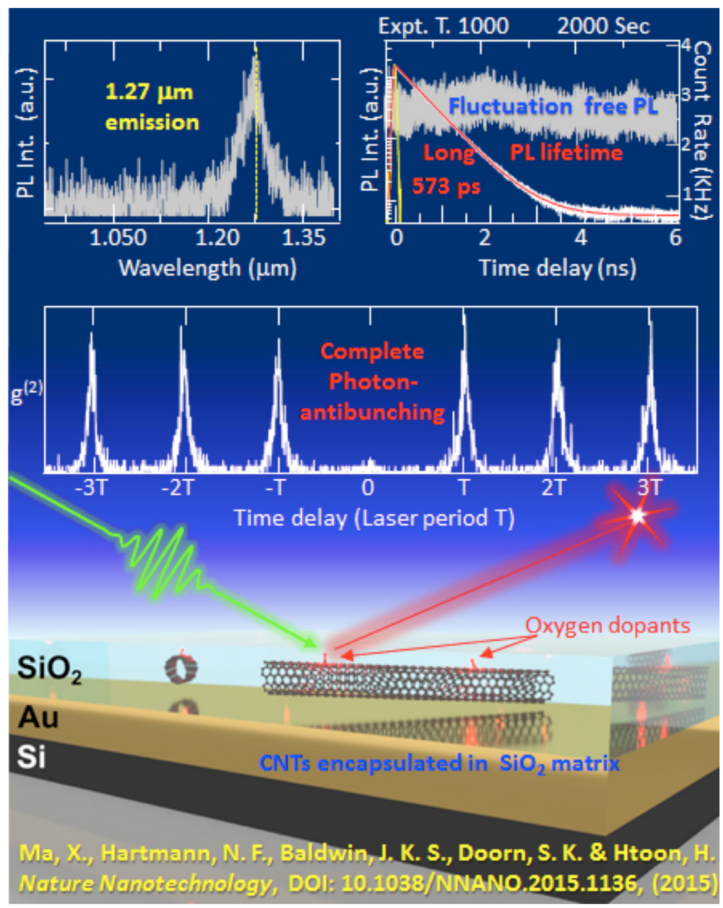


(Top) Left: Optical spectroscopic data of individual dopant states shows 1.27 µm photoluminescence emission. Right: Single exponential photoluminescence decay with 573-ps-long lifetime (white and red curves) and fluctuation-free photoluminescence emission (gray trace). (Middle): Second order photon correlation function provides evidence of single photon generation. (Bottom): Schematic illustration of carbon nanotube and oxygen dopant states encapsulated in SiO_2 matrix.

Nanotubes cont.

quantum photonic devices and networks. The team has demonstrated oxygen doped carbon nanotubes as a viable system for development of single photon sources. Beyond implementation of quantum communication technologies, nanotube-based single photon sources could enable transformative quantum technologies including ultrasensitive absorption measurements, sub-diffraction imaging, and linear quantum computing. The work has potential for photonic, plasmonic, optoelectronic and quantum information science applications. It is a significant advance for carbon nanotube optics and might motivate experimental and theoretical studies of new types of covalent dopants with quantum optical and spin properties that enable spintronic and quantum information processing functionalities.

Reference: "Room-temperature Single-photon Generation from Solitary Dopants of Carbon Nanotubes," *Nature Nanotechnology* (2015) published online ahead of print. Researchers include: Xuedan Ma, Nicolai F. Hartmann, Jon K.S. Baldwin, Stephen K. Doorn, and Han Htoon (MPA-CINT). The Laboratory Directed Research and Development program funded the work, which was performed at the Center for Integrated Nanotechnologies, a DOE Office of Basic Energy Sciences user facility. The research supports the Lab's Global Security mission area and the Materials for the Future science pillar via the development of materials for secure communication transmission.

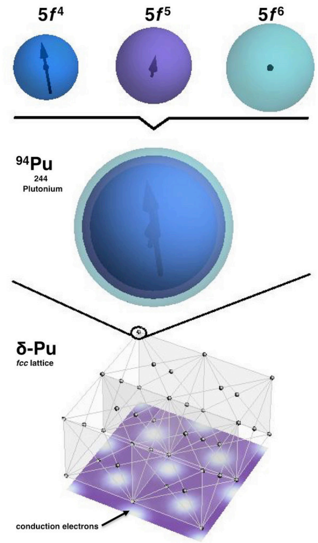
Technical contacts: Han Htoon and Stephen Doorn

Neutrons find "missing" magnetism of plutonium

Groundbreaking work at two Department of Energy (DOE) national laboratories has confirmed plutonium's magnetism, which scientists have long theorized but have never been able to experimentally observe. The advances that enabled the discovery hold great promise for materials, energy and computing applications.

Plutonium was first produced in 1940 and its unstable nucleus allows it to undergo fission, making it useful for nuclear fuels as well as for nuclear weapons. Much less known, however, is that the electronic cloud surrounding the plutonium nucleus is equally unstable and makes plutonium the most electronically complex element in the periodic table, with intriguingly intricate properties for a simple elemental metal. While conventional theories have successfully explained plutonium's complex structural properties, they also predict that plutonium should order magnetically. This is in stark contrast with experiments, which had found no evidence for magnetic order in plutonium.

Finally, after seven decades, this scientific mystery on plutonium's "missing" magnetism has been resolved. Using neutron scattering, researchers from DOE's Los Alamos and



Schematic of the valence-fluctuating ground state of delta-Pu determined by neutron scattering. Top panel, different possible 5f-electron valence states of plutonium. The 5f4 and 5f5 states carry a magnetic moment (arrows), while the 5f6 state is not magnetic (dot). Middle panel, schematic of the quantum mechanical admixture of the 5f-electron valence states of plutonium shown in the top panel. Bottom panel, Schematic of a face-centered cubic (FCC) lattice of mixed-valent Pu ions interacting with one another through a sea of conduction electrons.

Oak Ridge (ORNL) national laboratories have made the first direct measurements of a unique characteristic of plutonium's fluctuating magnetism. In a recent paper in the journal *Science Advances*, Marc Janoschek (Condensed Matter and Magnet Science, MPA-CMMS), the paper's lead scientist, explains that plutonium is not devoid of magnetism, but in fact its magnetism is just in a constant state of flux, making it nearly impossible to detect.

"Plutonium sort of exists between two extremes in its electronic configuration—in what we call a quantum mechanical superposition," Janoschek said. "Think of the one extreme where the electrons are completely localized around the plutonium ion, which leads to a magnetic moment. But then the electrons go to the other extreme where they become delocalized and are no longer associated with the same ion anymore."

Using neutron measurements made on the ARCS instrument at ORNL's Spallation Neutron Source, a DOE Office of Science User Facility, Janoschek and his team determined that the fluctuations have different numbers of electrons in plutonium's outer valence shell—an observation that also explains abnormal changes in plutonium's volume in its different phases.

Neutrons are uniquely suited to this research as they are able to detect magnetic fluctuations. "The fluctuations in plutonium happen on a specific time scale that no other method is sensitive to," said Janoschek.

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President of Poland awards Zelenay national professorship in chemistry

Piotr Zelenay (Materials Synthesis and Integrated Devices, MPA-11) was recently presented with the honorary title of Professor in Chemistry by Poland President Bronislaw Komorowski during a June 23 ceremony in the Presidential Palace in Warsaw.

Piotr Zelenay (left) with Poland President Bronislaw Komorowski.

The highly respected title of Professor, conferred by the president upon a motion of the Central Commission for Academic Degrees and Titles, may be awarded to those who have earned a degree of habilitated doctor (a degree above a PhD); have achievements exceeding those required for the habilitated doctor degree; and who have an excellent record in education.

Zelenay earned doctoral and doctor of science ("habilitation") degrees in chemistry from the University of Warsaw, where he later served as a professor. He joined Los Alamos as a technical staff member in 1997. He is world-recognized in the area of inexpensive, nonprecious metal electrocatalysts intended to replace platinum in polymer electrolyte fuel cells for use in fuel cell electric vehicles. Since becoming project leader for the Laboratory's Fuel Cell Program in 2000, Zelenay has led numerous research projects totaling nearly $60M in research funding.

Zelenay has published more than 150 research articles in renowned scientific journals, including *Nature*, *Science*,

Piotr Zelenay (right) is awarded the national title of Professor in Chemistry from Poland's president during a ceremony in Warsaw's Presidential Palace. At Los Alamos, he is a fuel cell project leader and electrocatalysis team leader.

Photos courtesy Wojciech Olkuśnik, Chancellery of the President of the Republic of Poland

Chemical Reviews, and *Accounts of Chemical Research*, and he has 18 patents and patent applications in the area of polymer electrolyte fuel cells. His honors include a Los Alamos Fellows Prize for Outstanding Research, an Electrochemical Society fellowship, an Electrochemical Society Energy Technology Division Research Award, and a U.S. Department of Energy Hydrogen Program R&D Award.

Zelenay is an affiliate professor at the University of Warsaw, an editorial board member of Electrocatalysis, and a steering committee board member for the International Academy of Electrochemical Energy Science.

Technical contact: Piotr Zelenay

Magnetism cont.

"This is a big step forward, not only in terms of experiment but in theory as well. We successfully showed that dynamical mean field theory more or less predicted what we observed," Janoschek said. "It provides a natural explanation for plutonium's complex properties and in particular the large sensitivity of its volume to small changes in temperature or pressure."

Janoschek's research was born out of a broader endeavor to study plutonium but was met with several obstacles along the way. Plutonium is radioactive and must be handled with great care, so the approval process for this experiment lasted two years before the project was finally accepted.

Furthermore, while the science team knew that neutron spectroscopy measurements were key to making progress on plutonium's "missing" magnetism, the analysis of previous neutron efforts by other teams taught them their sample needed to be improved in two unique ways: First, typically available plutonium predominantly consists of the isotope plutonium-239, which is highly absorbent of neutrons and would obscure the weak signal they sought. The team used plutonium-242 instead, an isotope that absorbs far fewer neutrons. In addition, plutonium typically adsorbs hydrogen, which leads to strong spurious signals exactly where the magnetic signals were suspected.

"We used a special method developed at Los Alamos to remove the hydrogen from our sample," said Janoschek. "Many people across our laboratory and the complex helped solve these problems, but I'm especially grateful to Eric Bauer, Capability Leader for Materials Synthesis and Char-

continued on next page

Magnetism cont.

acterization in the Condensed Matter and Magnet Science group at Los Alamos, for helping me design a successful experiment."

Siegfried Hecker, former director of Los Alamos and one of the foremost international authorities on plutonium science, said, "The article by M. Janoschek, et al., is a tour de force. Through a great combination of dynamical mean field theory and experiment, neutron spectroscopy, it demonstrates that the magnetic moment in delta-plutonium is dynamic, driven by valence fluctuations, rather than missing.

"It also provides the best explanation to date as to why plutonium is so sensitive to all external perturbations–something that I have struggled to understand for 50 years now," Hecker said.

That this work yielded groundbreaking results is also reflected in the reactions of fellow scientists in the plutonium community: "More than one person has stated this is the most significant measurement on plutonium in a generation," said Lawrence Livermore National Laboratory's Program Chair for Plutonium Futures Scott McCall.

These observations not only establish a microscopic explanation for why plutonium is structurally unstable, but more broadly, suggest an improved understanding of complex, functional materials that frequently are characterized by similar electronic dichotomies. Indeed, the dynamical mean field theory calculations used in this work have reached a new level of sophistication. Janoschek notes that the methods developed in this research promise to open the door for future investigations into those other complex materials that are considered as critical for future computing and energy applications. Janoschek and his team ran the dynamical mean field theory calculations on the Titan supercomputer located at the Oak Ridge Leadership Computing Facility at ORNL. Janoschek said the team used nearly 10 million core hours for their computations.

Janoschek's coauthors include Doug Abernathy and Mark Lumsden (ORNL); Pinaki Das, J.M. Lawrence, J.D. Thompson (MPA-CMMS), J.N. Mitchell, S. Richmond, M. Ramos (Nuclear Materials Science, MST-16), F. Trouw (Subatomic Physics, P-25), J.-X. Zhu (Physics of Condensed Matter and Complex Systems, T-4) and Eric Bauer (MPA-CMMS); G.H. Lander (European Commission; and B. Chakrabarti, K. Haule and G. Kotliar (Rutgers University).

This research was funded by DOE's Office of Science and the Los Alamos National Laboratory Directed Research and Development program. This research used resources of the Spallation Neutron Source and Oak Ridge Leadership Computing Facility at ORNL, which are DOE Office of Science User Facilities.

Technical contact: Marc Janoschek

HeadsUP!

When thunder roars, go indoors!

Remind yourself, your co-workers, and your children of the appropriate protocol when encountering lightning.

- No place outside is safe when thunderstorms are in the area; take cover immediately.
- If you hear thunder, lightning is close enough to strike. Immediately take shelter.
- Don't take shelter under a tree, on a cliff or rocky overhang, near a body of water, on an elevated area, or near an object that can conduct electricity (e.g. barbed wire or power line).
- Ideally, take shelter indoors or within a metal car.
- Once inside, stay away from corded phones, computers, and other electrical equipment that put you in direct contact with electricity.
- Stay away from sinks, bathtubs, showers, toilets, concrete, windows, and doors.

Celebrating service

Congratulations to the following MPA Division employees celebrating service anniversaries recently:

Scott Crooker, MPA-CMMS	20 years
Tomasz Durakiewicz, MPA-CMMS	15 years
Neil Harrison, MPA-CMMS	15 years
Roger Lujan, MPA-11	15 years
Antonya Sanders, MPA-CINT	15 years
Sergiy Gerashchenko, MPA-CMMS	5 years
Jacob Valdez, MPA-11	5 years

MPA Materials Matter

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To submit news items or for more information, contact Karen Kippen, ADEPS Communications, at 505-606-1822 or kkippen@lanl.gov.
To read past issues see www.lanl.gov/orgs/mpa/materialsmatter.shtml.

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