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 and fall 2018

**April 13– 4:00pm**
"Soft Materials in Complex Environments: from Porous Rocks to the Human Body"
SUJIT DATTA, Princeton University

**April 20– 4:00pm**
"Wind Farm Modeling and Control for Power Grid Support"
DENNICE GAYME, Johns Hopkins University

**April 27– 4:00pm**
"Emergent Mechanics and Origins of Behavior in Simple Non-Neuronal Systems"
MANU PRAKASH, Stanford University

**May 4– 4:00pm**
"Atomistic Transport Processes at Liquid-Vapor Interfaces"
JENNIFER LUKES, University of Pennsylvania

**September 14th– 4:00pm**
MAE Research Day

**September 21– 4:00pm**
ALEXANDRA TECHET, Massachusetts Institute of Technology

**September 28– 4:00pm**
DAVID CLEARY, Aramco Services

**October 5– 4:00pm**
SCOTT KEMP, Massachusetts Institute of Technology

**October 12– 4:00pm**
DAVID GRACIAS, Johns Hopkins University

**October 26– 4:00pm**
NICOLE SHARP, FYFD

**November 30– 4:00pm**
Crocco Colloquium – KATHARINA KOHSE-HÖINGHAUS

## MAE Undergraduates advance to NASA Big Idea Challenge Final

A team of five MAE undergraduates - Santiago Aguirre, Joshua Freeman, Colin Reilly, Benjamin Shi, and Maxwell Schwegman - competed in the finals of the 2018 NASA Big Idea Challenge competition held March 6 and 7 in Cleveland, Ohio.

## Summer Undergraduate Enrichment Program

New this summer: MAE will be hosting a Summer Undergraduate Enrichment Program alongside the Summer Practical Research Experience (SPRE). Undergraduate interns working with MAE faculty during the summer months will participate in weekly events such as scholarly talks, field trips and BBQs. The program will be administered by Michael Galvin, a member of Professor Jeremy Kasdin's research group.

## announcements

**Clancy Rowley** appointed head of Rockefeller College July 1, 2017.

**Lex Smits** transfers to emeritus status July 1, 2018. Recent transfers to emeritus include Szymon Suckewer (2016) & Phil Holmes (2105).

**Robert Jahn,** former dean of engineering and professor emeritus of mechanical & aerospace engineering died Nov. 15. He was 87.

# MAE news

MECHANICAL AND AEROSPACE ENGINEERING

School of Engineering and Applied Science PRINCETON

Spring 2018

*Dear Friends of MAE,*

*I am thrilled to share this third newsletter with you. The semester is nearing an end and the halls and labs around MAE are filled with the hustle and bustle of projects, assignments, problem solving of all kinds, and students talking about upcoming summer internships or positions following graduation (four years goes quickly!). With this newsletter we share with you a glimpse at some more of our talented undergraduate and graduate students and provide some updates on faculty activity and transitions. Do visit us if you are in the area.*

*With best regards, Howard Stone*

*Low-temperature multistage warm diffusion flames; Omar R Yehia; Christopher B Reuter; Yiguang Ju, Combustion and Flame, in press, 2018*

### In this issue...

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## student spotlight

**Grace Lynch & Soumya Sudhakar**
How Teamwork Drives Innovation

When Grace Lynch and Soumya Sudhakar sat next to each other in Thermodynamics they had no idea it would be the start of both a prolific partnership and a meaningful friendship. What began as partners working on highly defined problem sets in the library later evolved into dynamic lab mates formulating their own designs. Today, the seniors are tackling independent work in robotic control systems.

"Our partnership has showed me how important teamwork is in engineering. When one team member gets stuck on a problem, the other can help them go back to the basics, retrace steps, and see the bigger picture," explains Soumya.

*...continued p. 2*

## grad program info

**JOIN 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 in preparation for a comprehensive general exam, which is normally taken in January of the second year. Subsequent to passing the exam, the student prepares 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, 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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**Alex Glaser**, Associate Professor & Director of Graduate Studies, aglaser@princeton.edu
**Jill Ray**, Graduate Administrator, jfray@princeton.edu

*mae.princeton.edu*

# faculty spotlight

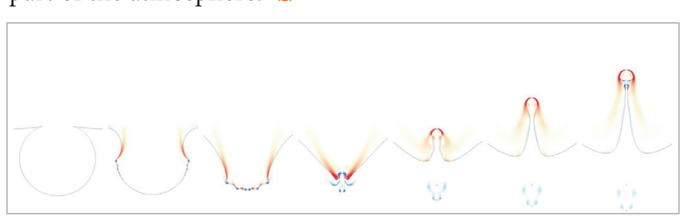

A day at the beach beset by heavy clouds or the sticky heat of a salty haze can seem like the work of large, unpredictable forces. But behind such atmospheric phenomena are billions of tiny interactions between the air and microscopic drops of saltwater cast upward as bubbles on the ocean's surface burst.

New research published in *Physical Review Fluids* describes the "jet velocity" of these droplets, or aerosols, as they occur in liquids such as seawater and sparkling wine. Luc Deike, PhD, Assistant Professor of Mechanical and Aerospace Engineering and the Princeton Environmental Institute (PEI), and his colleagues created a model for predicting the velocity and height of jet aerosols produced by bubbles from 20 microns to several millimeters in size, and in liquids up to 10 times more viscous than water.

The "jet" refers to the liquid that spurts up after a bubble has burst. Once the dome-like film of the bubble is gone, the small cavity the bubble created beneath the surface rushes to close. The bottom of the pocket rises rapidly as the sides of it collapse downward. When these forces meet, they launch a jet of water into the air that contains droplets ranging in size from 1 to 100 microns (the diameter of a human hair is roughly 100 microns).

Droplets from bursting bubbles are the principle means by which aerosols are produced above the open ocean, explains Professor Deike. Knowing the speed and height at which aerosols are being thrown into the air can lead to more accurate climate modeling or creating a perfect glass of champagne.

Professor Deike says that seawater aerosols transfer moisture, salt, and even toxins like algae from the ocean to the air. "I'm looking at this process to provide a better explanation of sea-spray aerosols that can be used to feed atmospheric models," he said. "This is something at a small scale that affects large-scale atmospheric processes, such as cloud formation and radiative balance. If you have a harmful biological agent on the water that is releasing toxins, those toxins can become part of the atmosphere." ◘



*In the illustration, once the bubble is gone (far left), the small cavity it created beneath the surface rushes to close. When these forces meet (center), they launch a jet of water into the air (right) that contains droplets ranging in size from one to 100 microns.*

## student spotlight *continued*

Grace and Soumya's interest in control theory began during junior year. After weeks of manipulating algorithms and tinkering with hardware, they finally succeeded in making a small model helicopter achieve a hover position. The duo recalls cheering in the middle of the quiet MAE laboratory.

"What I loved instantly about controls is that, even though it is a very mathematical field, it has immediate applications to real life," explains Grace. "We were able to take all of these beautiful theories we learned in class and use them to make a machine do something we wanted it to do."

The project inspired them to pursue control applications in drones for their senior thesis project. Since unmanned aerial vehicles (UAVs) can travel without a pilot for large distances and at fast speeds, they are an ideal way to survey large areas after a natural disaster or for the purpose of environmental monitoring. However, safety is a serious hurdle to their usability.

*Soumya and Grace in the lab*

"As drones become more widely available in commercial applications they need to be able to navigate around unavoidable obstacles, such as trees, buildings, and even people," explains Soumya.

The goal of Grace and Soumya's project is to gain insight into how to help drones avoid these obstacles.

To help ensure UAV safety they are implementing what is known as a propeller-hang on an existing fixed-wing UAV model airplane, which would allow it to turn when it detects an unavoidable obstacle using an onboard sensing system.

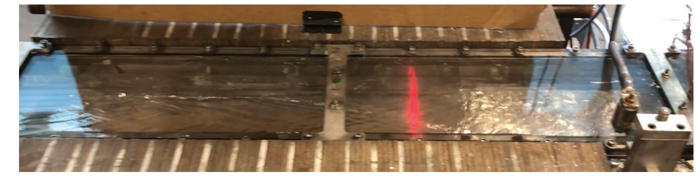
Once they achieve a proper hover, they plan to take the project a step further by designing controls that operate using only onboard sensing and computation. This means the UAV would be able to sense its own position and velocity in space. Some of their insights have come from scouring online hobbyist message boards. ◘



# a word from the lab

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

## Adam Fisher
### Making the Impossible Seem Possible

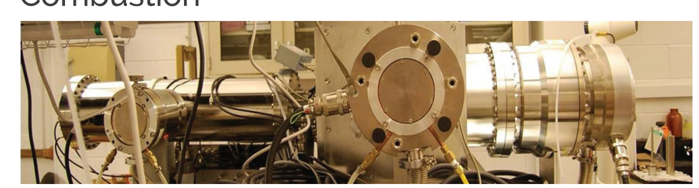


Remember in Back to the Future II when Doc throws the banana peel into Mr. Fusion and it creates enough power for them to travel through time? That was the sense of wonder Adam Fisher felt when he joined Assistant Professor Egemen Kolemen's nuclear fusion research group. "I felt like I would be doing something I had only dreamed about in science fiction," describes Adam, a third-year graduate student.

Today, Adam is helping solve one of the field's most pressing issues: heat flux. "When additional fuel for fusion is added to the tokamak (a fusion reactor that resembles a giant donut) the spent fuel byproducts and impurities eventually need to exhaust, posing a serious challenge for the axisymmetric geometry," explains Adam. "Heat flux at the divertor can be so prohibitively large that even the most heat-resistant materials boasting the highest of melting temperatures will melt and deform."

Adam has been developing a thin, fast-flowing liquid metal film that can restrain and control the depth of the liquid metal with electromagnetic forces so that it can change direction or press up against the surface of the tokamak. In 2018, his work was published in *Nuclear Fusion*. ◘

## Hao Zhao
### Overcoming Obstacles and Catalyzing Combustion



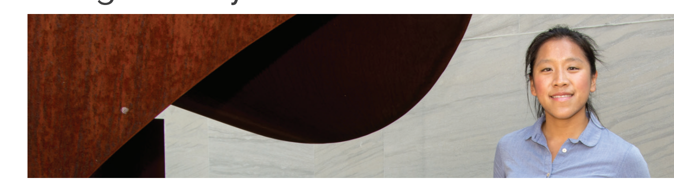
Hao Zhao says what matters in life is the process not the outcome. As a child, he was shy but pushed himself to the frontlines anyway. After being rejected by China's top college, Hao made his own opportunity as an exchange research student in Taiwan.

Every day he thinks about the obstacles he overcame when he walks around the Princeton campus. As a PhD student in Professor Yiguang Ju's group, Hao's work focuses on understanding low-temperature chemistry and high-pressure systems that can be used to design more efficient and sustainable engines.

"Low-temperature chemistry is essential for fundamental combustion studies on engine knocking, ignition delay time of engines, and fire safety in space," explains Hao. "The experiments showed that the presence of ozone dramatically enhances the low-temperature oxidation of dimethyl ether, while NOx plays a complicated role in fuel oxidation."

Hao has also been involved in studying super high-pressure systems (100-200 atm) that may be used in future aircraft engines and gas turbines. His goal is to be the first researcher in the combustion community to build a jet-stirred reactor at this critically high pressure. Given his track record, there is little doubt Hao will find a way. ◘

## Ting-Hsuan Chen
### Living Life Beyond Boundaries



Ever since Ting-Hsuan Chen visited her father's industrial design company, she has been fascinated with using materials to construct. As a PhD candidate in Professor Craig Arnold's group, she created a 3D microscope integrated with an ultrafast tunable lens for fluid dynamics visualization. Ting's work also involves high-efficiency laser material processing using an ultrafast vari-focal lens. The idea of fast scanning the focal position has significantly increased the material processing efficiency and opened the door to processing non-flat surfaces that have been traditionally challenging. ◘

## awards

**Craig Arnold** awarded 2017 Edison Patent Award

**Mikko Haataja**, **Luc Deike** & **Craig Arnold** receive the Eric and Wendy Schmidt Transformative Technology Fund Award

**Andrej Kosmrlj** received NSF Career Award

**Ed Law** & **Yiguang Ju** elected Fellows of the Combustion Institute

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