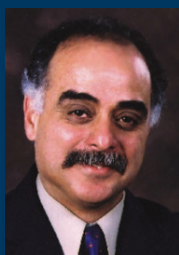
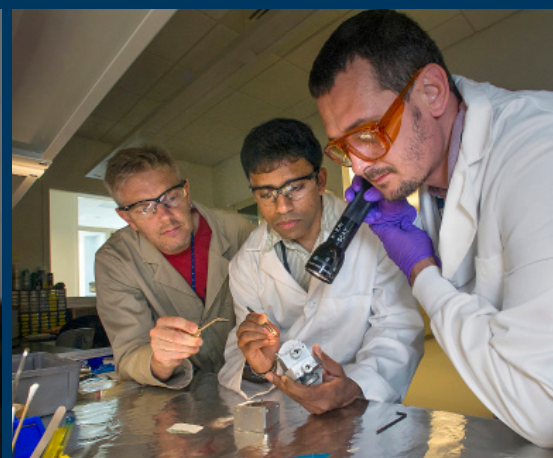


APAM NEWS

THE DEPARTMENT OF APPLIED PHYSICS & APPLIED MATHEMATICS

THE FU FOUNDATION SCHOOL OF ENGINEERING & APPLIED SCIENCE, COLUMBIA UNIVERSITY IN THE CITY OF NEW YORK



Dear Colleagues,
Students and Friends,

2013 is drawing to a close and the holidays are approaching. APAM has had a lot to be thankful for in 2013. Our applied mathematics (APMA) faculty is steadily growing and will

exceed 10 permanent members in 2014. The climate modeling/computation group, with professors Polvani, Shaw, Sobel and Tippet, is working hard to analyze the ever more frequent "extreme events"; Professor Sobel has been featured in many media outlets and has recently co-authored an op-ed piece in the *Los Angeles Times* on the increasing frequency of these hitherto rare events and their impact on the societies of the world. In our Materials Science and Engineering Program, Professor Billinge is working on the characterization of nano-particles, a very important new technology, using novel techniques. His efforts are highlighted in this issue.

We are also cognizant of some rough seas ahead. The decreases in the federal budget, possible effects of sequestration on grants, etc. are keeping us busy to make sure our research and our students are unaffected.

I wish all of you Happy Holidays and a wonderful New Year.

Best,

I.C. Noyan
Professor, Chair; APAM

Focus on Faculty Activities: Simon Billinge

This issue focuses on the recent research of the Billinge group at Columbia University and the U.S. Department of Energy's (DOE) Brookhaven National Laboratory.

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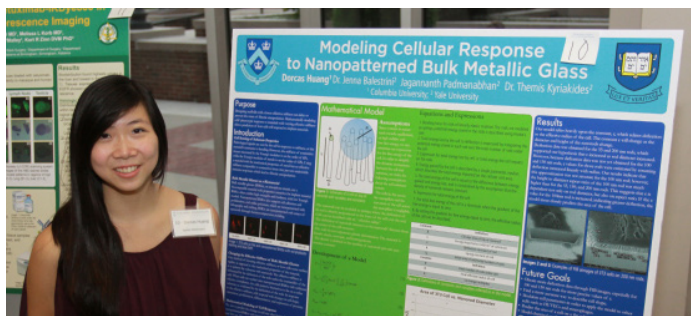
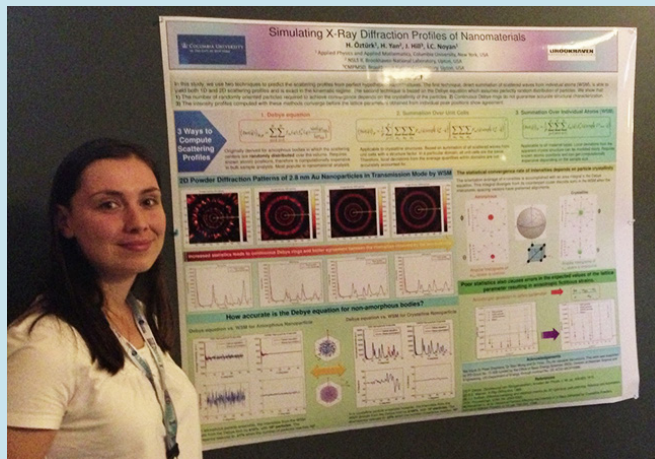
Ozturk Wins Best Diffraction Poster Award

by Hande Ozturk

The Denver X-Ray Conference is one of the most prominent annual meetings of the X-Ray Scattering community. This year I attended the conference with my presentation titled 'Simulating X-Ray Diffraction Profiles from Nanoparticles' and was awarded one of the three best posters.

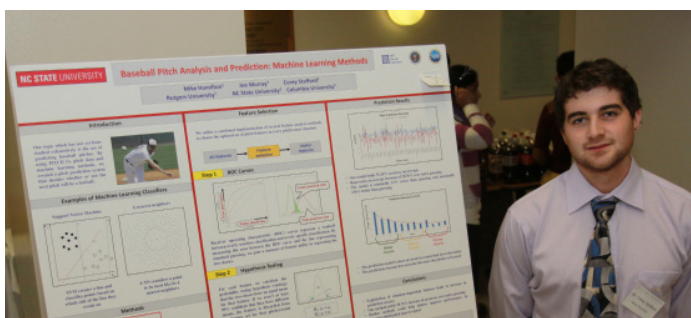
My research focuses on simulating X-Ray diffraction profiles of nanoparticles by first principle physics formulations. Although there is considerable literature on the X-Ray physics and the scattering phenomenon from macromaterials, nanomaterials represent a great challenge especially in the analysis of their diffraction profiles. What makes nanomaterials special is that they are not just really small pieces of a macromaterial; they are entirely different in terms of their structural and physical properties. Therefore we have to find new ways of looking at their diffraction phenomena. In other words, we need an extensive and critical evaluation of the current diffraction data analysis procedures.

The standard practice in the X-ray community is to look at a diffraction profile and try to recover the scattering object from its diffraction signature. By simulating fully controlled diffraction experiments on the computer with artificial nanocrystals, I am actually looking at the scattering problem from an opposite angle: forward modeling of the diffraction signal from a known sample makes it possible to understand the features that are specific to the sample and map them correctly to the sample's XRD profile. In this manner, I am hoping to develop new ways to improve and modify the current data analysis routines for proper characterization of nanomaterials.



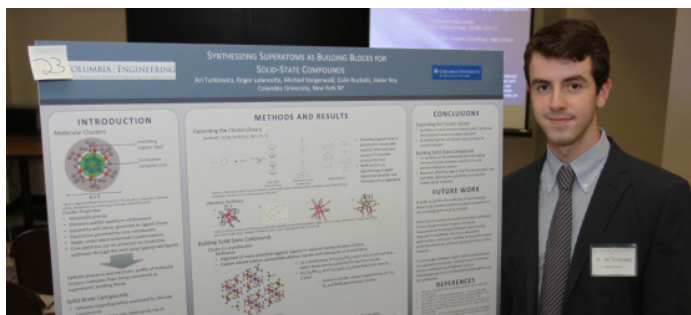
Dorcas Huang (Applied Math)

"Modeling Cellular Response to Nanopatterned Bulk Metallic Glass"



Corey Stafford (Applied Math)

"Baseball Pitch Analysis and Prediction: Machine Learning Methods"



Ari Turkiewicz (Applied Physics)

"Synthesizing Superatoms as Building Blocks for Solid-State Compounds"

Choi Wins NSERC Award

Wilkie Choi has been awarded a Postgraduate-Masters award by the Natural Sciences and Engineering Research Council of Canada (NSERC). This merit-based scholarship provides one year of support towards the masters portion of the recipient's education.

"Since NSERC's inception in 1978, the NSERC Postgraduate Scholarships (PGS) Program has been providing financial support to high-caliber scholars who are engaged in masters or doctoral programs in the natural sciences or engineering." - NSERC

Wilkie is currently in his first year of the M.S./Ph.D. program in Plasma Physics. He received his Bachelor's of Science - Engineering Physics from Queen's University, Kingston, Ontario in June 2013.

His research interest is in controlled fusion in plasma, with especial interest in technical challenges in energy production.

Student Award Winners

Congratulations to our new and continuing undergraduate and graduate student award winners!

Undergraduate Egleston Scholars

Haris Durrani (Applied Physics)
Matthew Miecnikowski (Applied Physics & Applied Mathematics)
Kui Tang (Applied Mathematics)
Ari Turkiewicz (Applied Physics)

Graduate Student Award Winners

Arun Batra, NSF Fellow (Solid State Physics)
John Dwyer, NASA Fellow (Atmospheric Science)
Eric Isaacs, DOE CSGF Fellow (Solid State Physics)
Mordechai Kornbluth, Presidential Fellow (Solid State Physics)
Peijie Ong, NSF Fellow (Solid State Physics)
Iva Vukicevic, NSF IGERT Fellow (Applied Mathematics)

Photos: Undergraduate Summer Research Symposium

APAM undergraduates, Dorcas Huang, Corey Stafford, and Ari Turkiewicz, participated in the SEAS 2nd Annual Undergraduate Research Symposium on October 3, 2013.



Chris Marianetti

Marianetti Wins DARPA Young Faculty Award

by Holly Evarts
originally published in *Engineering News*

Chris Marianetti, associate professor of materials science and engineering, has won the prestigious DARPA Young Faculty Award. Only 25 awards, which are presented annually to promising young faculty early in their careers, were given across all scientific/engineering disciplines this year.

"I am honored to be recognized by DARPA and excited to show how my research can impact disruptive technologies," says Marianetti, whose research involves using the first principles of quantum mechanics, together with high performance computing, to predict the behavior of materials from metals to ceramics to semiconductors. Applications of his work are equally diverse, spanning mechanical, electrical, and magnetic properties.

Marianetti plans to use the DARPA award to study a broad class of transition metal-oxides containing Jahn-Teller ions, requiring extensions and reformulation of current theoretical methods. "Jahn-Teller crystals display a broad range of emergent phenomena including colossal magnetoresistance and the spontaneous formation of peculiar structural features known as nanocheckerboards," he notes, "and these are exactly the sort of complex materials that have potential to deliver transformative technologies."

In addition to the DARPA award, Marianetti recently won a \$850,000 five-year grant for research he is conducting at the Focus Center on Function Accelerated nanoMaterial Engineering (FAME), one of six university-based research centers of the Semiconductor Technology Advanced Research Network (STARnet).

"I'm really thrilled to be representing Columbia Engineering in this effort, which is based out of UCLA," Marianetti says. "What's particularly rewarding is the fact that the leading companies in the industry — including IBM, Intel, Micron, and others — have recognized the relevance of the techniques I've helped develop over the past decade that were previously confined to predominantly fundamental scientific research. It is great to be able to take our theoretical work and use it to search for the next generation of electronic devices."

The FAME researchers are focused on developing new nonconventional atomic-scale engineered materials and nanostructures of multi-function oxides, metals, and semiconductors to accelerate innovations in analog, logic, and memory devices that will transform the

semiconductor and defense industries. The semiconductor industry has been very proactive in attempting to anticipate what might provide the next generation of transistors and memory devices, Marianetti observes, given that current technologies are rapidly approaching fundamental barriers.

He specializes in predicting the behavior of transition metal oxides from the first principles of quantum mechanics, particularly those displaying strongly correlated electron behavior with unusual electronic and magnetic properties. "Strongly correlated electron systems display a dizzying array of exotic properties including high temperature superconductivity, colossal magnetoresistance, Mott transitions, and many others," he explains.

He and his team are hoping that a new generation of electronic devices can be realized by harnessing the sensitive properties of strongly correlated electron systems. The starting point will be the standard theory of materials science — density functional theory (DFT) — which is a quantum mechanical modeling method used to investigate the electronic structure of many-body systems such as atoms, molecules, and materials. But, Marianetti points out, DFT sometimes qualitatively breaks down when addressing strongly correlated electron systems: "Luckily, there are now more advanced theories, like the dynamical mean-field theory (DMFT), that can deal with DFT's shortcomings and unlock the behavior of strongly correlated systems."

Marianetti is working on developing the DMFT method and merging it with DFT to create a robust hybrid DFT/DMFT theory. "This will give us predictive power over strongly correlated electron systems, allowing us to start with nothing but the laws of physics and make quantitative predictions of nature," he observes. "And, with these theoretical and computational developments, we'll be able to design new materials at the atomic scale and work with experimentalists to realize novel phenomena and functionality. We're really trying to push the envelope and tame some of the most difficult materials systems. Our experimental colleagues are already gearing up to grow a new class of oxide heterostructures which we designed virtually, containing multiple types of transition metals and cations."

STARnet projects, which are funded by the Defense Advanced Research Project Agency (DARPA) as part of public-private partnership with the Department of Defense and U.S. semiconductor and supplier industries, are aimed at helping to maintain U.S. leadership in semiconductor technology. Annually, \$40 million is dedicated to the program, with each university research center receiving about \$6 million. The projects were established by the Semiconductor Research Corporation (SRC), which also administers the program. Participating universities include Columbia, Cornell, UC Berkeley, MIT, UC Santa Barbara, Stanford, UC Irvine, UCLA, Purdue, Rice, UC Riverside, North Carolina State, Caltech, Penn, West Virginia, and Yale.

Alumni News

Ryan Bonaparte (M.S. '10, Materials Science & Engineering) released his first book, "Crazy Enough to Try," in hopes of helping young people find what they are passionate about pursuing in life. (Fall 2013 *Engineering News*)

Brian Grierson (Ph.D. '09, Plasma Physics) is a staff research physicist at PPPL. He works at the DIII-D National Fusion Facility in General Atomics in La Jolla, CA. (Fall 2013 *Engineering News*)

Katerina Kaouri (M.S. '99, Applied Physics) earned a D.Phil. in applied mathematics at the University of Oxford and then returned to her home in Cyprus to teach and research. She recently presented at talk at TEDxNicosia on rethinking mathematics. (Fall 2013 *Engineering News*)

Ralph Izzo (Ph.D. '81) was awarded an honorary degree from Rutgers University. (Fall 2013 *Engineering News*)

Feryal Ozel (B.S. 1996, Applied Physics) received the 2013 Maria Goeppert Mayer Award "for contributions to neutron star astrophysics, including the theoretical interpretation of X-ray emission from magnetars and determination of accurate masses and radii that yield constraints on the equation of state; and for her outstanding contributions to the public understanding of science."

Gideon Simpson (Ph.D. 2008, Applied Mathematics and Simon Prize Winner) is now a tenure-track professor at Drexel University in the Mathematics Department.

Emily Slutsky (M.S. '09, Medical Physics) recently graduated from University College Cork School of Medicine in Ireland. (Fall 2013 *Engineering News*)

Yutian Wu (Ph.D. 2012, Applied Mathematics) is now in a tenure track faculty position in climate modeling in the Climate Change Research Center at Purdue University in West Lafayette, IN.

New Applied Mathematics Faculty Members: Tippet and Létourneau



Michael Tippet

Prof. Michael Tippet

Dr. Michael Tippet is a new Lecturer in the Discipline of Applied Mathematics.

Dr. Tippet's research focuses on the use and development of mathematical approaches to characterize the variability and predictability of the climate system on a range of time-scales, from decadal variability of sea surface temperatures to seasonal drought, with emphasis on data-driven methods. Much of

his work uses empirical, low-dimensional descriptions of predictable components of the climate system. Most recently, he has been investigating with Prof. Adam Sobel the extent to which slow time-scale climate variability constrains the statistics of weather extremes, an issue of considerable societal interest with important implications for projections and predictions of future climate. They have demonstrated for the first time that monthly U.S. tornado activity can be predicted as much as one month ahead of time, and this work is being continued in collaboration with partners from the National Weather Service and the insurance industry.

He received his Bachelor's degrees in Electrical Engineering and Mathematics from North Carolina State University and an M.Sc. and Ph.D. from the Courant Institute of Mathematical Sciences at New York University. Tippet is teaching APMA E3101: Linear Algebra this semester.



Pierre-David Létourneau

Prof. Pierre-David Létourneau

Dr. Pierre-David Létourneau is the new Chu Assistant Professor of Applied Mathematics.

Dr. Létourneau received his Ph.D. in Applied Mathematics from Stanford University in 2013, under the supervision of Prof. Eric Darve and Prof. George Papanicolaou, and was the recipient of the Juan Simo Outstanding Thesis Award. His work was mostly concerned with the study of waves in random media. In particular, he theoretically analyzed and subsequently developed an algorithm together with a piece of software capable of simulating the propagation of acoustic waves in highly heterogeneous media. Such media include, for example, those constituted by a large amount of air bubbles in water and are known to present substantial computational difficulties. His past research also involved the development of a scheme generalizing the application of fast algorithms (methods for the accelerating dense linear algebra operations) to a larger classes of problems, the construction of generalized Gaussian quadrature, imaging in highly heterogeneous media as well as seismic imaging.

His current focus lies with the study of inverse problems associated with waves in complex media. Some of his current projects involve hybrid imaging problems (where various physical phenomenon are present; with Prof. Guillaume Bal) and the calculation and understanding of the scattering signature from Q-dot structures (with Prof. I.C. Noyan). He is also in the process of developing an algorithm capable of simulating the propagation of linear elastic waves in highly heterogeneous media which he plans to use to study numerically and theoretically the problem of imaging of small bodies embedded in an elastic media (with Prof. Mourad Sini, AAS, Linz, Austria).

Adjunct Faculty Update: Sabbagh Runs KSTAR Experiment

Steve Sabbagh, APAM Adjunct Professor and Senior Research Scientist, and Dr. Young-Seok Park, an Associate Research Scientist in APAM, ran the KSTAR tokamak experiment MP2013-05-03-003 for two sessions this summer at the National Fusion Research Institute (NFRI) in Daejeon, South Korea. Their experiment addressed high-normalized beta plasmas and studied several aspects of non-resonant $n = 2$ magnetic braking by neoclassical toroidal viscosity (NTV) in the device. Various magnetic field spectra were applied by utilizing the flexible capabilities allowed by KSTAR's in-vessel control coils over pulse lengths (~ 10 seconds) much longer than the momentum confinement time (~ 100 ms). Plasma collisionality was effectively changed by supersonic molecular beam injection of deuterium during the period of the applied $n = 2$ field, and rotation profile control by the combined effect of 110 GHz second harmonic and 170 GHz third harmonic electron cyclotron heating in the plasma core, and $n = 2$ NTV was examined. Along with the strong effect of $n = 2$ NTV to reduce plasma rotation in KSTAR, the various combinations of rotation control tools stated above were also used to change the toroidal rotation profile shear. Columbia APAM experiments by S.A. Sabbagh, et al. on both the National Spherical Torus Experiment (NSTX) at Princeton and at KSTAR, have shown significant controlled modification of plasma rotation by non-resonant NTV in each device ($\sim 100\%$ reduction in NSTX, $\sim 50\%$ reduction in KSTAR). As NSTX and KSTAR differ significantly in aspect ratio, comparison of KSTAR data to our NSTX data will provide important physics insight on the effect, and comparisons to NTV theory.



Steve Sabbagh

Faculty Updates



Prof. Daniel Bienstock was named a Fellow of the Institute for Operations Research and the Management Sciences (INFORMS). He received the award "for his fundamental contributions to the methodology of modeling and solving difficult optimization problems, like securing electric powergrid safety, shaping the contours of an ore-mine over time, or fighting certain epidemics."



Prof. Michael Mauel was featured on CBS News in an interview with Chenda Ngak on "Powering the Future: What will fuel the next thousand years?"



Prof. Adam Sobel, along with Suzana Camargo (CU) and Jean-Philippe Duvel (Ecole Polytechnique-LMD), recently received an Alliance Program joint projects grant for "Transitioning Atlantic hurricanes in a changing climate: future extreme weather risk for the eastern US and western Europe." He was also featured in several media sources, including CNN, AP, WNYC, Swiss Radio, ABC News, Los Angeles Times, USA Today, Columbia News, and the Columbia Spectator, on Typhoon Haiyan and Hurricane Sandy.



The American Mathematical Society (AMS) named Michael I. Weinstein a fellow, citing his "contributions to existence and stability of solitary waves and nonlinear dispersive wave propagation."



Prof. Chris Wiggins spoke at the TEDxColumbiaEngineering event, "A Better Tomorrow," on October 25. The organization's goal is to "facilitate dialogue on novel ideas and to inspire a greater sense of innovation and entrepreneurship among Columbia faculty and students." Wiggins was also featured in the article "Hacking the New Silicon Valley" in the Fall 2013 edition of Columbia Engineering.



Simon Billinge

New Kind of “X-Ray Vision” Reveals Objects’ Internal Nanoscale Structure, Chemistry

Nanomaterials made of particles with dimensions measured in billionths of a meter hold enormous promise for creating more efficient batteries, fuel cells, catalysts, and drug-delivery systems. Seeing how the nanostructured materials inside these devices evolve and interact as they operate is essential to gain insight into ways to optimize performance. But most studies have looked

at idealized samples of isolated components, not as they function in operating devices.

Now a group of researchers, led by Prof. Simon Billinge and the U.S. Department of Energy’s Brookhaven National Laboratory, has combined with experts in France and the UK to develop a new kind of “x-ray vision” — a way to peer inside real-world devices to map the internal nanostructures and properties of the various components, and even monitor how properties evolve as the devices operate. Billinge, one of the paper’s lead authors, a professor of materials science and applied physics and applied mathematics, as well as a research scientist at Brookhaven, describes the novel dual imaging method in the September 30 issue of *Nature Communications*. He explains how this new imaging method combines high-intensity x-rays for discerning nanoscale structures with cross-sectional “slices” of the device to pinpoint the precise location of the nanostructured components. It opens new opportunities for advances in a wide range of research disciplines from materials science to biomaterials, geology, environmental science, and health.

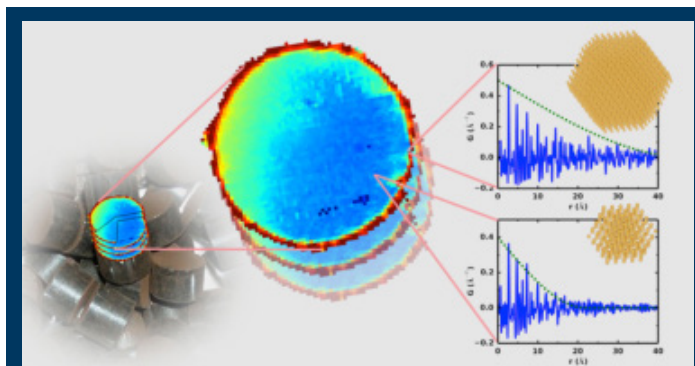
“If you think of a battery with an anode, next to a membrane, next to a solid electrolyte, next to another membrane, next to the cathode, and all this wrapped in a steel container, it’s pretty opaque from the outside,” said Billinge. “What we can do now, with this new dual-imaging method, is look inside the battery and extract the nanostructure from each of those parts of the battery separately, and we can do it without taking the battery apart, and we can also do it while the battery is operating, to follow the chemistry as the materials evolve.”

“One of the main challenges was the computational effort of handling so much data,” added Xiaohao Yang, a Ph.D. candidate in APAM and coauthor of the paper. “We had to develop powerful software tools to manipulate the floods of data coming from the experiment and to reveal the precise pictures of the nanoscale structure that we wanted.”

Internal fingerprints: The x-rays used for this technique are not like the ones used to image a broken bone. They are exquisitely intense, small beams with very high energy produced by a synchrotron light source, a precision scientific instrument located at select research centers around the world, including Brookhaven Lab and the European Synchrotron Radiation Facility in Grenoble, France, where this particular study was done. The x-rays generate measurements of the distribution of distances between pairs of atoms in the material — known as atomic pair distribution functions, or PDFs — which reveal the nanoscale structure.

Larger scale cross-sectional images of “slices” of the material taken from multiple angles using computed tomography (CT) — just like what doctors use to check for brain injuries after a bad fall — give scientists the spatial information they need to make a 3D map of the device’s material components and “place” the information about nanoscale structure on that map.

“Each method is powerful in its own right, but together they give us a whole new kind of picture,” Billinge said. “For the first time we can separate the



Peering inside a catalyst: A new dual-method imaging technique allowed scientists to map the internal nanostructure of these cylindrical catalyst bodies non-destructively. The technique combines computed tomography (CT) — which makes “slices” of the 3D structure (circles) — with x-ray particle distribution functions (PDFs, shown as graphs), to plot information about the internal nanostructure and chemistry (colors), pixel-by-pixel in three dimensions. The PDFs for the two pixels shown indicate that there are large palladium nanoparticles at the edge of catalyst body, and small palladium nanoparticles in the center (represented as different-sized clusters). The powerful method reveals the structure at many length scales — from the millimeter-scale catalyst body, to the micron-scale arrangements of the nanoparticles, to the billionths-of-a-meter nanoparticles, all the way down to the atoms themselves. (Image by Xiaohao Yang)

nanoscale signals from the different parts of a working device and see what the atoms are doing in each place, without dismantling the object.”

Like the imaging methods that have had a huge impact in health care and the physiological and neurological sciences, this technique offers unprecedented access to the internal workings of materials at the nanoscale.

“It is like being able to see what is happening, and making measurements, inside any room deep in the center of the Empire State Building but looking at it from the observation deck of 30 Rockefeller Center — oh, and if the Empire State and Rockefeller buildings were really tiny,” Billinge said.

Demonstrating the technique: To demonstrate the technique, the scientists made images of a complex phantom sample composed of a mixture of multiple amorphous and semi-crystalline materials. They were able to tell these distinct phases apart with ease.

Then they used the method to study the internal structure of a catalyst made of palladium nanoparticles on an aluminium oxide support that is widely used in the chemical industry.

“The efficiency of many industrial processes is dependent on the performance of catalysts deposited onto a structural support known as a catalytic body, so it’s extremely pertinent to understand how they are prepared and operate in practice,” Billinge said.

The technique clearly revealed a non-uniform distribution of particles, with larger particles on the surface and smaller ones on the inside of the material.

“It is not clear from this study whether the significant catalytic activity would originate from the larger and more numerous particles located at the periphery, or by the smaller ones in the interior,” Billinge said.

(continued on page 7)

New Evidence to Aid Search for Charge “Stripes” in Superconductors

A team of scientists from Columbia University’s School of Engineering and Applied Science and the U.S. Department of Energy’s (DOE) Brookhaven National Laboratory have identified a series of clues that particular arrangements of electrical charges known as “stripes” may play a role in superconductivity — the ability of some materials to carry electric current with no energy loss. But uncovering the detailed relationship between these stripe patterns and the appearance or disappearance of superconductivity is extremely difficult, particularly because the stripes that may accompany superconductivity are very likely moving, or fluctuating.

As a step toward solving this problem, the Brookhaven team used an indirect method to detect fluctuating stripes of charge density in a material closely related to a superconductor. The research, described in a paper published in *Physical Review Letters* August 30, 2013, identifies a key signature to look for in superconductors as scientists seek ways to better understand and engineer these materials for future energy-saving applications.

“The charge stripes are hard to see even when they are frozen,” said Simon Billinge, who holds a joint appointment between Columbia and Brookhaven Lab, and leads the collaboration that performed this study. “But they are impossible to see when they are moving. Tantalizingly, they always tend to show up in the vicinity of superconductivity, but we don’t know what their role is in this phenomenon.”

“In previous experiments, we’ve seen evidence of fluctuating ‘magnetic spin’ stripes — patterns of how adjacent atoms’ spin directions are arranged — that are compatible with superconductivity,” added Brookhaven physicist John Tranquada, a senior collaborator on the research team. “Now we’re trying to look at the arrangements of charge density, to see if there are alternating stripes of densely and more loosely packed charges. The charge part is harder to see.”

To get an idea of the difficulty of tracking moving stripes, think of the cars in a supermarket parking lot. The lines delineating the parking spots are like the positions of atoms making up a crystal, and the cars are like the electrons. If there’s a pattern to the arrangement — say alternating colors of cars in adjacent spots — it would be easy to spot in a single snapshot. But if you took a single photo (with a very long exposure) over the course of a busy shopping day as cars moved into and out of spots, all you’d see is a blur. You wouldn’t be able to tell if they continued to park in alternating order, if the details of the parking pattern were changing, or even whether there was a pattern at all.



Above: Scientists Simon Billinge, Milinda Abeykoon, Emil Bozin, and John Tranquada are making strides toward uncovering the role of “charge stripes” in superconductivity, the ability of some materials to carry electric current with no energy loss.

A series of individual snapshots might make the details more discernable. But in the case of analyzing materials science samples, the “snapshots” are often made with very intense x-rays or neutron beams. And access to beam time at these imaging facilities is limited, and expensive. “You can’t throw enough ‘light’ on the problem to see it,” Tranquada said.

Instead, the scientists tried a completely different approach. Rather than looking directly at the stripes, they looked for a telltale signal that indicates the presence of the stripes by association, but in a different measurement that can be done quickly and with much less precious beam time.

They started these experiments on a material they knew had a static striped pattern below a certain temperature to make sure that the signal was evident in this new measurement. They then studied what happened as the temperature rose to see whether the stripes would either disappear or persist but start to move.

The scientists ground up crystals of the test material into a fine powder and placed samples of it in line with a beam of neutrons at the Los Alamos Neutron Scattering Center at Los Alamos National Laboratory. Similar to the way light reflecting off an object enters your eyes to create an image, the neutron beams diffracted by the crystals’ atoms yield information about the positions of the atoms. The scientists used that information to infer the material’s electronic structure, and repeated the experiment at gradually warmer temperatures.

“We’re looking at the average crystal structure, the height-to-width aspect ratio of that structure, and how different the positions of the atoms are from that average,” said Milinda Abeykoon, lead author on the paper.

In the static striped arrangement, the atoms are displaced from the average in a regular way — like parking spots that are alternatingly wider or narrower than average. Such atomic displacements force the electrons to follow a stripe-ordered arrangement — the way smaller cars would fill the narrow parking spots alternating with wider SUVs.

With increasing temperature, the scientists found that while the aspect ratio of the crystal structure changed, the displacements from average structure persisted, leading them to conclude by inference that the striped pattern of charge density also remained, even though it was no longer static.

This is the first powder diffraction scattering evidence for fluctuating charge stripes above the temperature where we see static order,” said co-author Simon Billinge, referring to the new measurement.

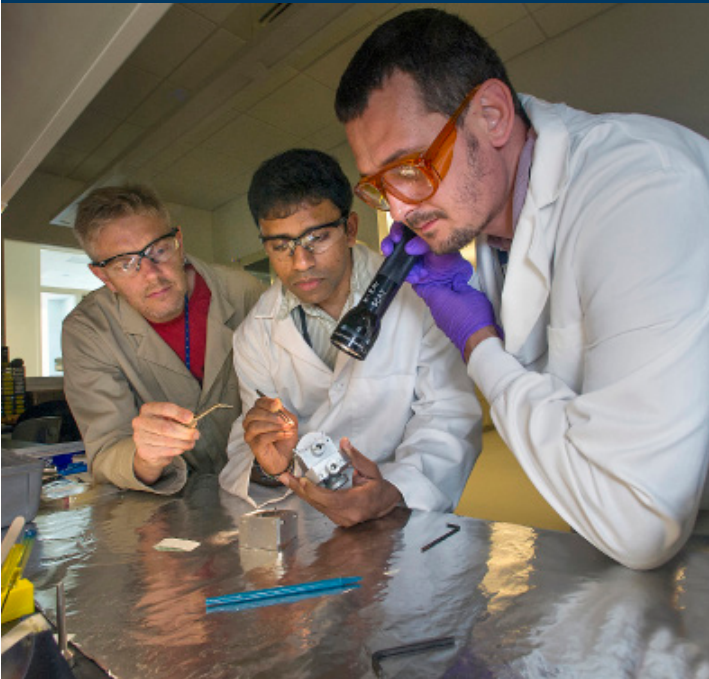
“One of the most critical aspects of this experiment is that we had lots of different data points, lots of temperatures — so you can catch small deviations,” said co-author Emil Bozin of Brookhaven. He also noted how improvements in detector technology made it possible to collect a lot of data within a fixed amount of time. “Ten years ago we would have needed a couple of weeks of beam time to do this experiment; we collected all our data in just a few days.”

The next step: Return to searching for stripes in superconductors. “This model system teaches us what diffraction-scattering signature to look for in copper-based superconductors to see if these fluctuations exist,” Bozin said.

That search should lead to better understanding of the role of stripes in superconductivity, and possibly to new approaches to engineer advanced superconductors for energy applications.

Additional collaborators include Wei-Guo Yin, Genda Gu, and John Hill of Brookhaven. This research was funded by the DOE Office of Science.

Below: Simon Billinge, Milinda Abeykoon, and Emil Bozin prepare to mount a sample for powder diffraction analysis



New Kind of “X-Ray Vision” Reveals Objects’ Internal Nanoscale Structure, Chemistry, continued from p. 5

“But by using dynamic PDF-CT to monitor the catalyst as it performs, it is now possible to provide a more complete picture of the catalyst sample and the evolutionary processes by which it develops and operates to understand these relationships, and ultimately to guide improved catalyst design.”

This research was performed while Billinge was on sabbatical from Columbia Engineering and Brookhaven, but will likely continue at the National Synchrotron Light Source II (NSLS-II) at Brookhaven, when it becomes operational in 2015.

“With modern synchrotron light sources, sub-micron x-ray beams are becoming more widely available, allowing for the possibility of PDF-CT imaging with resolution on nanometer length-scales in the near future,” Billinge said.

This research was done in collaboration with scientists from the University of Manchester, UK; the Research Complex at Harwell, Didcot, Oxfordshire, UK; University College London; ESRF; and Utrecht University, The Netherlands. The work was funded by the U.S. Department of Energy’s Office of Science and by the UK Engineering and Physical Sciences Research Council.

Articles & photos for “New Kind of “X-Ray Vision” Reveals Objects’ Internal Nanoscale Structure, Chemistry” and “New Evidence to Aid Search for Charge ‘Stripes’ in Superconductors” courtesy of the Brookhaven National Laboratory News Room. For more information, contact Karen McNulty Walsh, kmcnulty@bnl.gov, (631) 344-8350, or see <https://www.bnl.gov/newsroom>.

Billinge Group News

Congratulations to Dr. Kirsten Jensen for winning the prestigious Villum Foundation Post Doctoral Fellowship. Dr. Jensen was a visitor in the Billinge group for six months in 2011 and returned this fall as a Villum Post-doc.

Medical Physics Seminar Approved for Continuing Education Credit

The American Academy of Health Physics (AAHP), a national association that promotes professionalism in the field of Health Physics, has approved the Medical Physics Seminar for Continuing Education Credit (CEC). Membership in AAPH is open to individuals who have been certified in Comprehensive Health Physics by the American Board of Health Physics (ABHP). Members will be granted 1 CEC for each seminar attended in 2013-2016.

The Medical Physics Seminar, which is open to the University community, is a required course for all students in our CAMPEP-accredited M.S. Program in Medical Physics. Practicing professionals and faculty in the field present selected topics in medical physics, including radiation physics medical and health physics, and radiation biology.

The Medical Physics Seminar meets during the spring semester on Thursday afternoons, from 4:10-5:15 p.m. in room 214 in the S. W. Mudd Building, 500 W. 120th Street, between Broadway and Amsterdam. The Seminar schedule is posted online: <http://apam.columbia.edu/medical-physics-seminar>. On the day of the seminar, guests may also call 212-854-8434 or 212-854-4457 to confirm the schedule.

Havens Featured in *Columbia College Today*

Prof. William Havens (1920-2004) was featured in the Columbia Forum article, “WWII & NYC”, in the Summer 2013 edition of *Columbia College Today*.

“William W. Havens ‘46 GSAS, who began his career working on the Manhattan Project at Columbia and was for nearly two decades the University’s director of nuclear science and engineering, scans the screen of a cloud chamber in Pupin, watching the tracks of nuclear particles. The chamber is an apparatus, weighing more than 300 lbs., for making visible the paths of submicroscopic nuclear particles.

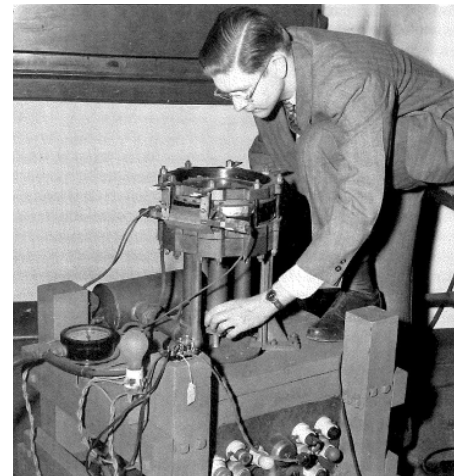


Photo by Manny Warman, Columbia University, Courtesy of the Columbia University Archives

SEAS Faculty Excellence Celebration

APAM faculty members were recognized at the SEAS Faculty Excellence Celebration on October 23. Honorees included William Bailey (Honorary Professorship), Daniel Bienstock (Election to Professional Society), Simon Billinge (Recognition/Achievement Award), Mark Cane (Election to National Academy of Sciences and recipient of 2013 Ewing Medal), Chris Marianetti (Faculty Early Career Development Award), Richard Osgood (Special Recognition), Tiffany Shaw (Faculty Early Career Development Award), Francesco Volpe (Honorary Professorship), Michael Weinstein (Scholarly Leadership), and Chris Wiggins (Special Recognition). Photos by Eileen Barroso



Above: Mary Boyce, Maria Feng, William Bailey, & Richard Logman;
Below: Simha Sethumadhavan, Martha Kim, & Chris Marianetti



Above: Mary Boyce, G. Michael Purdy, & Mark Cane;
Below: Christine Fleming, Martha Kim, Simha Sethumadhavan, & Chris Wiggins



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