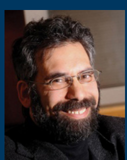
Columbia | Engineering
The Fu Foundation School of Engineering and Applied Science

Fall 2022, Vol. 17 Issue 1

APAM NEWS

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



Dear APAM Family,

Greetings and best wishes for a happy New Year. The Fall semester was extremely active in APAM and with this newsletter, we would like to share some of the fantastic achievements of our students, alumni, faculty, and scientists. We would also like to welcome several new members to the department as well as bid some long-standing members of the department farewell.

Faculty and students in all three APAM programs: Applied Physics, Materials Science, and Applied Mathematics have been working across a wide range of scientific problems and we share with you some highlights including advanced designs for fusion energy, optical properties of butterfly wings and flat lenses, the world's longest conductive nano-wire and new advances in machine learning and data science. We are proud of these achievements and the vibrancy and multi-disciplinary strengths of the department are reflected in multiple awards, honors, and leadership positions across the full range of APAM activities. We are also pleased to welcome several new faculty members to APAM who promise exciting new advances in computational plasma physics and applied mathematics.

While we celebrate the important opportunities afforded by new faculty, we also take the time to honor and remember beloved colleagues that we have recently lost. We began the semester with a moving tribute to Prof. Aron Pinczuk, co-organized by APAM and the Physics department. More recently, we mourn the passing of Prof. *Emeritus* C.K. "John" Chu, one of the founding members of APAM, and a pioneer in computational fluid mechanics. Prof. Chu was a tireless champion for Applied Mathematics, the Department, and the Engineering School. While we will miss them deeply, we celebrate lives well lived.

Best,

Marc Spiegelman, APAM Chair

Cover image: Colleagues, students, alumni, family, and friends gathered on October 8, 2022 to celebrate the life and work of Prof. Aron Pinczuk.

Columbia University Plasma Physicists at the 2022 APS-DPP Meeting

by Michael Mauel

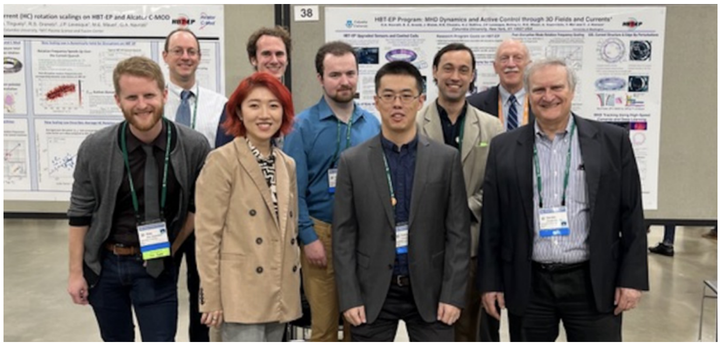


Photo of the poster session presentations from the HBT-EP research team. (from left to right) Alex Saperstein, Dr. Jeff Levesque, Boting Li, Nigel DaSilva, David Arnold, Yumou Wei, Rian Chandra, Prof. Mike Mauel, and Prof. Gerald Navratil.

Columbia University students, scientists, and faculty presented seventy-one research presentations at the 64th Annual Meeting of the APS Division of Plasma Physics held at Spokane, WA. The APS-DPP Meeting is the world's largest research conference for plasma physics. This year, over 1,900 students and scientists attended in person for the week-long event. Highlights of the meeting were invited lectures presented to the participants of the DPP Meeting and to several linked conferences addressing timely and important special topics.

Alex Saperstein (Applied Physics doctoral student) presented his invited lecture, titled "Rotation of non-axisymmetric halo current in disrupting plasmas." Alex combined observations from Columbia University's HBT-EP tokamak with observations from MIT's CMOD tokamak and presented a new drift-frequency-based scaling law for the rotation frequency of harmful asymmetric halo currents. Understanding the new scaling is important to efforts to prevent these halo currents in next step fusion energy devices, like ITER and SPARC.

Yumou "William" Wei (Applied Physics doctoral student) was invited to present his research at the 26th Workshop on MHD Stability Control. This workshop, organized by **Dr. Jeff Levesque** (PhD '12, Applied Physics), presented the latest developments in MHD control needs for burning plasma devices. William explained how deep-learning and neural net computing can be used for MHD mode tracking using high speed cameras. **Dr. Ryan Sweeney** (PhD '17, Applied Physics) was invited to present the "SPARC MHD Stability and the Error Field Strategy" developed for the upcoming burning plasma experiments at Commonwealth Fusion Systems (CFS) and MIT. Next, at the mini-conference on "Public-Private Partnerships for Fusion Energy" **Dr. Brian Grierson** (PhD '09, Applied Physics) and **Dr. Ben Levitt** (PhD '04, Applied Physics) presented corporate plans for fusion energy R&D from General Atomics and from Zap Energy.

Many graduate students and scientists presented their research in "poster sessions." The largest poster session from Columbia University presented research and analysis from the HBT-EP experiment. (See photo.) Other notable presentations from Columbia University graduate students included students from the APAM Department - **Alexander Battey, William Boyes, Anson Braun, Daniel Burgess, Jalal Butt, Hari Choudhury, Abdullah Hyder, Priyansh Lunia, Matthew Pharr,** and **Haley Wilson**, as well as students from the Astronomy Department **- Jorge Cortes, Navin Sridhar,** and **Aaron Tran**. Presentations were also given by Columbia University scientists **Luca Comisso** (Astronomy Department), **Jeremy Hanson** (APAM Department - PhD '09, Applied Physics), **Garima Joshi** (Astronomy Department), **Steven Sabbagh** (APAM Department - PhD '90, Applied Physics), and **Ian Stewart** (APAM Department - PhD '20, Applied Physics), as well by Columbia University faculty **Prof. James Anderson** (Electrical Engineering Department), **Prof. Michael Mauel** (APAM Department), **Prof. Gerald Navratil** (APAM Department), **Prof. Elizabeth Paul** (APAM Department), **Prof. Carlos Paz-Soldan** (APAM Department), and **Prof. Lorenzo Sironi** (Astronomy Department).

As is now tradition, today's students of plasma physics and fusion science are joined by alumni and collaborators for the annual Columbia University Plasma Lab Reunion Dinner. More than forty students and alumni gathered to celebrate the Lab's past and present research accomplishments. This year's Plasma Lab Reunion Dinner was organized by **Dr. Ken Hammond** (PhD 2017, Applied Physics).

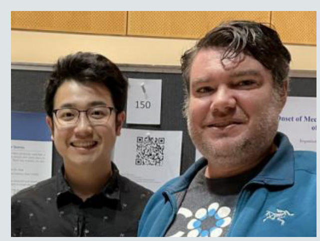
Fall 2022 Undergraduate Research Symposium

APAM undergraduate students participated in the Fall 2022 Columbia Research Symposium on Friday, October 21st, in Roone Arledge Auditorium.

Sophia Guizzo, Applied Physics '24
"Electron Beams for Cryogenic Pellet Ablation"

One major area of focus in fusion research is effective disruption mitigation strategies that can halt disruptions in fusion reactors like tokamaks. One method for stopping disruptions is injecting a cryogenic pellet deep into the core of the reactor to cool the runaway electrons. Therefore, a quantitative description of how pellets ablate (burn up) while passing through a plasma is strongly desired by fusion scientists. The Columbia Plasma Physics Lab is working on developing a laboratory setup to measure pellet ablation at Columbia using a high-energy electron beam to ablate frozen pellets. The electron beams will mimic a plasma but have much more controllable properties. The focus of this project was to perform computational analysis using theoretical pellet ablation models to determine the correct parameters for the electron beam and the viability of different pellet materials and setups. The project primary focused on hydrogen and noble gas pellets, and investigated the effect of the electron beam energy, current, and spot size on the expected percentage of the pellet that would be ablated. **Faculty Mentor: Professor Carlos Paz-Soldan**

Jinpai (Max) Zhao - Applied Math '23
"Storm Surge Modeling & Validation"



Max Zhao & Prof. Kyle Mandli

Coastal communities are home to approximately 40% of the world population. Consequently, loss of property and life has become a major concern when coastal hazards take place. One of the most common, wide-spread hazards is the storm surge, which is the significant and abnormal rise of sea water level caused by storm systems like hurricanes and typhoons. Being able to model and reconstruct these events is considered consequential. The software used was Clawpack (Conservation Law Package), which is a collection of finite volume methods for conservation law problems in linear or non-linear PDE systems. GeoClaw, a variant of the Clawpack, uses the two-dimensional depth-averaged shallow water equation in cooperation with the adaptive mesh refinement (AMR) algorithm to model many kinds of flows and waves over topography data with adjustable resolutions. My work used GeoClaw to simulate four major hurricanes in the 2021 Atlantic Hurricane Season. A rigorous verification and validation process between simulation and observation was performed on all storm systems studied. To reduce data collection time and make data more visualizable, an automated analysis program was developed to assist users in advance of storm surge modeling and validation process. The program was also made compatible with GeoClaw, so that majority of storm specific run-time parameters were selected and filled in automatically. **Faculty Mentor: Professor Kyle Mandli**

COMAP Mathematical Contest in Modeling

A team of Columbia University undergraduate students including Makoto Powers, Jane Ziqing Zhang, and Brianna Han, advised by George Dragomir, was named one of the winners of the 2022 Consortium for Mathematics and Its Applications (COMAP) Mathematical Contest in Modeling (MCM). One of the team members, **Makoto Powers**, is a rising sophomore in the APAM Department and also a participant in a Columbia Summer Undergraduate Research Experiences in Mathematical Modeling (CSUREMM).

The International COMAP Scholarship Award press release states, “This year 27,205 teams representing 1,468 institutions, consisting of 80,693 students participated in the Mathematical Contest in Modeling (MCM) ® and the Interdisciplinary Contest in Modeling (ICM)® contests. The International COMAP Scholarship Award is awarded to four top MCM/ICM teams; $10,000 per team with $9000 going to the team members and $1000 to the school, in the name of the advisor.”

APAM Career Events

The Graduate Career Placement team hosted an Employer Expo series instead of a traditional career fair, which allowed employers to create targeted events for specific programs. We could only have hosted such successful showcases with the help of our amazing alums. Students had the opportunity to connect with Wells Fargo, thanks to **Xuefei “Rebecca” Yuan** (PhD ‘10, Applied Mathematics), and learned about the Quantitative Analytics internship program and full-time roles within the firm. Following, students connected with Bank of America, thanks to **Mike Purewal** (PhD ‘08, Applied Physics), where they learned about the bank’s robust summer internship program.

The MechE, EEE, and APAM departments continued their partnership of hosting industry showcases. We hosted two showcases this semester, focusing on roles in the consulting and data science industries. **Harish Ramesh** (MS ‘19, Materials Science) sat on our consulting panel, answering questions about his work as a Life Science consultant at Azzur Group. We hosted **Mushan Zhang** (MS ‘21, Applied Mathematics) on our Data panel, who provided insight on her role as a Data Scientist at Simon-Kucher and Partners.

The Medical Physics program hosted an alumnus each month to learn about their career trajectories. In September, students chatted with **Peter Aiden** (MS ‘21, Medical Physics), who discussed his experience as a Chief Medical Physics Resident at Landauer. In October, **Will Martin** (MS ‘19, Medical Physics) returned to provide students with tips on the residency application process and to discuss life at Montefiore. In November, **Lyu Huang** (MS ‘20, Medical Physics) spoke about his journey to Northwell Health. We ended the semester with alum chats from **Kevin Liu** (MS ‘20, Medical Physics), a doctoral student at The University of Texas MD Anderson Cancer Center, and Aimee Moses (MS ‘20, Applied Mathematics), a Machine Learning Engineer at Expedition Technology.

If you are interested in collaborating with the department for a virtual event or have full- time/part-time, or summer internships available, please reach out to the Graduate Career Placement team at **hiretalent@columbia.edu**.

Alumni Return to Speak at Plasma Colloquium

Two Plasma Physics alumni, **Brian Grierson** (PhD ’09, Applied Physics) and **Matthew Lanctot** (PhD ‘10, Applied Physics), returned to Columbia to present talks at the Plasma Physics Colloquium this past fall semester..

Dr. Grierson presented a talk on “General Atomics’ Plans for an Advanced Tokamak Fusion Pilot Plant”. He is now the Director of the Fusion Pilot Plant Design Hub at General Atomics in San Diego, CA. His research specialities include tokamak transport, confinement, diagnostics, heating and current drive.

Dr. Lanctot presented a talk on the “Impact of Stakeholder Input on the Fusion Energy Sciences Program”. He is currently a program manager working in the Fusion Energy Sciences (FES) Research Division within the Office of Science at the U.S. Department of Energy (DOE). He manages three FES program areas: the DIII-D National User Facility, Long Pulse Tokamak, and Artificial Intelligence and Machine Learning.

Mandal ‘19 Named Assistant Professor at Princeton University

Jyotirmoy Mandal (PhD ‘19)

Jyotirmoy Mandal (PhD ‘19, Applied Physics) will be joining Princeton University as a new Assistant Professor in the Department of Civil and Environmental Engineering and an associated faculty member at the Princeton Institute of Materials in January 2023. His research involves understanding, controlling and modelling nano-to-macro scale radiative heat flows in both natural environments and artificial surfaces, with characterizing and mitigating ambient heat in a warming world as a guiding theme.

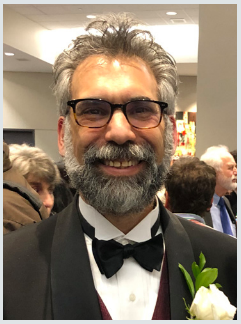
On the scientific front, Dr. Mandal’s work lies at the intersection of optics and materials science, and involves the creation of photonic and plasmonic metamaterials and designs with novel optical properties. On the Civil and Environmental Engineering front, he designs scalable materials that radiatively thermoregulate and make human environments more sustainable and climate resilient, and model their interactions with the environment and impact on buildings and cities.

Dr. Mandal’s other research interests include optical component design for infrared heat detection and characterization, water harvesting using passive cooling technologies, modelling large-scale impact of radiative cooling designs for geoengineering, and optical/radiative phenomena in the natural world. He is also passionate about designing novel but inexpensive technologies to address critical needs in developing countries.

Dr. Mandal received his B.A. in Physics and Mathematics, with a minor in Materials Science, from Vanderbilt University in 2014. He received his Ph.D. in Applied Physics from the Department of Applied Physics and Applied Mathematics (APAM) at Columbia University in 2019. During his time there, he was advised by Prof. Yuan Yang and collaborated with Prof. Nanfang Yu’s group at Columbia Engineering. He received the Robert Simon Memorial Prize for the most outstanding dissertation in the APAM Department at Columbia Engineering in 2020 and was also named a Schmidt Science Fellow in 2020 for his postdoctoral research at the University of California, Los Angeles. Dr. Mandal will join the faculty at Princeton University in Spring 2023 and is currently recruiting potential postdocs and graduate students. To learn more, see: **https://jyotirmoymandal.com/**

Lee ‘21 & Murthy ‘22 Win NSF Fellowships

Joseph Lee (BS ‘21, Applied Physics) and Anushka Murthy (BS ‘22, Applied Mathematics) have received NSF graduate research fellowships! “The Graduate Research Fellowship Program (NSF-GRFP) represents one of the nation’s most prestigious honors for young engineers, scientists, and social scientists, and this year’s group represents one of the largest cohorts from Columbia.” (Undergraduate Research and Fellowship News) https://bit.ly/3XPSauV



Marc Spiegelman

Spiegelman Named AGU Fellow

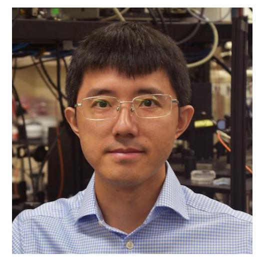
We are pleased to announce that **Marc Spiegelman** has been elected a Fellow of the American Geophysical Union (AGU) joining 53 other individuals in the 2022 Class of Fellows. Since 1962, the AGU Union Fellows Committee has selected less than 0.1% of members as new Fellows. AGU, a nonprofit organization that supports 130,000 enthusiasts to experts worldwide in Earth and space sciences, annually recognizes a select number of individuals as part of its Honors and Recognition program.

Prof. Spiegelman holds a joint appointment between Columbia University's Department of Earth and Environmental Sciences and the Department of Applied Physics and Applied Mathematics at Columbia Engineering (where he is currently chair). He is also a long-standing member of Columbia's Lamont-Doherty Earth Observatory where he started as a Lamont Postdoctoral Research Fellow in 1989. He received his BS in Earth Sciences in 1985 from Harvard University and his PhD from Cambridge University in 1989 supervised by Prof. Dan McKenzie.

Prof. Spiegelman's research concerns the dynamics and chemical consequences of coupled fluid-solid flow in the solid earth. Much of his work concerns the generation and transport of partially molten rock in the convecting mantle, but together with students and colleagues he has also made contributions to the understanding of reactive flow in brittle materials with applications to geological carbon sequestration, as well as the interaction of subglacial hydrology and ice-sheet dynamics. More recently he has been involved in multiple projects to develop useful software for reproducible computation of both geodynamics and thermodynamics.

AGU recognized this year's recipients during the AGU 2022 Fall Meeting, December 12-16, in Chicago, IL, and online. Learn more at www.agu.org

Nanfang Yu Receives $1.25M to Study Nanostructures in Butterfly Wings



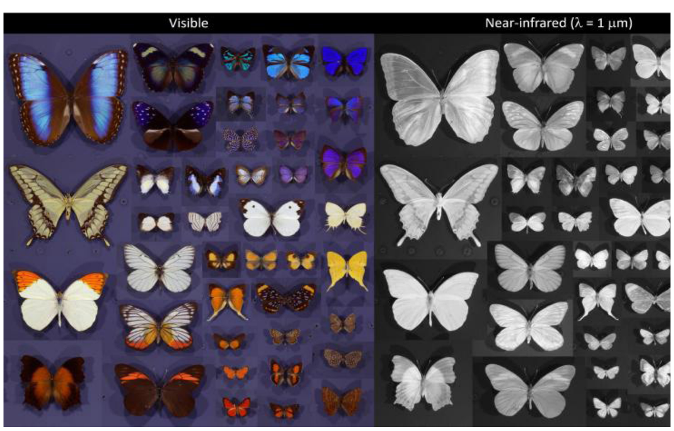
Nanfang Yu

The experimental physicist will use the award from the Gordon and Betty Moore Foundation to explore the optical properties of nanostructures in the wings of butterflies and moths.

Originally published by Columbia Engineering

The Gordon and Betty Moore Foundation has awarded **Nanfang Yu**, associate professor of applied physics and applied mathematics, a $1.25 million grant through the Experimental Physics Investigators (EPI) Initiative. This initiative is designed to support outstanding physicists to advance the scientific frontier in experimental physics through innovative, high-risk research.

Over the next five years, Yu and colleagues from Harvard's Museum of Comparative Zoology will conduct a systematic characterization of the structural and optical properties of butterfly and moth wings. This ambitious research will be based on tens of thousands of specimens from the Museum, including representatives of more than 500 species from all seven butterfly families, as well as representative species from over 100 families of moths. The project will reveal physical adaptations for the survival of the insects and uncover mechanisms through which nanostructured materials control light waves, from the ultraviolet to the infrared.



"Why are butterflies uniformly bright under near-infrared light?" is one of many problems that the Moore EPI project will investigate. Credit: Cheng-Chia Tsai

In his 1863 book, *The Naturalist on the River Amazons*, Henry Walter Bates wrote, "on these expanded membranes [butterfly wings] Nature writes, as on a tablet, the story of the modifications of species." We know today indeed that over the course of hundreds of millions of years, physical constraints (e.g., thermoregulation, prevention of UV damage) and requirements to fulfill biological functions (e.g., flight, sexual selection, warning coloration, camouflage) have acted jointly and resulted in a diversity of finely tuned structural and optical features.

"All these features are juxtaposed over butterfly wings, so studying the wings is akin to deciphering an encoded book," Yu says.

The researchers will leverage developments in computational electromagnetism and deep learning to enhance the efficiency of "deciphering" the butterfly and moth wings. They will analyze the data through the lens of the life history and evolutionary history of butterflies and moths to maximize discoveries of novel materials and structures for bio-inspired design that address energy and environmental challenges. The research could lead to the development of nanomaterials that enable microclimate regulation, energy harvesting, and soft robotics.

Yang Receives DURIP Award

Yuan Yang

Yuan Yang, Associate Professor of Materials Science and Engineering at Columbia Engineering, was awarded an instrument from the Defense University Research Instrumentation Program (DURIP) program. Prof. Yang, who designs, characterizes, and analyzes materials and devices for electrochemical energy storage and conversion (e.g. batteries, water splitting), and thermal management, received a universal mechanical tester inside a glovebox filled with inert gas. As many battery materials are air sensitive, a mechanical tester inside a glove box will enable Prof. Yang to measure their mechanical properties without degradation due to oxygen and moisture. Learn more at **https://www.defense.gov/**

Oleg Gang Wins MURI Grant for Responsive 3D Nanomaterials

Oleg Gang

Columbia Engineering leads U.S. and Australia team to focus on a tool box for creating 3D nano-architectures that respond to stimuli.

By Allison Elliot, Originally published by Columbia Engineering

Oleg Gang, professor of chemical engineering and applied physics and applied mathematics, has received a Department of Defense Multidisciplinary University Research Initiative (MURI) grant for a project he is leading on functionally switchable nanomaterials. The team includes Columbia Engineering colleague Nanfang Yu, professor of applied physics and applied mathematics (pictured on the previous page), as well as investigators from Johns Hopkins, University of Michigan, and University of Wisconsin-Madison, and a co-team from Australia. The anticipated amount is $6.25M with an additional $5M for their Australian partners.

The project, “Bio-architected Responsive Materials with 3D Nanoscale Order,” will help advance the MURI program’s mission to develop new technologies that address the Department of Defense’s stated challenges by bringing together insights from multiple disciplines. The Columbia Engineering proposal will leverage expertise in various areas, including nanoparticle assembly, responsive macromolecules, molecular circuits for signal processing, optical nanomaterials, as well as energy transduction and reconfigurations at various scales. The major goal of this effort is to establish a new class of nanomaterials systems that can operate as complex nanoscale devices, from receiving signals to processing received information to making decisions about next actions, and to switching structural states and functional properties.

“We are thrilled to be chosen among the projects for this year’s MURI grants,” said Gang, who joined Columbia Engineering in 2016 and is the leader for the Soft Matter and Biomaterials Theme at the Center for Functional Nanomaterials at Brookhaven National Laboratory. “This project is an incredibly collaborative effort with partners from the U.S. and Australia who have broad expertise in experimental and computational materials science and nanotechnology. We’re confident that bringing together traditionally separated fields and unexplored ideas will result in some truly transformative concepts.”

While biological organisms are able to respond and adapt to external signals, man-made material systems have not yet been developed that can mimic these responses to stimuli. Gang’s team seeks to understand the underlying principles at work in such signal-to-action mechanisms in order to build 3D dynamic materials systems using nanoscale materials. For their project, they plan to create switchable nanomaterials with engineered optical and magnetic functions; in the long run, the proposed platform could be used for a broad range of nanoscale objects and functions.

The highly competitive MURI grants were given to 28 projects from among 340 proposals. The kick-off meeting for the project was hosted this summer by Gang, who recently won a Keck Foundation Award for a collaborative interdisciplinary project on novel ways to generate designed quantum systems with Professor Vlad Pribiag from the University of Minnesota.

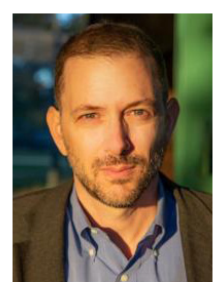
Daniel Bienstock

Bienstock Awarded the 2022 Khachiyan Prize

Daniel Bienstock has been awarded the 2022 Khachiyan Prize for his fundamental methodological and computational contributions to optimization, with an emphasis on very large-scale, non-convex and discrete optimization problems.

Bienstock, the Liu Family Professor of Industrial Engineering and Operations Research and Professor of Applied Physics and Applied Mathematics at Columbia Engineering, is a unique scholar who blends deep mathematics with elegant computational implementation. To obtain practical solutions to large-scale optimization problems, one needs to leverage problem structure to design methodologically sound strategies, and then implement them in a computationally efficient manner - the trade-off between methodology and implementation has to be carefully calibrated for the effort to succeed. Dan has demonstrated this ability many times in his research career, over a wide range of such problems. Dan’s research focuses on fundamental methodological and computational aspects of optimization, with an emphasis on very large-scale, non- convex and discrete optimization problems. He is very broad, prolific, and his research is unique in emphasizing both deep mathematics and efficient practical implementations. Seminal methodological contributions include fast approximate solution to very large, structured linear programs, and extended formulations for hard combinatorial integer programs. Dan’s work has also had a significant impact on several application areas, such as optimal development of open pit mines, and real time control of the power grid. **(https://connect.informs.org)**

Sobel Receives 2022 AGU Jule Gregory Charney Lecture



Adam Sobel

Adam Sobel, Professor of Applied Physics and Applied Mathematics and of Earth and Environmental Sciences, is the 2022 recipient of the American Geophysical Union’s (AGU) Jule Gregory Charney Lecture.

The Charney Lecture is presented annually to a prominent scientist who has made exceptional contributions to the understanding of weather and climate. “The Charney Lecture is also a part of the Bowie Lecture Series, established in 1989 to commemorate the 50th presentation of the William Bowie medal, AGU’s highest honor. The Bowie medal is named in honor of AGU’s first president.” (AGU.org)

In addition to receiving an invitation to present the Charney Lecture and at the Fall 2022 AGU Meeting, Sobel will also receive a lecture certificate, recognition in the journal *Eos*, and a complimentary ticket to attend the Atmospheric Sciences business meeting during the Fall Meeting 2022 AGU Meeting in Chicago, IL, from December 12th-16th.

Sobel studies the dynamics of climate and weather phenomena, particularly in the tropics. In recent years he has become particularly interested in understanding the risks to human society from extreme weather events and climate change. He is author or co-author of over 150 peer-reviewed scientific articles; a popular book, *Storm Surge*, about Hurricane Sandy; and numerous op-eds.

Elizabeth Paul

New Applied Physics Faculty Member: Elizabeth Paul

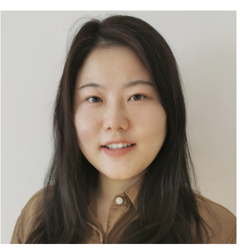
The APAM Department is proud to announce that **Dr. Elizabeth Paul** has joined the faculty as a tenure-track Assistant Professor of Applied Physics.

Dr. Paul uses theoretical and computational methods to study the magnetic confinement of plasmas for fusion energy sciences. Controlled fusion holds promise of providing a carbon-neutral, safe, and sustainable energy source. Her work focuses on the advancement of the stellarator magnetic confinement concept, a complex toroidal device which enjoys enhanced stability properties.

Dr. Paul's research integrates applied mathematical techniques to improve the design of stellarator configurations through numerical optimization. She studies the rich behavior present in three-dimensional magnetic confinement devices, including the nonlinear dynamics of fast particle populations.

Dr. Paul received her A. B. in Astrophysical Sciences with concentrations in Applied and Computational Mathematics and Applications of Computing from Princeton University in 2015. In 2020 she received her Ph.D. in Physics from the University of Maryland, College Park. In 2021 Dr. Paul received the Marshall N. Rosenbluth Award from the American Physical Society in recognition of her doctoral work, "*For pioneering the development of adjoint methods and application of shape calculus for fusion plasmas, enabling a new derivative-based method of stellarator design.*" Prior to joining Columbia University, Dr. Paul was a Presidential Postdoctoral Research Fellow at Princeton University.

Prof. Paul will be building her on-campus theory and computation research group in addition to building partnerships with the experimental efforts at Columbia University's Plasma Laboratory. She looks forward to partnering with and teaching the next generation of plasma physicists and further developing the Columbia plasma curriculum.



Shanyin Tong

New Applied Mathematics Faculty Member: Shanyin Tong

The APAM Department is proud to announce that **Dr. Shanyin Tong** has joined the Applied Mathematics faculty as a limited term Assistant Professor in Applied Mathematics.

Dr. Tong received her B.Sc. in computational mathematics from Peking University in 2017. She earned her Ph.D. in mathematics in 2022 from New York University's Courant Institute of Mathematical Sciences under the supervision of Georg Stadler and Eric Vanden-Eijnden.

Her research focus is on applied and computational mathematics, in particular on uncertainty quantification, PDE-constrained optimization, optimization under uncertainty, rare events and inverse problems. The main applications driving her research are the hazard assessment of extreme tsunami waves, optimal portfolio allocations, and seismic inversion. Currently, She is also interested in using machine learning methods in scientific computing and uncertainty quantification.

Dr. Tong was named a "Best Paper for Young Researchers" finalist at the 2022 International Conference on Continuous Optimization, was named a Rising Star in Computational and Data Sciences in 2022, received the Bella Manel Prize in 2020, and was the recipient of the Isaac Barkey and Ernesto Yhap Fellowship in 2019. She is a member of the Association for Women in Mathematics at the Courant Institute and is a member of the Women Enhancing Technology (WeTech) Program.

Paz-Soldan Appointed Member of DOE Fusion Energy Sciences Advisory Committee (FESAC)

Carlos Paz-Soldan

Carlos Paz-Soldan, Associate Professor of Applied Physics and Applied Mathematics, has been appointed a member of the Department of Energy's (DOE) Fusion Energy Sciences Advisory Committee (FESAC).

The advisory committee, reporting to the Director of the DOE Office of Science, will provide recommendations and advice on technical, scientific, and programmatic issues relating to the DOE's fusion energy sciences program. He will serve on the committee until June 2025.

Paz-Soldan's research focuses on the dynamics of magnetically confined plasmas - especially the instabilities appearing in toroidal plasma configurations called tokamaks. Prof Paz-Soldan has pioneered techniques to destabilize unwanted populations of energetic electrons that appear after the tokamak plasma is shut down. Prof Paz-Soldan also has also contributed to the development of new control techniques for edge localized plasma instabilities.

Prof Paz-Soldan runs a research group of students, postdocs, and research staff at Columbia University to advance the state of the art in these and other topics.

Faculty Named Highly-Cited-Researchers

Several Columbia Engineering faculty members from the APAM Department were identified by Clarivate as 2022 "Highly-Cited-Researchers" in the Physics and Cross-Field categories. **Alexander Gaeta**, the David M. Rickey Professor of Applied Physics and Materials Science and **Michal Lipson**, the Eugene Higgins Professor of Electrical Engineering and Professor of Applied Physics, were recognized in the physics category. **Yuan Yang**, Associate Professor of Materials Science and Engineering, and **Nanfang Yu**, Associate Professor of Applied Physics, were recognized in the cross-field category.

"Highly Cited Researchers have demonstrated significant and broad influence reflected in their publication of multiple highly cited papers over the last decade. Highly cited papers rank in the top 1% by citations for a field or fields and publication year in the Web of Science. Of the world's population of scientists and social scientists, Highly Cited Researcher are 1 in 1,000." (Clarivate.com)

Columbia Faculty Listed in Stanford's 2022 World's Top 2% Scientists Report

Numerous Columbia faculty members were listed in Stanford University's 2022 World's Top 2% Scientists report. APAM faculty included **Katayun Barmak, Daniel Bienstock, Simon Billinge, Allen Boozer, Siu-Wai Chan, Qiang Du, Alexander Gaeta, Irving Herman, Michal Lipson, Richard Osgood, Lorenzo Polvani, Adam Sobel, Marc Spiegelman, Michael Tippett, Latha Venkataraman, Michael Weinstein, Renata Wentzcovtich, John Wright, Yuan Yang,** and **Nanfang Yu**. To learn more, see **https://bit.ly/3iwSSO4**

Wentzcovitch Named President-elect of AGU's Mineral and Rock Physics Section

Renata Wentzcovitch

Renata Wentzcovitch, professor of material science and applied physics, and earth and environmental sciences, has been named president-elect of the American Geophysical Union's Mineral and Rock Physics division.

In a recent interview with the American Geophysical Union (AGU), Prof. Wentzcovtich said, "I was born in Brazil of Italian, Portuguese, Spanish, French, and indigenous descent. This diverse ancestry brought transnational identity awareness very early. I am a U.S., Brazilian, and Italian citizen. I grew up in São Paulo, a cultural melting pot of >20 million inhabitants today. I moved to the U.S. nearly four decades ago. I have also lived in England and Italy and have spent considerable time in Japan and Germany. This multi-cultural experience made me appreciate what all people have in common. Commonalities are profound; differences are more superficial. I assimilated multiple times and recognized my identity was immutable. I am a citizen of Earth in heart and mind. Similar experiences bring friendliness; differences bring shyness. As such, I became a magnet for international students in the U.S. I have had numerous advisees from Latin America, East, South, Central Asia, and Eastern and Central Europe. An Innovation Fund Award from the American Physical Society (APS), the U.S.-Africa Initiative in Electronic Structure (USAfrI), is now providing means for me to work with African researchers. I enjoy international collaborations immensely and am glad to promote much-needed interaction between the U.S. and Africa. More details of my identity are available in the American Institute of Physics Oral History Project."

"I am a computational materials physicist who was inspired by mineral physicists and started contributing to this field thirty years ago. This happened in England while I was searching for a home for my research. Crossing a scientific boundary felt similar to crossing a geographic one, an exciting adventure. Since then, I have served two societies, AGU and APS. I have contributed to AGU's goals of catalyzing discovery, promoting and exemplifying an inclusive scientific culture, and partnering broadly with other organizations to address scientific challenges. I have been cross-pollinating two communities with research ideas and event organizations that foster and advance inter-disciplinarity and education in Mineral Physics (MP). I have aggressively promoted MP and planetary modeling in the computational physics community (e.g., see International Union of Pure and Applied Physics 2022 Conference in Computational Physics). It is not uncommon today to see computational materials physicists embracing MP. Conversely, I have assisted in the introduction of materials simulations in MP and have witnessed its growth in importance. With every advance in materials simulations, another challenging class of problems in MP or geochemistry is tackled. Applications of materials simulations in planetary sciences are endless. The future of the field depends heavily on them. I bring to the AGU a diverse perspective, experience forged in scientific discovery and exploration, and familiarity with best practices in scientific society leadership. I have served in the chair-line of the APS Division of Computational Physics (2017-21). I will be honored to continue promoting MP through the presidency of the Mineral and Rock Physics section."

Prof. Wentzcovtich served on the AGU fellowship committees for Mineral and Rock Physics (MRP) and the Study of the Earth's Deep Interior (SEDI) in 2021 and 2022 and has been the AGU Meeting Session co-organizer for MRP and SEDI sessions almost every year since 2009. From 2017-2021, she served as the Vice-Chair, Chair-Elect, Chair, and Past-Chair of the Division of Computational Physics (DCOMP) of the American Physical Society (APS). She has also served on selected committees for DCOMP and organized the DCOMP program for the 2019 APS March Meeting. She currently serves on the Honors Task Force of the APS. **(This article was originally published by www.agu.org)**

2022 Workshop on Recent Developments in Electronic Structure

2022 Workshops of the US-Africa Initiative in Electronic Structure (USAfri)

Prof. Renata Wentzcovitch co-hosted two workshops as part of the U.S.-Africa Initiative in Electronic Structure (USAfri).

The *2022 US-Africa Initiative in Electronic Structure Workshop* was a virtual event that took place from May 25th-27th. The program included a presentation from keynote speaker Sossina Haile, as well as invited talks from Valentino Cooper, Gebremedhn Gebreyesus Hagoss, Steve Ndengué, and Maria Chan. Recordings of the talks are available online at: **https://bit.ly/3FfsDTl**

Prof. Wentzcovitch, along with Timothy Berkelbach (Columbia University and Flatiron Institute), Johannes Flick (Flatiron Institute), Raquel Queiroz (Columbia University), and David Reichman (Columbia University), organized the 2022 Workshop on Recent Developments in Electronic Structure at Columbia University from June 1st-3rd, at International House. The hybrid event featured 25 talks, a poster session, and a banquet. Recordings of the talks are available online at: **https://bit.ly/3h8KwLP**

"The U.S.– Africa Initiative in Electronic Structure (USAfri) aims to create a platform for exchange between African and U.S. physicists with opportunities to have a major impact on research and education in Africa. Electronic Structure is a natural choice because it is an essential part of research with applications in many fields, and there is a network of capable researchers in Africa generated by sustained efforts over the past 10 years. The U.S.-Africa Initiative in Electronic Structure is supported by of the Innovation Fund of the American Physical Society."
https://usafricainitiative.org/

Optical Magic: New Flat Glass Enables Optimal Visual Quality for Augmented Reality Goggles

Columbia engineers invent a flat lens that exclusively focuses light of a selected color—it appears entirely transparent until they shine a beam of light with the correct wavelength onto it, when the glass turns into a lens.

By Holly Evarts, Originally published by Columbia Engineering

As anyone who has recently tried out an augmented reality headset knows, the technology is not yet ready to be part of our everyday lives. Researchers have been working to perfect high-performing augmented reality (AR) glasses, but there are a number of challenges. One major problem with conventional AR glasses is that there is a tradeoff in terms of quality and brightness between the external scene you actually see and the contextual information you also want to visualize. Early solutions like Google Glass used multiple bulky optical components that were partially reflective and partially transmissive to mix the real-world and contextual scenes, with the result of a dimmed and distorted vision of both scenes.

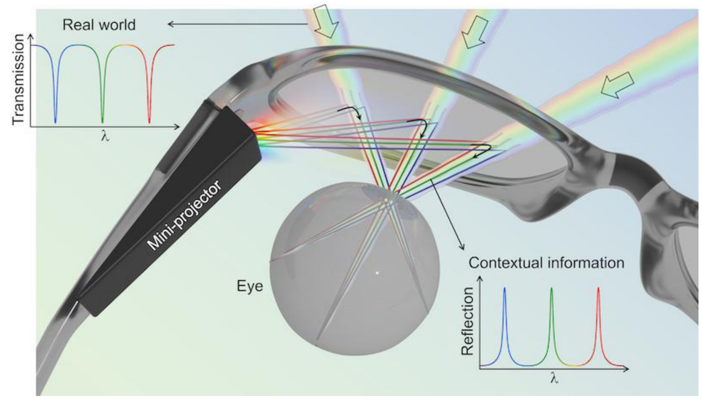


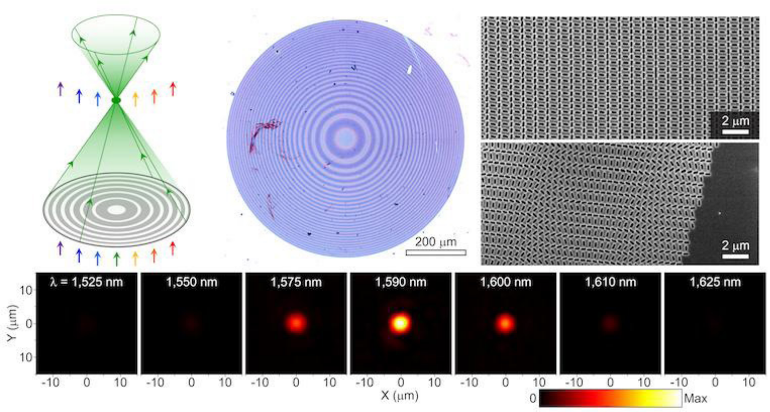
Illustration showing the operation of an augmented reality headset with multifunctional nonlocal metasurfaces as optical see-through lenses. Credit: Nanfang Yu, Stephanie Malek, Adam Overvig/Columbia Engineering

More recent AR head-mounted-display eyeglasses have been patterned with diffractive gratings (fine grooves) with wavelength-sized spacing that deflect contextual information from a miniprojector beside the glasses to the viewer's eye. But these eyeglasses still dim and distort the external scene because real-world light passing through the glass inevitably gets scattered and dispersed by the gratings. The distortions get worse when several sets of overlapping gratings must be used to handle multiple distinct colors from the miniprojector. AR glasses that perfectly blend the external environment and contextual information for the human eye would be highly useful for many applications. As a head-up display, the technology could give navigation instructions to someone driving a car or feed data from sensors to the pilot flying a plane without requiring them to look away from their windshields. As a head-mounted display, the technology could enable surgeons and soldiers to view information related to their tasks at hand with unprecedented ease and efficiency.

The glass needs to not only be highly transparent over almost the entire visible spectrum, allowing for unattenuated and undistorted vision of the outside world, but also to function as a highly efficient lens that focuses light from a miniprojector into the human eye to form a visual context accompanying the external real-world scene.

Study demonstrates new kind of wavelength-selective, wavefront-shaping glass: Researchers at Columbia Engineering report that they have now invented just this kind of glass. Led by **Nanfang Yu**, associate professor of applied physics and applied mathematics, the team has created a flat optical device that focuses only a few selected narrowband colors of light while remaining transparent to nonselected light over the vast majority of the spectrum. The paper was published online August 8, 2022, by Light: Science & Applications.

"We've built a very cool flat optical device that appears entirely transparent—like a simple piece of glass—until you shine a beam of light with the correct wavelength onto it, when the device suddenly turns into a lens," said Yu, a leader in nanophotonics research. "To me this is optical magic."

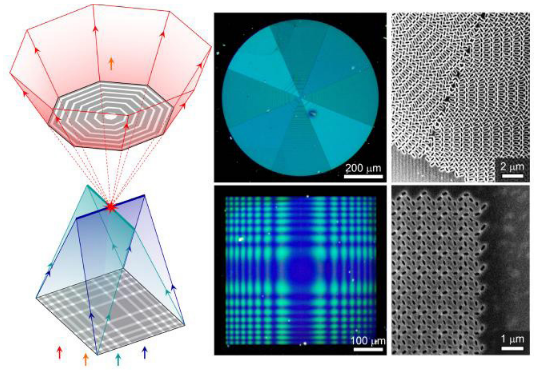


Top row: (Left) Illustration showing the operation of a wavelength-selective metalens, with "green" light being focused, while the other colors are passed without distortion. (Middle) Optical image of a wavelength-selective metalens composed of rectangular apertures etched into a silicon thin film. (Right) Scanning electron microscope (SEM) images of the metalens at its center and edge. Bottom row: A series of two-dimensional (2D) far-field scans shows that focusing is most efficient at the center of the resonance, l= 1590 nm, with the focusing efficiency dropping at the two shoulders of the resonance, l= 1575 nm and 1600 nm, and that the focal spots become almost undetectable at wavelengths tens of nanometers away from the center of the resonance. Credit: Nanfang Yu, Stephanie Malek, Adam Overvig/ Columbia Engineering

Metasurfaces: Yu's group develops flat optical devices based on metasurfaces—ultra-thin optical components—to control light propagation in free space and in optical waveguides. Metasurfaces are made of two-dimensional (2D) arrays of designer scatterers, called "optical antennas" — a tiny version of radio antennas that have nanometer-scale dimensions. The key feature of metasurfaces is that the optical scatterers are all different optically. The light they scatter 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 focusing or steering light beams, or switching optical signals on integrated photonic chips.

Nonlocal metasurfaces: Yu's team invented a "nonlocal metasurface" that can manipulate light waves in distinct ways at distinct targeted wavelengths, while leaving light at untargeted wavelengths unaffected. The new devices exert both spatial and spectral control over light by selecting a color (spectral) and focusing it (spatial) not just at a single wavelength but also independently at multiple different wavelengths. For example, one demonstrated device functions both as a converging lens that focuses light at one color, and as a concave lens that disperses light at a second color, while staying transparent, like an unpatterned slab of glass, when illuminated with light at colors over the rest of the spectrum.

Optical Magic: New Flat Glass Enables Optimal Visual Quality for Augmented Reality Goggles, continued



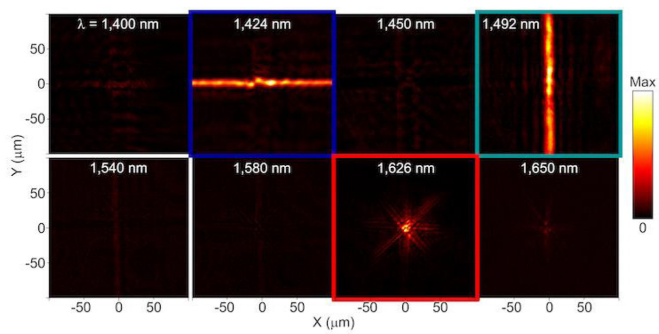
Left: Illustration showing the operation of a three-function metalens doublet. The doublet is able to generate three distinct focal patterns (two focal lines orthogonal to each other and a star-shaped focal spot) at three different wavelengths, while staying transparent at other wavelengths. The doublet is composed of a quasi-radial metalens as a diverging element and a dual-function cylindrical metalens as a converging element. Middle: Optical images of the quasi-radial metalens and the dual-function cylindrical metalens. Right: SEM images showing the corners of the quasi-radial metalens and the dual-function cylindrical metalens. Credit: Nanfang Yu, Stephanie Malek, Adam Overvig/ Columbia Engineering

Breaking symmetry to radiate light and shape its wavefront: These new devices originated from theoretical explorations by Adam Overvig, a former PhD student in Yu's group and co-author of the study, into how to manipulate symmetry in photonic crystal (PhC) slabs, such as a 2D periodic structure that is a square array of square holes defined in a thin film of silicon. PhC slabs are known to support a set of modes, the frequencies or colors of which are determined by the geometry of the slab (e.g., periodicity of the array and size of the holes). The modes are essentially a sheet of light that is spatially extended (nonlocal) along the slab but otherwise confined in the direction normal to the slab.

Introducing a symmetry-breaking perturbation to an otherwise structurally repetitive PhC slab, such as simply by deforming square holes of the PhC into rectangular ones, lowers the degree of symmetry of the PhC so that the modes are no longer confined to the slab: they can be excited by shining a beam of light from free space with the correct color and can also radiate back into free space.

Significantly, instead of applying a uniform perturbation over the entire PhC slab, the researchers spatially varied the perturbation, orienting the rectangular holes along different directions over the device. In this way, the surface emission from the device could have a molded wavefront in relation to the pattern of the orientation angles of the rectangles.

First to make lenses that focus light of just the desired color: "This is the first time that anyone has experimentally demonstrated wavelength-selective, wavefront-shaping optical devices using an approach that is based on symmetry-breaking perturbations," explained Stephanie Malek, a doctoral student in Yu's group who was lead author of the study. "By carefully choosing the initial PhC geometry, we can achieve wavelength selectivity, and by tailoring the orientations of the perturbation applied to the PhC, we can sculpt the wavefront of the selected color of light. This means that we can make lenses that focus light of only the selected color."



Above: A series of 2D far-field scans showing the three focal patterns at l=1,424 nm, 1,492 nm, and 1,626 nm and minimal wavefront shaping over the rest of the spectrum. Credit: Nanfang Yu, Stephanie Malek, Adam Overvig/Columbia Engineering

The most highly multifunctional and multicolor metasurface yet: The team demonstrated a multifunctional device that shapes the optical wavefronts independently at four distinct wavelengths but acts as a transparent substrate at other nonselected wavelengths. This makes it the most highly multifunctional and multicolor metasurface that has been demonstrated so far, and also suggests that in the future full-color AR displays can be made by independently controlling a few colors of virtual information.

AR applications: These new wavelength-selective, wavefront-shaping "nonlocal" metasurfaces offer a promising solution for AR technologies, including head-up displays on the front windshield of cars. The optical see-through lens can reflect contextual information to the viewer's eye at selected narrow-band wavelengths of the miniprojector while also allowing an unobstructed, undimmed, broadband view of the real world. And, because the wavelength-selective metasurface lenses are thinner than a human hair, they are well-suited to developing AR goggles that look and feel like comfortable and fashionable eyeglasses.

"We've built a very cool flat optical device that appears entirely transparent—like a simple piece of glass—until you shine a beam of light with the correct wavelength onto it, when the device suddenly turns into a lens. To me this is optical magic."

- Prof. Nanfang Yu

Quantum optics: Yu's flat metasurfaces can also be used to substantially reduce the complexity of quantum optics setups that manipulate ultracold atoms. Because multiple laser beams at distinct wavelengths have to be independently controlled for cooling, trapping, and monitoring cold atoms, these setups can become massive. This complexity has made it difficult for researchers to widely adopt cold atoms for use in atomic clocks, quantum simulations and computations. Now, instead of building several ports around the vacuum chamber for the cold atoms, each with their unique beam-shaping optical components, a single metasurface device can be used to simultaneously shape the multiple laser beams used in the experiment.

What's next: demonstrating the concept in visible spectrum range: The devices in this study simultaneously and independently control the wavefronts of several near-infrared beams using nanostructured silicon thin films. The team plans next to demonstrate the concept in the visible spectral range, to fully control the wavefronts of three narrowband visible laser beams using a device platform featuring low absorption loss in the visible, such as thin-film silicon nitride and titanium dioxide. They are also exploring the scalability of the wavelength-selective metasurface platform by including more than two perturbations into a single metasurface and by stacking more than two metasurfaces into a compound device.

Device fabrication was carried out at the Columbia Nano Initiative cleanroom, and at the Advanced Science Research Center NanoFabrication Facility at the Graduate Center of the City University of New York. The study published in *Light: Science & Applications* is titled: "Multifunctional Resonant Wavefront-Shaping Meta-Optics Based on Multilayer and Multi-Perturbation Nonlocal Metasurfaces." The authors are Stephanie C. Malek, Adam C. Overvig, Andrea Alu, and Nanfang Yu.

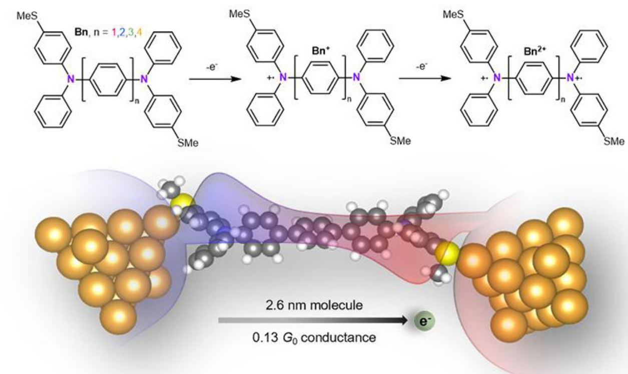
Led by Columbia Engineering, Researchers Build Longest, Highly Conductive Molecular Nanowire

A 2.6nm-long single molecule wire has quasi-metallic properties and shows an unusual increase of conductance as the wire length increases; its excellent conductivity holds great promise for the field of molecular electronics

By Holly Evarts, Originally published by Columbia Engineering

Latha Venkataraman

As our devices get smaller and smaller, the use of molecules as the main components in electronic circuitry is becoming ever more critical. Over the past 10 years, researchers have been trying to use single molecules as conducting wires because of their small scale, distinct electronic characteristics, and high tunability. But in most molecular wires, as the length of the wire increases, the efficiency by which electrons are transmitted across the wire decreases exponentially. This limitation has made it especially challenging to build a long molecular wire—one that is much longer than a nanometer—that actually conducts electricity well.



Above: A brief abstract figure of this work. The geometry of the highest conducting trimer (n=3) molecule in the molecular junction. Red and blue regions are artistic depictions on the coupling between the two edge states.

Columbia researchers announced today that they have built a nanowire that is 2.6 nanometers long, shows an unusual increase in conductance as the wire length increases, and has quasi-metallic properties. Its excellent conductivity holds great promise for the field of molecular electronics, enabling electronic devices to become even tinier. The study was published in *Nature Chemistry*.

Molecular wire designs: The team of researchers from Columbia Engineering and Columbia's department of chemistry, together with theorists from Germany and synthetic chemists in China, explored molecular wire designs that would support unpaired electrons on either end, as such wires would form one-dimensional analogues to topological insulators (TI) that are highly conducting through their edges but insulating in the center.

While the simplest 1D TI is made of just carbon atoms where the terminal carbons support the radical states--unpaired electrons, these molecules are generally very unstable. Carbon does not like to have unpaired electrons. Replacing the terminal carbons, where the radicals are, with nitrogen increases the molecules' stability. "This makes 1D TIs made with carbon chains but terminated with nitrogen much more stable and we can work with these at room temperature under ambient conditions," said the team's co-leader **Latha Venkataraman**, Lawrence Gussman Professor of Applied Physics and professor of chemistry.

Breaking the exponential-decay rule: Through a combination of chemical design and experiments, the group created a series of one-dimensional TIs and successfully broke the exponential-decay rule, a formula for the process of a quantity decreasing at a rate proportional to its current value. Using the two radical-edge states, the researchers generated a highly conducting pathway through the molecules and achieved a "reversed conductance decay," i.e. a system that shows an increasing conductance with increasing wire length.

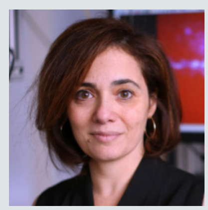
"What's really exciting is that our wire had a conductance at the same scale as that of a gold metal-metal point contacts, suggesting that the molecule itself shows quasi-metallic properties," Venkataraman said. "This work demonstrates that organic molecules can behave like metals at the single-molecule level in contrast to what had been done in the past where they were primarily weakly conducting."

The researchers designed and synthesized a bis(triarylamines) molecular series, which exhibited properties of a one-dimensional TI by chemical oxidation. They made conductance measurements of single-molecule junctions where molecules were connected to both the source and drain electrodes. Through the measurements, the team showed that the longer molecules had a higher conductance, which worked until the wire was longer than 2.5 nanometers, the diameter of a strand of human DNA.

Laying the groundwork for more technological advancements in molecular electronics: "The Venkataraman lab is always seeking to understand the interplay of physics, chemistry, and engineering of single-molecule electronic devices," added Liang Li, a PhD student in the lab, and a co-first author of the paper. "So creating these particular wires will lay the groundwork for major scientific advances in understanding transport through these novel systems. We're very excited about our findings because they shed light not only on fundamental physics, but also on potential applications in the future."

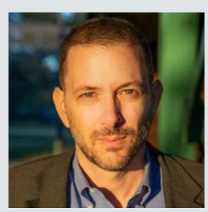
The group is currently developing new designs to build molecular wires that are even longer and still highly conductive.

The study, "Highly conducting single-molecule topological insulators based on mono- and di-radical cations," was published in *Nature Chemistry.* Authors: L. Li, J. Z. Low, J. Wilhelm, G. Liao, S. Gunasekaran, C. Prindle, R. Starr, D. Golze, C. Nuckolls, M. Steigerwald, F. Evers, L. Campos, X. Yin, L. Venkataraman, https://doi.org/10.1038/s41557-022-00978-1



POET Technologies Names Lipson Adviser

POET Technologies, a Semiconductor technology company, has appointed **Professor Michal Lipson** an adviser to its board of directors. Lipson is president-elect of Optica, a MacArthur Fellow, a member of the National Academy of Sciences, founder of three startups, and an inventor whose work led to 45 U.S. patents related to photonic technologies. She serves as a Eugene Higgins Professor of Electrical Engineering and professor of applied physics at Columbia University. POET nominated Lipson as a director at its annual general meeting on October 6. (Originally published by photonics.com) **https://bit.ly/3VuhzZI**

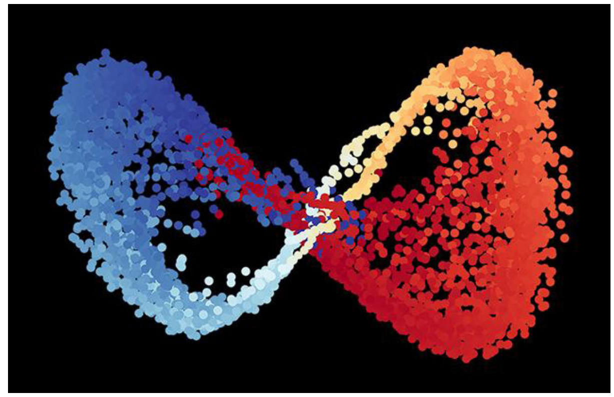


Sobel on SANDY+10: Resilience, Equity, Climate Justice

Professor Adam Sobel spoke at the event, SANDY+10 - Resilience, Equity, Climate Justice, on October 28. The conference, hosted by the Columbia Climate School, created "a space for reflection, collective learning and calls to action for a community of storm survivors, activists, practitioners, public servants, and academics whose life and work changed to meet the challenges of Hurricane Sandy recovery." Learn more at **https://bit.ly/3ONOfuy**

Columbia Engineering Roboticists Discover Alternative Physics

A new AI program observed physical phenomena and uncovered relevant variables—a necessary precursor to any physics theory



Latent embeddings from framework colored by physical state variables. Credit: Boyuan Chen/Columbia Engineering

By Holly Evarts, Originally published by Columbia Engineering

Energy, Mass, Velocity. These three variables make up Einstein's iconic equation E=MC2. But how did Einstein know about these concepts in the first place? A precursor step to understanding physics is identifying relevant variables. Without the concept of energy, mass, and velocity, not even Einstein could discover relativity. But can such variables be discovered automatically? Doing so could greatly accelerate scientific discovery.

This is the question that researchers at Columbia Engineering posed to a new AI program. The program was designed to observe physical phenomena through a video camera, then try to search for the minimal set of fundamental variables that fully describe the observed dynamics. The study was published on July 25 in *Nature Computational Science*.

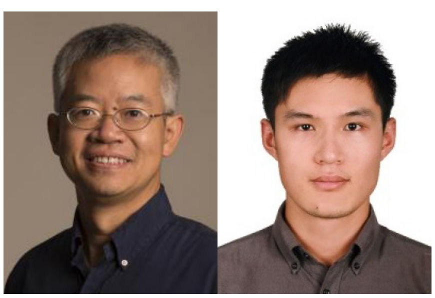
The researchers began by feeding the system raw video footage of phenomena for which they already knew the answer. For example, they fed a video of a swinging double-pendulum known to have exactly four "state variables"—the angle and angular velocity of each of the two arms. After a few hours of analysis, the AI outputted the answer: 4.7.

"We thought this answer was close enough," said Hod Lipson, director of the Creative Machines Lab in the Department of Mechanical Engineering, where the work was primarily done. "Especially since all the AI had access to was raw video footage, without any knowledge of physics or geometry. But we wanted to know what the variables actually were, not just their number."

The researchers then proceeded to visualize the actual variables that the program identified. Extracting the variables themselves was not easy, since the program cannot describe them in any intuitive way that would be understandable to humans. After some probing, it appeared that two of the variables the program chose loosely corresponded to the angles of the arms, but the other two remain a mystery. "We tried correlating the other variables with anything and everything we could think of: angular and linear velocities, kinetic and potential energy, and various combinations of known quantities," explained Boyuan Chen PhD '22, now an assistant professor at Duke University, who led the work. "But nothing seemed to match perfectly." The team was confident that the AI had found a valid set of four variables, since it was making good predictions, "but we don't yet understand the mathematical language it is speaking," he explained.

After validating a number of other physical systems with known solutions, the researchers fed videos of systems for which they did not know the explicit answer. The first videos featured an "air dancer" undulating in front of a local used car lot. After a few hours of analysis, the program returned 8 variables. A video of a Lava lamp also produced 8 eight variables. They then fed a video clip of flames from a holiday fireplace loop, and the program returned 24 variables.

A particularly interesting question was whether the set of variable was unique for every system, or whether a different set was produced each time the program was restarted. "I always wondered, if we ever met an intelligent alien race, would they have discovered the same physics laws as we have, or might they describe the universe in a different way?" said Lipson. "Perhaps some phenomena seem enigmatically complex because we are trying to understand them using the wrong set of variables." In the experiments, the number of variables was the same each time the AI restarted, but the specific variables were different each time. So yes, there are alternative ways to describe the universe and it is quite possible that our choices aren't perfect.



Qiang Du & Kuang Huang

The researchers believe that this sort of AI can help scientists uncover complex phenomena for which theoretical understanding is not keeping pace with the deluge of data—areas ranging from biology to cosmology. "While we used video data in this work, any kind of array data source could be used—radar arrays, or DNA arrays, for example," explained **Kuang Huang** (PhD '22, Applied Mathematics), who coauthored the paper.

The work is part of Lipson and **Fu Foundation Professor of Mathematics Qiang Du**'s decades-long interest in creating algorithms that can distill data into scientific laws. Past software systems, such as Lipson and Michael Schmidt's Eureqa software, could distill freeform physical laws from experimental data, but only if the variables were identified in advance. But what if the variables are yet unknown?

Lipson, who is also the James and Sally Scapa Professor of Innovation, argues that scientists may be misinterpreting or failing to understand many phenomena simply because they don't have a good set of variables to describe the phenomena. "For millennia, people knew about objects moving quickly or slowly, but it was only when the notion of velocity and acceleration was formally quantified that Newton could discover his famous law of motion F=MA," Lipson noted. Variables describing temperature and pressure needed to be identified before laws of thermodynamics could be formalized, and so on for every corner of the scientific world. The variables are a precursor to any theory. "What other laws are we missing simply because we don't have the variables?" asked Du, who co-led the work.

The paper was also co-authored by **Sunand Raghupathi (BS '20, Applied Physics)** and Ishaan Chandratreya (BS '24, Computer Science), who helped collect the data for the experiments. Since July 1, 2022, Boyuan Chen (Phd' 22, Computer Science) has been an assistant professor at Duke University. The work is part of a joint University of Washington, Columbia, and Harvard NSF AI institute for dynamical systems, aimed to accelerate scientific discovery using AI.

Video: Columbia Engineering Roboticists Discover Alternative Physics - Boyuan Chen explains how a new AI program observed physical phenomena and uncovered relevant variables—a necessary precursor to any physics theory. https://bit.ly/3H6JxXc

Data Science in Context: Foundations, Challenges, Opportunities

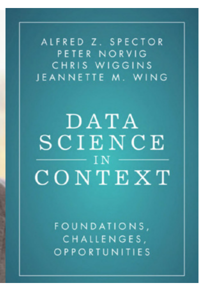
APAM is pleased to announce the publication of **Chris Wiggins**'s recent book, "Data Science in Context," co-authored with Peter Norvig (Stanford/Google), Jeanette Wing (Columbia University), and Alfred Spector (MIT), by Cambridge University Press.

The book has been selected as the "Top Book Pick for 2022" by Ben Lorica's Gradient Flow newsletter, which praised the book as providing "a comprehensive overview of what students and practitioners need to know to use data science more effectively and ethically," and as offering "valuable insights and guidance on data science, drawing on the authors' extensive experience in the field."

Lorica also emphasized the book's practical, real-world advice and its value as a resource for anyone looking to use data science in real-world applications. Lorica recommended the book to friends who teach at business schools and encouraged readers to check it out and share it with colleagues.

In addition to "Data Science in Context," Wiggins is set to publish a second book in March, "How Data Happened: A History from the Age of Reason to the Age of Algorithms," co-authored with Matt Jones of Columbia's history department. This book is based on Professor Wiggins's class "Data, Past Present and Future," which includes important readings and teaches students how to use Python to understand and model real world data.

As a textbook, Lorica recommended "Data Science in Context" as a "valuable resource for anyone looking to use data science and AI in real-world applications." It is available to view in the APAM office, and we encourage all interested students and faculty to take a look!



Chris Wiggins

co-author of
Data Science in Context: Foundations, Challenges, Opportunities

Cambridge University Press, 2022
ISBN: 9781009272209, 1009272209

Rising Voices, Changing Coasts: the National Indigenous & Earth Sciences Convergence Hub

Kyle Mandli is part of an NSF funded project combining indigenous knowledge with climate science - The Large Scale CoPe: Rising Voices, Changing Coasts: The National Indigenous and Earth Sciences Convergence Hub. Prof. Mandli will be involved with the coastal flooding and climate change components.

"Haskell Indian Nations University, a Bureau of Indian Education-operated Tribal University in Lawrence, Kansas, is the recipient of a $20 million award from the National Science Foundation for an Indigenous science hub project. Funded under the American Rescue Plan Act of 2021, the award is for five years and is the largest research award ever granted by the NSF to a Tribal college or university.

The project will create The Large Scale CoPe: Rising Voices, Changing Coasts: The National Indigenous and Earth Sciences Convergence Hub, a space for the convergence of disciplines and epistemologies where Indigenous knowledge-holders from diverse coastal regions will work with university-trained social, ecosystem and physical Earth system scientists and students on transformative research to address coastal hazards in the contexts of their communities."
www.bia.gov/news/

APAM in the News

Adam Sobel wrote several articles and opinion pieces about climate science and extreme weather.

"A climate scientist's personal reckoning"
Bulletin of the Atomic Scientists, Nov. 21, 2022
https://bit.ly/3AUCixB

"Where the hurricane risk is growing"
CNN Opinion, Oct. 3, 2022, **https://cnn.it/3VKufLx**

"The Inflation Reduction Act is a huge victory in this existential fight"
CNN Opinion, Aug. 13, 2022, **https://cnn.it/3UluRGw**

"The Supreme Court's EPA decision heralds a broad assault on democracy" *Bulletin of the Atomic Scientists*, July 1, 2022
https://bit.ly/3XNjH0h

Research from faculty members was featured in multiple news outlets.

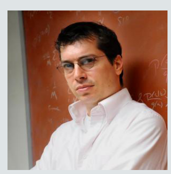
Qiang Du

"In NYC, digital twin project tackles traffic"
American Society of Civil Engineers - Sept. 21, 2022
https://bit.ly/3EV0YqJ

"Artificial physicist to unravel the laws of nature"
Advanced Science News - Aug. 11, 2022
https://bit.ly/3EQB33m

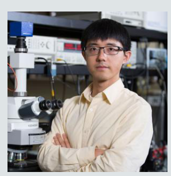
Alexander Gaeta

"Engineers resolve single photons 70x faster than other techniques"
Tech Explorist - June 28, 2022
https://bit.ly/3UL0OIx



Chris Wiggins

"How machine learning helps the *New York Times* power its paywall"
Venture Beat - Sept. 6, 2022
https://bit.ly/3Fm2BiN



Nanfang Yu

"Glass device can tell objects apart without needing a computer"
NewScientist - Nov. 4, 2022
https://bit.ly/3udSgz2

"Nonlocal Metasurface Distinguishes Augmented Reality Platform"
Photonics Media - Oct. 13, 2022
https://bit.ly/3VGwP5s

'Optical magic': New flat glass enables optimal visual quality for augmented reality goggles"
Phys.org - Sept. 28, 2022
https://bit.ly/3VOZ8OT

"Thermal Imaging Lets Researchers See Beyond the Surface of Butterfly Wings"
The Engineer, Sept. 13, 2022
https://bit.ly/3EV4VM5

"What temperature is too hot for butterflies?"
Weird News Era, July 1, 2022
https://bit.ly/3UoCdsJ

In Memoriam: Professor Chia-Kun "John" Chu

C.K. Chu (1927-2023)

The Columbia Engineering and Applied Science community mourns the loss and celebrates the life of **Chia-Kun (John) Chu**, the Fu Foundation Professor *Emeritus* of Applied Mathematics and a pioneer in computational mathematics.

Professor Chu's work in fluid dynamics, magnetohydrodynamics, and shock waves garnered him international recognition while his zeal for his life's work prompted him to work tirelessly to create a home for applied mathematics at Columbia University. He is one of only seven mathematicians to receive an Honorary Doctor of Science Degree in Columbia's 252-year history.

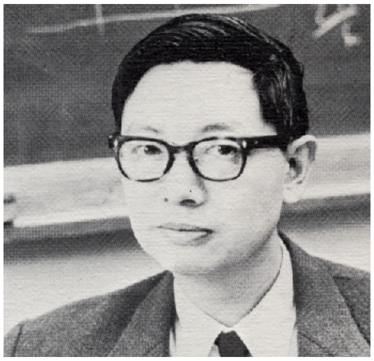
Professor Chu was born in Shanghai and was the son of parents with various degrees of Western education - his father received an MBA from NYU in 1929 and his mother spoke fluent English. He graduated in 1944 from St. John's University High School, where the curriculum was half Chinese and half English. He was accepted at St. John's University but decided to take the entrance examination for Chiaotung (now Jiaotong) University, the national science and engineering university.

"I didn't think I had much of a chance, but I got in," he said. After doing extremely well in his university studies, Chu came to the United States for graduate work. He received his master's degree in 1950 from Cornell and accepted a job as an engineer at General Electric. "I was happy at GE," he said, "and was all set in a special advanced program for engineers. And then, in 1953, a major incident occurred."

That incident was a telephone call from Professor Chu's advisor at Cornell, who had moved to Stevens Institute of Technology, offering him a position as an assistant professor there. The selling point was that Professor Chu would be near the Courant Institute of Mathematical Sciences. "On Friday, I interviewed for and accepted the position at Stevens and, on the following Monday, I interviewed with Richard Courant. He asked me what I needed for a salary and I said, 'I suppose if they are offering me an assistant professorship, my answer to you should be zero.' I was accepted as a Ph.D. student and it changed my life."

In 1959, he became the first Chinese student to receive a Ph.D. from Courant Institute. He taught at Pratt Institute and NYU Engineering before joining the Columbia Engineering and Applied Science faculty in 1963 as a visiting research scientist in the plasma physics laboratory. He was granted tenure at Columbia and was named a full professor in 1968. He was one of the original nine members of the faculty of the Department of Applied Physics and Nuclear Engineering; he served as the chair of the Plasma Physics Committee from 1966-1967, 1970-1971, and 1974-1977; and was chair of the Applied Mathematics Committee from 1978-2003. He also served as Chair of the Department of Applied Physics and Nuclear Engineering from 1982-1983, 1985-1988, and 1995-1997.

In 1999, he was named Fu Foundation Professor of Applied Mathematics. As a theoretician working with plasma physics, he was delighted when then dean Peter Likins asked him to form a new program in applied mathematics as a successor to the Mathematical Methods program already functioning well under Prof. Morton Friedman. Its first home was in Applied Physics and, in 1997, the name of the department was changed to Applied Physics and Applied Mathematics, fully recognizing the program.



Prof. Chu (above) in 1967 and (below) in 1986

Professor Chu was key in promoting the endowment that established the Fu Foundation School of Engineering and Applied Science. This endowment spurred the expansion of the School, and its rise in prominence.

Professor Chu was named a John Simon Guggenheim Foundation Fellow from 1971-1972, a Fellow of the American Physical Society in 1971, and Fellow of the Japan Society Promotion of Science in 1979. He was listed in Who's Who in America in 1983 and was a Sherman Fairchild Distinguished Scholar at Caltech in 1984. He was named an Advisory Professor at Shanghai Jiao Tong University in 1985, an Honorary Research Professor at the Institute of Mechanic from the Academia Sinica in 1988, the Wei Lun Foundation Lecturer at the Chinese University of Hong Kong in 1991, and an Honorary Professor of Mechanical Engineering at Hong Kong University in 1993. He received Columbia University's Great Teacher Award in 1985.

Professor Chu, whose advice and guidance helped hundreds of students for more than four decades, retired in 2003 but he continued to maintain contact with most of his 24 Ph.D. students and many of his former undergraduate students. He was awarded an Honorary Doctor of Science Degree from Columbia University in 2006 and was recognized by the Asian Columbia Alumni Association (ACAA) at their 20th Anniversary Gala in 2016.

In a letter nominating Professor Chu for an honorary degree, Professor Michael Mauel, former APAM Department Chair, wrote: "Chu is one of the great pioneers of computational mathematics and he is the visionary leader for applied mathematics within Columbia University. His work in fluid dynamics, magnetohydrodynamics, and shock waves is internationally recognized. He coined the term "computational fluid dynamics" and pioneered numerical and mathematical methods for understanding the propagation of shock waves that occur in many different physical circumstances. These contributions have made a lasting and profound impact to the development of applied mathematics.

Professor Chu has also been the spiritual force driving the growth of applied mathematics at Columbia University and a beloved and founding leader of the Department of Applied Physics and Applied Mathematics. With a warm and engaging personality, Chu inspired his colleagues to interdisciplinarity, departmental harmony, and devotion to the University. By way of personal example in both teaching and service, he has been pivotal to hundreds of undergraduate and graduate students, and he has helped to secure the lasting success of applied mathematics within the Fu Foundation School of Engineering and Applied Science."

A memorial service for Professor Chu will be held at St. Paul's Chapel on Columbia University's Morningside Heights campus later this spring. The event will also be livestreamed. Details will be posted on the APAM website: apam.columbia.edu

Aron Pinczuk (1939-2022)

Symposium to Honor the Life and Work of Aron Pinczuk

The APAM Department and Physics Department co-hosted a symposium to honor the life and work of Professor Aron Pinczuk (1939-2022). The Symposium, *The Science and Life of Aron Pinczuk*, took place on Saturday, October 8, 2022, in Davis Auditorium and featured talks by Aron's collaborators, students and family, followed by a time of opening sharing for othes. Below is a list of the invited speakers, the titles of their talks, and abstracts.

Horst Stormer, Columbia University - "Aron, from my angle" - Abstract: A journey.

Roberto Merlin, University of Michigan - "Aron Pinczuk: The early days of light scattering in solids at Penn, the return to Argentina and the pioneering work on two-dimensional electrons at Bell Labs"

Loren Pfeiffer, Princeton - "My three and one-half decade physics collaboration with Aron Pinczuk"
Abstract: In the summer of 1987 Aron Pinczuk and I were both Members of Technical Staff at Bell Laboratories in New Jersey. Aron Pinczuk was one of the resident experts in optical studies of 2D electron systems in semiconductors, and I was learning to grow 2D electron systems in Gallium Arsenide quantum wells by Molecular Beam Epitaxy. My samples were just starting to show exceptionally high electron mobilities and Fractional Quantum Hall signatures in electron transport, but no one had ever looked at them using sophisticated optical techniques. Bell Labs management brought us together as collaborators. It was a match made in the local heaven for physicists that was Bell Labs in those days. Aron soon was using optical photoluminescence that could tell him the exact 2D electron density in our quantum wells, and we found his photoluminescent values checked perfectly with our electron magneto-transport measurements. Over the course of our collaboration Aron pioneered Resonant Raman Scattering techniques which revealed ultra-sharp resonance linewidth-Raman-energy shifts as narrow as 25 micro-eV full width at half maximum. The unprecedented sharpness of these Raman-shift-resonances correlates nicely with the magneto-transport mobility of the quantum well, and may actually be a better measure of the 2D electron uniformity and coherence than transport mobility itself. The light-scattering experiments that Aron pioneered over his long career quite literally opened a bright new window on the physics of low dimensional electron systems.

Vittorio Pellegrini, BeDimensional - "Aron and me: a wonderful journey in the flatland"
Abstract: I first met Aron on January 15th 1996, late afternoon, in front of Bell Labs in Murray Hills, New Jersey. I was a PhD student of Scuola Normale in Pisa Italy. That event represented the beginning of a collaboration between Aron and me that has impacted my career and my personality. Aron introduced me to the investigation of electron correlation and quantum phases in two-dimensional electron systems in GaAs quantum wells. Later, we studied graphene systems and we started to look together at artificial ways of creating graphene-like honeycomb lattices in semiconductors with the idea of engineering electronic bands and tune electron correlation phenomena in two dimensions. In this talk, I highlighted the most relevant findings of more than 25 years of collaboration and emphasized how influential Aron was in my carreer.

Cyrus Hirjibehedin, MIT Lincoln Lab; Irene Dujovne, UMass, Amherst; & Rui He, Texas Tech University - "Aron @ Columbia: The "early" years"
Abstract: Aron Pinczuk moved from Bell Labs to Columbia University in 1998. We were the first three graduate students to join Aron's group at Columbia, and we have highlighted our experiences working in his group - from having the opportunity to do research in his old lab at Bell Labs to, setting up his new labs at Columbia. We also share stories of how he influenced our careers, and how he continued to support us and stay in touch with us well after we graduated.

Sankar Das Sarma, University of Maryland - "Aron Pinczuk: A Friend for 40 Years with Plasmon Modes in Our Minds"
Abstract: Aron Pinczuk was a close friend of mine for 40 years, and we both loved collective excitations, particularly plasmon modes, in low dimensional semiconductor structures. Ours is a story of deep friendship based on a theme: how electrons collectively respond to light, how to measure them, and how to understand the measurements. In this talk, I also recapitulate aspects of the physics of my friendship with Aron.

Trevor Rhone, Rensselaer Polytechnic Institute - "Emergent spin phenomena in the age of artificial intelligence"
Abstract: When the dimensionality of an electron system is reduced from three-dimensions to two dimensions, new behavior emerges. This has been demonstrated in gallium arsenide quantum Hall systems since the 1980's, and more recently in van der Waals (vdW) materials, such as graphene. In my talk, I discussed the emergent behavior of electrons in reduced dimensions with a focus on their spin degrees of freedom. In particular, I emphasized recently discovered vdW materials with intrinsic magnetic order, such as CrI3 and CrGeTe3. How many of these materials exist in nature? What are their properties? These materials are at the forefront of research in condensed matter physics. We combine high-throughput first-principles calculations and artificial intelligence to accelerate the discovery of vdW magnets and to gain physical insight into their magnetic and thermodynamic properties. Furthermore, this nontraditional approach to materials research paves the way for the rapid discovery of materials with other exotic electronic spin and charge degrees of freedom, such as those with topological order.

Ursula Wurstbauer, WWU Münster - "Emission is complicated: the beauty of resonant inelastic light scattering"
Abstract: In one of my first discussions as a new postdoc in Aron's group at Columbia, I asked him a question about photoluminescence (PL) spectra taken on a high-mobile two-dimensional electron system in a GaAs quantum well. I did just finish those initial optical measurements – and I was a newbie to optical experiments in those days. His initial short answer was underlined with his kind, unique smile: "Emission is complicated." Then he started an insightful as well as patient explanation on the resonant inelastic light scattering (RILS) spectra taken on the same sample in row with the PL spectra. Over time, working closely with Aron, I became more and more convinced about the strengths and fantastic insights we are able to get from RILS on (quantum) states of matter through their low-lying collective excitations – even if the experimental approach needs typically different kind of efforts than PL measurements. In my presentation I discussed some recent RILS result from my lab in Münster on two-dimensional quantum materials including the role of Fröhlich exciton-LO phonon coupling in the valley depolarization process in MoS2 monolayers, low-frequency modes in MoSe2/WSe2 hetero-bilayers hosting a degenerate quantum Bose system, anisotropic modes in the dilute magnetic semiconductor CrSBr as well as on phonon confinement to estimate defect densities in defect engineered MoS2 monolayers towards deterministic quantum light sources. We will see that the combination of resonant inelastic light scattering experiments - pioneered by Aron Pinczuk – together with photoluminescence and spectroscopic imaging ellipsometry is a modern and powerful set of tools to explore the fascinating world of two-dimensional quantum materials.

Jainendra Jain, Penn State University - **"Aron Pinczuk: My Friend and Collaborator"**

Ana Pinczuk - "Reminisces from Aron's family"

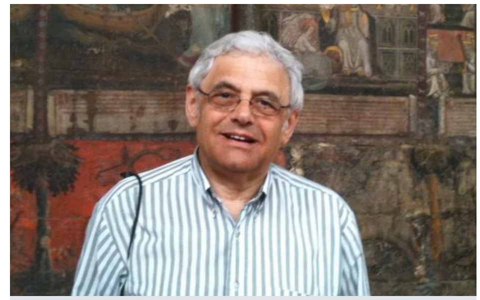
Solid State Communications Honors Pinczuk

Since 2005, Aron Pinczuk served as the Editor in Chief of *Solid State Communications*. In honor of his many years of service and his countless contributions, the journal will publish an special issue in honor of his life and work. For more information, please see: **https://www.sciencedirect.com/journal/solid-state-communications**

(Above) Over 125 colleagues, students, friends, and family members of Prof. Pinczuk attend *The Science and Life of Aron Pinczuk* on October 8, 2022. Half of the in-person attendees also stayed for a special dinner at a nearby restaurant following the symposium.

(Above) Aron Pinczuk's daughter, Ana Pinczuk, shared personal photos and cherished memories from the Pinczuk family. Her slides and photos are available online at: https://bit.ly/3OUCF0B

(Above) Many of Aron's former students, researchers, and colleagues shared memories as well as stories of how Prof. Pinczuk influenced their careers and contintued to support them and stay in touch.



Professor Aron Pincuzk

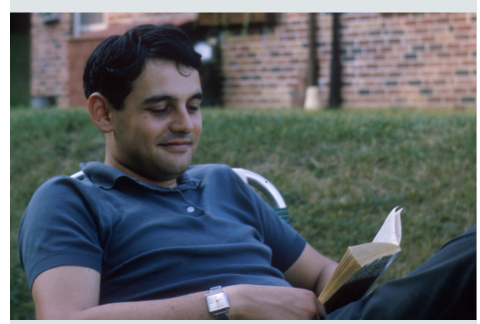
Sympoium Slides, Photos, & Tributes

Presentation slides from the symposium, photos, and tributes from family, friends, and students are available online at: **https://bit.ly/3OUCF0B**

Professor Pincuzk, 1960's

Pinczuk Memorial Candy Bowl

A consistent theme and source of humor during the symposium was the recollection of Aron's love of candy - chocolate, in particular. He felt communication was enhanced and tensions calmed when people could share something sweet. There is now a glass candy bowl in the APAM Department, engraved with Aron's name, so that we can fondly remember our dear friend and remember to slow down and savor life.



Professor Pincuzk, 1966

In Memoriam - Neil Patel:* *We are very sad to report that Neil S. Patel, BS '98 Applied Math and MS '20 Applied Physics/Medical Physics, passed away in January 2022. Following his time at Columbia, he earned a medical degree at SUNY Downstate Medical Center, completed his residency in ophthalmology at the New York Ear and Eye Infirmary of Mount Sinai, and completed his fellowship in vitreoretinal diseases and surgery at University of California, Irvine, School of Medicine. Neil then returned to New York City and served as the president and founder of New York Ophthalmology, focusing on underserved communities. More details about his life and work can be found at https://bit.ly/3I0lhXa

Student & Department News

New Student Associations: WDAPAM & AMPS

Women & Diversity in APAM (WDAPAM)

WDAPAM is a new association in the APAM Department for diversity, equity, and inclusion efforts. The purpose of this association is to support and increase the visibility of its members: individuals of historically marginalized minorities in APAM, including but not limited to women. The group is overseen by Prof. Shanying Tong and all APAM students, postdocs, researchers, and faculty are welcome! Planned activities in Spring 2023 include:

- Research Panel and Discussion: Female faculty, researchers and senior PhD students will share their research experiences and career stories. This will be followed by a casual discussion among participants.
- Research Mentorship Program: We will provide undergraduate or master students who are women or from other STEM underrepresented minority groups (URMs) with research opportunities and mentorship by APAM PhD students.
- Peer application review program: We will invite prospective students, especially URMs, to get help with application materials for our PhD program from current APAM PhD students.

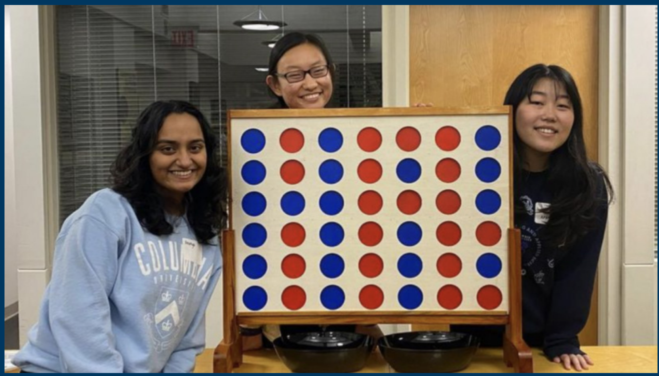
To learn more, see: https://bit.ly/3FBVz9P

Association of Applied Math, Applied Physics, Materials Science, & Medical Physics Students (AMPS)

AMPS is a student council that represents all APAM graduate students. Our mission is to improve APAM grad students' social and academic experiences and build community in APAM by planning social and professional events and advocating on behalf of students with the department and the school. So far, we have hosted more than 6 social events this year, including a Joe coffee hour for APAM graduate students and APAM Fridays. We also conducted a survey on APAM PhD student experiences regarding the qualifying examination process, and in response to this feedback, are working with faculty during their review of the qualifying process. We have also been helping create the new diversity equity and inclusion committee for APAM, called Women & Diversity in APAM (WDAPAM). Our AMPS board meets semi-regularly and is open to all in APAM— we would love to hear your suggestions! Please email amps@columbia.edu to learn about our next meeting. https://amps.studentgroups.columbia.edu/

Fall 2022 Undergraduate Mixer

Undergraduate students attended a mixer in the APAM Department on November 14. Students and faculty enjoyed an evening full of program planning and socializing. Photos by Kayla Kim '24 / CU SIAM



Farewell to Stella Lau & Kristen Henlin

Stella Lau, the APAM Director of Finance and Administration, and Kristen Henlin, the Assistant Director of Career Placement, are moving on to new positions outside of APAM. The Department warmly thanks Stella and Kristen for their time, committment, and enthusiasm. We will miss you!

Contributing Authors

Andrew Bishop, Columbia Engineering, Columbia Engineering Magazine, Columbia News, Allison Elliot, Holly Evarts, Kristen Henlin, Michael Mauel, Shanyin Tong, Chris Wiggins

Photos/Images

Eileen Barosso, Columbia Engineering, Columbia Engineering Magazine, Kayla Kim, Stephanie Malek, Adam Overvig, Jeffrey Schifmann, Cheng-Chia Tsai, Nanfang Yu

Contact Us

We'd love to hear from you and stay connected! Follow us on social media and please send your news and updates to **apam@columbia.edu**

Department of Applied Physics & Applied Mathematics
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