MAE news

MECHANICAL AND AEROSPACE ENGINEERING

School of Engineering and Applied Science
PRINCETON

SPRING 2021

Dear friends of MAE,

I hope that this note finds you well. During the past 16 or more months everyone has experienced many challenges. Hopefully we are rounding the corner on the pandemic and in the coming months, with more and more people vaccinated, we will see life return to something approaching the pre-pandemic activities. Of course, we have learned some lessons that can help us as we move forward.

In this newsletter, you will get a glimpse of some of the recent activities in MAE. We have been fortunate that many students were back on campus for the Spring semester. Although most classes were virtual, a few were hybrid, but we did our best to provide a quality education for our undergraduate and graduate students. In MAE, the faculty and staff worked hard to make adjustments to manage the new learning environment, including sending materials to students who remained off campus, or were on campus and unable to come to labs. Also, we benefitted from excellent input from our students about ways to improve our courses within the constraints we faced. Finally, one of the highlights of the Princeton experience is the senior thesis/design project. Our students did very well and completed a diverse set of excellent projects across the spectrum of mechanical and aerospace engineering.

On behalf of all of my colleagues, I wish all of our recent graduates best wishes in their next steps beyond Princeton and we all look forward to welcoming students back to campus for the fall semester!

Best regards, Howard Stone

In this issue...

student spotlight

Michael Hauge:
Solving Spacecraft Challenges From Launch to Interplanetary Travel

Michael Hauge and his student colleagues from around the country were exuberant on their Zoom call as NASA live streamed the Perseverance Mars rover landing on February 18, 2021. The senior at Princeton, who is majoring in MAE, worked as a research intern in NASA's Jet Propulsion Laboratory as part of the WFIRST Coronagraph Instrument team.

Coronagraphs, which are made up of optical masks, prisms, detectors, and mirrors, are attached to a space telescope. Their job is to block out a star's light and correct light distortions so planets around the star can be revealed. Michael characterized and tested samples of black silicon to improve the manufacturing process of ultra-dark materials that enable coronagraphs to absorb as much unwanted light as possible.

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grad program info

IN OUR PhD PROGRAM

All PhD students are fully supported with tuition and a living expense stipend during the entire program. A First Year Fellowship covers tuition and stipend in year one. The remaining years of the program are fully funded through a combination of teaching and research support provided by the student's adviser. As a candidate for the doctoral program, the student, in consultation with a faculty adviser, develops an integrated program of study which culminates with a dissertation showing technical mastery of their chosen field and contribution to the advancement of knowledge, followed by a public presentation of the material. Princeton's Department of Mechanical and Aerospace Engineering has played a leading role in propulsion, combustion, aerospace dynamics, and fluid dynamics over the past half century. In recent decades the Department has extended its reach as a leading presence in dynamics and control, robotics, biomechanics, applied physics, and materials science. By exploiting its multi-disciplinary character and stressing science and engineering fundamentals, the Department seeks to educate the very best students – undergraduate and graduate - for future positions of leadership in areas of rapidly evolving technology.

GET MORE INFO

Howard Stone, MAE Chair, hastone@princeton.edu

Michael Mueller, Associate Professor & Director of Graduate Studies, muellerm@princeton.edu

Katerina S. Zara, Graduate Administrator, kzara@princeton.edu

mae.princeton.edu

faculty spotlight

Kelsey Hatzell:
Battery and Energy Storage Expert Joins Faculty

Kelsey Hatzell, PhD, has joined Princeton as an Assistant Professor of MAE and the Andlinger Center for Energy and the Environment. A specialist in the field of batteries and energy storage, she previously led the "Inks and Interfaces" lab at Vanderbilt University where she also served as assistant professor.

"I am looking forward to being part of a highly interdisciplinary engineering program and building new research and educational collaborations across campus," she says. Professor Hatzell's work focuses on answering fundamental questions related to dynamic processes that occur at solid-solid and solid-liquid interfaces in batteries and energy conversion systems, along with translational research related to battery manufacturing.

"My research group is looking forward to expanding our footprint in energy storage," she adds. "We have been thinking about energy storage primarily in terms of electrochemical systems, but we are also interested in technologies that can enable long-duration energy storage. We have a goal of broadening our lens into energy conversion (fuels) and thermal energy storage."

Professor Hatzell's expertise is in solid-state batteries, which use a solid electrolyte instead of a liquid- or polymer-gel electrolyte used in common lithium-ion batteries. Solid-state batteries allow for more energy-dense anodes, meaning electric vehicles can potentially run for more mileage before needing to recharge. They also are not flammable, averting safety risks that have arisen around some lithium-ion batteries in cars and other applications. In addition to batteries, she also studies other types of energy storage systems, namely thermal energy storage, for long-duration uses.

Mechanical engineering is all about the flow of energy, she explains. Professor Hatzell looks forward to teaching classes related to energy such as thermodynamics and electrochemical engineering. She is excited to bring a new interdisciplinary class on electrochemical systems for mobility to Princeton.

Dr. Hatzell received a B.S. in engineering and B.A. in economics from Swarthmore College, a M.S. in mechanical engineering from Pennsylvania State University, and a Ph.D. in materials science and engineering from Drexel University. She has received numerous honors and accolades, including the National Science Foundation Career Award. ¤

student spotlight *continued*

Michael has long been captivated by space exploration. In elementary school, he observed the Mercury capsule on display at the National Air and Space Museum. He was amazed at how such a seemingly simple spacecraft could carry an astronaut into space.

But it was a summer internship program in the High Contrast Imaging Laboratory that cinched his decision to major in MAE. "It is next to impossible to get an internship after only one year for most students," Michael says. "But MAE offers this research internship to freshman and sophomore students to introduce them to work in a lab."

Michael used his programming skills to integrate electrical, optical, and mechanical components into a Python-based hardware-in-the-loop simulation of Starshade-telescope alignment and other dynamics. Like with a coronagraph, the purpose of the Starshade is to block out starlight in order to discover exoplanetary systems.

"Theoretical science can be exciting—you are always learning and discovering new things," Michael says. "But it is very appealing to be able to build something that is real and tangible."

Eager to be a part of another hands-on astronautics project, Michael joined the Princeton ThinSat Team. He fabricated circuit board components for the electronics payload, which is designed to test the survivability of rapidly prototyped circuits in the launch and space environments. The ThinSat was launched two days after the Perseverance Mars rover landing.

Michael also worked on an independent project to design a miniature satellite called a CubeSat frame that could be manufactured in-house by students for a fraction of the commercial cost. For his undergraduate senior thesis, he created an advanced MATLAB-based software tool to simulate the altitude control of the CubeSat in a novel, low-cost way. He is now using the tool to design and build the CubeSat's altitude control system, which points a spacecraft in the correct orientation while it is in orbit.

Michael continues to run full tilt as graduation nears. Fascinated by the stars, moon, and planets, aerospace engineering remains the vehicle of his passion. ¤

a word from the lab

APPLIED PHYSICS ▫ DYNAMICS & CONTROLS ▫ FLUID MECHANICS ▫ MATERIALS SCIENCE ▫ PROPULSION & ENERGY SCIENCES

Timothy Chen:
Laser Diagnostics, Plasma, and Sustainable Chemical and Fuel Development

"Nonequilibrium plasma is like magic," says Timothy Chen, a fifth-year graduate student in MAE at Princeton. "It allows you to do things you normally would not be able to do." In Professor Yiguang Ju's lab, he uses laser diagnostics to study the potential for plasma-assisted conversion of carbon dioxide, methane, and other gases into sustainable chemicals and synthetic fuels. Plasma is ionized gas that is electrically conductive.

Obtaining accurate measurements of electron temperature and density are critical in investigating these plasmas. When he first came to Princeton, Tim spent a year building and testing a high-resolution measurement device cobbled together from mostly off-the-shelf parts.

One goal of Tim's research is to use plasma to turn natural gas, mostly consisting of methane, directly into methanol to reduce flaring—the process of burning off gas in a controlled manner. Gas leakage during oil extraction and processing on rigs is common. In this case, it is uneconomical to capture, store, and transport in highly pressurized pipelines what is largely considered methane "waste."

Tim has also developed novel techniques to measure other plasma characteristics, such as the electric field. He created a SEE-FISH method, which enhances our ability to obtain these electric field measurements. ¤

Danielle Chase:
Understanding Fluid-Driven Phenomenon

Danielle Chase credits both an amazing professor and runs along the Mississippi River for her interest in fluid mechanics. She became curious about the physics of water and applied to a research program in microfluidics.

For three years, the Ph.D. student has been working in the Complex Fluids Group at Princeton. Her work involves experiments and mathematical modeling of fluid-driven fracturing in porous media, relaxation of a fluid-filled blister on a porous substrate, and experiments on the motion of particles near rough surfaces.

Her first project focused on developing a lab experiment to study the relaxation dynamics of a fluid-filled blister on a porous substrate. The experiment was combined with a model and field data from the Greenland Ice Sheet to study the relaxation dynamics of ice sheet uplift following the drainage of surface lakes. The timescale for the ice sheet relaxation can be used to understand the hydrologic structure beneath the ice sheet.

"It was really interesting to learn about this phenomenon and to see the application of the lab experiment—which can be held in my hand—to help understand the physics of an ice sheet that is many orders of magnitude larger," Danielle says. ¤

Anvitha Sudhakar:
The Mechanics of Living Shapes

For second-year Ph.D. student Anvitha Sudhakar, inspiration starts at home. Raised in India, her mother pushed hard work and financial independence.

Today, from more than 8,000 miles away, Anvitha is exploring the mechanics of biological science in the Kosmrlj Group. She is developing a computational model of lizard alveoli (tiny air sacs in the lungs) during embryonic development in an effort to make artificial alveoli. In another project, she is also modeling self-folding of origami/kirigame structures. ¤

awards and honors

Michael Mueller – named winner of 2nd USSCI Early Career Combustion Investigator Award

Fred Dryer (Professor Emeritus)
– elected to the National Academy of Engineering

Daniel Cohen – receives National Science Foundation Career Award

Anirudha Majumdar – receives Young Faculty Researcher Award from Toyota Research Institute
– receives the National Science Foundation Career Award

Jesse Jenkins – testified in the US House of Representatives Science & Technology Committee on the Texas crisis and electricity reliability.

Naomi Leonard – named the first recipient of the William R. and Jane G. Schowalter Research Fund

Yiguang Ju – received the Distinguished Paper Award at the 38th International Symposium on Combustion
– received the 2021 AIAA Propellants & Combustion Award

For full stories, visit: http://mae.princeton.edu/about-mae/spotlight

PRINCETON UNIVERSITY

Mechanical & Aerospace Engineering
Engineering Quad - D Wing
Princeton University 08544

Visit **mae.princeton.edu/about-mae/events** for event updates and location information. Events are free and open to the public.

Newsletter Editor: Carolyn Sayre

events: spring 2021

SEMINARS SERIES

Friday, February 19, 2021
MICHAEL BURKE
COLUMBIA UNIVERSITY

Friday, March 19, 2021
AIMY WISSA
THE UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

Friday, March 26, 2021
JEAN BOTTI
VOLTAERO SA

Friday, April 2, 2021
RUI NI
JOHNS HOPKINS UNIVERSITY

Friday, April 9, 2021
CATHERINE GORLÉ
STANFORD UNIVERSITY

Friday, April 16, 2021
IOANNIS MIKELLIDES
JET PROPULSION LAB, CALIFORNIA INSTITUTE OF TECHNOLOGY

Friday, April 23, 2021
ACHINTYA BHOWMIK
STANFORD UNIVERSITY

Friday, April 30, 2021
MAMADOU DIAGNE
RENSSELAER POLYTECHNIC INSTITUTE

Announcements

Undergraduates Awards and Honors:

The Sigma Xi Book Award

KEVIN ANDRADE, 1st Co-winner

Optimizing a 2D Airfoil Using Data-Driven Surrogate Modeling for In-Flight Wing Morphing
Advisor: Luigi Martinelli

SHALAKA MADGE, 1st Co-winner

Determine if and how batteries' stress concentration can be made uniform across the entire battery body
Advisor: Craig Arnold

Book: Princeton University and Neighboring Institutions: An Architectural Tour (The Campus Guide)