# FOCUS

UAH Research Magazine // Fall 2021

## HUGE DISCOVERY

UAH scientists find space cloud bigger than the Milky Way

page 14

## WILDFIRE IMPACTS

Over half of U.S. affected by Western blaze plumes

page 16

THE UNIVERSITY OF ALABAMA IN HUNTSVILLE

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# New UAH research partnership with the FBI aims to defeat bombs

Welcome to *FOCUS: The UAH Research Magazine*. Protecting the public and first responders, and providing responders with better tools to more quickly disarm bombs, are the goals behind an exciting new partnership between UAH and the FBI called RAPID – the Research and Prototyping IED Defeat program – that is our cover story on page 4.

The effort pairs UAH researchers across several disciplines with the FBI Hazardous Devices School at Redstone Arsenal to better understand the science and engineering behind improvised explosive devices and develop technologies to defeat them.

Meanwhile, UAH biologist Dr. Matthew Niemiller is exploring underground waters to catalog and discover life under a $1.029 million National Science Foundation (NSF) CAREER grant, and we have the story on page 8. Dr. Niemiller's efforts will also employ citizen scientists and primary and secondary school students to do research across the central and southeastern United States.

A $500,000 NSF CAREER grant is funding research by Dr. Jianqing Liu to harness inherent instabilities in wireless devices to perform security functions, something that could also make our devices more efficient by requiring fewer error control modules in the design, as a story on page 10 relates.

Molecular biophysicist Dr. Jerome Baudry's lab is collaborating with four other institutions in two different strategies to discover and perfect pharmaceuticals that are active against the COVID-19 virus, according to a story on page 12. The Baudry Lab is sharing a half-million dollars in research funding with its collaborators.

A lonely cloud, is how UAH physicist Dr. Sun Ming describes the gas cloud bigger than the Milky Way that a team he led found in space, far from any galaxy from which it may have come. In fact, it was found in a kind of galactic "no-man's land," says the story on page 14.

The smoke from Western wildfires is affecting 3 million asthmatics and covering half of U.S. states with small, breathable particulates that could affect health, according to research covered on page 16 by Zhixin (May) Xue, a second-year doctoral student in atmospheric science and her advisor, atmospheric science professor Dr. Sundar Christopher.

The first female chair of the Association for Unmanned Vehicle Systems International is Dr. Suzy Young, director of UAH's Office for Proposal Development, a story on page 18 says, and Jerry Hendrix, director of UAV programs at UAH's Rotorcraft Systems Engineering and Simulation Center, is the new Huntsville AUVSI Pathfinder chapter president.

Big Data applications research and her leadership, mentoring and empowerment of women and minorities in STEM have earned computer scientist Dr. Vineetha Menon the Institute of Electrical and Electronics Engineers Eta Kappa Nu Outstanding Young Professional award, a story on page 20 says.

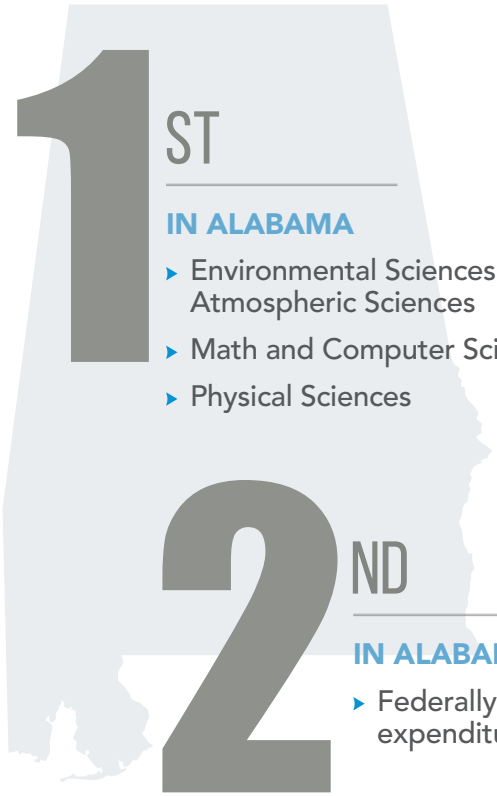
Our students continue to excel, as well. Two UAH space science students have earned competitive NASA FINESST awards, we learn on page 21, and a story on page 23 says that senior design students have worked with the U.S. Navy on stowage solutions aboard submersibles that may actually see use in the craft.

We are proud of the accomplishments of our faculty, staff, students and alumni. We are excited about the future and welcome collaborative partnerships. Please contact the Office of Research and Economic Development for more information on the efforts featured in this magazine or any other research project at UAH. ■

## THE UNIVERSITY OF ALABAMA IN HUNTSVILLE

A **RESEARCH INTENSIVE** national university that serves as the anchor tenant of the second-largest research park in the United States, UAH is considered one of the nation's premier research universities.

## IN ALABAMA



**1ST**

**IN ALABAMA**

- Environmental Sciences, including Atmospheric Sciences
- Math and Computer Sciences
- Physical Sciences

**2ND**

**IN ALABAMA**

- Federally-funded research expenditures

## NATIONALLY

- **6TH** Federally-financed Aerospace/ Aeronautical/Astronautical research
- **10TH** Federally-financed Atmospheric Sciences research
- **11TH** Federally-financed Computer and Information Sciences research
- **13TH** NASA R&D expenditures
- **14TH** Federally-financed Astronomy research
- **15TH** Federally-financed Economics research
- **17TH** Federally-financed Industrial and Manufacturing Engineering research
- **26TH** Department of Defense R&D expenditures

SOURCE: National Science Foundation

## RESEARCH

**$489 million**
Five-year contract and grant research total

**Over $2 million**
Five-year license and royalty revenue total

**$131.6 million**
Fiscal 2020 research expenditure total

[ISSUED PATENT TOTAL – 112]

## COVER



## RESEARCH FOCUS



## FACULTY & STAFF FOCUS



## STUDENT FOCUS



- Cover: Stacie Bohanan, UAH Research Institute principal research scientist, and Ian Vabnick, chief scientist for RAPID under an FBI contract, at the FBI's Redstone Arsenal R&D facility.

# BIG BANG THEORY

## UAH and FBI join forces to develop better bomb thwarting technologies


▲ UAH student Baxter Barnes tests metal strength in the Materials, Manufacturing and Mechanics Group lab in the UAH Optics Building.



A collaborative effort between UAH and the Federal Bureau of Investigation (FBI) is developing technologies that enable first responders to more effectively defuse threats posed by improvised explosive devices (IEDs), more commonly called bombs.

Known as RAPID, or the Research and Prototyping IED Defeat program, the effort is part of the FBI's Critical Incident Response Group and involves researchers from across campus, says Dr. Ian Vabnick, a retired FBI supervisory special agent and special agent bomb technician who is now the chief scientist for RAPID as an FBI contract employee.

With a doctorate in physics and 18 years of experience as a bomb technician, Dr. Vabnick is responsible for coordinating RAPID, including research efforts between UAH and the FBI Hazardous Devices School at Redstone Arsenal, which is one of the beneficiaries of technologies developed under the program.

IEDs are intended to create fear within a population, Dr. Vabnick says.

"The IED threat is perhaps more scary than other types of threats because bombers are unpredictable and often target everyday locations where innocent people, including children, often become victims," he says. "Unfortunately, their objective of disrupting society outweighs the consequences of loss of human life. By nature, explosions are violent and the potential of that level of destruction happening without warning can be scary for any society, and no one is exempt from the threat."

When a bomb is discovered, someone has the responsibility of disposing of the device in a manner that preserves life, property and evidence.

"It has been a passion of mine for over 18 years to protect our first responders and to provide tools and techniques to help them do their jobs," Dr. Vabnick says. "Bombs are a technical challenge that are always changing with the evolution of new bomb designs and explosives."

Many factors need to be considered simultaneously to defeat an IED without causing it to react during neutralizing procedures. IEDs can be structurally complex and hardened, they can be booby-trapped and they can contain sensitive explosives.

"As a physicist, I must understand the theory and application of classical mechanics, material properties, explosives chemistry, shock physics, ballistics and electronics," says Dr. Vabnick. "On a daily basis, I am challenged with designing new technologies and test methodologies to study their effectiveness against the IED threat."

The process requires an understanding of several science and engineering disciplines, he says.

"As a scientist, I also have to isolate many parameters, but ultimately, we have to use our methods and technology solutions on authentic IEDs we build for our experiments."

## BOMB SCHOOL

Established in 1971 on a sprawling 455-acre campus, the FBI Hazardous Devices School has provided training

to more than 20,000 local, state and federal first responders and bomb technicians. Its campus includes classrooms, explosive ranges and mock villages that include a train station, apartment complexes, a movie theater and a strip mall. New bomb technicians spend six weeks learning about electricity, fuses and improvised explosives.

"The technologies developed by RAPID get funneled to the FBI Hazardous Devices School," says Dr. Vabnick, who also has extensive counter-terrorism and counter-intelligence experience. "We have a very good system to develop the technology and then get it directly to the first responders through the school."

RAPID is vital to equipping bomb technicians with the most up to date research, says Unit Chief John Stewart, the school's director.

"The research UAH is conducting in support of the RAPID program translates directly to improving the safety of public safety bomb technicians (PSBT) by advancing the reliability and success of IED disruptor tools and techniques," Stewart says. "The Hazardous Devices School on Redstone Arsenal, the nation's only facility to train and certify all PSBTs across the United States, implements the advances through its curriculum during certification or recertification courses."

RAPID evolved from a research and development program for bomb neutralization that began with the Department of Homeland Security and the Department of Defense under Dr. Vabnick's leadership at the FBI Academy, the law enforcement training and research center near the town of Quantico, Va. RAPID also works with the Navy Explosive Ordnance Disposal Technical Division to develop counter techniques for the military.

About two years ago, agency personnel came to campus to assess UAH's capabilities.

"We pulled everybody together in meetings, and from across the university researchers proposed various projects that might be of interest," says Dr. Robert Lindquist, who was UAH's vice president for research and economic development at the time and currently is the university's interim provost. "We were testing the waters to see how we could fit together, and how the university could assist the Critical Incident Response Group."

Those involved in the meetings found quite a bit of common ground.

"There was a lot of synergy," Dr. Lindquist says. "We found that it actually was an easy fit and that we had many common research interests."

From that exchange of information, the FBI and UAH partnered in technological research that is now located much closer in proximity to the Hazardous Devices School.

"We began to educate UAH scientists in what IEDs are and how to kill them, or disrupt bombs," Dr. Vabnick says. "The idea behind this is, before we go out and spend huge amounts of money on a technology, we can model it to simulate its behavior."


The FBI Hazardous Devices School at Redstone Arsenal trains local, state and federal first responders and bomb technicians.

*Wayne Forde / FBI*

▲ UAH students Megan Flannagin, left, and Baxter Barnes with the dynamic compression test machinery in the Materials, Manufacturing and Mechanics Group Lab in the UAH Optics Building.

## NEW FIELD

"We are developing a new field of engineering called counter-IED neutralization and UAH is at the forefront," says Dr. Vabnick. "The computational theory and experimentation with UAH in collaboration is really starting to bear fruit."

Five areas of research and about 35 scientists are involved at UAH, and the work encompasses a broad spectrum of academic disciplines across campus, including mechanical engineers, computational physicists, battery experts and technical writers. It also involves investigations into the use of projectiles to neutralize IEDs.

In another facet of the research, the FBI and UAH scientists are working to develop software with predictive power that can aid first responders in disarming bombs.

RAPID publishes first responder technical reports known as special technician bulletins to quickly funnel technological advances to the Hazardous Devices School, where they become part of the ever-evolving training curriculum.

The teams and team leaders are:

- **Testing and Computational Program for the Study of C-IED Technologies**

  Dr. Steven Messervy (B.S., business administration–management, 1975; M.A., administrative science, 1976), director, Research Institute

  Mark Zwiener (B.S., electrical engineering, 1997; M.S., mechanical engineering, 2013), principal research engineer, Research Institute

  Dr. Jason Cassibry (Ph.D., mechanical engineering, 2004; Propulsion Research Center graduate), associate professor, Department of Mechanical and Aerospace Engineering

- **Physics Modeling of 9 Volt Alkaline Batteries Under High Impact Loading**

  Dr. Jason Mayeur, assistant professor, Department of Mechanical and Aerospace Engineering

- **In Situ Quantification of Property Degradation of 9 Volt Alkaline Batteries During Impact**

  Dr. Jason Mayeur, assistant professor, Department of Mechanical and Aerospace Engineering

  Dr. George Nelson, associate professor, Department of Mechanical and Aerospace Engineering

- **Performance and Penetration Mechanism Analysis of the SPIKE Penetrator**

  Dr. Kader Frendi, professor, Department of Mechanical and Aerospace Engineering

- **Technical Writing**

  Dr. Ryan Weber, associate professor, English; director, Business and Technical Writing ■

# HIDDEN LIFE

## $1.029 million grant funds study of groundwater biodiversity

A UAH assistant professor of biological science will study life forms hidden from everyday view with a five-year, $1.029 million National Science Foundation (NSF) CAREER award to conduct the first comprehensive assessment of groundwater biodiversity in the central and eastern United States.

"Groundwater, which is water found in aquifers below the surface of the Earth, is one of the world's most essential natural resources," says Dr. Matthew Niemiller, who has a lab in the Shelby Center for Science and Technology at UAH, a part of the University of Alabama System.

"For instance, of all the unfrozen freshwater on Earth, 97% is estimated to reside in groundwater aquifers," Dr. Niemiller says. An essential source for irrigation and drinking water, it is a challenged resource, he says.

Exploitation of groundwater for agriculture and human consumption have resulted in aquifer depletion and environmental degradation in many regions of the world, Dr. Niemiller says.

"Other activities, such as mining and urbanization, have altered water flow patterns and increased levels of contamination in groundwater habitats," he says. "These stressors, as well as the current biodiversity crisis, have led to urgent calls to study groundwater life and develop effective strategies for protection and conservation."

The NSF-funded project offers the opportunity to develop novel approaches to studying biodiversity while generating broad hypotheses and tackling central questions in ecology and evolutionary biology, he says, and will provide valuable data for the management and conservation of groundwater species.

Since he arrived at UAH in 2017, Dr. Niemiller's lab has focused on addressing important gaps in knowledge of subterranean biodiversity in the United States and in the Tennessee-Alabama-Georgia (TAG) region in particular, with a focus on groundwater.

"These knowledge gaps include understanding what species are present in caves, springs and other subterranean habitats as well as where are they distributed, how abundant they are, and better understanding aspects of their life history, ecology and conservation," he says.

The research will explore how long different species live, their habitat requirements, and potential and existing threats to their long-term survival.

"Because human-sized caves only offer a small window into a complex subterranean environment and can be particularly challenging to access and study, we know relatively little about the vast majority of subterranean species," Dr. Niemiller says.

New sampling and emerging environmental genetic approaches, such as environmental DNA (eDNA), offer promise for studying biodiversity in challenging ecosystems, including caves.

"We can now collect a sample from water, soil, a spiderweb or a flower, for example, then isolate and extract the DNA of organisms from that sample to identify, monitor and study a single species or the community of organisms living in various habitats," Dr, Niemiller says.

"Environmental DNA has been employed with great success in many different habitats and ecosystems and different groups of organisms, from endangered and invasive fishes to soil microbes and pollinators of wildflowers."

Researchers in Niemiller's lab have already used eDNA to detect and monitor rare individual species of cave crayfishes native to Alabama.

"We have the potential to leverage DNA from a groundwater sample to learn much more about entire populations and communities of organisms that are living in caves and other subterranean habitats, such as determining levels of genetic diversity and searching for species new to science," he says. "The darkness and stable environmental conditions in many groundwater habitats may promote long-term persistence of eDNA and recovering of longer DNA fragments."

Research aspects of the project will directly involve primary and secondary school students and educators, undergraduate and graduate students, two postdoctoral researchers and citizen scientists, with an emphasis on groups that are grossly underrepresented in caving and science.

The effort includes a student-focused community-science initiative for aquatic cave biodiversity monitoring, educational summer camps for grades 3-5, an undergraduate student research and training program, and teacher workshops.

Community Analysis of groundwater Via Environmental DNA (CaveDNA) is a community initiative that will involve undergraduate students, middle and high school science students and other local groups to monitor groundwater habitats.

"We will be sending water sampling and filtering kits to teachers and other educators in the TAG region, as well as learning modules to provide background information about eDNA and groundwater biology," says Dr. Niemiller. "My wife, Dr. Denise Niemiller, and I have developed other biodiversity and ecosystem learning modules for K-12, and she will be intimately involved in the educational and outreach aspects of this project."

Dr. Denise Niemiller is a lecturer in the Department of Biological Sciences.

Students will collect and filter water samples from caves, springs and wells to send to Dr. Niemiller's lab to determine the species present. Data will be shared with teachers for classroom analysis and discussion, as well as incorporated into the research.

"Finally, this grant will support the development of an online portal for groundwater and cave biodiversity data and resources for future research, and support conservation and management efforts called the CaveBio Data Portal," Dr. Niemiller says. "The data portal will offer a network for maintaining and disseminating biodiversity and molecular data, publications and other resources for cave and groundwater fauna."

▼ Dr. Matthew Niemiller during a biological survey of a cave in Coffee County, Tenn. *Chuck Sutherland*

# RESEARCH TO MAKE WIRELESS DEVICES MORE EFFICIENT, SECURE EARNS NSF CAREER AWARD

Research to harness commonplace errors in wireless devices to make them usable and provide for better security and efficiency has won a UAH assistant professor of electrical and computer engineering a five-year, $500,000 National Science Foundation (NSF) CAREER award.

◀ Dr. Jianqing Liu's lab in the Optics Building is co-located with UAH's Center for Cybersecurity Research and Education.

"My CAREER project is to control and manipulate data errors in wireless devices using hardware and software co-design approaches," says Dr. Jianqing Liu, who has a lab in the Optics Building.

He says every wireless device is very shaky and unreliable in operations such as communication, computation and storage.

"This might not sound very intuitive, as we see these wireless devices running pretty smoothly in our daily life," says Dr. Liu, whose lab is co-located with UAH's Center for Cybersecurity Research and Education (CCRE). "The reason is that there are lots of error control modules in those devices that combat noises, failures and imperfect behaviors of internal electronics."

On one hand, he says the error control modules consume a significant amount of wireless device battery, storage space and processor resources.

"On the other hand, data errors are not always harmful, but sometimes are benign or even beneficial," says Dr. Liu, whose research interests lie broadly in wireless communications, networking and security. "For instance, the fundamental idea of protecting security is through noise injection or encryption, whose intention is to corrupt and garble the original data."

He's probing whether error control module parameters can be relaxed to permit certain data errors which then could be manipulated for wireless security or other uses.

"The benefits are two-fold," Dr. Liu says. "First, we save resources that are otherwise wasted by running error control modules. Second, we don't need dedicated modules such as encryption algorithms to create corrupted data, but instead can harvest errors from wireless devices to provide that security. This idea is like the old saying, 'Kill two birds with one stone.'"

CCRE Director Dr. Tommy Morris is mentoring Dr. Liu in the research. Dr. Liu is collaborating with Dr. Na Gong, an associate professor of electrical and computer engineering at the University of South Alabama. His CAREER award application was supported by UAH Department of Electrical and Computer Engineering Chair Dr. Ravi Gorur, Nickolas Old (MBA, 2020) and Michelle Massey (post-bachelor technical communication certificate–EH, 2016) from UAH's Office for Proposal Development and Dr. Kavan Hazeli, a UAH associate professor of mechanical and aerospace engineering.

Dr. Liu's CAREER award funding will join continuing funding from the NSF Directorate of Engineering's Division of Electrical, Communications and Cyber Systems, and the Established Program to Stimulate Competitive Research.

There are many potential benefits to his research for wireless devices and customers, Dr. Liu says.

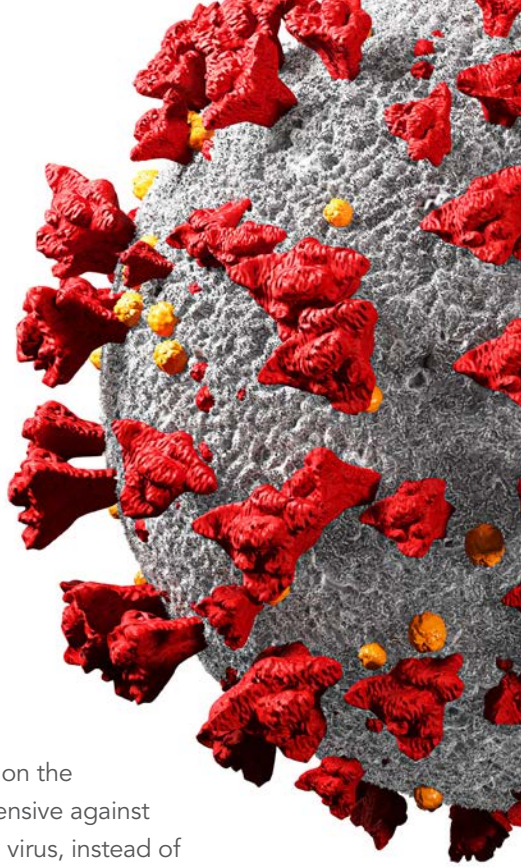
"Just to name a few, our wireless devices can become more lightweight and power-saving once some heavy and redundant modules can be removed," he says. "It will also make our wireless devices more secure because we do not need a third-party program to ensure system security anymore, but instead our wireless devices can protect our data by themselves."

He already began work on some relevant topics in early 2019.

"Because of the early start, I was able to show some preliminary findings in my CAREER proposal," Dr. Liu says. "Thanks to NSF's funding, I will be able to continue this research and show more exciting findings in the next few years." ■

# Targeting COVID

## BAUDRY LAB PART OF HALF-MILLION-DOLLAR DRUG THERAPY EFFORT



Two different strategies to discover and perfect pharmaceuticals active against the COVID-19 virus have attracted a half million dollars in research funding to support five institutions, including UAH's Baudry Lab.

The lab is led by Dr. Jerome Baudry (pronounced Bō-dre), a molecular biophysicist and the Mrs. Pei-Ling Chan Chair in the Department of Biological Sciences. It will receive a portion of the funding, which originates from the National Institutes of Health (NIH) National Institute of Allergy and Infectious Diseases and from Saint John's Cancer Institute, a private organization located in Santa Monica, Calif.

"Both awards are the recognition of our hard work and success of the last year, when we used supercomputers to identify natural products that have the potential to prevent infection by the COVID-19 virus or to prevent its replication in our cells," says Dr. Baudry, who is also a professor of biological science.

"We have had quite an impact, together with our collaborators at Oak Ridge National Laboratory (ORNL), Hewlett Packard Enterprise and the Alabama Supercomputing Authority," he says. "And it led us to join these two new collaborative projects and apply for these two grants, which were both awarded, which is a pretty unusual and happy outcome, as research grants are usually very difficult to obtain."

In their segment of the new research, the UAH scientists will continue to work with chemicals found in nature, which are called natural products. Dr. Baudry is joined in the work by Maher Mansur, a senior molecular physics doctoral graduate student, and the pair are training junior scientists to help with the effort.

"Natural products are very interesting chemicals. Sometimes, the natural products can work by themselves and it leads to phytotherapy or to nutraceuticals." Dr. Baudry says. "Sometimes the natural products are not quite powerful enough, or they can be toxic for humans. In the latter case, medicinal chemists can modify the natural products' chemicals to become very potent and safe pharmaceuticals."

He says that could be a likely outcome as the new research progresses.

"We will still use our supercomputers to identify natural products that appear to do well, and we will use this information coming from nature and the expertise of the chemists to 'chisel' the natural products to be very efficient against the virus and very safe for our cells," Dr. Baudry says.

"So far in our research what has usually taken many years has taken a few months, and that's why we now can go on the offensive against the virus, instead of staying on the defensive."

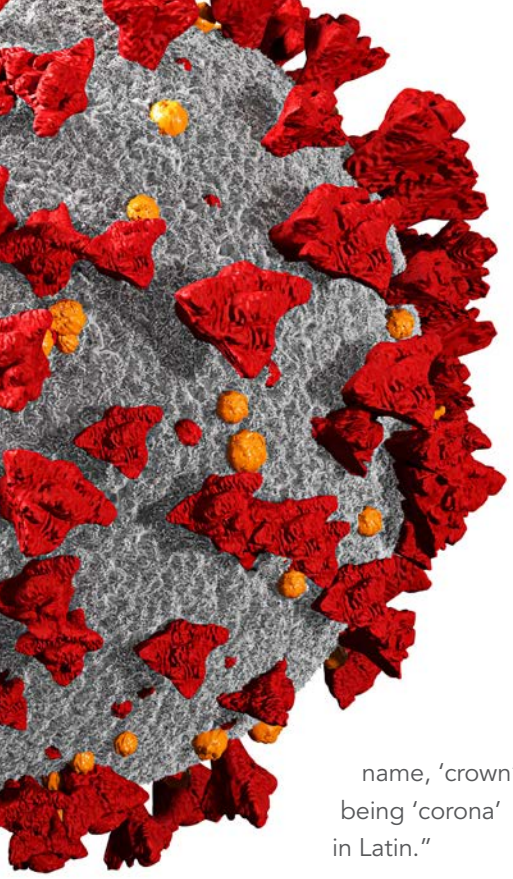
There's a synergy between modern science and ancestral knowledge in natural products that allows advancement, he says.

"Natural products are a fantastic source of chemicals and medicine, and preserving our natural history, including our knowledge about what the plants and fungi do and how they work, is very important."

### SPIKES AND TORPEDOES

In the SARS CoV-2 research grant awarded by St. John's Cancer Institute, Dr. Baudry's team is working with Dr. Venkata Mahidhar Yenugonda, director of Saint John's Cancer Institute Experimental Therapeutics Research Program. Dr. Yenugonda is an internationally known medicinal chemist who is leading the project.

"In this first project, we are going to identify molecules that have the potential to bind to the virus' spike protein," says Dr. Baudry. "That protein is on the outer surface of the coronavirus, which leads to its crown-like appearance and



name, 'crown' being 'corona' in Latin."

The virus' spike protein allows it to attach to the cell, which is the first step in infection.

"Our strategy is to design a molecule that binds to the spike protein, preventing the virus from attaching to cells, and therefore preventing infection," says Dr. Baudry.

In the other, NIH-funded project, the Baudry Lab is working with Dr. Jennifer Golden, the project's lead principal investigator, who is an assistant professor and the associate director of the Medicinal Chemistry Center at The University of Wisconsin-Madison; Dr. Jeremy Smith, the Governor's Chair Professor in the Department of Biochemistry and Cellular and Molecular Biology at the University of Tennessee (UT) in Knoxville and director of the UT/ORNL Center for Molecular Biophysics; and Dr. Colleen Jonsson, director of the University of Tennessee Health Science Center Regional Biocontainment Laboratory in Memphis.

The project uses promising compounds that might attack COVID-19's polymerase inhibitors.

"These potential drugs torpedo some proteins that the virus forces the infected cell to make," Dr. Baudry says. "These proteins are indispensable for the virus to re-assemble itself in the infected cell and then to leave to infect new cells. If we can block that process, the virus cannot infect new cells in the body and it is doomed."

## ESSENTIAL RESEARCH

UAH has mobilized resources for research vital to establishing a strategy in the fight against COVID-19 and other, new viruses that may appear down the road, Dr. Baudry says.

"I have worked on COVID-19 with senior scientists and graduate students in my UAH lab, and it has established us on the research map, and UAH was present to help in many ways," he says. "UAH students should know that if they do research here, they can be in the spotlight, that we do work at the very top level in the nation."

The Alabama Supercomputer Facility, a state resource located in Huntsville, has been a valuable partner.

"I think it is important for the region, and indeed for all Alabamians, to know that their support of science, of research and development, and of universities pays dividends and goes a long way," Dr. Baudry says.

Discovering therapeutic pharmaceuticals is essential to helping COVID patients as the pandemic evolves, he says.

"The vaccines are here and they are literally life savers," he says.

"Now there are new variants coming all the time, in particular with mutations of the spike proteins we are going after, and we all have started to hear about variants such as Delta, which is more contagious than the original strains, or Epsilon, which may be partially resistant in some cases to vaccines."

New vaccines probably can be created relatively quickly to address variants, he says.

"But there is still an immense need for pharmaceuticals, not vaccines, because pharmaceuticals could be used to fight new strains of the virus while new vaccines are being developed against new strains," Dr. Baudry says.

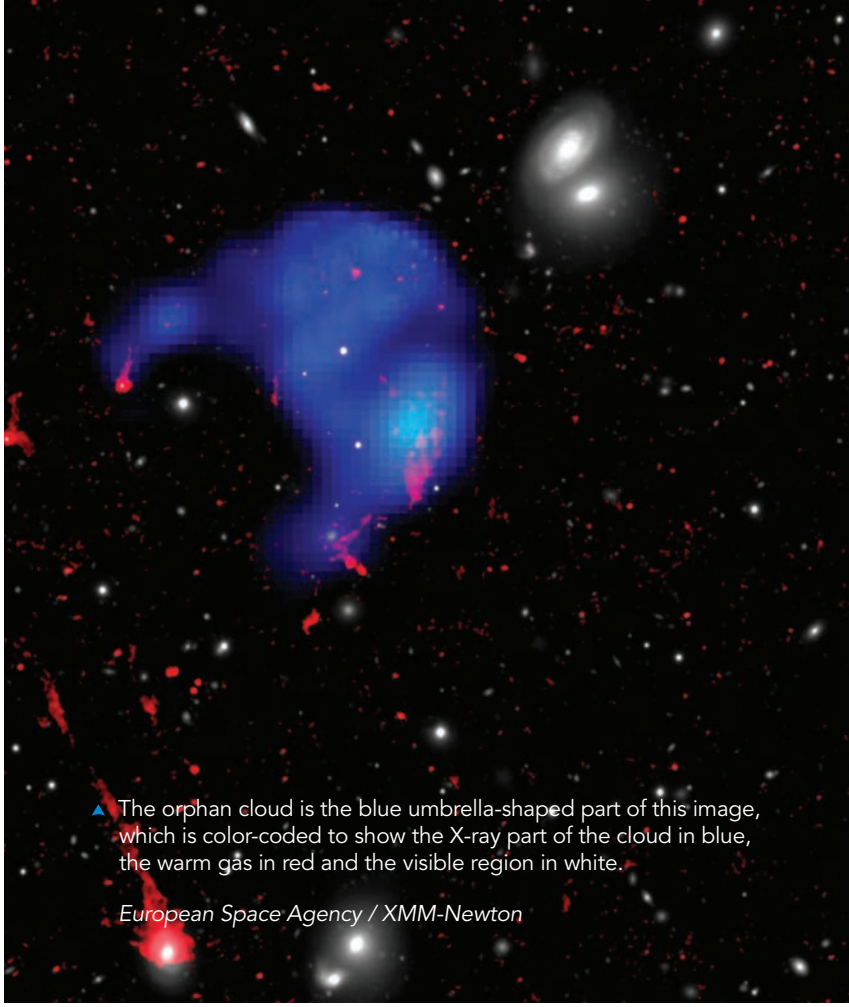
"The nation's effort has been supporting vaccines, with a remarkable success, and we are now kind of switching gears to augment our arsenal with pharmaceuticals. Pharmaceuticals and vaccines are not duplicating each other, they complement each other."

The ultimate goal is to achieve a protocol much like what exists for the flu, where vaccines help keep the disease in check but antivirals like Tamiflu are available to treat vaccinated patients with breakthrough infections or the unvaccinated who get ill. Tamiflu has as its starting material shikimic acid, which is present in the pods of star anise.

"The situation with COVID-19 can very well be similar: a vaccine that overall works very well and medications to help those who still get sick," Dr. Baudry says. "And what we learn in this work against COVID-19 will also be a very important source of knowledge in case a new, different virus appears down the road." ■

# LONELY CLOUD

## PHYSICS TEAM FINDS HOT GAS AREA BIGGER THAN THE MILKY WAY



▲ The orphan cloud is the blue umbrella-shaped part of this image, which is color-coded to show the X-ray part of the cloud in blue, the warm gas in red and the visible region in white.

*European Space Agency / XMM-Newton*

A scientifically mysterious, isolated cloud bigger than the Milky Way has been found by a UAH physics research team in a "no-man's land" for galaxies.

The so-called orphan or lonely cloud is full of hot gas with temperatures of 10,000-10,000,000 degrees Kelvin (K) and a total mass 10 billion times the mass of the sun. That makes it larger than the mass of small galaxies.

The cloud was discovered in Abell 1367 by a group led by Dr. Ming Sun, an associate professor of physics. Also called the Leo Cluster, A1367 contains around 70 galaxies and is located around 300 million light years from Earth.

The research paper was led by Dr. Sun's UAH postdoctoral researcher, Dr. Chong Ge, and the second author is also his postdoctoral researcher, Dr. Rongxin Luo. Dr. Sun is third author and the corresponding author. Also included on the paper is Tim Edge (M.S., physics, 2019), who now works at Dynetics Inc.

The cloud was found using the European Space Agency (ESA) X-ray Multi-Mirror Mission (XMM-Newton), Europe's flagship X-ray telescope. The cloud was also observed with the

European Southern Observatory Very Large Telescope/Multi Unit Spectroscopic Explorer (VLT/MUSE) and Japan's flagship optical telescope, Subaru. An image of the cloud is on the ESA site.

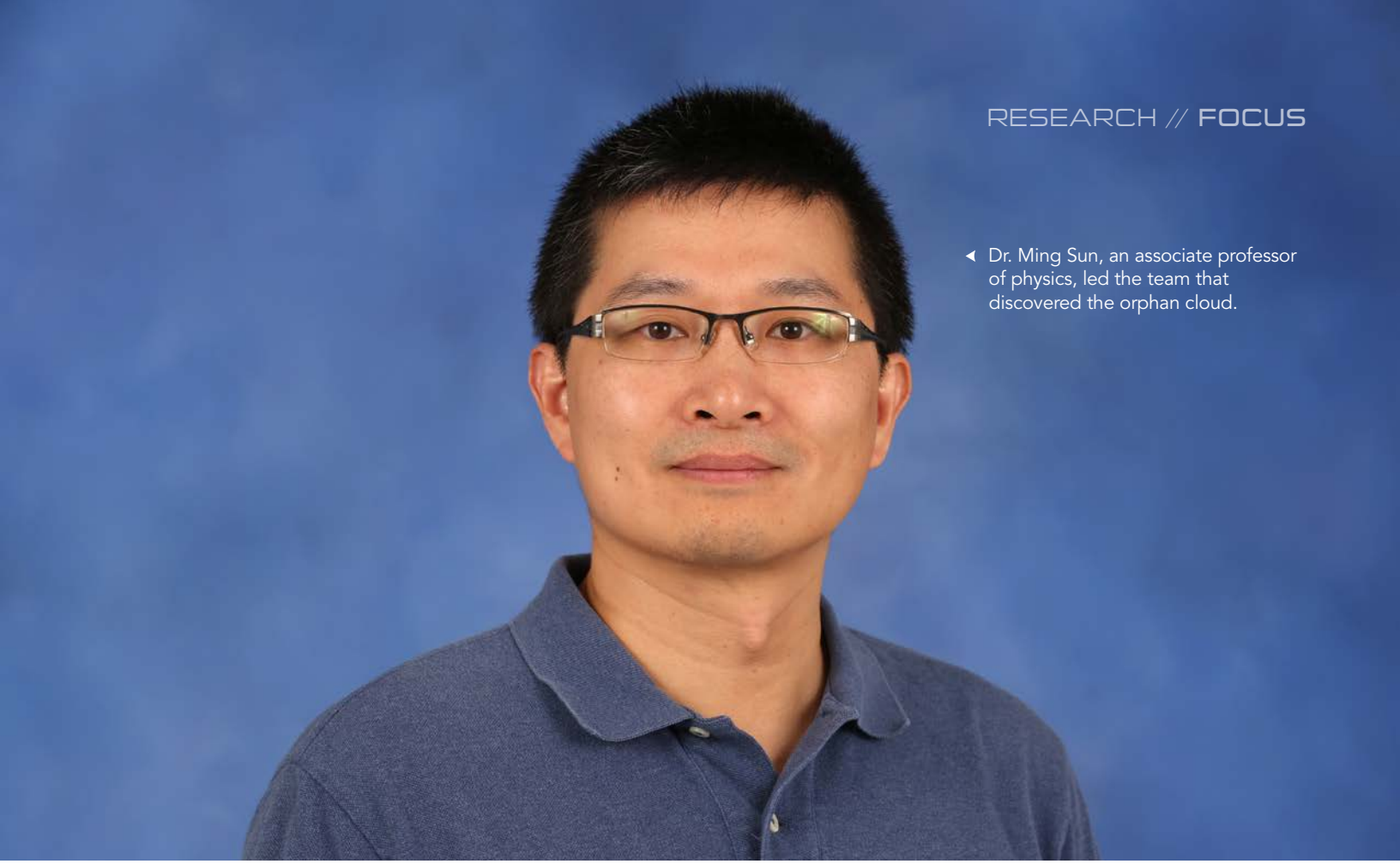
"This is an exciting and also a surprising discovery. It demonstrates that new surprises are always out there in astronomy, as the oldest of the natural sciences." Dr. Sun says. "Apparently ESA agrees, as our discovery was selected as an ESA image release, which has been very selective."

XMM took the X-ray image of the cloud and the optical images were taken by VLT/MUSE and Subaru. Except for the Subaru images, Dr. Sun is the principal investigator for the XMM and VLT/MUSE data.

"The cloud was serendipitously discovered in our XMM data," says Dr. Sun. "The optical data come from our VLT/MUSE data and confirm the cloud is located in the cluster."

The cloud was discovered in a cluster of galaxies where thousands of galaxies are bound together with tenuous hot gas with temperatures of about 100,000,000 K existing between them, says Dr. Sun.

"However, the cloud is not associated with any galaxy and is in a 'no-galaxy's land,'" he says, adding that the cloud most likely originated from a large, unknown galaxy in the cluster.



Dr. Ming Sun, an associate professor of physics, led the team that discovered the orphan cloud.

***"This is an exciting and also a surprising discovery. It demonstrates that new surprises are always out there in astronomy, as the oldest of the natural sciences." Dr. Sun says***

"The gas in the cloud is removed by ram pressure of the hot gas in the cluster, when the host galaxy is soaring in the hot gas with a velocity of 1,000-2,000 kilometers per second."

That's about 50 times faster than the orbital speed of Earth around the sun. That level of force at work can rip the interstellar medium out of a galaxy, and in this case the researchers found that the temperature of the cloud is consistent with having originated from a galaxy.

"It is like when your hairs and clothes are flying backward when you are running forward against a strong headwind," Dr. Sun says. "Once removed from the host galaxy, the cloud is initially cold and is evaporating in the host intracluster medium, like ice melting in the summer."

Yet it is estimated that this massive, mysterious cloud has survived for hundreds of millions of years after removal from its host galaxy.

"This surprising longevity is poorly understood but may have something to do with the magnetic field in the cloud," Dr. Sun says.

The field may act to hold the cloud together by suppressing unstable forces that would otherwise cause it to dissipate, the scientists think.

With future study, Dr, Sun says that the lonely cloud and others that are yet to be discovered could help scientists better understand stripped interstellar mediums at great distances from their galaxies, as well as the effects of turbulence and heat conduction.

"As the first isolated cloud glowing in both the H-alpha spectral line and X-rays in a cluster of galaxies, it shows that the gas removed from galaxies can create clumps in the intracluster medium, and these clumps can be discovered with wide-field optical survey data in the future." ■

# OVER HALF OF U.S. AFFECTED BY WILDFIRE SMOKE, ACCORDING TO UAH RESEARCH

An estimated 3 million asthmatics and over half of the United States are being affected by particulates from fires in Canada and the western U.S., according to new UAH research.

"More than half of the U.S. states, especially the western U.S., have experienced significant short-term pollution increase due to wildfires," says Zhixin (May) Xue, a second-year doctoral student in atmospheric science and the lead author of the research paper, written with her advisor and coauthor, Dr. Sundar Christopher (M.A., psychology, 2002), a professor of atmospheric science.

Half of affected states have 17-day mean inhalable particulate matter ($PM_{2.5}$) increases larger than 100% of baseline values taken from 2011, a low fire year. Using Centers for Disease Control data that 8% of the population is asthmatic, the researchers calculated the number of those affected.

Among the hardest hit states are Washington, California, Wisconsin, Colorado and Oregon, all of which have populations greater than 4 million.

"Using satellite observations which contain the whole atmospheric column information along with meteorological data that from model simulations, we are able to extract the portion of pollution close to surface. A significant portion of this pollution is due to fires that occur in Canada," Xue says.

"The northwestern U.S. experiences six to seven times more than the 24-hour Environmental Protection Agency standards."

Supported by a NASA grant, the scientists processed large volumes of datasets using state-of-the-art NASA satellite data plus ground observations of $PM_{2.5}$ concentrations, various meteorological datasets and a statistical model to provide surface $PM_{2.5}$ concentrations over the entire area of study.

Research by Zhixin (May) Xue estimates that 3 million asthmatics in the U.S. may be affected by Western wildfire particulates.

"Most of the data used in our study is publicly available," says Xue. "It is important to note that ground measurements of $PM_{2.5}$ are not available everywhere and therefore satellite data provides an excellent opportunity to map the spatial distribution of air pollution."

The authors cite other research that says from 2013 to 2016, over 76% of Canadians and 69% of Americans were at least minimally affected by wildfire smoke. The UAH research shows that in just one wildfire event in 2018, up to 52% of residents in the U.S. and Canada were exposed to particulate matter, something Xue says should be of concern to policymakers because of the health implications.

"Wildfire smoke exposure can cause small particles to be lodged in lungs, which may lead to exacerbations of asthma, chronic obstructive pulmonary disease (COPD), bronchitis, heart disease and pneumonia," she says. "In addition, exposure to wildfire smoke is also related to massive economic costs due to premature mortality, loss of workforce productivity, impacts on the quality of life and compromised water quality."

Frequent and widespread wildfires in the northwestern U.S. and Canada have become the "new normal" during the Northern Hemisphere summer months, which significantly degrades particulate matter air quality in the U.S., according to Xue.

The $PM_{2.5}$ aerosols act as a new source of pollution that works against air quality gains made under the 1970 U.S. Clean Air Act, she says.

"Furthermore, in a changing climate, as surface temperature increases and humidity decreases, the flammability of land cover also increases and thus accelerates the spread of wildfires, leading to increase in $PM_{2.5}$ concentrations," Xue says. "The smoke aerosols from these fires increase fine particulate matter concentrations and degrade air quality." ■

# DR. SUZY YOUNG AND JERRY HENDRIX IN NEW AUVSI LEADERSHIP POSITIONS

The first female chair of the 7,000-member Association for Unmanned Vehicle Systems International (AUVSI) and the new president of the Huntsville AUVSI Pathfinder chapter both have deep experience in the unmanned vehicle field, and both are employees of UAH.

Dr. Virginia "Suzy" Young, director of UAH's Office for Proposal Development, was named the first female chair of the AUVSI national board of directors. Dr. Young, who will serve for three years, also authors a policy blog on the AUVSI website.

Jerry Hendrix, director of UAV programs at UAH's Rotorcraft Systems Engineering and Simulation Center, is the new Huntsville AUVSI Pathfinder chapter president.

AUVSI is the world's largest non-profit organization dedicated to the advancement of unmanned systems and robotics, and Dr. Young says she is honored to serve with such a distinguished group of professionals on the AUVSI board from across the unmanned vehicle industry.

"I have been on the board for many years, but to serve as the chair only means I get to work closer with the great staff at AUVSI national and our industry partners," she says.

"This is probably the most exciting era for the introduction of these systems – in the air, on land and at sea – into the national airspace," Dr. Young says, citing the U.S. Department of Transportation's work in automated vehicles and also programs like the June voyage of the Mayflower, the first transatlantic crossing of a fully autonomous ship.

"Commercial applications continue to grow as the needs of remote delivery, inspection, fire and rescue, surveillance

Dr. Virginia "Suzy" Young is the first female chair of the AUVSI national board of directors. Jerry Hendrix is the new Huntsville AUVSI Pathfinder chapter president.

and even the film industry are more apparent than ever, with expectations of more autonomy."

Dr. Young says the theme of the first live conference AUVSI held since the start of the COVID-19 pandemic in Atlanta is one she wants to keep going.

"I want to continue the theme of that conference, of 'Assured Autonomy,' and encourage progress in the area of making unmanned systems smarter, but also safer and reliable," she says.

"Also, as a board member for the non-profit Robonation, I want to spend some time on more programs for STEM educational efforts, building on existing competitions for all ages, and encouraging more interaction with our future workforce," Dr. Young says. "I love that our students at UAH have the opportunity to have hands-on knowledge of unmanned systems, and that this community is the home of the U.S. Army offices for all Army drones."

Hendrix says that when he takes office in September, he looks forward to bringing opportunities to the local AUVSI to look at very broad aspects of the unmanned aircraft systems research being done in Huntsville.

"It's an exciting time to lead this advocacy group to foster more community relationships across industry, new and evolving governmental partners and academia," Hendrix says. "This offers a great opportunity for UAH's AUVSI student organization to create great technical relationships."

His efforts will focus on re-establishing communication and collaboration after the disruption of the pandemic, getting more people involved and presenting ideas at the monthly meetings held at the U.S. Space & Rocket Center.

"We will also strive to again make our AUVSI Pathfinder Conference world renowned by putting emphasis on the Department of Justice during one day of the conference, while maintaining our strong relationship with the Department of Defense," he says. "And finally, our primary goal is to provide funding incentives to the STEM programs across our community in the robotic and unmanned systems areas, thus establishing our future students and work force." ■

# DR. VINEETHA MENON IS THE 2021 **IEEE OUTSTANDING YOUNG PROFESSIONAL**

Dr. Vineetha Menon, assistant professor in the Department of Computer Science and director of the Big Data Analytics Lab, has been named the Institute of Electrical and Electronics Engineers Eta Kappa Nu (IEEE-HKN) Outstanding Young Professional for 2021.

The award, made by the IEEE Educational Activities Board, is for exemplary contributions that uphold the core values of IEEE-HKN through scholarship in multidisciplinary Big Data applications research and for leadership, mentoring and empowerment of women and minorities in STEM.

Dr. Menon was nominated by Dr. S.K. Ramesh, the 2016 IEEE-HKN president and one of the 2022 IEEE presidential candidates. Dr. Ramesh is a professor of electrical and computer engineering and the former dean of the College of Engineering and Computer Science at California State University, Northridge.

"Being acknowledged as the 2021 IEEE-HKN Outstanding Young Professional in these challenging times was a very humbling experience," says Dr. Menon. "I would like to thank IEEE and IEEE-HKN for creating wonderful platforms for young professionals to follow their aspirations and make impacts in the society."

Since 2011, Dr. Menon has held global leadership roles and taken part in professional activities in the IEEE, IEEE-HKN and IEEE Women in Engineering communities.

Last year, she was selected by the National Academies of Sciences, Engineering and Medicine as one of 20 recipients of a Gulf Research Program Early-Career Research Fellowship.

At UAH, Dr. Menon has collaborated to expedite a COVID-19 drug discovery process using big data analytics with Dr. Jerome Baudry, the Mrs. Pei-Ling Chan Chair in the Department of Biological Sciences. She collaborated to develop a personalized artificial intelligence-based stress monitoring and detection system to address healthcare worker stresses during COVID-19 with Dr. Emil Jovanov, a professor in the Department of Electrical and Computer Engineering.

"My achievements today would not have been possible without the support of a great department, wonderful colleagues and supportive college of science that encourages cross-disciplinary collaborations," she says.

Dr. Menon is also the faculty advisor for the Association of Computing Machinery (ACM) and the ACM-W women's chapter at UAH, and she sponsors activities that include student mentoring, recruiting and outreach.

She is committed to promoting and increasing the number of women and minorities in Science Technology Engineering and Mathematics (STEM) fields.

"This award is a responsibility," Dr. Menon says. "It invigorates me to continue my pursuit of multidisciplinary research to address challenging scientific problems, help my students excel in school and their professions, and dedicate my life in service to the larger scientific and non-scientific community. ■

# TWO PROPOSALS FROM SPACE SCIENCE DOCTORAL STUDENTS ACHIEVE NASA FINESST AWARDS

Two UAH Department of Space Science doctoral students' proposals have been awarded highly competitive, three-year Future Investigators in NASA Earth and Space Science and Technology (FINESST) grants.

Katherine Davidson and Dinesha (Dinesh) Vasanta Hegde each won a $135,000 stipend to cover tuition, research activities and travel costs to attend workshops and conferences to continue their research.

Davidson, in the second year of her doctorate, is exploring the processes that cause the light shows on Earth called auroras. Davidson's proposal is titled, "Investigating Ionosphere-Thermosphere Coupling in the Nightside Auroral Oval." She is advised by Dr. Ying Zou, an auroral scientist and assistant professor of space science.

Hegde, a second-year doctoral student working as a Graduate Research Assistant in the Department of Space Science and at the UAH Center for Space Plasma and Aeronomic Research, is researching space weather. Hegde's proposal is titled, "Modeling Space Weather with Quantified Uncertainties." He is advised by Dr. Nikolai Pogorelov, a space weather scientist and a distinguished professor of space science.

NASA grants FINESST awards to graduate students who are pursuing research that is aligned with the NASA Science Mission Directorate in Earth sciences, heliophysics, planetary science and astrophysics.

Davidson says she found out about the award at an interesting juncture.

"I actually found out right after getting a root canal, so it definitely brightened up my day!" she says. "I am extremely grateful for this opportunity to pursue my Ph.D. while being supported by NASA."

Her dissertation research will attempt to quantify the relationship between geomagnetic activity and thermospheric wind response to changes in ionospheric convection.

"This work is relevant because momentum transfer from the ionosphere to the thermosphere is an important mechanism for dissipating the large amount of energy injected into the high latitude ionosphere during solar storms and substorms, so we should know how geomagnetic activity affects that momentum transfer," Davidson says.

The FINESST award reflects the recognition that the science is compelling and impactful, and that Davidson has a feasible and robust research plan, Dr. Zou says.

"This is a tremendous encouragement, especially considering that Kat had only worked on the project for about half a year at the time of applying," she says.

The award means that Davidson becomes an independent young investigator who can test and pursue her research ideas freely and confidently, Dr. Zou says.

"With this award being one of the most prestigious student awards – if not the most prestigious one – offered by NASA, Kat has the brightest future in front of her," Dr. Zou says. "She will be a talented scientist that every institution would dream to have and will be offered all needed resources for her to grow into a world-class expert."

Hegde says his offer letter boosted him after he initially thought he had not been selected.

Katherine Davidson and Dinesha (Dinesh) Vasanta Hegde each won a NASA Future Investigators in NASA Earth and Space Science and Technology award.

"I was so glad and surprised to know the selection," Hegde says.

"Since the notification deadline was already over, we had thought that our project would not have been selected. I double checked the offer letter to make sure of the selection," he says. "Soon after, I received the email from my supervisor that it got confirmed. Immediately I called my sister, who is in India, to share this good news."

He is studying the properties of the solar wind, a continuous stream mainly consisting of protons and electrons in a plasma state that flows outward from the sun and carries the embedded solar magnetic field along with it.

To do that, Hegde is using time dependent, data-driven and nearly real-time numerical models of the solar atmosphere and heliosphere being developed by Dr. Pogorelov's research group, along with data from NASA missions including the Parker Solar Probe (PSP).

"The solar wind is a key driver of the space weather that forms the backdrop to the propagation of solar coronal disturbances – such as coronal mass ejections and energetic particles – towards the Earth's orbit," Hegde says.

The events can be harmful for space instruments, radio communication and electric power transmission. Better space weather forecasting can help safeguard the near-Earth environment, Hegde says.

Dr. Pogorelov says that Hegde arrived at the Department of Space Science with a clear interest in space physics and, especially, in simulations driven by observational data.

"Such simulations are invaluable for space weather predictions. Dinesh is a highly motivated student with interest in both data analysis and modeling, and he has obtained some fascinating results already," Dr. Pogorelov says. "The FINESST fellowship awarded to Dinesh opens new possibilities for him to get involved in space weather research and pursue his Ph.D. goals." ■

From left, team members Nadia Alexander, Tegan Ruffalo and Jay Hayman build a prototype in the early manufacturing process.

*Courtesy Nadia Alexander*

# SENIOR DESIGN CLASS DEVELOPS STORAGE SYSTEM THAT COULD SEE NAVY USE

A unique storage system for a U.S. Navy submersible developed by a senior design class team in UAH's Department of Mechanical and Aerospace Engineering (MAE) is in the running for actual Navy use.

The students worked with the U.S. Special Operations Command in a unique partnership that enables UAH students to have the opportunity to work directly with U.S. Department of Defense (DoD) customers. In turn, the DoD is provided with designs that they may choose to incorporate into their systems for U.S. military personnel.

Team lead Nadia Alexander, a mechanical engineering major from Rochester, Minn., says the project was "super cool" and the team had a great time working on it.

"Our understanding is that we are the only team working on this project," Alexander says. "At the end of the day I'm excited that the ideas and the hard work of my team will be seen by the submersible operators and that some of our ideas may become part of the design for future submersibles."

Besides Alexander, team members were Jay Hayman, a mechanical engineering major from Memphis, Tenn.; Tegan Ruffalo, a mechanical engineering major from Huntsville, Ala.; Christopher Smith, an aerospace engineering

major from Charlotte, N.C.; Kayli Wood, a mechanical engineering major from Austin, Texas; and Nic Shelton, a mechanical engineering major from Meridianville, Ala.

The team was given a list of objects that need to be stored on the submersible and some pictures of what the interior looked like.

"We just rolled with it," Alexander says. "We essentially determined every location where there was a small amount of space and said, 'Can we fit something here?' and then designed a storage solution for that space."

> ***"At the end of the day I'm excited that the ideas and the hard work of my team will be seen by the submersible operators and that some of our ideas may become part of the design for future submersibles."***
>
> ***- Nadia Alexander***

Students met with the customer every few weeks to present the various stages of the project and ensure that the team was still on the right track and within the requirements.

"Before the first meeting, we were told the general idea of what the customer is looking for and then we sent them a questionnaire to determine the requirements," Alexander says. "From there, we made a few preliminary designs, determined which one we wanted to pursue, then proceeded with the rest of the engineering process to bring the product to life."

The goal was to deliver a final, usable product to the customer. It was a fluid process and the storage solution design the team manufactured bore very little resemblance to its initial design.

"We determined spaces that needed to remain clear, objects that needed priority access, and we designed for comfort as well as practically," she says.

Throughout the life cycle of the project there were technical analyses done of the parts through finite element analysis, Alexander says, as well as calculations as to how the added weight may affect the balance of the craft and how to account for that.

Besides the design challenges, Alexander says the team faced hurdles from the pandemic.

"One of the largest hurdles we had to overcome was the inability to travel," she says. "Being able to travel would have been really helpful to truly understand the point of view of the operators, outside of some pictures and drawings. In addition, the team experienced delayed parts delivery, which shortened the time available for manufacturing."

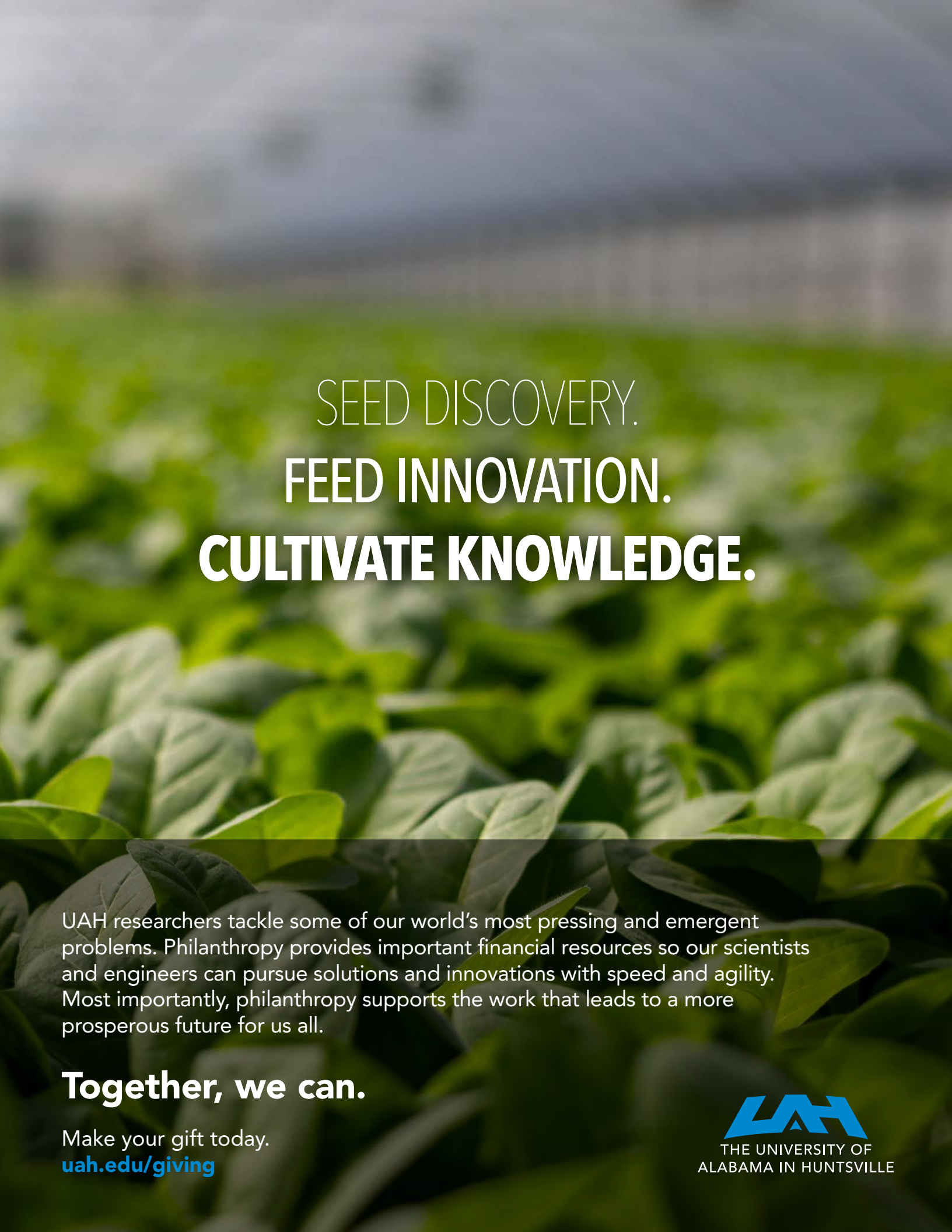
After a product readiness review, the product was shipped to the Navy for testing in the operational environment of a submersible. The students' semester concluded with a product certification review that conveyed final testing and cost results.

Alexander says the class blended all of her team's previous engineering education.

"There are the big things like evaluation matrices and working through iterative designs, then there are the things that sneak up on you, like considering off-gassing due to material interactions and how adding components can affect the existing interfaces. It's always important to keep in mind that even though something may look good on a CAD, you have to think about exactly how someone will use it, as well as build it," she says.

"One of my biggest takeaways definitely comes from the scheduling aspect, and how to deal with the issues that arise in a calm manner, and not let any one aspect overshadow the rest of the project," Alexander says.

"I'm very lucky to be working with such an amazing team full of people ready to step up and help out their fellow teammates. Everyone had great ideas that blended together into a really cool product. We did great work, and we had a fun time doing it. It was a joy to work with such fantastic people." ■

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