MAE news

MECHANICAL AND AEROSPACE ENGINEERING

School of Engineering and Applied Science
PRINCETON

FALL 2020

Dear friends of MAE –

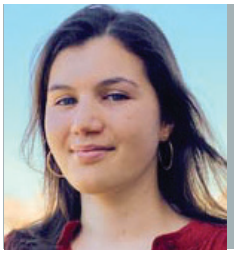
I hope that this note finds you all healthy and well, though I know the past seven or more months have been filled with challenges, from battling the pandemic to wildfires and major storms in different parts of the US. We have re-started classes, but most everything at the University is operating remotely, except for research labs, which are functioning with reduced density of the researchers. So there is a lot of activity, but it is not evident in the hallways of SEAS or on the campus. The faculty, staff, and students of MAE spent much of the summer preparing for classes, including a major effort led by Professor Littman, to re-think laboratories and hands-on activities critical to key MAE classes. Many materials were shipped to students before the semester began (and during the first weeks of the semester) to give students lab-like activities that they can do from home as part of some of our core undergraduate courses. We look forward to learning how successful were these initiatives and activities.

The summer also included a weekly seminar series (via webinar) "Conversations with National Laboratories," run by Professor Julia Mikhailova, which gave us an opportunity to hear former undergraduates and PhD students describe some of their on-going work, as well as to learn their career paths. Inside this Newsletter you will get a glimpse at some of the many activities on-going in MAE.

Best regards, Howard Stone

In this issue...

student spotlight



Claire Dashe:
Crossing Disciplines in Engineering and Entrepreneurism

Claire Dashe does not have to worry about leaving her heart in San Francisco. Two months after students were supposed to return to campus, she is still in California. But geography could never stand in the way of Claire finding a way to combine her passion for engineering with her entrepreneurial spirit.

"A lot of engineers have tunnel vision," says the senior in MAE who is leaning towards a career that combines engineering and business. "Many engineering start-ups have brilliant ideas but no business sense. Others are great at the business but do not have a product."

Claire grew up learning these skills at the family winery business: Dashe Cellar. She helped her parents build outdoor wine gardens and construct cooling

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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

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faculty spotlight

Julia Mikhailova, PhD:
Using Laser Pulses to Understand How Materials Behave in High Fields

A lot in Julia Mikhailova's world comes down to synthesis and balance. As a student, she was the only physics major who rounded-out her education with a second degree in journalism. As a mother of young children, she works hard to maintain a delicate harmony between home and professional life. And as a physicist, she spends her days exploring the balance between forces exerted by intense light and forces that shape matter.

"We want to find ways, quantum mechanics permitting, to peek into the multitude of transient phenomena in materials and see what is happening there in atoms and molecules, in two-dimensional crystals, inside hot dense plasmas of stars, the Universe antimatter, and our own cells," explains Professor Mikhailova, PhD, Assistant Professor in MAE.

When she joined the faculty in 2013, Professor Mikhailova built all of the infrastructure she needed to run the experiments from scratch. Today, ETOILES — Experimental and Theoretical Optics of Intense Laser Envelopes and Strong Fields — is one of the most powerful university laser laboratories in the world, exploring the physics of intense light-matter interactions, ultrafast and high-field science, and quantum phenomena.

Professor Mikhailova uses bright light delivered by a powerful laser to break atoms in solids and gases and free the electrons, thus creating a state of matter known as plasma. The dynamic balance between the forces of the laser and the forces of plasma causes electrons to accelerate almost as fast as the speed of light and follow distinct trajectories that resemble those of particles in a synchrotron. As a result, those electrons emit ultrashort bursts of intense ultraviolet and x-ray light. The spectra of these bursts consist of high-order harmonics of the driving laser and can be viewed as plasma fingerprints carrying information about their source. These bursts can also serve as an attosecond-speed shutter allowing researchers to get a glimpse of the innate dynamics inside materials.

"What makes me excited about the future, is that the high electric and magnetic fields produced in our experiments could allow us to control matter in some sense," she describes.

student spotlight *continued*

systems for the wine tanks. But her appreciation for combining entrepreneurism with engineering came in high school when she co-founded Swish, LLC—a company that allows people within a community to rent items. Claire was featured in the documentary, CodeGirl, and won second place at the Google Technovation Challenge in 2015 for her work. As an intern at Shoplook, a social commerce platform, she also helped launch an iOS application and manage a website.

She chose MAE because it offered a variety of potential paths. At Princeton, Claire has been working as an integration engineer on a Search and Rescue Robot project. As the manager of four design sub-teams, Claire was responsible for making sure all of the robot parts worked in cohesion. The wheel design team, which she led, used CREO software to perform analysis and optimize the robot wheel dimensions. Unfortunately, in March when the pandemic hit, the teams had to finish the project using online simulations. With nine people working from nine different time zones, the parameters of the day stretched beyond what Claire could ever have imagined.

Now, she is working on her thesis topic: modular tiny houses, which is part of the Tiny House Movement—an architectural and social movement that advocates living simply in small homes. Claire and her partner are working with solar-insulated panels. The idea of these tiny homes—which are often as small as 8 by 8 feet—is that they are mobile and de-emphasize consumerism. Claire sees the topic as another possible start up idea.

Another one of Claire's passions is animals. She has been a volunteer for six years at San Francisco's SPCA—a global animal rescue organization—and is captain of Princeton's Equestrian team, where she manages a team of 30.

Nowadays, she has two homes, spread 3,000 miles apart. One day, she hints at a future that aligns with her thesis: hitting the road in a tiny house. "Someday," says Claire, "I would love to live in the middle of nowhere."

a word from the lab

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

Hongtao Zhong:
Searching for a Larger World

Hongtao Zhong was raised in a small town in China by parents who encouraged him to explore his surroundings. As a fourth-year PhD student in MAE, Hongtao does exactly that by investigating the impact of chemistry on instability in weakly ionized plasma.

This instability has largely been attributed to plasma's Joule heating, but Hongtao recently discovered that chemical interactions also play a role in plasma instability. In pioneering work with his research team, Hongtao developed a theoretical formulation and numerical model for plasma chemistry instability. The research demonstrated that chemical kinetics involving electron attachment, electron-impact reactions, and plasma-assisted low temperature fuel-oxidation reactions can dramatically change the onset boundary of plasma instability. Hongtao also developed an analysis method, based on computational singular perturbation theory, to identify key chemical species and elementary reactions that contribute to chemical instability in plasma.

These advancements have been recognized by the U.S. Department of Energy and the National Science Foundation. When Hongtao is not in the lab, he enjoys exploring the world by hiking his favorite trails in Wyoming, Norway, and the Wuyi Mountains back home. ▫

Vincent Pacelli:
Writing the Equations Behind Robotics

Some of Vincent Pacelli's best insights in physics come from playing softball. When he catches a ball, the second-year PhD student in MAE uses a simple instinctual decision-making strategy called gaze heuristics. Vince fixes his eyes on the ball and runs so that it remains at a fixed point in his vision. This simple rule naturally puts him at the location the ball will land.

As part of the Intelligent Robots Motion Lab, Vince tries to find ways to make robots automatically emulate human instinct. He is designing algorithms that find simple heuristics for doing dexterous tasks, such as picking up a fork or catching a ball.

First, Vince has to describe a task for the robot mathematically by developing an algorithm on the computer. Then, the robot needs to be able to decide what part of the environment around them is important to their task. For example, they might need to change their path if an object is too close to them or ignore an object if it is too far away.

"Robotics has the power to help many people," says Vince. His algorithms can be applied to different types of robots including drones, quad runners, and autonomous cars. ▫

Philippe Bourrianne, PhD:
Understanding COVID-19 Transmission

Philippe Bourrianne, PhD, analyzes the trajectory of respiratory droplets as a singer performs in the Princeton laboratory. The collaboration with the Metropolitan Museum of Opera to develop safe social distancing practices is one of many projects the postdoc has been involved with since the pandemic hit. Philippe came to Princeton to study biologic systems, but his focus quickly shifted to numerous COVID-19 projects including studying the effects of facial masks and developing devices for open ventilation systems. ▫

awards and honors

Amir Ali Ahmad – receives the Teaching Award of the Princeton Engineering Council

Anirudha Majumdar – receives the Alfred Rheinstein Award

Emily Carter –Elected a Member of the European Academy of Sciences

– the UCLA Chemistry & Biochemistry Distinguished Lecturer, University of California, Los Angeles

Jesse Jenkins – receives the Princeton Engineering Commendation List for Outstanding Teaching, School of Engineering and Applied Science

Naomi Leonard – receives the John R. Ragazzini Education Award, American Automatic Control Council

Alexander Smits –receives the Batchelor Prize in Fluid Mechanics (International Union of Theoretical and Applied Mechanics)

– Fellow, American Academy of Arts & Sciences (AAAS)

Howard A. Stone –receives the ASME Fluids Engineering Award (Lecture to be delivered in July 2021)

– Named Co-editor, Annual Review of Fluid Mechanics

Salvatore Torquato – receives One of the American Physical Society Outstanding Referees

– receives the Princeton Engineering Commendation List for Outstanding Teaching

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: fall 2020

SEMINARS SERIES

Friday, September 11, 2020
RESEARCH DAY

Friday, September 25, 2020
EGEMEN KOLEMEN, MAE, PRINCETON UNIVERSITY

Friday, October 2, 2020
KAREEM AHMED, UNIVERSITY OF CENTRAL FLORIDA

Friday, October 9, 2020
KRISTIN M. MYERS, COLUMBIA UNIVERSITY

Friday, October 16, 2020
DMITRY SAVRANSKY, CORNELL UNIVERSITY

Friday, October 30, 2020
SONIA MARTINEZ DIAZ, UC SAN DIEGO JACOBS SCHOOL OF ENGINEERING

Friday, November 6, 2020
CHLOE E. DEDIC, UNIVERSITY OF VIRGINIA

Friday, November 13, 2020
GRACE X. GU, UNIVERSITY OF CALIFORNIA, BERKELEY

Friday, November 20, 2020
KAREN MULLENERS, EPFL

Friday, December 4, 2020
SAMUEL GRAHAM, GEORGIA INSTITUTE OF TECHNOLOGY

Announcements

Hands-on Learning At-Home

At the end of May, MAE faculty started to plan laboratories and lectures for the possibility that the fall semester would be in part, or fully, remote. For eight weeks over the summer, faculty and staff partnered with 21 MAE undergraduates to test and develop a variety of ways to deliver the best possible teaching and learning experiences remotely, along with the policies, processes, and technology to support them. For example, several MAE fall courses have student-tested lab kits for at-home use, manipulatives for following along in real-time with demonstration lectures, remote-controlled lab experiments, and much more. In addition, we shared our ideas with other Princeton departments and hope that some of the remote teaching ideas will provide long-term educational and organizational benefits.

Remote kits were sorted, packed, and shipped over the past several weeks. Thank you to everyone who helped plan for a new educational landscape this fall. It's another example of how the spirit of innovation and collaboration within our MAE community brings out the best in all of us, especially during the challenges of academic life during a pandemic.