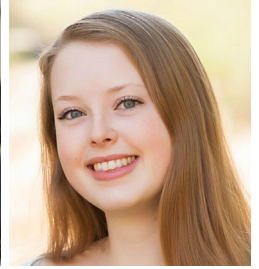
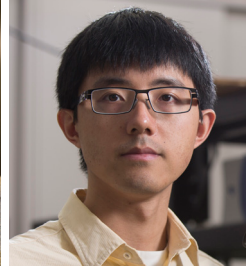
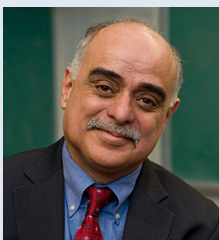


APAM NEWS

Applied Physics & Applied Mathematics Department,
with Materials Science & Engineering
Columbia University in the City of New York



Message from the Chair



Dear Friends
of APAM,

I am delighted to report a successful conclusion to the 2016-2017 academic year.

As you can see from the attached reports, our graduates have been successfully placed in jobs or graduate schools, our faculty have been recognized for the important work they do and, thanks to our staff, the administrative machinery facilitating our mission has performed flawlessly.

We now start a two month period of recuperation and preparation. Rest assured that APAM will be ready to take on any challenges it might face in the upcoming school year.

I wish all of you a restful and productive summer.

Best,

I. Cevdet Noyan
APAM Chair

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Dr. James Lee-Thorp (Simon Prize Winner), Prof. Katayun Barmak (Kim Prize Winner), Prof. Mark Cane (Vetlesen Prize Winner), Prof. Renanta Wentzcovitch (new faculty member), Prof. Nanfang Yu (DARPA Director Fellowship Winner), & Lauren Riddiford (Undergraduate Applied Physics Faculty Award Winner)

Lee-Thorp Wins 2017 Simon Prize

The Robert Simon Memorial Prize is awarded annually by the APAM Department to the graduate student who has completed the most outstanding dissertation. This year's prize was awarded to **Dr. James Lee-Thorp**.

Dr. James Lee-Thorp grew up and attended college in South Africa at the University of Cape Town, where he graduated with a B.S. in Applied Mathematics in 2010.

In 2011, he moved to New York to start his doctoral studies at the Department of Applied Physics and Applied Mathematics at Columbia University under the supervision of Professor Michael I. Weinstein. James said, "I had never visited New York up until the few days before my first term started. However, I could not have been happier with the move and with the Department – my fellow Columbia and APAM students were not only bright and talented, but they were outgoing, friendly and very welcoming."

His doctoral dissertation was a "Bifurcation perspective on topologically protected and non-protected states in continuous systems." Together with Professor Weinstein and collaborators, he studied the mathematical properties of topologically protected edge states (in 2D) and localized solutions (in 1D). Their main results relate to the rigorous mathematical construction of solutions via bifurcations governed by effective equations that underlie the protected or non-protected character of the solutions. Their models capture many aspects of (a) the phenomenon of topologically protected edge states observed in honeycomb structures such as graphene and "photonic graphene", and (b) TM- electromagnetic modes for a class of photonic waveguides.

James is currently a postdoctoral associate at the Courant Institute of Mathematical Sciences at New York University, where he is pursuing related work on the mathematical and numerical modeling of materials science problems.

His advisor, **Prof. Michael Weinstein**, said, "James is an outstanding choice for this year's Simon Memorial Prize for top thesis. His work is first-rate, is having impact in the Mathematics (applied and fundamental) and Applied Physics communities, and is a model of the kinds of deep and cross-disciplinary work that our department strives to promote."

Robert Simon (1919-2001) spent a lifetime making valuable contributions to the field of computer science. He received a B.A. degree cum laude in Classics from CUNY in '41 and an M.A. in Mathematics from Columbia in '49. He was a Lieutenant in the U.S. Armed forces serving in England, France, and Italy. He worked for 15 years at Sperry's Univac Division and also worked at the Fairchild Engine Division as Director of the Engineering Computer Group. He directed the establishment of several company computer centers at sites throughout the U.S. and was a partner with American Science Associates, a venture capital firm. He was a founder and Vice President of Intech Capital Corporation and served on its board and a founder and member of the board of Leasing Technologies International, Inc. until his retirement. The Prize was established by Dr. Jane Faggen with additional support from friends and relatives of Mr. Simon.



Right-left: Prof. Michael Weinstein, Dr. Jane Faggen, Dr. James Lee-Thorp, & Prof. Aron Pinczuk



(left-right) Prof. Noyan, Lauren Riddiford, Erica Yee, & Andres Soto

Undergraduate Awards Winners

Lauren Riddiford, Applied Physics Faculty Award

Lauren maintained an excellent GPA throughout her undergraduate years, earning no less than seven A+ grades. She was also involved in research in material science as well as at research in high-energy physics at the CERN laboratory in Switzerland. One faculty member said, "She was exceptional. She applied herself to understanding physics while also actively being involved in dance at Columbia." ([Learn more about Lauren in the Senior Spotlight on page 3.](#))

Andres Soto, Applied Mathematics Faculty Award

Andres has a passion for bio-mimicry and sustainable design and has sought to understand how patterns of nature can influence innovation and creativity. He is a student of Chinese language and was a recipient of a 2014 Presidential Global Fellowship. One faculty member said, "Andres consistently demonstrated a keen intellect and inquisitiveness in all of his classes. He also has contributed to his own peers' education by helping to develop advanced course materials for numerical methods." Another faculty member commented, "He was one of the most participatory members of the senior seminar, closing with an excellent talk on Consensus in Collective Dynamics, building on work by Professor Eitan Tadmor, which he presented with his colleague Nellie Leddy."

Erica Yee, Francis B. F. Rhodes Prize for Materials Science

Erica is one of our cherished materials majors. During her sophomore year, she studied abroad at University College London (UCL). Outside of classes, she also actively participated in and was a board member for both the Society of Women Engineers and the women's Ultimate Frisbee Club. She was also an ESC Peer Major Advisor and Peer Advisor at the Office of Global Programs. One faculty member said, "Her senior design project involved assembling and implementing an X-ray fluorescence detector into the group's X-ray chamber, which allowed for the successful qualitative elemental analysis of various materials." In the fall, Erica will start working at Northrop Grumman.

2016-2017 Graduates

October 2016 Degree Recipients

B.S. - Adrian Febre (AP)

M.S. - Jared Ginsberg (AP), Zane Martin (AM), Jaewon Moon (MSE), Daniel Sievers, (MSE/CVN), Rajiv Srinivasan (AM/CVN)

M.Phil. - Wilkie Choi (AP), Peijie Ong (AP), Hasan Ozen (AM), Dennis Wang (AP)

Ph.D. - Aditi Dandapani (AM), Paul Hughes (AP), Eric Isaacs (AP), Jiaxing Liu (MSE), Qian Peng (AP), Diego Scarabelli (AP), Daniel Shaevitz (AM), Sheng Wang (AP), Datong Zhang (AP)

February 2017 Degree Recipients

B.S. - Alek Anichowski (AM), Jonathan Fletcher (AP), Haris Nair (AM)

M.S. - Abhinandan Antony (AP), Han Bao (MSE), Joshua Cabrera (AP), Qingrui Cao (MSE), Nicholas Careghini (AP), Hong-Syuan Chen (MSE), Xin Chen (MSE), Xiwen Chen (MSE), Szu Chia Chen (MP), Michelle Cloutier (MP), Richard Creswell (AM), Rong Deng (MSE), Sicen Du (MSE), Lyuwen Fu (MSE), Xingchen Ge (MSE), Amber Goel (MSE), Keren He (MSE), Pei-Yu Hung (MSE), Meiyan Ji (MSE), Fangchao Jiang (MSE), Di Jin (MSE), Ryan Joseph (MP), Sung Kim (AM), Miriam Klein (MP), Sharareh Koufigar (MP), Hsiaoowen Lee (MSE), Ting Li (MSE), Shih-Chi Lin (MP), Jason Moody (MP), Ye Lin (MSE), Qi Liu (MSE), Sarah Newbury (AM), Phuong Nguyen (AP), Tianyi Shao (AM), Xin Shen (AM), Yu-Hsuan Shih (AM), Da Yeon Song (MSE), Akshay Sripada (AM), Sheng-Hsuan Sun (MP), Yunkai Sun (MSE), Akhilesh Kalpathy Suresh (MSE), Ji Tong (MSE), Talia Tseriotou (AM), Ye Wang (MSE), Yi Fang Wang (MP), Shuyue Xue (MP), Yijun Xiong (MSE), Pengyu Xu (MSE), Yinjie Xu (MSE), Jiaqi Xue (MSE), Long Yang (MSE), Teng Yang (MSE), Farshad Yeroshalmi (AP), Lei You (MSE), Haiyan Carol Yu (AM), Zhujun Zhang (MSE), Zifeng Zheng (MSE)

M.Phil. - Zhengqian Cheng (AP), Bernard Lipat (AM), Hongjian Qi (AP), Alexander Watson (AM)

Ph.D. - Wencan Jin (AP), Xiaochuan Tian (AM)

May 2017 Degree Recipients

B.S. - Alexander Franklin Battey (AP), Michael Alan Berkson (MSci), Abhinaba Chatterjee (AM), Tyler Cowan (AP), Rui Ding (AM), Anshul Doshi (AM), Yue Du (AM), Devin Etcitty (AM), Drew Feldman (AP), Jingru Hu (AM), Ben Israeli (AP), Ha Young Kim (AM), Christopher Lam (AM), Helen Leddy (AM), Ga Young Lee (AM), Justin Lee (AM), Tomer Solomon Mate (AM/CC), Max Mattioli (AM), Sean Collins Mbogo (MSci), Sean McDonald (AM), Kelsey Nanan (AM), Jonathan Pagan (AM), James Walter Page (AP), Joo Won Park (AM), Bindu Patel (AM), Lauren Riddiford (AP), Avi Schwarzschild (AM), Farrah Simpson (AP), Tomer Solomon Mate (AM/CC), Da Song (AM), Andres Soto (AM), Triana Steward (AM), Hang Su (AM/CC), Crystal Tanaka (AM), Kevin Teng (MSci), Derek Tropic (AP), Colin Burgess Valentini (AM/GS Valedictorian), Edwin Vargas (AP), Jayati Verman (AM/CC), Yumou Wei (AP), Larry Xiao (AM), Linxuan Yang (AM), Erica Eileen Yee (MSci), Chen Zhang (AP), Huiying Zhang (AM)

M.S. - Rober Foust (MSE/CVN), Alex Gandhi (MP), Heqing Huang (AP), Bok Young Kim (AP), Avi Mehta (AM), Trien Nguyen (AP/CVN), Jessica Oehrlein (AM), Killian Rutherford (AP), Alexander Soloviev (AM), Abhishek Sunkara (AP), Yocheved Ungar (AP), Zilong Wang (MSE), Sheng Zhang (AM), Zhen Zhang (AP)

M.Phil. - E-Dean Fung (AP), Jiao Li (AM), Jyotirmoy Mandal (AP), Haowei Zhai (MSE)

Ph.D. - Kenneth Hammond (AP), Mordechai Kornbluth (AP), Haixing Li (AP), Dov Rhodes (AP), Andrew Weisman (AP)

AM: Applied Math, AP: Applied Physics, CC: Columbia College, CVN: Columbia Video Network, GS: General Studies, MP: Medical Physics, MSci: Materials Science, (undergraduate program), MSE: Materials Science & Engineering (graduate program)

Senior Spotlight: Lauren Riddiford

by Jesse Adams originally published by *Columbia Engineering*



Lauren Riddiford '17 was masterfully applying physics long before it became her major and took her to the CERN laboratory in Switzerland, where physicists working with an enormous particle accelerator explore the secrets of the universe. As a dedicated dancer growing up in Phoenix, she was equally passionate about mathematics and the arts, and intent on pursuing both in college.

"I never felt like I fit the stereotypical mold of an engineer," she said. "So I came to Columbia, where I could get a rigorous engineering education with some of the best professors in the country, but also take conservatory-caliber dance classes and be involved in nontechnical extracurriculars and live with people studying very different things."

In an accelerated physics course sequence, Riddiford found that applied physics fit her love of problem-solving by unlocking the fundamental reasons why the world works the way it does. Soon she was helping **Prof. Katayun Barmak**, who also was a dancer in her youth, study transformation properties of the iron-nickel compound FeNi₃ to explore sustainable magnet applications, research that was later published in the *Journal of Alloys and Compounds*. Riddiford also worked closely with **Prof. Latha Venkataraman**. At the same time, she minored in dance and dove into the New York City dance world.

The spring of her junior year, Riddiford took a semester off to conduct full-time research at CERN. She joined physicists from the University of Toronto working on the ATLAS ITk project, which is devoted to studying components for the eventual upgrade of the ATLAS detector on the Large Hadron Collider that has been involved in searches for the Higgs Boson and particles that could make up dark matter. After her three month program formally ended, she continued working on the project.

On campus, Riddiford has also led tours for the Undergraduate Recruitment Committee and served as the course assistant for the APAM lab section of *The Art of Engineering*. She will begin working on her Ph.D. in applied physics at Stanford this fall and, in the long run, hopes to become a researcher or professor in the field.

"The most exciting parts of being an engineer go hand in hand with the most frustrating parts," Riddiford said. "There's nothing quite like working on a problem—whether it be a problem set or a research-related issue or a code bug—for tens of hours and then finally realizing the solution. It trains you to be persistent!"

2017 Senior Design Expo

APAM seniors participated in the annual SEAS Senior Design Expo on May 3 in Roone Arledge Auditorium in Lerner Hall and presented posters on their senior research projects. Pictured below, from left to right, are Derek Tropic, Erica Yee, Kevin Tang, Sean Mbogo, and Michael Berkson.



Brooks Wins DOE SCGSR Award & USBPO Scholarship



John Brooks, a Plasma Physics graduate student in **Prof. Michael Mauel's** group, received a U.S. Department of Energy (DOE) Office of Science Graduate Student Research (SCGSR) award for a proposed research project entitled "Controlling MHD instabilities through active feedback on scrape-off-layer currents." The project will be conducted at the Princeton Plasma Physics Laboratory (PPPL) this summer and next fall.

Dr. Ping Ge, in the DOE's Office of Workforce Development for Teachers and Scientists, stated, "The selection of John Brooks for the SCGSR award was in recognition of his outstanding academic accomplishments and the merit of the SCGSR research proposal . . . it reflects his potential to advance his Ph.D. studies and make important contributions to the mission of the DOE."

Brooks also received a United States Burning Plasma Organization (USBPO) scholarship to attend the 9th ITER International School (IIS) which took place from March 20-24, 2017 in southern France.

The goal of IIS is to prepare young scientists for working in the field of nuclear fusion and its application to research topics associated with the ITER project. The focus of this year's IIS was on the physics of plasma disruptions and their active control methods. It also included a trip to see ITER, the world's largest magnetic confinement plasma physics experiment, which is under construction and is projected to be operational in 2025.

"This trip was one of the best professional experiences I've had," says John. "The material taught was targeted at physicists of my level, and it made me aware of many of the other issues relevant to the field that we don't focus on here at Columbia. I also met and became friends with many of my peers in the field and have no doubt that the combination of the material I learned and the networking will greatly help my post-graduate career."

Chen's Science Paper Named a Top 10 Breakthrough of 2016

Shaowen Chen, a Ph.D. student in Solid State Physics, authored a paper which was named one of the top ten breakthroughs of 2016 by *Physics World* magazine. The paper, "Electron optics with p-n junctions in ballistic graphene," was published in the September 2016 issue of *Science*, Volume 53. Chen is advised by Prof. Cory Dean in the Physics Department.

Mandal Selected as Nickolaus Named Fellow

Jyotirmoy Mandal, a Solid State Physics Ph.D. student in **Prof. Yuan Yang's** group, was selected as the SEAS Nickolaus Named Fellow for the 2016-2017 academic year. Named fellowships, such as this, are funded by donations from alumni, parents, and friends of Columbia Engineering.

Li Wins APS Student Travel Award

Haixing Li, a Solid State Ph.D. student from **Prof. Latha Venkataraman's** group, received an Ovshinsky Student Travel Award for the 2017 March APS Meeting in New Orleans. The Award was presented by the APS Division of Materials Physics (DMP) during the March Meeting and each recipient was presented with a certificate and received a \$500 check.

Alumni Updates

Reina Maruyama (B.S. 1995, Applied Physics) recently presented a seminar in the Physics Department at Columbia. She is an Associate Professor of Physics and Astronomy at Yale University and her research explores new physics in nuclear and particle astrophysics, in particular, in dark matter and neutrinos. Her group carries out direct detection of dark matter experiments in terrestrial-based detectors and searches for neutrinoless double beta decay.

Wenjia Jing (Ph.D. 2011, Applied Mathematics) joined the Yau Mathematical Sciences Center at Tsinghua University as a tenure-track assistant professor in October 2016. Before that, he was a Dickson instructor of mathematics at The University of Chicago from 2013-2016 and was a postdoctoral researcher at Ecole Normale Supérieure Paris from 2011-2013.

Francois Monard (Ph.D. 2012, Applied Mathematics) is now an Assistant Professor in the Department of Mathematics at the University of California Santa Cruz.

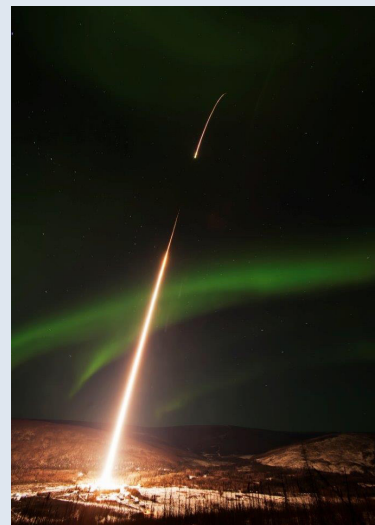
Seth Olsen (B.S. 2016, Applied Physics) and **Veronica Reynolds** (B.S. 2014, Materials Science) received graduate research fellowships from the National Science Foundation. Only 2,000 students were selected out of a pool of 13,000 applicants.

Matt Steiner (B.S. 2008, Applied Physics) started as a tenure-track Assistant Professor in Materials Science and Engineering at the University of Cincinnati in 2017. He received his Ph.D. in Engineering Physics at the University of Virginia in 2014.

Launching Four Spacecrafts with One Rocket

Thomas Max Roberts (Ph.D. 2015, Applied Physics) participated in the 2016-2017 NASA sounding rocket campaign, ISINGLASS. On March 3, 2017, a sounding rocket successfully launched from Poker Flat research range outside Fairbanks Alaska. 120 seconds after launch, a novel measurement system developed at the Lynch Rocket Laboratory at Dartmouth College was successfully deployed. Four subpayloads were ejected in a cross pattern from the main payload, each carrying a suite of instruments to measure the plasma. This system enables multipoint measurement of auroral plasma structures on a length scale too small to be observed from the ground. Making measurements at multiple points in the plasma allows for separation of the spatial and temporal dynamics, which isn't possible with a single payload. As the payloads move away from the rocket, the measurements are made at increasing scale length. Results from the flight will be used to determine the lower bounds to spatial scales of important auroral dynamics, improving our understanding of the coupling between the magnetosphere and ionosphere.

Roberts is a postdoctoral researcher at Dartmouth College. He is responsible for interpretation of the plasma measurements and has developed methods to determine the position and attitude of the deployed spacecraft.



Awards & Recognitions

Bailey's Hybrid Learning Course Award

William Bailey, Associate Professor of Materials Science and Engineering, was recently informed that his application to the Provost's Hybrid Learning Course Redesign and Delivery Request was selected to receive funding. Projects were evaluated with positive feedback by a review committee of faculty from across the University and only eighteen of the forty proposals submitted were chosen to receive this award. Prof. Bailey will receive access to the resources available at the Columbia Center for Teaching and Learning (CTL) which includes content development, instructional design, media production, systems integration, assessment and project management. In addition, he will receive funding for the amount of \$19,800.

Du Invited to Speak at ICM2018

Qiang Du, the Fu Foundation Professor of Applied Mathematics, was invited to give a lecture at the next International Congress of Mathematicians. ICM2018 will take place in Rio de Janeiro from August 1-9, 2018 and "some of the world's best researchers in Mathematics and related areas will come together to share knowledge and take part in various activities, from prizes and technical talks to outreach events." According to Wikipedia, "being invited to talk at an ICM has been called the equivalent, in this community, of an induction to a hall of fame."

Herman Named Columbia University Senator

Irving P. Herman, the Edwin Howard Armstrong Professor of Applied Physics, began serving his two-year term as a member of the Columbia University Senate in May 2017. The Senate makes policy, with Trustee concurrence, on issues that affect the entire University or more than one school, including educational programs, budgets, and the welfare of faculty, students and other members of the University community. It has 108 voting seats, with 63 reserved for faculty and the remaining for students and other constituencies. Prof. Herman is one of the four senators elected from the tenured SEAS faculty.

Noyan Presents Opening Lecture at SNSS-21

I. Cevdet Noyan, Chair of the APAM Department, Professor of Materials Science and Engineering, and of Earth and Environmental Engineering, gave the opening lecture at the 21st Swedish Neutron Scattering Society Meeting (SNSS-21) at Siegbahnsalen in the Ångström Laboratory at Uppsala University, from May 15-16, 2017. His lecture was entitled, "Measuring Stress/Strain Distributions in Suspension-Bridge-Cable Components with Neutron Diffraction."

Sobel Elected Academic Sector AMS Councilor

Adam Sobel, Professor of Applied Physics and Applied Mathematics and of Earth and Environmental Sciences, was elected the 2017 Academic Sector American Meteorological Society (AMS) Councilor. Sobel stated, "We face a political scene in which issues related to our science are urgently important, yet polarization and dysfunction often obscure the facts. We need to continually evaluate where AMS public statements or other outward-facing communications are needed, and how to make them effective. I believe that the AMS has a critical responsibility to speak on behalf of its membership about climate and weather issues that come before the public."



Barmak Receives Kim Award

Katayun Barmak, the Philips Electronics Professor and the Chair of the Materials Science and Engineering Program Committee in the APAM Department, was the recipient of the 2017 SEAS Edward and Carol Kim Award for Faculty Involvement.

The award, which was established in 2000 by Edward and Carol Kim, parents of Brian Kim '01, was created to honor a faculty member who is not only an excellent teacher, but one who also shows a special and personal commitment to students.

Dean Mary Boyce (pictured above on the left) presented the prize to Prof. Barmak at the SEAS Class Day ceremony on Monday, May 15, 2017. Prof. Barmak follows in the footsteps of **Prof. Latha Ventakaraman** who received the award in 2010.

Cane Wins Vetlesen Prize for Achievement in Earth Sciences



Mark Cane, the G. Unger Vetlesen Professor *Emeritus* of Earth and Climate Sciences, Professor *Emeritus* of Applied Physics and Applied Mathematics, and Special Research Scientist at the Lamont-Doherty Earth Observatory, was one of two scientists to win the 2017 Vetlesen Prize for "scientific achievement resulting in a clearer understanding of the Earth, its history, (and) its relation to the universe."

The \$250,000 prize, designed to be the Nobel Prize for earth sciences, was awarded to Prof. Cane, along with Prof. S. George Philander of Princeton University, for their work on El Niño forecasts. Kevin Krajick, from the Columbia's Earth Institute, reported, "The men laid out the cyclic interaction of winds and currents that sweep the tropical Pacific Ocean every two to seven years, affecting weather across the world. Their work led to practical forecasts of such swings; institutions worldwide now monitor warning signs to help prepare for crop planting, disease control, and floods or droughts."

For more information on the prize and the background on each winner, please read the full article online at:

<http://www.ldeo.columbia.edu/news-events/two-who-enabled-el-nino-forecasts-win-2017-vetlesen-prize>



New Faculty Member: Renata M. M. Wentzcovitch

Renata M. M. Wentzcovitch is a new Professor of Materials Science and Engineering in the Applied Physics and Applied Mathematics Department, Earth and Environmental Sciences Department, and Lamont-Doherty Earth Observatory at Columbia University.

She was formerly a Professor of Materials Science and Engineering in the Department of Chemical Engineering and Materials Science at the University of Minnesota where she was a member of the graduate faculties at the in the School of Physics and Astronomy, Department of Earth Sciences, Chemical Physics Program, and Scientific Computation Program, where she was Director of Graduate Studies. Originally from Brazil, she holds a Ph.D. in Condensed Matter Physics from UC-Berkeley. She has been a regular visiting professor at the International School for Advanced Studies (SISSA), Trieste (IT) since 1998, and at Tokyo Institute of Technology since 2002. Over the past two decades her research has been focused primarily on Earth and planetary materials with special emphasis on acoustic/seismic properties of minerals including those containing iron and undergoing spin state crossovers. She is a fellow of APS, AGU, MSA, AAAS, and American Academy of Arts and Sciences. She has received the Senior US Scientist Award of Humboldt Foundation and the 2016 Wilhelm Heraeus visiting professorship from University of Frankfurt.

Research in her group is devoted to computational quantum mechanical studies of materials. She addresses electronic, structural, and vibrational properties from a fundamental and inter-related perspective. She has developed and applied materials simulation methods particularly to investigate materials properties at high pressures and temperatures. Such investigations help to expand insights on materials properties and assess and improve the accuracy of methods used in materials simulations. She applies these methods to problems in, e.g., mineral physics and geophysics, discovery of materials at ultra-high pressures, H₂O-ice physics, complex oxides, and crystalline defects.

Wentzcovitch Elected Vice Chair of APS/DCOMP: Prof. Wentzcovitch was elected by the Division of Computational Physics (DCOMP) of the American Physical Society as its next Vice Chair. In the past decade she served as DCOMP Member-at-Large, and as Vice-Chair (2012) and Chair (2016) of the Aneesur Rahman Prize in Computational Physics Selection Committee. She will serve in the DCOMP Executive Committee as Vice-Chair for one year starting in April 2017, then for one year as Chair-Elect, followed by one year as Chair, and then as Past Chair in the final year. During this period she will serve in the APS March Meeting Program Committee, and at different stages she will chair the DCOMP Nominating Committee, Fellowship Committee, Information Committee, International Liaison Committee, and other ad hoc committees. As a DCOMP officer she will also be involved in recruiting new members and fundraising for DCOMP. For more information, please see: <http://www.aps.org/units/dcomp/index.cfm>

Thunderstorms Pose as Much Property Risk as Hurricanes

Article and image originally published by Columbia's Center for Climate and Life, adapted from a Willis Re and Columbia University press release

Risk to U.S. property from thunderstorms is as high as from hurricanes, according to new research published by Willis Re, the reinsurance division of Willis Towers Watson, the global advisory, broking and solutions company.

A report compiled with Columbia University, a member of the Willis Research Network (WRN), Managing Severe Thunderstorm Risk, says that the average annual loss from severe convective storms (SCS) was \$11.23 billion, compared with \$11.28 billion from hurricanes for the period 2003–2015. For the past decade, SCS was the largest annual aggregated risk peril to the US insurance industry. The report also says that SCS frequency in the U.S. is higher following La Niña, and lower following El Niño.

Prasad Gunturi, executive vice-president, Willis Re said: "Regional variability in increased or reduced severe convective storm frequency due to the El Niño-Southern Oscillation (ENSO) phase can have a significant impact on regional and single state property insurance companies. In collaboration with Columbia University, we are working to develop a climate conditioned severe convective storm event set for portfolio probabilistic loss estimates. We hope the climate conditioned view of risk can help companies understand, manage and mitigate the regional and year over year variability in severe convective storm losses."

Michael Tippett, associate professor of Applied Physics and Applied Mathematics, said: "The latest research shows that ENSO and other climate signals modulate the frequency of tornado and hail activity in the U.S. We're excited to be using that research as a scientific basis for making long-range (up to a month) forecasts of the meteorological factors that go along with severe convective storms."

The report was written to increase understanding of the impact of ENSO on tornado and hail frequencies, and to introduce the concept of ENSO-conditioned event rates. Using data from Columbia researchers, Willis Re now plans to produce monthly forecasts of tornado and hail activity for client use.

Other contributors to the report are Chiara Lepore of Lamont-Doherty Earth Observatory and **Adam Sobel** of the APAM Department and the Lamont-Doherty Earth Observatory, and director of Columbia's Initiative on Extreme Weather and Climate.



Faculty in the News

Alexander Gaeta, the David M. Rickey Professor of Applied Physics and Materials Science, and his group's work on Color Duality in Photons was selected as an APS Highlights of the year. The research, "Ramsey Interference with Single Photons," by Stéphane Clemmen, Alessandro Farsi, Sven Ramelow, and Alexander Gaeta, was originally published in *Physics Review Letters*, Nov. 23, 2016.

Kyle Mandli, Assistant Professor of Applied Physics and Applied Mathematics, and two of his group members were recently featured in the *SIAM News* article, "Adaptive Mesh Refinement: An Essential Ingredient in Computational Science," by Paul Davis.

"Mandli, working with Colton Conroy and Jiao Li of Columbia, used patch-based AMR to solve the shallow water equations with added terms in order to assess the risk of storm-surge flooding in coastal cities. The trio sought efficient, reliable answers to some of the fundamental questions of flood management design and forecasting: How high should we build surge protection barriers? Will the water deflected by the barriers cause flooding elsewhere? They found partial answers by solving a Riemann problem over a region where barriers were modeled as thin walls at cell boundaries, although much work remains."

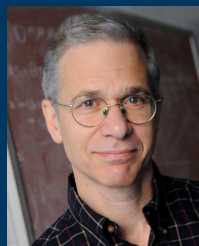
Chris Marianetti, Associate Professor of Material Science and Applied Physics and Applied Mathematics, was featured in the *Columbia News* article, "'Habanero' Spices Up High-Performance Computing at Columbia," by Acacia O'Connor. The high-performance computing cluster, nicknamed Habanero, is located in the subbasement of the Jerome L. Greene Science Center and possesses "enough computing power to perform 269 trillion mathematical calculations per second." Marianetti is the chair of the faculty committee that oversees Habanero and other shared research computing.

Latha Venkataraman, Professor of Applied Physics and Chemistry, was featured in the article, "Rebooting the molecular computer: The idea of using single molecules as key components in computers has been around for more than forty years. What progress is it making?" by Mark Peplow in *Chemical & Engineering News*.

"Researchers have achieved some impressive milestones. In 2015, for example, Latha Venkataraman and Luis M. Campos of Columbia University and Jeffrey B. Neaton of Lawrence Berkeley National Laboratory unveiled what is arguably the best single-molecule diode ever made (*Nat. Nanotechnol.* 2015, DOI: 10.1038/nnano.2015.97). Diodes allow current to flow freely in one direction but not in the opposite direction, and the team's thiophene-based device had a very high on-off ratio of more than 200 — meaning 200-fold as many electrons flowed in one direction as the other. The diode relies on a polar solvent, which aligns the molecule's orbitals so they produce the desired electrical response. Crucially, Venkataraman's work has been consistently reproducible, unlike a lot of previous single-molecule work, and has revealed important details about electronic behavior. 'She's one of the top three people in the world at doing these measurements,' Ratner says."

Chris Wiggins, Associate Professor of Applied Mathematics, was featured in Georgette Jasen's *Columbia News* article, "Collaboratory@Columbia to Embed Data Literacy Throughout Curriculum," about the new *HSAM: History and Applied Mathematics* code in the directory of classes. "The course is among the first from the Collaboratory@Columbia, an initiative jointly founded last year by Columbia's Data Science Institute and Columbia Entrepreneurship to embed data literacy in Columbia's curriculum by pairing data scientists with professors in other fields to develop and teach new courses."

Workshops & Symposia



Weinstein Co-Hosted Workshop on "Topologically Protected States"

Michael Weinstein, Professor of Applied Mathematics and Professor of Mathematics was lead organizer of the recent workshop on "Mathematical and Physical Aspects of Topologically Protected States" which took place at Columbia University from May 1-3, 2017. Co-organizers were Professor Shi Jin of University of Wisconsin and Professor Jianfeng Lu of Duke University.

The workshop was supported by Prof. Weinstein's Math + X Investigator Award from the Simons Foundation and by KI-Net, a National Science Foundation Research Network. The workshop, with about 60 participants, was aimed at the community of research mathematicians, physicists, and engineers working in the very active field of "Topological Matter" and its analogues and applications in, for example, electronic physics, photonics and acoustics.

For more information, see the conference announcement online at http://www.ki-net.umd.edu/content/conf?event_id=727
Lecture slides are online at <http://www.ki-net.umd.edu/lectures#727>



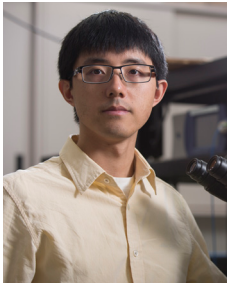
Yang Co-Hosted MRS Symposium

Yuan Yang, Assistant Professor of Materials Science and Engineering, along with Mauro Pasta from the University of Oxford, Kristin Persson from the University of California, Berkeley, and Jia Zhu from Nanjing University, organized "Symposium ES2: High-Capacity Electrode Materials for Rechargeable Energy Storage" at the Materials Research Society's (MRS) spring meeting and exhibit which took place from April 17-21 in Phoenix, AZ.

Over 50 oral presentations and over 80 posters were presented in this symposium. Prof. Yang served as a chair for the several poster sessions, as well as for the sessions on "Energy Storage Overview and Solid Electrolyte" and "Other Battery Materials and Systems."

DSI's Frontiers in Computing Systems Inaugural Symposium

Columbia's new Frontiers in Computing Systems Working Group, part of the Data Science Institute, convened its inaugural symposium on March 24. Renata Wentzcovitch was a panelist on the "Views from the Computing Frontier: Insights from Experts" session which was moderated by Kyle Mandli, a Working Group committee member and the High Performance Computing Liaison. Qiang Du also serves on the committee and other APAM faculty, including Daniel Bienstock, Mark Cane, David Keyes, Chris Marianetti, and Renata Wentzcovitch are affiliated members.



Yu Wins DARPA Director's Fellowship

Prof. Nanfang Yu has won a DARPA Director's Fellowship. The Fellowship, which is awarded only to the highest achieving recipients of a DARPA Young Faculty Award (YFA), will support his research on actively tunable "flat optics". He will investigate the fundamental physics of strong interactions between light and 2D metamaterials ("metasurfaces") and explore novel electrically tunable optical materials for applications in active photonic devices. The aim is to demonstrate ultra-thin and ultra-fast spatial light modulators (SLMs) that are able to shape optical wavefronts into complex patterns with high speed. The outcome of this research could make a profound impact on many technological areas such as navigation and surveillance, remote detection of chemicals, obstacle detection and recognition for autonomous navigation, adaptive optics for telescope, ophthalmology, and biomedical imaging, and virtual reality (VR) and augmented reality (AR) glasses.

Columbia Engineers Invent Method to Control Light Propagation in Waveguides

A new technique using nano-antennas to make photonic integrated devices smaller with a broader wavelength range could transform optical communications

by **Holly Everts**, originally published by *Columbia Engineering*

A team of researchers, led by Applied Physics Assistant Professor **Nanfang Yu**, has invented a method to control light propagating in confined pathways, or waveguides, with high efficiency by using nano-antennas. To demonstrate this technique, they built photonic integrated devices that not only had record-small footprints but were also able to maintain optimal performance over an unprecedented broad wavelength range.

Photonic integrated circuits (ICs) are based on light propagating in optical waveguides, and controlling such light propagation is a central issue in building these chips, which use light instead of electrons to transport data. Yu's method could lead to faster, more powerful, and more efficient optical chips, which in turn could transform optical communications and optical signal processing. The study is published online in *Nature Nanotechnology* April 17.

"We have built integrated nanophotonic devices with the smallest footprint and largest operating bandwidth ever," Yu says. "The degree to which we can now reduce the size of photonic integrated devices with the help of nano-antennas is similar to what happened in the 1950's when large vacuum tubes were replaced by much smaller semiconductor transistors. This work provides a revolutionary solution to a fundamental scientific problem: How to control light propagating in waveguides in the most efficient way?"

The optical power of light waves propagating along waveguides is confined within the core of the waveguide: researchers can only access the guided waves via the small evanescent "tails" that exist near the waveguide surface. These elusive guided waves are particularly hard to manipulate and so photonic integrated devices are often large in size, taking up space and thus limiting the device integration density of a chip. Shrinking photonic integrated devices represents a primary challenge researchers aim to overcome, mirroring the historical progression of electronics that follows Moore's law, that the number of transistors in electronic ICs doubles approximately every 2 years.

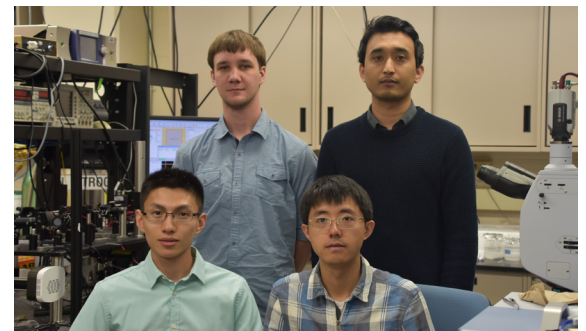
Yu's team found that the most efficient way to control light in waveguides is to "decorate" the waveguides with optical nano-antennas: these miniature antennas pull light from inside the waveguide core, modify the light's properties, and release light back into the waveguides. The accumulative effect of a densely packed array of nano-antennas is so strong that they could achieve functions such as waveguide mode conversion within a propagation distance no more than twice the wavelength.

"This is a breakthrough considering that conventional approaches to realize waveguide mode conversion require devices with a length that is tens of hundreds of times the wavelength," Yu says. "We've been able to reduce the size of the device by a factor of 10 to 100."

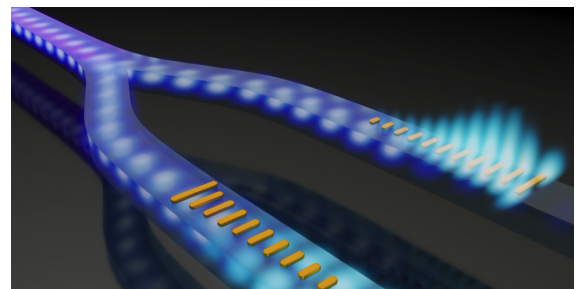
Yu's teams created waveguide mode converters that can convert a certain waveguide mode to another waveguide mode; these are key enablers of a technology called "mode-division multiplexing" (MDM). An optical waveguide can support a fundamental waveguide mode and a set of higher-order modes, the same way a guitar string can support one fundamental tone and its harmonics. MDM is a strategy to substantially augment an optical chip's information processing power: one could use the same color of light but several different waveguide modes to transport several independent channels of information simultaneously, all through the same waveguide.

"This effect is like, for example, the George Washington Bridge magically having the capability to handle a few times more traffic volume," Yu explains. "Our waveguide mode converters could enable the creation of much more capacitive information pathways."

He plans next to incorporate actively tunable optical materials into the photonic integrated devices to enable active control of light propagating in waveguides. Such active devices will be the basic building blocks of augmented reality (AR) glasses — goggles that first determine the eye aberrations of the wearer and then project aberration-corrected images into the eyes — that he and his SEAS colleagues, Professors **Michal Lipson**, **Alex Gaeta**, Demetri Basov, Jim Hone, and Harish Krishnaswamy are working on now. Yu is also exploring converting waves propagating in waveguides into strong surface waves, which could eventually be used for on-chip chemical and biological sensing.



(left-right) Front row: **Zhaoyi Li & Nanfang Yu**,
Back row: **Adam Overvig & Sajan Shrestha**



Artistic illustration of a photonic integrated device that in one arm an incident fundamental waveguide mode (with one lobe in the waveguide cross-section) is converted into the second-order mode (with two lobes in the waveguide cross-section), and in the other arm the incident fundamental waveguide mode is converted into strong surface waves, which could be used for on-chip chemical and biological sensing. (Figure by Adam Overvig and Nanfang Yu)

Yang: Freezing Lithium Batteries May Make Them Safer and Bendable

Columbia Engineers use ice-templating to control electrolyte structure in lithium batteries; solid-state is non-flammable, non-toxic, and flexible with longer battery life

by Holly Evarts, originally published by *Columbia Engineering*

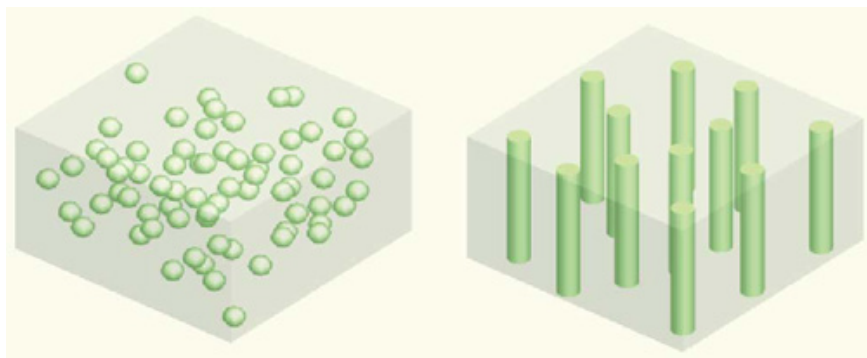
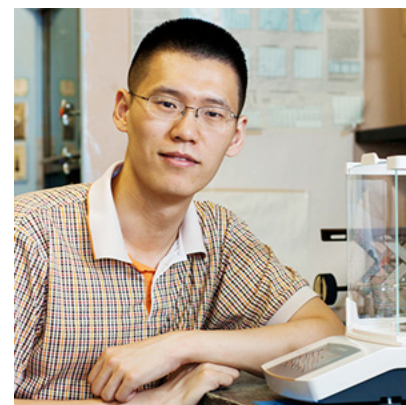
Yuan Yang, assistant professor of materials science and engineering, has developed a new method that could lead to lithium batteries that are safer, have longer battery life, and are bendable, providing new possibilities such as flexible smartphones. His new technique uses ice-templating to control the structure of the solid electrolyte for lithium batteries that are used in portable electronics, electric vehicles, and grid-level energy storage. The study is published online April 24 in *Nano Letters*.

Liquid electrolyte is currently used in commercial lithium batteries, and, as everyone is now aware, it is highly flammable, causing safety issues with some laptops and other electronic devices. Yang's team explored the idea of using solid electrolyte as a substitute for the liquid electrolyte to make all-solid-state lithium batteries. They were interested in using ice-templating to fabricate vertically aligned structures of ceramic solid electrolytes, which provide fast lithium ion pathways and are highly conductive. They cooled the aqueous solution with ceramic particles from the bottom and then let ice grow and push away and concentrate the ceramic particles. They then applied a vacuum to transition the solid ice to a gas, leaving a vertically aligned structure. Finally, they combined this ceramic structure with polymer to provide mechanical support and flexibility to the electrolyte.

"In portable electronic devices, as well as electric vehicles, flexible all-solid-state lithium batteries not only solve the safety issues, but they may also increase battery energy density for transportation and storage. And they show great promise in creating bendable devices," says Yang, whose research group is focused on electrochemical energy storage and conversion and thermal energy management.

Researchers in earlier studies used either randomly dispersed ceramic particles in polymer electrolyte or fiber-like ceramic electrolytes that are not vertically aligned. "We thought that if we combined the vertically aligned structure of the ceramic electrolyte with the polymer electrolyte, we would be able to provide a fast highway for lithium ions and thus enhance the conductivity," says Haowei Zhai, Yang's PhD student and the paper's lead author. "We believe this is the first time anyone has used the ice-templating method to make flexible solid electrolyte, which is non-flammable and nontoxic, in lithium batteries. This opens a new approach to optimize ion conduction for next-generation rechargeable batteries."

In addition, the researchers say, this technique could in principle improve the energy density of batteries: By using the solid electrolyte, the lithium battery's negative electrode, currently a graphite layer, could be replaced by lithium metal, and this could improve the battery's specific energy by 60% to 70%. Yang and Zhai plan next to work on optimizing the qualities of the combined electrolyte and assembling the flexible solid electrolyte together with battery electrodes to construct a prototype of a full lithium battery.



Schematic of vertically aligned and connected ceramic channels for enhancing ionic conduction. In the left figure, ceramic particles are randomly dispersed in the polymer matrix, where ion transport is blocked by the polymer matrix with a low conductivity. In the right one, vertically aligned and connected structure facilitates ion transport, which can be realized by the ice-templating method. (Image courtesy of Yuan Yang/Columbia Engineering)

"This is a clever idea," says Hailiang Wang, assistant professor of chemistry at Yale University. "The rationally designed structure really helps enhance the performance of composite electrolyte. I think that this is a promising approach."

The work is supported by the National Science Foundation MRSEC program through Columbia in the Center for Precision Assembly of Superstratic and Superatomic Solids (DMR-1420634).

The study is titled "A Flexible Solid Composite Electrolyte with Vertically Aligned and Connected Ion-Conducting Nanoparticles for Lithium Batteries." Authors are Haowei Zhai, Pengyu Xu, Mingqiang Ning, Qian Cheng, Jyotirmoy Mandal, and Yuan Yang.

The authors declare no competing financial interests.

Recognition of Columbia Ph.D. in Applied Mathematics

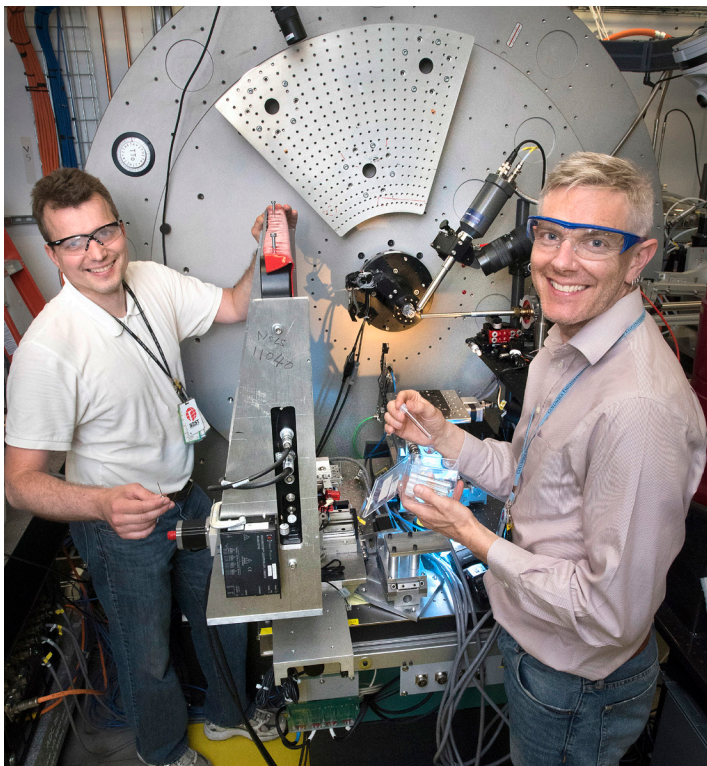
The APAM Department's graduate program in Applied Mathematics has produced many outstanding Ph.D. students over the years, who have gone on to successful and influential careers in academia, government and in the private sector. For historical reasons, students' training was recognized as an Applied Mathematics concentration within the Applied Physics Ph.D. program.

With support from SEAS and the Columbia University leadership, Columbia's Applied Mathematics Ph.D. program has won New York State approval of an officially designated Ph.D. in Applied Mathematics. This recognition reflects the ever-increasing importance of the field of Applied Mathematics and its impact across the Physical Sciences, Engineering, the Biological and Medical Sciences, and Social Sciences, and the broad impact of the program on graduate education in SEAS and Columbia.

Billinge & Gang Featured in BNL's "Top-10 Science Successes of 2016"

Reprinted with permission from the Brookhaven National Laboratory Newsroom

Two APAM faculty members who hold joint appointments as the U.S. DOE's Brookhaven National Laboratory, **Simon Billinge**, Professor of Materials Science and Engineering and Applied Physics and Applied Mathematics, and **Oleg Gang**, Professor of Applied Physics and Materials Science and Professor of Chemical Engineering, were featured in Brookhaven National Laboratory's "Top-10 Science Successes of 2016."



Above: (left-right): Pavol Juhas & Simon Billinge

Oleg Gang: DNA Shaping Up to be Ideal Framework for Rationally Designed Nanostructures

A cube, an octahedron, a prism — these are among the polyhedral structures, or frames, made of DNA that scientists at the Brookhaven National Laboratory have designed to connect nanoparticles into a variety of precisely structured three-dimensional (3D) lattices. The scientists also developed a method to integrate nanoparticles and DNA frames into interconnecting modules, expanding the diversity of possible structures.

These achievements, described in papers published in *Nature Materials* and *Nature Chemistry*, could enable the rational design of nanomaterials with enhanced or combined optical, electric, and magnetic properties to achieve desired functions.

"We are aiming to create self-assembled nanostructures from blueprints," said physicist **Oleg Gang**, who led this research at the Center for Functional Nanomaterials (CFN), a DOE Office of Science User Facility at Brookhaven. "The structure of our nanoparticle assemblies is mostly controlled by the shape and binding properties of precisely designed DNA frames, not by the nanoparticles themselves. By enabling us to engineer different lattices and architectures without having to manipulate the particles, our method opens up great opportunities for designing nanomaterials with properties that can be enhanced by precisely organizing functional components. For example, we could create targeted light-absorbing materials that harness solar energy, or magnetic materials that increase information-storage capacity." [Read the full article online at: https://www.bnl.gov/newsroom/news.php?a=111846](https://www.bnl.gov/newsroom/news.php?a=111846)

Simon Billinge: Computational Tools Help Unlock Nanostructures, Secrets of the Universe, and Untapped Computing Resources

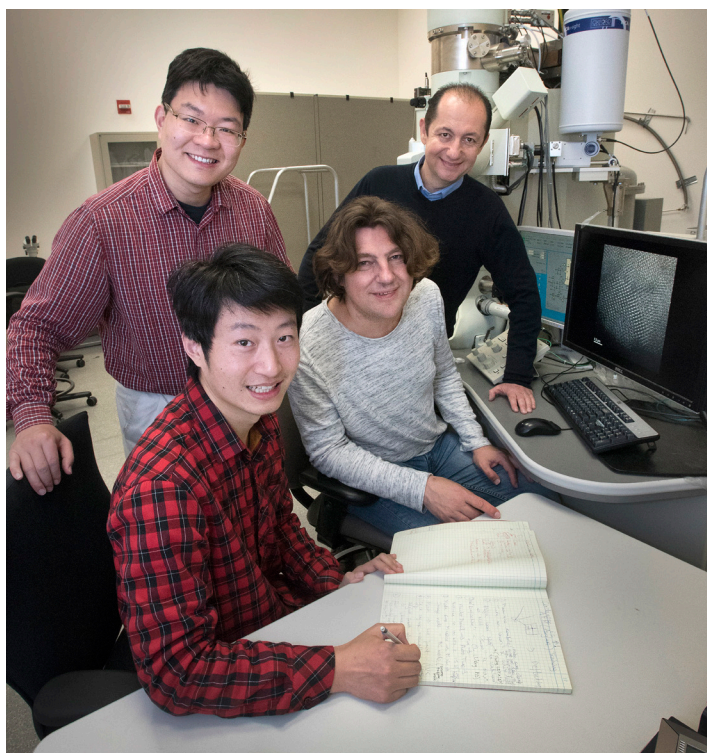
Chemically the same, graphite and diamonds are as physically distinct as two minerals can be, one opaque and soft, the other translucent and hard. What makes them unique is their differing arrangement of carbon atoms.

Polymorphs, or materials with the same composition but different structures, are common in bulk materials, and now a new study in *Nature Communications* confirms they exist in nanomaterials, too. Researchers describe two unique structures for the iconic gold nanocluster $\text{Au}_{144}(\text{SR})_{607}$, better known as Gold-144, including a version never seen before.

"We discovered that the same number of gold atoms can arrange to form two different versions of the nanosized cluster," said co-first author Pavol Juhas, a physicist at BNL (and former research scientist at Columbia University).

Their discovery gives engineers a new material to explore, along with the possibility of finding other polymorphic nanoparticles.

"This took four years to unravel," said coauthor **Simon Billinge**, a physicist at Brookhaven Lab, a physics professor at Columbia Engineering, and a member of the Data Science Institute at Columbia University. "We weren't expecting the clusters to take on more than one atomic arrangement. But this discovery gives us more handles to turn when trying to design clusters with new and useful properties." [Read the full article online at: https://www.bnl.gov/newsroom/news.php?a=111849](https://www.bnl.gov/newsroom/news.php?a=111849)



(left-right) Back: Yugang Zhang & Oleg Gang, Front: Alexei Tkachenko & Ye Tian

Applied Math Faculty & Researchers Visit Mumbai

Applied Mathematics faculty members, **Prof. Adam Sobel** and **Prof. Kyle Mandli**, along with Prof. Suzana Camargo, Research Professor at the Lamont-Doherty Earth Observatory, and Chia-Ying Lee, Associate Research Scientist in Columbia's International Research Institute for Climate and Society (IRI), visited Mumbai in January 2016. This trip was part of their project with the President's Global Innovation Fund (which supports projects at the CU Global Centers), titled "Storm surge risk to Mumbai: a challenge to sustainable urbanization in India's largest city."

Sobel said, "We went to Mumbai to get a first hand view of the city's topography, geography, infrastructure, and culture; and to meet Indian colleagues, exchange ideas, and build the foundation for collaborations. It was an immensely stimulating trip to a vibrant and complex city, highlighted by our one-day workshop organized by the Columbia Global Center. Our research on the risk to Mumbai of a cyclone strike and storm surge has been proceeding well since then, and we intend it to be the jumping off point for a larger research program on catastrophe modeling for disaster risk reduction and climate adaptation."



Top photo: Columbia faculty and researchers, including Madhavi Rajadhyaksha from the Columbia Global Center in Mumbai, met with a team of architects and community members from the experimental action and research collective Urbz (urbz.net) in Dharavi slum, Mumbai. Bottom left photo: Adam Sobel at the India Meteorological Department's Mumbai office, Bottom right photo: Chia-Ying Lee, Suzana Camargo, & Kyle Mandli in front of the Gateway of India. (Photos courtesy of Prof. Camargo)

New faculty research videos on apam.columbia.edu

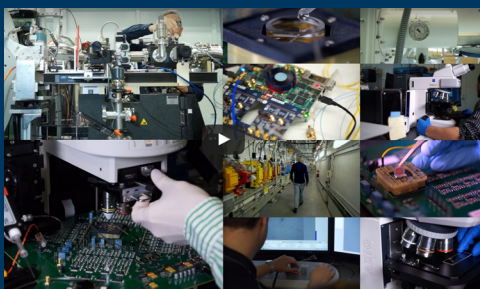
APAM faculty members are featured in several new research videos produced by Columbia Engineering.

Simon Billinge, Chris Marianetti, and Latha Venkataraman appear in the "Columbia Nano Initiative" video about their research in nanoscale science and engineering.

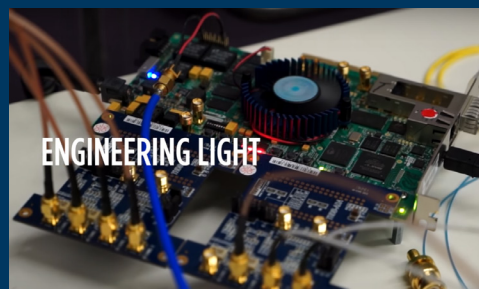
Alexander Gaeta, along with Keren Bergman and Michal Lipson, are featured in the "Engineering Light" video about their ground breaking work in nanophotonics.

Nanfang Yu's video, "The Engineer and the Butterfly," describes his research in mid and far-infrared optics, optoelectronic devices, metamaterials, biophotonics, and biologically inspired flat optics.

Adam Sobel presented a talk on climate change and extreme weather at the "Science-on-Hudson" public lecture series hosted by Columbia's Nevis Laboratories in Irvington, NY. (This video was produced by Nevis Laboratories)



"Columbia Nano Initiative"
 Profs. Billinge, Marianetti, Venkataraman



"Engineering Light"
 Prof. Gaeta



"The Engineer & the Butterfly"
 Prof. Yu



"Climate Change & Extreme Weather"
 Prof. Sobel



Photo Gallery: Photos from the APAM Senior Dinner, Commencement Reception, Medical Physics Faculty Lunch, and APAM Staff Lunch.

Contact Us



Applied Physics & Applied Mathematics Department
 Fu Foundation School of Engineering & Applied Science
 Columbia University in the City of New York
 500 W. 120th Street, Room 200 Mudd, MC 4701
 New York, NY 10027
 Phone: 212-854-4457
 Fax: 212-854-8257
 apam@columbia.edu
 www.apam.columbia.edu

Editors: I. Cevdet Noyan, Stella Lau, Christina Rohm

Contributing Authors: Jesse Adams, Amy Biemiller, Brookhaven National Lab News Room, John Brooks, *Columbia Engineering*, *Columbia Magazine*, Holly Everts, Thomas Max Roberts, Adam Sobel, Renata Wentzcvitch, Michael Weinstein

Photos/Images: Eileen Barosso, Shah Faisal Bin, Suzana Camargo, Columbia Engineering, Adam Overig, Lauren Riddiford, Timothy Lee Photographers, Nanfang Yu

Design: Christina Rohm

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