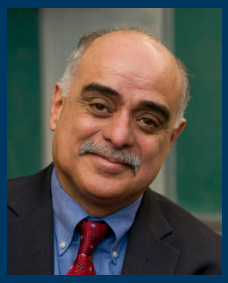
Spring 2014, Vol. 8 Issue 2

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 Alumni and Friends of APAM:

Spring semesters are bitter-sweet for academic institutions. While the faculty and staff look forward to a "less-than-hectic" summer term, in which the corporeal and spiritual rejuvenation of the Department can be undertaken, we also have to say good-bye to cherished colleagues with whom we have been working together for many years.

Most of our undergraduate and graduate students finish their studies in May and depart to take their place in the outside world. In 2013-2014 APAM had 45 graduating seniors. In the same time-frame 57 graduate students, 11 with Ph.D. and 46 with M. Sci. degrees, received their diplomas.

We at APAM are proud of all of our graduates, present and past, and wish them success in their future endeavors. In addition, I, personally, would like to extend my best wishes for a restful and productive summer to the entire APAM community.

Best,

I. Cevdet Noyan
Chair, APAM

Prof. Adam Sobel was interviewed over the last year by several media sources on extreme events, including the severe cold in the US, Typhoon Haiyan and Hurricane Sandy (pictured above). He is also the AXA Research Fund's first recipient of the AXA Award, given to him in Climate and Extreme Weather. See p. 5 for details.

In This Issue

(left-right) Jane Faggen, Latha Venkataraman, Sriharsha Aradhya, I.C. Noyan, & Aron Pinczuk

2014 Simon Prize Winner: Dr. Sriharsha Aradhya

The Robert Simon Memorial Prize is awarded annually by the department to the graduate student who has completed the most outstanding dissertation. Dr. Sriharsha Aradhya, from the Venkataraman lab, is the recipient of this year's award.

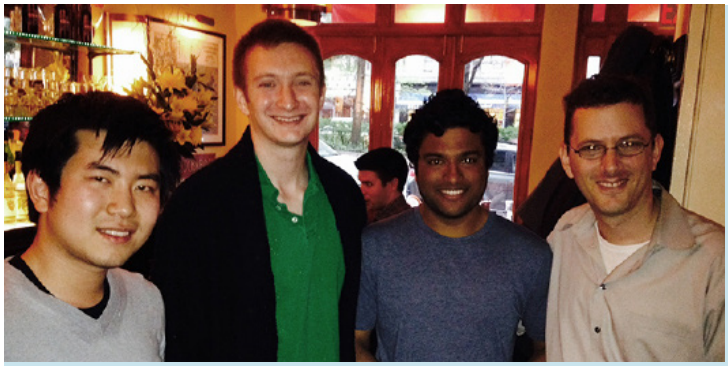
Dr. Aradhya earned his B.S. from Indian Institute of Technology - Madras, Chennai, India in 2006 and M.S. from Purdue University, West Lafayette, Indiana in 2008, both in Mechanical Engineering. His research at these stages resulted in two U.S. patents. He joined APAM for his Ph.D. in Applied Physics in 2008. Shortly thereafter, he began working on his dissertation in the group of Prof. Latha Venkataraman and collaborating with scientists in the Chemistry Department and Brookhaven National Laboratory.

Dr. Aradhya's thesis on the 'Interplay between Mechanics, Electronics, and Energetics in Atomic-scale Junctions' is substantial and includes impressive original research that deserves the award of the Simon Prize. For his doctoral research, Dr. Aradhya assembled a conducting Atomic Force Microscope (AFM) with force sensitivities that are superior to the best commercial units available. With this instrumentation he proceeded to measure bond rupture forces in single atomic and molecular junctions. He also created automated analysis protocols to extract useful physical parameters from a vast amount of experimental data which had been challenging to obtain before. Prof. Venkataraman highlights among other results the studies of bond rupture forces for pyridines, which bind to the gold electrodes through a gold-nitrogen bond as well as the van der Waals (vdW) interaction. The analysis of this data determined quantitative effects of vdW's interactions at the single molecule level. This is the first time anyone has succeeded in providing a direct measure of the subtle vdW force at the single molecule level.

Aradhya's graduate work was outstanding and resulted in many publications including first author papers in *Nature Materials*, *Nano Letters* and *ACS Nano* as well as an invited review article about the state-of-the-art in this field of research in *Nature Nanotechnology*. For his contributions Dr. Aradhya was awarded the Materials Research Society graduate student Gold Award in 2013.

Dr. Sriharsha Aradhya is currently a post-doctoral researcher in the Departments of Applied Physics and Physics at Cornell University.

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 in various capacities including marketing, planning, systems engineering, systems programming and information services. He also worked at the Fairchild Engine Division as Director of the Engineering Computer Group. He personally directed the establishment of several company computer centers at sites throughout the U.S. He 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 Simon Prize was established in 2001 by Dr. Jane Faggen with additional support from friends and relatives of Mr. Simon.*



(left-right) Kui Tang, Matthew Miecnikowski, Rohit Prasanna, & Prof. Adam Sobel

Matthew Miecnikowski, Applied Physics Faculty Award

Matthew Miecnikowski is an Egleston Scholar and an outstanding double major in Applied Physics and Applied Mathematics with remarkable physical insight, quick wit, and humility. Though Matt came to Columbia as a prospective engineering major, he became increasingly interested in physics. He did extremely well both in the classroom as well as in the lab, equally comfortable with theory and experiment and has already participated in two computational condensed matter research projects, one at University of Florida and one at Columbia. He plans to attend graduate school at the University of Colorado, Boulder, and intends to pursue a career in experimental atomic, molecular, and optical physics.

Undergraduate Student Award Winners

Outstanding seniors were recognized at the APAM Senior Dinner on May 8. Winners received a glass paper weight and a check for $250. Their names are also inscribed on plaques inside the Department.

Kui Tang, Applied Mathematics Faculty Award

Kui Tang is an exceptional student and researcher. He is an Egleston scholar, has served as president of Society for Industrial and Applied Mathematics, and coauthored 5 papers during his time here. He spent the summer of 2011 as a HackNY Fellow working at the startup Hunch, which has now been acquired by eBay. Kui will be staying at Columbia to start his Ph.D. work with Prof. David Blei, who just joined the Institute for Data Sciences & Engineering (IDSE) from Princeton.

Rohit Prasanna, Francis B.F. Rhodes Prize

Rohit Prasanna is an outstanding materials science major who excelled in his core courses, in his electives, and in his research projects at the X-ray Research Group at Columbia and abroad at Ecole Polytechnique in Paris. He is interested in materials chemistry, and in the design, synthesis, and application of nanostructured materials. He was accepted to the Ph.D. programs at MIT, Caltech, Stanford, Northwestern, and Cambridge. He has decided to join Stanford for graduate study, and plans to focus on materials science for electronics and energy applications.

2013-2014 Graduates

October 2013

B.S. - Stefan Countryman (AM), Yasmin Vera (AM)

M.S. - Larry Hu (AP), Yevgeniy Kalantarov (MP)

M.Phil. - Sarah Angelini (AP), Pubudu Galwaduge (AP), Yu Gu (AM), Paul Hughes (AP), Michael Jenkinson (AM), Zhisheng Li (AP), Kerry Stevens (AM)

Ph.D. - Sriharsha Aradhya (AP), Theodore Kramer (MSE), Jonathan Widawsky (AP), Ningyao Zhang (AM), Xiang Zheng (AM)

February 2014

M.S. - Asma Ahmed (AM), Nina Bahar (MP), Christopher Choi (AP), Shu-Jhen Dai (MP), Jing Dong (MSE), Matthew Drexel (MP), Xiaorui Fan (AM), Kenneth Hammond (AP), Hailiang Huang (MP), Kevin Jeng (MSE), Yiwei Jin (MSE), Jing Jing (MSE), Chanul Kim (AP), Mordechai Kornbluth (AP), Nicholas Lavini (MP), Jingjing Ling (MSE), Chenhong Liu (MP), Chia-Hao Liu (AP), Michael Liu (MP), Nicholas Majtenyi (MP), Ahmadali Moghimi (AM), Aileen Nielsen (AP), Wenkai Pan (AP), Abhimanyu Ramachandran (AM), Stephen Robertson (MP), Garrett Rogren (MSE), Marae Sarkuni (AM), Wei Shen (MSE), Salar Souri (MP), Francis Stabile (MP), Ryan Sweeney (AP), Dennis Wang (AP), Haoyu Wang (MSE), Chia Hong Wu (MSE), Qu Yuan (MSE),

M.Phil. - Andrew Weisman (AP)

Ph.D. - Cheng Cheng (MSE)

May 2014

B.S. - Walid Ahmad (AM), Jake Barrotta (AM), Eric Borczuk (MSE), Michael Case (AM), Bernard Cheng (AM), John Dodaro (AM), Yuanxin Han (AM), Deryn Jakolev (AM), Michael Jiang (AP), Soo Yeon Kim (AM), Chang Hee Lee (AM), Sangyoon Lee (AM), Jonathan Liou (AP), Matthew Miecnikowski (AM / AP), Samuel Murphy (AM), Kenneth Nakazawa (AM), Tzu-Yang Ni (AP), Victoria Nneji (AM), Rohit Prasanna (MSE), Isabel Reich (AM), Kyle Reuther (AP), Veronica Reynolds (MSE), Daniel Rieman (AM), Elena Ripp (AM), Richard Roberts (MSE), Andrew Ryba (AM), Danika Simonson (AM), Raspberry Simpson (AP), Charles Starr (AP), Kui Tang (AM), Suchith Vasudevan (AP), Brian Velez (AM), Oliver Wai (AM), Diane Wang (AM), Shaoxiang Wang (AM)

M.S. - Jason Anderson (AP), Andrew Bentz (AM), Nicolas Biekert (AP), Minsung Han (AM), Jinhwan Kim (AM), Michelle Kislak (MP), Kaung Lin (AP), Adam Overvig (AP), Hongjian Qi (AP), Roshan Sharma (AM), Sajan Shrestha (AP), Matthew Ward (AM)

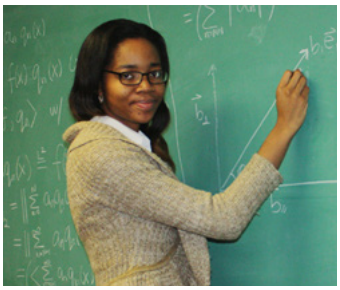
M.Phil. - Olgun Adak (AP), Chenyang Shi (MSE), Ying Wang (MSE), Jin Wang (MSE), Xiaohao Yang (MSE)

Ph.D. - Bryan Debono (AP), Yu Gu (AM), Sarah Angelini (AP), Weiwei Shen (AM)

Photos (top): Medical Physics Graduates, Professors, & Staff
(bottom) C.K. Chu, Iva Vukicevic, & Michael Weinstein

Senior Spotlight: Victoria Chibuogu Nneji

by Melanie A. Farmer, originally published by *Columbia Engineering News*



Victoria Chibuogu Nneji

Born in Lagos, Nigeria, but raised primarily in Durham, NC, Victoria Chibuogu Nneji, who immigrated to the U.S. at age five, credits her hard-working mother for instilling early on the value of education.

"We actually lived in a trailer park in rural South Carolina for some time but my mother never gave up on getting us into environments with greater educational resources," recalls Nneji, 21. "Although I'm part of the first generation in my family to pursue higher education like this, my mother works so hard to ensure that I have everything I need to do well in school." Along with her mother's constant support, Nneji's determination and intellect earned her admission junior year of high school to North Carolina School of Science and Mathematics (NCSSM) — a unique public boarding school that enables students of any socioeconomic background, like Nneji, an opportunity of a quality education.

Says Nneji, "The school's motto is 'accept the greater challenge,' and that I did!"

Her childhood interest in math, science, and technology is something she continues to hone today as an applied mathematics major. After graduation, she hopes to make a difference in education, and is currently considering two job offers where she would be working on more innovative ways to make better use of technology in an educational setting.

"In whatever career I have, I aspire to do great things for the people I serve," says Nneji. "I want to be in a position of solving problems and leading a team toward decisions that have positive returns."

So far, she is right on track, having made major strides in the last four years toward her goal. She has conducted applied mathematics research, with the support of Prof. Adam Sobel, at a Teachers College think tank, where she did quantitative analysis on how changes in financial aid could impact a student's performance in community college, and how long it would take them to complete their associate's degree. For a senior project, she worked on better understanding an algorithm developed by genomics researchers at Columbia University Medical Center for the purpose of identifying genetic networks leading to psychological disorders. And, as a Kenneth Cole Fellow, Nneji got a chance to serve as a consultant for Northern Manhattan Improvement Corp. (NMIC) in Washington Heights. She and her team interviewed some 100 residents to learn more about their economic status since immigrating to the U.S. **(Continued on page 7)**

Alumni Updates

Lisa Chen (B.S. '08, Materials Science) presented a special MSE Colloquium this spring in the APAM Department. She is currently a Ph.D. student in the Department of Materials Science at the University of Pennsylvania.

Michael Hahn (Ph.D. '09, Plasma Physics) was featured in the article, "Astrophysicists Tackle the Sun and One of Physics' Biggest Unsolved Problems," in *The Record*. He also presented a lecture at APAM's Plasma Physics Colloquium on, "Evidence for Wave Heating in the Solar Corona." To learn more about Dr. Hahn's research, see **http://news.columbia.edu/research/3264**

William T. Sha's (Eng.Sc.D. '64, Nuclear Engineering) book, "Novel Porous Media Formulation for Multiphase Flow Conservation Equations," was published by Cambridge University Press in September 2011 and a new paper on "Recent Improvements of Novel Porous Media Formulation of Multiphase Flow Conservation Equations" was recently submitted for publication. "My intention is that after the paper is published, I will merge my book and the paper to issue a new edition of my book. As far as I know, there is no multiphase flow conservation equations that for both laminar and turbulent flows have been derived based on the first principle."

Yutian Wu (Ph.D. '12, Applied Math) presented a talk at the SEAS Colloquium in Climate Science this past spring. She is currently an Assistant Professor in the Department of Earth, Atmospheric, and Planetary Sciences at Purdue University.

Chris Wiggins

New York Times Taps Wiggins as Chief Data Scientist

by Holly Evarts, originally published by *Columbia Engineering News*

Chris Wiggins, associate professor of applied mathematics, has just been appointed to an exciting new role at *The New York Times*: chief data scientist.

This new role is one of several for Wiggins, who is also a member of Columbia's Institute for Data Sciences and Engineering, a founding member of the University's Center for Computational Biology and Bioinformatics (C2B2), and co-founder of hackNY. "The New York Times is creating a machine learning group to help learn from data about the content it produces and the way readers consume and navigate that content," says Wiggins. "As a highly trafficked site with a broad diversity of typical user patterns, *The New York Times* has a tremendous opportunity to listen to its readers at web scale."

"Data science in general and machine learning in particular are becoming central to the way we understand our customers and improve our products," adds Marc Frons, chief information officer of *The New York Times*. "We're thrilled to have Chris leading that effort."

Wiggins, whose activities at Columbia range from bioinformatics to mentoring activities to keep students off "the street" (Wall) by helping them join New York City's exploding tech startup community, focuses his research on applications of machine learning to real-world data.

"The dominant challenges in science and in business are becoming more and more data science challenges," Wiggins explains. "Solving these problems and training the next generation of data scientists is at the heart of the mission of Columbia's Institute for Data Sciences and Engineering."

In creating the Institute, the University is drawing upon its extraordinary strengths in interdisciplinary research: nine schools across Columbia are collaborating on a broad range of research projects. Wiggins and his colleagues at the Engineering School are integrating mathematical, statistical, and computer science advances with a broad range of fields: "We're enabling better health care, smarter cities, more secure communications, and developing the future of journalism and media."

The Institute is already having a dramatic impact on the local economy, and is expected to generate $3.9 billion in economic activity for New York City over the next 30 years, helping to address the immense shortages predicted for both technical and management talent in data sciences and seeding the City's rapidly growing tech startup community with its strong emphasis on entrepreneurship.

"This is an important and exciting appointment for both Chris and the Institute," notes Kathleen McKeown, director of the Institute and Henry and Gertrude Rothschild Professor of Computer Science. "Working with *The New York Times* demonstrates how Columbia faculty care both about advancing data science as a field and engaging with important New York City companies to help our city's economy."

Nanfang Yu

Yu Receives Air Force MURI Grant

by Holly Evarts, originally published by *Columbia Engineering News*

Nanfang Yu, assistant professor of applied physics, is part of a team of researchers from Columbia, Harvard, Purdue, Stanford, and UPenn who have won a $6.5 million 5-year grant from the Air Force Office of Scientific Research (AFOSR) Multidisciplinary University Research Initiative (MURI) program. Their project, "Active Metasurfaces for Advanced Wavefront Engineering and Waveguiding," is targeted at developing "flat" optical devices based on "metasurfaces" — ultra-thin optical components — to control light propagation in free space and in optical waveguides. "This is critical research that will study the interaction between light and low-dimensional designer structures and will address the challenge of miniaturizing optical components and devices," says Yu.

The researchers hope to get rid of current bulky optical elements such as compound lenses and complex optical instrumentations and replace them with either highly integrated chips that run light as signals or with planar optical components that can realize sophisticated control of light when a light beam traverses through them. The team's findings could lead to flat microscopes, flat beam-steering devices for optical radar, and integrated photonic circuits that process quantum information.

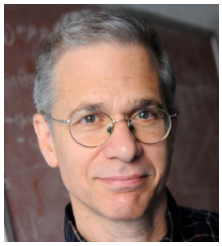
Metasurfaces are made of two-dimensional (2D) arrays of designer scatterers, such as optical antennas, which are miniature version of radio antennas and have nanometer-scale dimensions. The key feature of metasurfaces is that the optical scatterers are all different optically; that is, the scattered light from them can have different amplitude, phase, or polarization, so that metasurfaces can introduce a spatially varying optical response that can control light in extremely flexible ways. As a result, metasurfaces make it possible to realize functionalities that conventionally require 3D optical components or devices with a much larger footprint, such as, for example, focusing or steering light beams, or switching optical signals on integrated photonic chips.

"The interface between two materials is usually thought of as merely a passive boundary," Yu explains. "The essence of metasurfaces, however, is to make an interface useful and functional via clever designs. Such designer optical interfaces can mold optical wavefronts of light propagating in free space into arbitrary shapes and can control surface waves propagating along the interfaces. We are seeing new physics and novel device functionalities introduced by metasurfaces that are distinctly different from those observed in 3D materials."

An optical radar uses light instead of microwave or radio wave used in conventional radar to probe objects far away from the observer. Usually carried by an airplane to scan the terrestrial surface, optical radar technology has the benefits of higher resolution and the ability to access the chemical information, if the frequency of the light is tuned to match with the absorption bands of the chemical to be detected.

(Continued on page 7)

2014 Latsis Symposium: Prof. Mark Cane, Prof. Tiffany Shaw, and Prof. Adam Sobel will speak at the 2014 Latsis Symposium on Atmosphere and Climate Dynamics: From Clouds to Global Circulations, from June 18-21, 2014 in Zurich, Switzerland. The goal of the this year's symposium is to bring together researchers from diverse subcommunities in the climate sciences, in order to map out the most promising research avenues and answer the most pressing questions in climate dynamics.



Michael Weinstein

Weinstein Hosts Distinguished Colloquium Series

Professor Michael I. Weinstein, along with Professors Donald Goldfarb (IEOR), Eitan Grinspun (Computer Science and APAM), and Ioannis Karatzas (Mathematics), initiated a new Distinguished Colloquium Series in Interdisciplinary and Applied Mathematics this spring. See the link: **http://engineering.columbia.edu/distinguished-colloquium-series-interdisciplinary-and-applied-mathematics**

This Colloquium Series, which will continue during the 2014-2015 academic year, highlights the dynamic exchange between mathematics and engineering, computation, the physical sciences, the biological sciences and the social sciences.

The Spring 2014 speakers included Robert V. Kohn, Professor of Mathematics, Courant Institute — NYU, who spoke on "A Variational Perspective on Wrinkling Patterns in Thin Elastic Sheets;" Stanley Osher, Professor of Mathematics and Director of Applied Mathematics, UCLA, who spoke on "What Sparsity and L^1 Optimization Can Do for YOU;" and George C. Papanicolaou, Robert Grimmett Professor of Mathematics, Stanford University, who spoke on "Correlation Based Imaging and Geophysical Applications."

This lecture series is made possible with the generous support of Columbia SEAS Dean Mary C. Boyce.

Faculty Updates

Woodhead Publishing Series in Electronic and Optical Materials recently released "Metallic Films for Electronic, Optical and Magnetic Applications: Structure, Processing and Properties," edited by Katayun Barmak, the Philips Electronics Professor in the APAM Department at Columbia University, and Kevin Coffey, a Professor in the MSE Department of at the University of Central Florida.

Philip Kim was awarded the 2014 Oliver E. Buckley Condensed Matter Prize "For his discoveries of unconventional electronic properties of graphene." The focus of Prof. Kim's group research is the mesoscopic investigation of transport phenomena, particularly, electric, thermal and thermoelectrical properties of low dimensional nanoscale materials. Professor Kim is Fellow of American Physical Society and received numerous awards including Dresden Barkhausen Award, IBM Faculty Award and Ho-Am Science Prize.

Adjunct Faculty Update

The paper "Overview of physics results from the conclusive operation of the National Spherical Torus Experiment" (NSTX), by S.A. Sabbagh, J.-W. Ahn, J. Allain, et al., Nuclear Fusion 53 (2013) 104007 was recently featured among papers of other top authors in the '13 Nuclear Fusion Highlights collection. NSTX is 1 of 3 large magnetic fusion energy experiments in the U.S. The paper provides a brief review of the entire NSTX scientific research program including plasma stability, confinement, and heat exhaust. Prof. Steven A. Sabbagh continues research with Dr. John W. Berkery, Dr. James M. Bialek, and Dr. Young-Seok Park from APAM on the stability and control of high performance plasmas in NSTX, preparing for the new NSTX-Upgrade device scheduled to begin operation at the end of 2014.

Adam Sobel

Sobel Sobel Wins AXA Award in Climate and Extreme Weather

by Holly Evarts, originally published by *Columbia Engineering News*

Superstorm Sandy expert Adam Sobel is getting ready to launch a new initiative on extreme weather, thanks to a €250,000 two-year AXA Award in Climate and Extreme Weather he has just received from the AXA Research Fund. He and colleagues from Columbia Engineering, Lamont-Doherty Earth Observatory, and several other schools and groups at Columbia will use the award to study the local dynamics and global patterns of extreme precipitation and other extreme weather events.

"This award will enable my colleagues and me to work towards our vision of a broadly conceived 'science of extremes,' and I am deeply honored and grateful to receive it," says Sobel, professor of Applied Physics and Applied Mathematics and of Earth and Environmental Sciences. Sobel is organizing an interdisciplinary team, including researchers from the Law School and the School of International and Public Affairs, that is working to establish a new research initiative on Extreme Weather and Climate.

"This initiative will take advantage of the broad expertise that already exists across the University in both the science of extreme weather events—like hurricanes, tornadoes, floods, droughts, and heat waves — and their relation to climate," notes Sobel. "It will also explore both the societal impacts of these events and possible engineering solutions. Receiving this award is great as it's the first external support to our new emerging initiative and will really help seed our program."

The AXA Research Fund recently established the AXA Awards to spur and accelerate the pace of academic innovation, and Sobel is the first AXA awardee. The awards are designed to support mid-career researchers with extremely high potential for innovation in their fields and are given by AXA's Scientific Board following recommendations from independent search committees composed of eminent academics.

Prof. Sobel was interviewed over the last year by several media sources on extreme events, including the severe cold in the US, Typhoon Haiyan & Hurricane Sandy. To learn more, see: apam.columbia.edu/sobel-interviewed-typhoon-haiyan-and-hurricane-sandy

Simon Billinge

Billinge Named Fellow of Neutron Scattering Society of America

Prof. Simon Billinge was named a fellow of the Neutron Scattering Society of America in recognition of his "seminal contributions to the field of local structure and nanostructure studies using atomic pair distribution function methods and impact on the field of neutron diffraction."

This technique uses the information from neutrons scattered from materials to discern the atomic arrangements in nanoparticles, enabling scientists to better understand the link between structure and function. This information paves the way toward rational design of new materials with improved properties for applications from medicine to new energy-saving technologies. For more information, see:

neutronscattering.org/prizes/nssa-fellows/

Climate Conditions Help Forecast Meningitis Outbreaks

APAM Associate Research Scientist, Carlos Pérez García-Pando (NASA GISS), was recently featured in *Astrobiology Magazine* in the following article by Michael Shirber.

Determining the role of climate in the spread of certain diseases can assist health officials in "forecasting" epidemics. New research on meningitis incidence in sub-Saharan Africa pinpoints wind and dust conditions as predictors of the disease. The results may help in developing vaccination strategies that aim to prevent meningitis outbreaks, such as the 1996-1997 epidemic that killed 25,000 people.

Many diseases become more prominent at certain times of the year. A common example is influenza, which peaks in colder months. Meningitis — an infection of the thin lining surrounding the brain and spinal cord — is also seasonal. In the Sahel (a semi-arid region stretching through Mali, Niger, Chad and Sudan), meningitis incidence is highest in the dry season from November to May.

"For more than 60 years, we have known that meningitis epidemics in sub-Saharan Africa are partly related to climate and environmental conditions," said Carlos Pérez García-Pando of NASA Goddard Institute for Space Studies and Columbia University. "But factors other than climate, and a lack of data and knowledge have hindered the quantification of this relationship."

Pérez and his colleagues have compared meningitis incidence in Niger from the years 1986 to 2006 to climate variables over the same time period. In the journal *Environmental Health Perspectives*, they report that wind strength and surface dust concentration in November and December can be used to predict the rate of meningitis infection over the subsequent months.

"Our paper shows that in Niger dust and wind conditions along with information on the amount of cases during the pre-season months have a certain amount of predictability on the seasonal cases of meningitis," Pérez said.

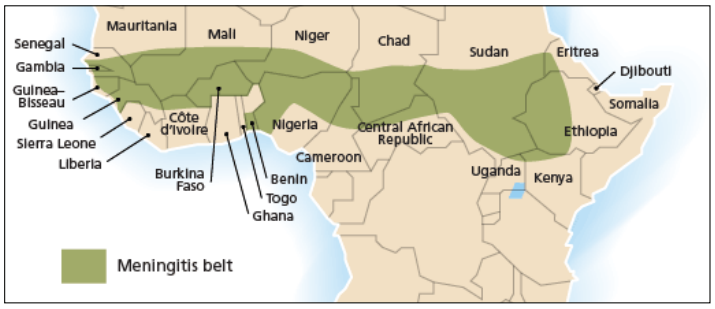
Being able to forecast the possibility of a meningitis epidemic could give health officials more time to prepare.

Meningitis Belt: There are several different causes of meningitis, including viruses, bacteria and fungi. However, large outbreaks of the disease are typically the result of the bacteria Neisseria meningitidis. Roughly 10 percent of people carry this bacteria in their throat to no ill effect. The bacteria only become a problem when they infect the meninges, the thin lining around the central nervous system. Bacterial meningitis has a rapid onset that leads to death in roughly 1 in 10 cases. Those that survive often suffer from mental retardation, deafness, epilepsy, or necrosis.

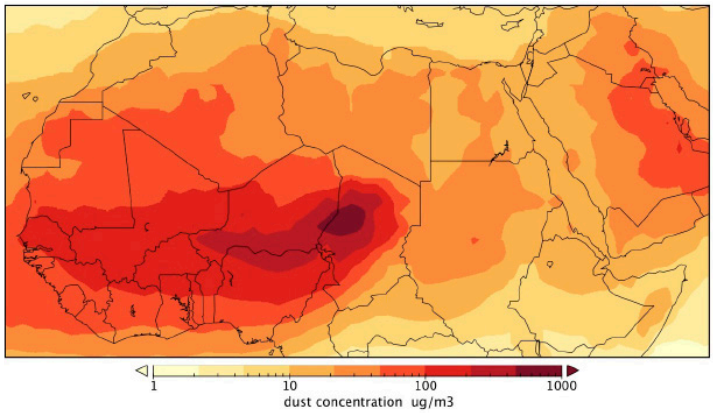
In the last 100 years, numerous meningitis epidemics have occurred around the world. The most affected area has been the Sahel, or what is sometimes called the "Meningitis Belt." Every 8 to 12 years, a large epidemic (in which more than 1 out of 1000 people are afflicted) sweeps over this region. The largest recorded epidemic occurred in 1996-1997 with 250,000 cases and 25,000 deaths, according to the World Health Organization (WHO).

Vaccines do exist for bacterial meningitis, but they typically provide immunity for only two to three years. The standard procedure, therefore, has been reactive immunization. If the number of cases in a district reaches a certain threshold, then vaccinations and antibiotics are ordered for that district. But sometimes the response can be too late.

"The problem with the thresholds is that they rely on surveillance, and sometimes there can be delays in reporting," said William Perea, an epidemiological officer at WHO.



Above: The African meningitis belt (Image: World Health Organization)
Below: Estimated dust concentration averaged from Oct.-Dec. over the period 1985-2006 in micrograms of dust per cubic meter. Maximum values over the Bodélé Depression in Chad extend towards southern Niger. (Image: Carlos Pérez García-Pando)



Recently, health officials have begun administering a new vaccine that provides long-term immunity. It targets a specific type of Neisseria meningitidis bacteria (designated serogroup A) that accounts for 80 percent of all cases. This vaccine may reduce the threat of epidemics, but other meningitis serogroups are likely to continue to be a problem.

In order to better anticipate future outbreaks, scientists from a variety of disciplines have come together as part of the Meningitis Environmental Risk Information Technologies (MERIT) initiative. Led by WHO in support of health ministries across the Sahel, MERIT aims to create predictive models for the disease based on climate and environmental variables.

"Building a consortium effort has helped speed up the research and its translation to operations," said Madeleine Thomson, a founder of MERIT from the International Research Institute for Climate and Society.

As part of MERIT, Pérez and Thomson, along with other colleagues, investigated the climate factors that may influence the disease.

A Factor Among Factors: The spread of any infectious disease will depend on a multitude of factors, such as the level of immunity and, in the case of person-to-person transmission, the types of social interactions inside a given community. It can be hard, therefore, to isolate the effect of climate on disease.

The climate connection has been studied before in other diseases. The incidence of malaria, for example, has a strong dependence on temperature. Scientists have explained this with laboratory experiments that look at the effects of temperature on both the mosquitoes that transmit malaria and the malaria parasite itself.

Meningitis, by contrast, is transmitted person-to-person, so the role of climate is not as easy to isolate, Pérez said.

The disease has a strong seasonality, evidenced by the fact that the rate of infection jumps up during the driest months of the year between January and May. In the rainy season, by contrast, the incidence drops by more than a factor of 100. In fact, rain has been described as the most effective vaccine for the disease. **(Continued on page 7)**

Climate Conditions Help Forecast Meningitis Outbreaks

(Continued from page 6)

"The epidemics usually end when the first rain drops fall," said Perea.

The strong seasonality could be due to changes in temperature, humidity and dust. The amount of dust is particularly high in this part of the world thanks to the Harmattan, a strong wind that comes in from the northeast. The Harmattan picks up dust as it blows over desert regions like the Bodélé Depression, a dried-up lake bed in central Chad that is the largest dust source on Earth. The resulting dust storms are so thick that they can block out sunlight for several days.

Dust may influence the spread of meningitis in a number of ways. The most common proposed mechanism is that dust particles can irritate a person's throat, making it more vulnerable to infection. Dust storms also force people to stay indoors, where they may transmit the disease more easily to each other.

To investigate the role of dust, Pérez and his colleagues used observations from the ground and from satellites to construct a model that could compute the level of near-surface dust at different times during the study period (1996-2006). Along with these dust estimates, they compiled a list of climate variables, such as temperature, winds and humidity.

They then compared their climate and dust variables to the meningitis incidence during the peak season (January through May) in order to see which variables had the most significant association with the disease. They found that the associations were stronger when including cases in the early months (prior to January). These "early cases" give an indication of how susceptible a certain population may be to the disease.

On the national level, the researchers found the best forecasting model was one that combined early cases and the average east-to-west wind strength in November and December. A similar model based on surface dust concentration performed equally well.

Future Efforts: Pérez imagines these climate predictors could become part of the national health programs in the Sahel region. For example, if the early-season wind and dust levels are strong and the population is susceptible, then health officials might be able to plan ahead.

"This could give more lead time for distributing vaccines to vulnerable districts," Pérez said. He believes some pilot studies would be the first step in sizing up how effective such a strategy would be.

"If the models here can be validated, we'll have an additional tool to anticipate the next epidemic," Perea said.

Senior Spotlight: Victoria Chibuogu Nneji

(Continued from page 3)

They presented their findings to NMIC and Kenneth Cole for the community to supplement a pilot cleaning business started by women in NMIC's domestic violence recovery group, EcoMundo, with a new one that will provide greater economic freedom and opportunity over the next few years.

"I was able to bring my math skills into this project by developing a coding system for us to capture the qualitative responses in a method that we could visually present the data effectively to stakeholders," she says of that fellowship experience.

Nneji genuinely loves to problem solve; as she puts it, "that's my thing," and it also is what initially led her to pursue applied mathematics at the School. That, and a positive experience during Columbia Engineering Experience (CE2) invitational, where she had the opportunity to learn what it would be like to be an engineering student at Columbia.

At CE2, she began to recognize that "being in a city like New York at a global university like Columbia would provide me with an environment to stretch my reach and grow in my potential," she says. She also credits CE2 for linking her to an unforgettable experience at Google headquarters in Mountain View, CA. During CE2, prospective students paid a visit to the Google site in New York and were introduced to scholarship opportunities. As a result, Nneji applied and ended up spending the summer before her freshman year in California as a Google computer apprentice. "CE2 literally changed my life," she says.

Columbia Engineering has helped Nneji not only become a better mathematician but also a more well rounded student overall.

"Whenever I meet someone new, regardless of whether the conversation is about something 'techy' or something 'artsy,' I don't ever feel like I can't contribute something valuable," says Nneji.

When she's not studying complex math, Nneji volunteers on community service projects related to public health and education. She also makes time to enjoy New York City, whether it's taking in a Broadway show or going on a neighborhood food tour. "And, once the weather is warm," she adds, "I'll have fun bike riding along the Hudson greenway, from Dumbo to the Cloisters!"

Learn more about Dr. Pérez's research in the video "Dust and the Wind: Climate and Meningitis in Niger" produced by Columbia University/IRI on Vimeo: http://vimeo.com/87435144

Yu Receives Air Force MURI Grant

(Continued from page 4)

But, says Yu, the major challenge with optical radar technology is that the laser beam must be scanned very fast in a two dimensional way over a solid angle. The current method uses a steering mirror to mechanically bend the light beam, but it is slow and prone to mechanical problems. In addition, the system is bulky and needs to be housed in a big radar cone, cumbersome for the airplane carrying the optical radar.

One of the aims of the MURI project is to demonstrate a flat optical radar made of a 2D-array of phased optical elements that can bend the propagation of light as the beam traverses the flat optical radar. The bending direction is controlled by electronics integrated with the optical elements so the flat optical radar will not have any movable compartments and can be easily integrated directly onto the surface of an airplane.

And it's not just radar that Yu is thinking about. Flat devices are lightweight and can be made flexible. "So they are more portable and can conform to non-conventional surfaces, like the human body," he says. "Common optical instruments, from microscopes to cameras to telescopes, could be made flat and could even be wearable. There are amazing things we could develop with this new technology!"

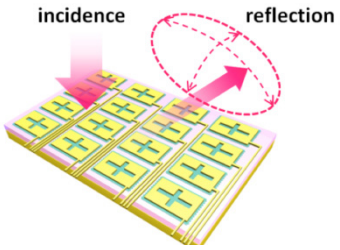
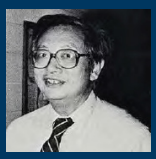


Image: Schematic of a beam-steering metasurface used for optical radar applications. The metasurface is made of a 2D array of optical scatterers that introduce different amounts of delay to different portions of the incident optical wavefront, which leads to a reflected light beam pointing to desirable directions. The reflection direction is controlled electrically by tuning the phase response of the optical scatterers.

SEAS 150th Anniversary: APAM Department Timeline

1961 Founding faculty, including Robert Gross & C.K. (John) Chu, establish the Plasma Physics Laboratory, beginning a long & prominent tradition at the forefront of high-temperature & fusion plasmas aided by a major expansion of APAM's fusion efforts in 1975.



1968 Helping to unlock the secrets of phenomena that had puzzled scientists for centuries, C.K. Chu develops finite difference approximations of the equations of fluid dynamics & coins the now-standard phrase, "Computational Fluid Dynamics."

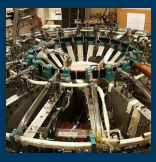
1978 Dean Peter Likins' proposal combines the Plasma Physics Committee, an interdepartmental doctoral program, with the existing Division of Nuclear Science & Engineering to form the Applied Physics & Nuclear Engineering (APNE) Department.

1984 C.K. Chu spearheads the department's expansion into solid state physics & applied mathematics. In 1990, the nuclear engineering program ended, & APNE became the Department of Applied Physics.

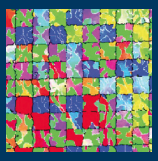
1985 Thomas Marshall, a pioneer in developing free electron lasers, publishes the first book on this subject.

1988 Gertrude Neumark develops & patents the process of non-equilibrium doping that enables significant advances in light-emitting & laser diodes, particularly in the blue-green region, which many companies later use to improve consumer products, including to develop sharper laser printers, increased-capacity DVDs, & better traffic lights, mobile-phone screens & flatscreen TVs.

1990 Michael Mauel & Gerald Navratil conduct the first joint experiments with the Tokamak Fusion Test Reactor at the Princeton Plasma Physics Laboratory (PPPL) & achieve the highest poloidal beta operation of a tokamak. In 1993, they participate in the world's first demonstration of fusion energy production using a deuterium-tritium plasma in the PPPL's Tokamak Fusion Test Reactor.



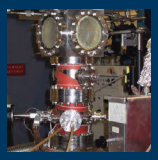
1993 Gerald Navratil & Michael Mauel complete the High Beta Tokamak-Extended Pulse (HBT-EP), the third & largest in a series of tokamaks built at Columbia.



1996 James Im receives the first of many patents on advanced laser-crystallization of silicon thin films. This technology makes possible high-resolution screens featured in products manufactured by Apple, Samsung, Blackberry, & Nokia, among others.

1998 The Applied Physics Department changes its name to the Department of Applied Physics & Applied Mathematics (APAM) to reflect the faculty's commitment to disciplines on a scale made possible by The Fu Foundation's generous endowment to the School.

1998 Horst Stormer shares the Nobel Prize in Physics with two others "for their discovery of a new form of quantum fluid with fractionally charged excitations," the fractional quantum Hall effect.



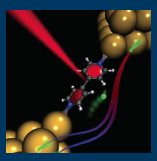
1998 The National Science Foundation establishes the Materials Research Science & Engineering Center (MRSEC) on nanostructured materials at Columbia, which helps set the stage for Columbia's prominence in nanoscience; Irving P. Herman is named director.

2000 APAM expands its role in mathematical earth science by creating two jointly budgeted faculty members with the Department of Earth & Environmental Sciences (DEES) in the Graduate School of Arts & Sciences.

2000 Adam Sobel develops the weak temperature gradient approximation method for modeling tropical precipitation, revolutionizing scientists' understanding of tropical weather patterns & opening a new avenue for computer modeling & simulation.

2000 Dean Zvi Galil places the Materials Science & Engineering Program of the Henry Krumb School of Mines within APAM, thereby creating a collaborative, multidisciplinary department with research interests in applied physics, applied mathematics, & materials science & engineering.

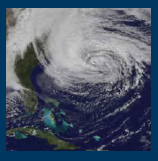
2002 Gerald Navratil extends Columbia's active feedback stabilization for tokamaks to the General Atomics DIII-D tokamak, bringing practical fusion energy a step closer, & which leads to his sharing the 2007 Dawson Prize for his pioneering work.



2007 Latha Venkataraman transforms break junction measurements into a reliable procedure, setting the stage for her important discoveries that have advanced understanding of the electrical conductance of single molecules.

2010 Making an advance with extensive research applications, Michael Mauel & collaborators at MIT demonstrate that the plasma physics of planetary magnetospheres can be reproduced in laboratory settings by magnetically levitating a million ampere superconducting current ring for a number of hours.

2011 Lorenzo Polvani shows the first link between ozone depletion & climate change in the Southern Hemisphere, which follows his 2008 study suggesting that winds in the Southern Hemisphere will be greatly impacted by the projected recovery of the ozone hole in the latter 21st century.



2012 Adam Sobel takes a leading role explaining the science behind Superstorm Sandy to the media & the public, & embarks upon research exploring Sandy's relationship to our present climate & what is likely to happen in the future.

Special thanks to Prof. Irving Herman for compiling this timeline, as well as the school's time capsules on the SEAS 150th website:
http://seas150.columbia.edu/multimedia

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