Dear Colleagues,
Students, Alumni,
& Friends of APAM,

In 2014 we had good and bad news. Our Applied Mathematics Program was strengthened by the arrivals of Professors Qiang Du and Kyle Mandli. We were able to successfully recruit Professor Alex Gaeta from Cornell University to join our Condensed Matter/Optics program. He will be coming on board in 2015. Our Materials Science Program is renovating its teaching laboratories and is in the process of revising its undergraduate and graduate curriculum. Our new transmission electron microscope is on schedule to be delivered on December 18th. We are also in the process of searching for a faculty member who is an expert in materials synthesis, who, we hope, will join us next year. We are, thus, entering 2015 with optimism.

On the other hand, we are saddened by the loss our beloved colleague Professor Morton B. Friedman who was the co-founder of our Applied Mathematics Program. We will truly miss him.

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

Best regards,

I. Cevdet Noyan
Chair, APAM
of one particular goal but the sum force of all his passions being realized. Fittingly, what's exciting to Durrani about his future isn't the realization of the field that I feel I can go into, helping to form its paradigms rather than the law now, we can make sure the final frontier is a feasible one. It's a space debris and policy. "I believe that if we invest the time in forming also the catalyst for his interest in space law.

Durrani is committed to the pursuit of social justice, and it underlines all responsibility and humanities that I didn't see elsewhere," he says. What is especially impressive about Durrani is his pan-disciplinary thirst of robotics.

Whether it's pioneering space law, writing a book on the human heart, fashioning works of art, catalyzing research in the materials using clusters as building blocks, and recently published his research in the field of quantum spintronics, his already stellar collection of achievements.

The Takeaway

Congratulations to our outstanding student award winners!

Undergraduate Scholar:

Sean Ballinger (AP), Fruitful Futures Task Force and Ari Tulun (AP), Aromanian Neighbors for Sustainability. "Literature helped me understand that engineering and science exist in their social contexts and that an understanding of social, political, and moral implications is as important for chemistry as for engineering formulars and methods." It was this social consciousness that drew Haris to continue his scientific pursuits as a means of contributing to positive social responsibility and humanities that I didn't see elsewhere," he says.

Haris Durrani

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Knew early on what set engineering apart for him. "Most fields are fascinating in theory," he says. "Engineering is a field that I love from the meta to the micro." What is especially impressive about Durrani is his pan-disciplinary thirst for the interesting and his ability to let his various interests inform one another. An Applied Physics fellow at Columbia, Durrani is also a talented actor. He uses literature as an outlet for exploration—a vehicle to contextualize science, engineering, space—and as a means to examine his identity as a Pakistani, American Muslim.

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Yu Wins NSF Grant

Nanfang Yu, Assistant Professor of Applied Physics, leads a team of researchers who have won a $400,000 grant from NSF. The grant will support their work in the field of Nanomechanics, which involves the study of small-scale mechanical properties of materials. The project focuses on developing new computational methods to simulate the behavior of materials at the nanoscale.

The team will investigate some long-standing mysteries regarding the ability of insects to perceive and respond to infrared radiation, which can be as weak as 10^-19 watts per square meter. While many studies have focused on the physical optics of living systems in the UV and visible spectral range, an understanding of the role of infrared light in the lives of insects and other animals is rather limited. A number of compelling examples support the hypothesis that insects can perceive and respond to broad-spectrum infrared radiation with high sensitivity, or narrowly tuned “fingerprint” infrared radiation with high specificity. The objective of the project is to understand the physical mechanisms underlying the ability of insects to perceive broadband or narrowband infrared radiation.

The team includes physicists lead by Prof. Yu from APM and biologists led by Prof. Jia from Penn State, and Nanomaterials from the Organic and Evolutionary Biology Dept. and the Museum of Comparative Zoology at Harvard.

New Applied Mathematics Faculty Members

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Science and Engineering News

Twisted Atomic Half-Pipe

Everything breaks under enough stress, of course, but not everything means the end of the world. In graphene, boron nitride, and other materials, for example, doesn’t enter a strange phase as it creeps toward its breaking point—just simply snaps. Monolayers meet their end, but play by very different rules.

Within the honeycomb-like lattices of monolayers like graphene, boron nitride, and graphene, the atoms rapidly vibrate in place. Different vibrational states, which dictate many of the mechanical properties of the material, are called “modal vibrations.” The breaking points for such monolayers are strung out at “soft modes”—the vibrating atoms that drive those transition points. As the material undergoes a distinct distortion towards trigonal pyramidal coordination. What’s the impact? Everything from microscopic to macroscopic, from the atomic structure and vibrational modes of materials under different degrees of stress. Scientists and engineers need these insights to control the breaking points of materials—albeit virtually.

Graphene and other monolayer materials feature exotic, electronic and mechanical properties: atomically thin, ultra-light, and stronger than steel. Their properties promise materials that transform and fail under strain.

What did the scientists learn? They pinpointed the breaking points and failure mechanisms for these atom-thin super materials. When stressed, so-called “soft mode” instabilities emerge that cause characteristic atomic reconfigurations—surprisingly, this behavior persisted across different monolayer materials.

How did they do it? Using quantum mechanical simulations and such baby steps, they combined the atomic structure and vibrational modes of materials under different degrees of strain. Scientists and engineers need these insights to control the breaking points of materials—albeit virtually.

Simulated Shattering

Monolayer materials experience strain on atomic scales, demanding different investigative expertise than that of the average demolition crew. Isaacs and his collaborators turned to a mathematical framework called density functional theory (DFT) to describe the quantum mechanical processes unfolding in the materials.

“DFT lets us study materials directly from fundamental laws of physics, the results of which can be directly compared to experimental data,” said Isaacs. “Density functional theory is a sound tool for quantum mechanical calculations. Our research was enabled by large-scale quantum mechanical calculations that were performed on supercomputers at Brookhaven.”

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Professor Qiang Du is an Assistant Professor of Applied Mathematics. He currently works at Cameron Mellon University, after which he has held faculty positions at University of Iowa and University of California at Davis. Professor Du has also been a visiting scholar at Lawrence Berkeley National Laboratory, Lawrence Livermore National Laboratory and Brookhaven National Laboratory.

His research interests include numerical analysis, mathematical modeling and scientific computation with applications in electronic properties. But to fully exploit these atomically tailored materials, it will be extremely difficult to explore experimentally.

They discovered that the strain induced the materials a novel phase transition — a restructuring in their near-perfect crystalline structures that leads to instability and failure. Surprisingly, the phenomenon persists across several different materials with disparate electronic properties, suggesting that monolayers may have intrinsic instabilities that could be either overcome or exploited. The results were published in the journal Physical Review B.

“Our calculations exposed these monolayers’ fundamental shift in structure and character when stressed,” said study coauthor and Ph.D. candidate Eric Isaacs, “which allows new functional materials to be engineered based on the way people engage with that content,” Wiggins says. “If you think about the way people engage with that content, then you can think about the way they would be expected or how they would be expected to break under stress.”

Fortunately, researchers have now pinpointed the breaking mechanism of several monolayer materials hundreds of times stronger than steel with exotic properties that could revolutionize everything from armor to electronics. A Columbia University team used supercomputers at the U.S. Department of Energy’s Brookhaven National Laboratory to simulate and understand the phenomena, which would be extremely difficult to experimentally.

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“Qiang Du” (continued on p.6)
FOCUS ON FACULTY ACTIVITIES: ADAM SOBEL

Adam Sobel: Storm Surge
Prof. Adam Sobel’s first book, Storm Surge: Our Changing Climate, and Extreme Weather of the Past and Future, was published by Harper-Collins on October 14, 2014. His book focuses on Hurricane Sandy and related issues, such as climate change, the science behind both weather forecasts and climate projections, and how we as human beings and societies cope with environmental risks.

Was Hurricane Sandy a freak event—or a harbinger of things to come? Was climate change responsible? What connects the spiraling clouds our satellites saw from space, the brackish water that rose up over the city’s seawalls, and the slow simmer of greenhouse gases? Why wasn’t we better prepared?

In this fascinating and accessible work of popular science, atmospheric scientist and Columbia University professor Adam Sobel addresses these questions, giving us insight into the sophisticated science that led to it all, as well as an understanding of why our meteorological vocabulary failed our leaders in warning us about this “Superstorm”—part hurricane, part winter-type nor’easter.

Storm Surge brings together the melting glaciers, the shifting jet streams, and the warming oceans to make clear how our changing climate will bring together the melting glaciers, the shifting jet streams, and the warming oceans to make clear how our changing climate will make New York and other cities more vulnerable than ever to huge storms and how we can hope to mitigate the damage. Sobel’s book provokes us to rethink the future of our climate and how we can better prepare for the storms to come.

2014 AGU Atmospheric Sciences Ascent Award
Prof. Adam Sobel has been awarded the 2014 AGU Atmospheric Sciences Ascent Award. Established in 2012, the Atmospheric Sciences Ascent Award aims to reward exceptional mid-career scientists in the fields of the atmospheric and climate sciences. The award recognizes achievements in research and leadership in the field. The award will be presented at the Atmospheric Sciences Banquet on Tuesday evening, December 16, during the AGU Fall meeting in San Francisco.

Follow Prof. Sobel on Twitter @profadamsobel, Facebook https://www.facebook.com/adam.sobel, or on his blog http://adamsobel.org/

Medical Physics Faculty Honored
The American Association of Physicists in Medicine (AAPM) awarded Prof. Howard J. Amols and Prof. Edward L. Nickoloff its Edith H. Qumby Lifetime Achievement Award in Medical Physics. The AAPM recognizes AAPM members whose careers have been notable based on their outstanding achievements. Recipients must be participating AAPM fellows who have made significant scientific achievements in medical physics, had a considerable influence on the field, or shown leadership on various international organizations.

Prof. Amols, a founding member of Columbia’s M.S. Program in Medical Physics, is currently teaching advanced radiation therapy. Prof. Nickoloff retired in 2012 after teaching diagnostic radiology for 20 years to students in the Medical Physics Program.

Prof. Amols and Prof. Nickoloff were honored at the AAPM Awards and Honors Ceremony during the 56th Annual Meeting in Austin, TX in July 2014. Prof. Lawrence Rothberg was so honored in 2007.

Monolayer Renovations
Aimed with this knowledge, researchers may now be able to figure out how to delay the onset of the newly characterized instabilities and improve the strength of existing monolayers. Beyond that, scientists may even be able to engineer new ultra-strong materials that anticipate and overcome the soft mode weakness.

“Beyond the thrill of the discovery, this work is immediately useful to a large community of researchers excited to learn about and exploit graphene and its cousins,” Isaacs said. “For example, we’ve been working with Columbia experimentalists who use a technique called ‘nanointeraction’ to experimentally measure some of what we simulated.”

The work was supported by the National Science Foundation (Grant No. CMIP-0927981) and the New York Center for Computational Sciences, a joint venture between Brookhaven Lab and Stony Brook University that is supported by the U.S. Department of Energy and the State of New York.

Keller Receives Honorary Degree
Joseph B. Keller, Professor Emeritus of Mathematics and Mechanical Engineering at Stanford University, was conferred an Honorary Doctor of Science degree at the 2014 University Commencement. Prof. Michael Weinstein of APAM commented, “Joe Keller has been an inspiration to generations of mathematicians and applied scientists. His work is characterized by deep creativity and startlingly elegant formulations with profound impact. This is combined with a sense of playfulness and joy in thinking mathematically about the world, as in his studies of the mathematical qualities of soap bubbles and the dynamics of dice-throwing.” Prof. Keller was nominated for the Nobel Prize in Physics, which he shared with Aleksandr M. Prokhorov and Nicolai G. Basov, 38 awards, and 31 honorary degrees.

Townes Celebrates 99th Birthday
The University of California, Berkeley hosted a special celebration for Charles Townes’ 99th birthday on July 29, 2014. Townes accepted a faculty position at Columbia University in 1948 and was appointed provost and professor at MIT in 1961. From 1966-1978 he served as the chair for the NASA Science Advisory Committee for the Apollo lunar landing program and in 1967, he was named a Professor Emeritus of the University of California, Berkeley. Career highlights include a 1964 Nobel Prize in Physics, which he shared with Aleksandr M. Prokhorov and Nicolai G. Basov, 38 awards, and 31 honorary degrees.

For the full story, please see: www.universityofcalifornia.edu/news/birthday-hale-celebrate-laser-inventor-charles-townes’-99th
Several APAM undergraduate students presented posters at the third annual SEAS Undergraduate Summer Research Symposium on Tuesday, October 7, 2014, in the Teatro Italiano.

This event was hosted by SEAS Undergraduate Student Affairs & Global Programs, the Engineering Student Council, and the Columbia Undergraduate Scholars Program.

Sean Ballinger, Applied Physics '16, Egleston Scholar - “Optimizing Plasma Boundary Control in Superconducting Tokamaks” (Supervised by David Humphreys, General Atomics)

Anton Baleato Lizancos, Applied Physics ‘16, Egleston Scholar - “LOFAR-discovered Supernova remnants” (Supervised by Gemma Anderson, Jess Broderick, & Rob Fender, Physics, Univ. of Oxford)

Haris A. Durrani, Applied Physics ‘15, Egleston Scholar - “Space Debris: Observation, Mitigation, Remediation & their Legal Factors” (Supervised by Michael Massimino, Mechanical Engineering)


Ari Turkiewicz, Applied Physics ‘14, Egleston Scholar - “Molecular Clusters as Building Blocks for Solid-State Materials” (Supervised by Xavier Roy, Chemistry)