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Contact: asharpe@ontar.com to register!

Date: April 28th and April 29th 2020
Time: 9:00 am–5:00 pm
Location: Anaheim Marriott
700 West Convention Way
Anaheim, CA
Price: $1,199

Larry B. Stotts is a consultant, active researcher, and program manager in various technical areas, including free-space optical and RF communications, navigation and guidance technologies, underwater and atmospheric propagation, infrared and visible surveillance and reconnaissance, and integrated and fiber optics. He has held management positions at the Defense Advanced Research Projects Agency (DARPA), Department of the Army, and the Federal Aviation Administration, as well as being a Program Manager at DARPA and a staff research scientist at the Naval Ocean Systems Center (SSC PAC). He has published over 100 journal articles, presentations, and reports; has seven patents; and authored/co-authored three books and two book chapters. He is a Life Fellow of IEEE, a Fellow of SPIE, and a Senior Member of OSA. He received the Department of Defense Medal for Distinguished Civilian Service (2013); a DARPA Technical Achievement Award for his management of the Future Combat Systems Communications Program (2006); the National Partnership for Reinventing Government Award as part of the Maritime and Nationwide Differential GPS Service Team (1999); the Secretary of Defense Medal for Meritorious Civilian Service (1991 and 1996); the Technical Cooperation Program Technical Achievement Award (1991); the Naval Ocean Systems Center Technical Director's Award (1986); and the Outstanding Technical Achievement by an Individual Government Agent, DARPA Award (1985).

John Schroeder is a staff scientist at the Ontar Corporation. He has been involved with the development and use of atmospheric and sensor computer models and atmospheric databases such as LOWTRAN, FASCODE, MODTRAN, Hitran-Pc, and the HITRAN database for over 40 years. He, along with R. E. Good of AFRL, were responsible for the first Cooperative Research and Development agreement between the US Department of Defense and a private company in 1988. This led to the commercialization of LOWTRAN and the subsequent development and commercialization of MODTRAN. Schroeder is also a director of the Institute for Industrial Art and History (IIAH), a non-profit museum. The IIAH is guided by the words of Theo Jensen: “The walls between art and engineering exist only in our minds.” The IIAH promotes the idea that the technology we enjoy today is an extension of our scientific and industrial heritage and works to help the public experience this heritage and enjoy it as both engineering and art.

NOTE: Ontar Corporation is independently offering this workshop and is not affiliated with SPIE Short Courses.
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Astronomers Feel the Animal Heat

Astronomers help ecologists locate at-risk animals using imaging techniques honed from decades of hunting for stars.

By Mara Johnson-Groh

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Sensing an Autonomous Vehicle Future

Far-infrared sensors will play an important role in overcoming some of the problems that plague sensor platforms on autonomous vehicles.

By Mark Venables

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Nature’s Infrared Club

A handful of species can detect infrared radiation. Envious of this evolution-honed sensory superpower, researchers with technical visions are working to emulate it.

By Ivan Amato

Near-infrared imagery of the 2017 Santa Rosa, California wildfire, a scene of interest to certain species of heat-sensing beetles. Photo Credit: Planet.
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On the Cover
Infrared image of a car photographed with a FLIR T1020. Photo Credit: FLIR.

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The Long Wave

THIS ISSUE OF PHOTONICS FOCUS will go to press the first week of February, when tens of thousands of people working in photonics will be gathered in San Francisco to discuss their latest research and products at SPIE Photonics West.

This massive conference reflects the breadth and depth of photonics research and applications, and includes many of the topics under the photonics umbrella, including biomedical optics, optical components, laser science, neurophotonics, additive manufacturing, display technology, and photonic chip development, to name just a few.

The photons that unite all of these fields travel in very long (radio), long (infrared), short (ultraviolet), or incredibly short (gamma) waves, each with different properties and capabilities. This issue of Photonics Focus is absorbed with one slice of that spectrum: the infrared range. (See what I did there?)

Infrared radiation has its best-known applications in military and defense contexts—think night vision goggles—but the infrared spectrum is the enabler of extensive civilian applications as well, including free-space communications, automotive sensing, theranostics, astronomical imaging, fiber optics, and even photonic circuits. It’s truly a democratizing wavelength that spans research and applications across all SPIE communities. Kind of like Photonics West (which had 385 papers with “infrared” in either the title or abstract).

The feature articles in this issue explore the role of infrared radiation in tracking endangered species under dense vegetative cover using imaging techniques borrowed from astronomy; the potential for thermal imaging in the race for commercial autonomous vehicles; and an examination of the select “infrared club” of creatures who have the benefit of native infrared vision—and how scientists may soon give humans that ability using nanotechnology.

In honor of Women’s History Month (March), the Luminary article sets the record straight about one woman’s pioneering physics demonstration of the greenhouse effect slightly before John Tyndall, who was historically credited with the work. Their research, with others, paved the way for modern climate science.

The Bandwidth section has some helpful career advice for entrepreneurs considering a new startup, and for researchers who might like to better communicate their results in the scientific literature.

I enjoyed all of the reader feedback about our first issue (you can see a sampling to the right), and would like to continue the dialogue. If you have thoughts to share about Photonics Focus—criticisms or praise—please be in touch! photonicsfocus@spie.org, or @SPIEtweets.

Thanks for reading,

GWEN WEERTS, PHOTONICS FOCUS MANAGING EDITOR

Reader comments about the first issue of Photonics Focus

"The new magazine is written at just the right level to provide an overview of novel results in the literature—looking forward to the next one!" Alexander May (@the_atman)

Re: “Where is the New Collar Workforce?” by Gwen Weerts

“SPIE has launched its new Photonics Focus magazine and this article hit home for me.” Donn Silberman

“We have the only AS degree program in optics and photonics in New England and lots of high paying jobs going unfilled. Yet we are still working hard to fill seats...Where is the disconnect indeed!” Nicholas M. Massa

Re: “Alien Light” by Sophia Chen

“Popular science writing done right!” Rohit Goswami (@rgOswami)

“As I am developing laser detection technology I have been explaining that lasers don’t occur naturally and they are therefore a techno-signature. I was enlightened by this article...that they do! (sort of).” Dr. David Benton, (@DrDavidBenton)

Re: “Ten Simple Steps to Writing a Scientific Paper” by Andrea Armani

“Look what I found in Jan/Feb edition of Photonics Focus!! Thank you for the evergreen, always relevant, unanimously applicable advice, @ProfArmani!” Akhil Kallepalli (@OptoMedDr)

“Also in the first issue of the new magazine Photonics Focus from @SPIEtweets is a wonderful article from @ProfArmani on 10 steps to write a paper.” John Dudley (@johnmdudley)
From Lab to Launch
The four components of a healthy startup

Good ideas for new optical, photonic, and imaging products are all it takes to launch a successful business, right? Not quite, according to Sujatha Ramanujan, managing director of the Luminate Accelerator Program in Rochester, New York. Before you launch a new business, she recommends answering four important questions.

1. WHAT IS YOUR TECHNOLOGY?

The first and most important question is, do you have a product that solves a real problem? If there isn’t a clear answer, then you might have a product, but you don’t have a business. The success or failure of a startup is not dependent on clever marketing or an excellent sales team. It rides on having a product that meets a well-defined customer need. To truly define and validate the problem, interview as many potential customers as you can, not just a handful. This will help identify if the problem is pervasive and will yield a large enough market to go after.

When ride-hailing service Uber launched in San Francisco in 2009, it addressed people’s desire for price transparency, which stemmed from a distrust of strangers. By quoting the ride’s cost up front, Uber offered the promise of building driver-rider trust through a transparent review system. The problem was clearly defined, and visionary software engineers designed a product that solved them.

Can you identify who, exactly, cares about what you’ve built? Resist the urge to make assumptions here. Put together a list of companies that you believe will want your product. This list should include who actually makes the decision to buy, in addition to who will influence the decision, such as the user of the technology.

2. WHO IS YOUR MARKET?

When you are confident that you know your customer, then thoroughly scan the competition. Make sure you haven’t reinvented something that’s already out there. If you’re lucky, you might even hear of someone who tried something similar and failed. Insight into earlier failures can make all the difference in your own success. Look to the Israeli lidar company Oryx Vision, which shut down operations in August 2019, for an example. They saw that the field of lidar was becoming a place for big companies and big players, and as a small company, they couldn’t justify the investments that would be needed to stay in the game until lidar took off commercially. They tried to sell, but couldn’t. For an entrepreneur wanting to enter the lidar space, their story could be important.

Also, research your market to make sure that it can support the cost of your solution. If your product will cost $200 to manufacture, but your target customer is only willing to pay $50, then you need to either find a way to reduce your costs, or find a new customer to target. Free-space optics company AOptix launched with funding in 2000 but folded sixteen years later when the market was looking for cheaper telecommunication solutions than its $80,000 links.

3. WHAT’S YOUR ADVANTAGE?

Once your product and market are clearly defined, be able to articulate your advantage. Why is your solution the best solution to the problem? Startups often differentiate on one
of three different value propositions: a unique outcome, a reduced cost, or an environmental improvement. You must be able to articulate your value proposition.

However, if you are differentiating on cost, be cautious. Supply chains change and manufacturing costs are volatile. Your price advantage can be quickly wiped out by a competitor who is able to make a similar product for even less.

4. WHO IS ON YOUR TEAM?

So, you know you've got a technology that solves a problem, you know exactly who you're going to solve the problem for, and you know why your solution is the best. But do you have the right team? Many great ideas based on solid science fail at this point just because the teams aren't made up of the right people.

Successful teams include a diversity of skills and thought. This diversity manifests in technical strengths, business savvy, contrasting personality types, and market knowledge. For example, in addition to finding someone with the right skills to fill the CFO and CTO roles, look for a pessimist to balance an optimist. If the project leader is a big-picture person, make sure you've got someone who likes to get stuck in the details. If your product is an innovative new moisture sensor for baby diapers, someone on your team better have an infant.

In addition, it's important that the team has a singleness of purpose and shares similar values and business goals. Are you building a lifestyle business that you want to be involved in for the next 20 years, or a business that you want to sell for $2 million five years from now? You'll run the business differently depending on the answer.

Once these four questions are answered, you'll be better prepared to start down the path of a new startup. Remember that you'll likely hear no a thousand times before you hear yes, and that you will learn more from failure than success. Good luck on your journey!

SUJATHA RAMANUJAN, PhD, is the managing director of Luminate, an intensive accelerator program for optics, photonics, and imaging-enabled applications located in Rochester, New York. Each year, ten teams from around the world receive $100,000 each to attend the six-month program, which provides business development training, technical facilities, mentoring, and access to potential partners and investors. The Luminate program also invests an additional $2M annually in follow-on funding to the most promising fledgling companies.

Ask the Community

We asked Reddit entrepreneurs (r/startups):

“What do you know now that you wish you knew before you started?”

“Startups have a much better chance of working out when your prime motivation for starting the company is because you are unbelievably passionate about the problem you’re trying to solve—and not the solution. You need to be able to find a problem space that’s broad enough to keep you engaged as you pivot on the solutions you and your team develop for it.”

@gozmike

“Validate your idea before you invest.”

@marlouwe

“If you’re joining a startup very early, make sure you give it your best every day. Come early, leave late, take initiatives, execute instead of talk, and so on. Being a well-regarded star internally early on could potentially be life changing in terms of career, finances, etc.”

@twoMono

“Be curious about the company’s goals and initiatives, curious about how you can improve your department/position, and curious about how you can help others out. Startups are so unique in that the opportunity is so big, but if you’re not a go-getter and genuinely interested in what’s going on, you will definitely get looked over for promotions.”

@mocaro

“Target the hot traffic. Hot traffic = the people who are currently searching for someone to hire for the kind of service you want to offer (or for the product you sell).”

@BeingsBeingBeings

“Focus on your initial customers, make them so happy they will never leave. Also design and UX is so important, not just for customers but for potential hires and investors.”

@SheSupplyPi
Can You Improve Your Technical Writing?  
(Spoiler: YES!)

How to become an engaging, communicative writer

When was the last time you took a dedicated writing class? If you’re like most scientists or engineers, the last one you took was in high school or college. I’ll ask another question: When was the last time you communicated your latest research findings in written form? Whether it takes the form of a memo, white paper, proposal, or journal paper, written communication is a critical piece of life as a scientist or engineer. In particular, the ability to write scientific articles that are clear, informative, provocative, and interesting can have positive and long-lasting implications on your career.

Crafting successful technical articles requires focusing on two key elements, the first of which is strong content. Most of you are already good at this, since scientists and engineers do important and impressive work. Often neglected, however, is the second key element: effective writing. I argue that the writing itself—the language, the structure, and, yes, the grammar—plays an equally large role in the success of a written piece. Yet, the emphasis on effective writing practices generally takes a back seat to the emphasis placed on content.

In your next written piece, consider the importance of strong technical writing to complement your strong technical content. The three tips below can help you get started:

KATIE KIRSCH is a mechanical engineer with ten years’ experience teaching effective scientific communication strategies. Outside of her communication courses, she works as a research and development engineer with expertise in additive manufacturing, heat transfer, and design.
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Keep it interesting. I’m not talking about content—I’m talking about your written voice. A common mistake among inexperienced writers is to write using the same sentence structure over and over, which can put your reader into a trance. For example: “The objectives of the current optimization study were...” “Results indicate that...” “The current method showcases...”

Repeating five “subject-verb” openers in a row underscores a lack of writing experience. Consider changing it up. Varying your sentence structure establishes an attention-grabbing rhythm.

Pay close attention to how your text looks on the page. Long paragraphs appear intimidating to readers. Oftentimes, you’ll hear limits placed on the number of sentences allowed in a paragraph, but sentence number is not the most important metric. Instead, take a step back from your paper and squint: how much white space do you see? Whether the format of your target publication uses single, double, or triple columns, having single paragraphs that take up a significant amount of one column is intimidating. When you’re done drafting your article, mock it up in roughly the same format as your target journal. You’ll see which paragraphs appear too long—a good rule of thumb is to break up any paragraph that takes up over 40 percent of a column’s length.

Study expert writers. Undoubtedly, much can be learned about new methods and advancements in your field from reading peer articles. However, when it comes to becoming a better writer, I point you to the experts—those who have studied literature and clearly excel in the field. The best way to learn new sentence structures, grammatical constructs, and expanded vocabulary is by reading the work of professional novelists, short story writers, and newspaper and magazine authors. The type of creative writing is irrelevant: what matters is that you expose yourself to writing techniques that differ from technical articles in your field.

In conclusion, approach the writing—the language, the structure, the grammar—of your next technical article with the same rigor as your technical content. Becoming a stronger writer isn’t going to happen overnight. Utilizing the above tips, however, is a step in the right direction. In addition, numerous tools exist to help you improve. For one, The Craft of Scientific Writing, by Michael Alley, serves as an excellent resource for experienced and inexperienced writers alike.
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In 2019, SPIE provided over $5 million in community support including scholarships and awards, outreach and advocacy programs, travel grants, public policy, and educational and career development resources.

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The Wild West of Automotive Lidar

Varying use cases, competing technologies, and tricky unstructured environments complicate the development of lidar standards.

THE CITY OF HOUGHTON is in the far north of Michigan’s upper peninsula, along the southern shore of Lake Superior. It’s famous for two things: the notable engineering school, Michigan Technical University, and being two miles past the end of the Earth. It’s more than 200 miles away from the closest freeway, and averages 250 inches of snowfall per year.

Jeremy Bos, assistant professor of electrical and computer engineering at Michigan Tech, finds this environment ideal for research on autonomous vehicles (AV). He’s working to resolve corner cases—those situations that are rare and difficult to plan for, but do happen. Like epic amounts of snow.

“What is a normal condition up here in the UP—snowbanks, covered roads, etc., —that’s a once in 100-year event in Chicago,” says Bos. “But it does happen in places where you might actually want to field AVs. If AVs replace taxis in all major urban centers and they can’t handle a snowstorm, what good are they?”

In addition to studying corner cases, Houghton is a good test case for unstructured environments, because few man-made features are present outside of town. “The problem in an unstructured environment is that one tree looks very much like another. You don’t have these features like walls or corners or roadways or lane markings in order to localize yourself and say I’m here,” he says.

Lidar is one of several technologies that enable autonomous vehicles. Bos’s group at Michigan Tech has been testing and evaluating various automotive lidars to figure out the minimum information needed relative to an unstructured environment to accomplish autonomous driving tasks. It’s a challenge that Bos has to figure out as he goes, because there are no standard measurements available for lidar, which means that neither lidar suppliers nor auto manufacturers have a way to compare lidar products.

Bos’s work testing lidars put him in contact with Paul McManamon, lidar expert, author, and president of Exciting Technology, LLC. “It’s a wild west right now,” says McManamon. “You can’t compare between one [lidar] and the other. And no one tells you the performance. They won’t tell you how it works, and they won’t tell you the performance.”

Frustrated by this lack of transparency, McManamon asked Bos to help him develop a series of multi-vendor benchmarking tests so that auto lidar companies will have something to compare against. This inaugural event will take place in Anaheim, California, during SPIE Defense + Commercial Sensing in April.

The Angel Stadium parking lot will be set up to test key lidar capabilities: range of effective object detection; resolution, which is how accurately the lidar identifies and classifies objects; and reflectance confusion, meaning how well the lidar can see something in the presence of bright objects, like reflective signs or bright sun.

Developing a set of standards for automotive lidar will be no easy task. Different lidar companies rely on different types of lidar technology, including the standard spindle-type, which spins to give a 360-degree view; solid-state lidar, which has a fixed field of view, but no moving parts, and can use either MEMS or optical phased arrays to steer the beams; and flash lidar, which spreads a flash of light over a large field of view before the signal bounces back to a detector.

Moreover, automotive lidar has different range requirements depending on use case. If a car is driving on the autobahn, for example, then the car needs to be equipped with 250-meter lidar. But other applications, like congested city driving, really only need lidar to detect objects 50 meters away or less. “Everyone claims to have the best thing imaginable, but there are specific use cases for these lidars, and automotive manufacturers want to know that they work,” says Bos.

These variations, along with closely guarded lidar IP, have made technology standards slow to develop. However, lidar is a key enabler in a growing market for autonomous vehicles, which means that measuring lidar performance will have a direct impact on the safety of those vehicles.

Automotive lidar may be a wild west, but McManamon and Bos know that the railroad is coming. The development of standard lidar measurements will help lay the first tracks.

GWEN WEERTS is the managing editor of Photonics Focus.
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ALTHOUGH ASML HAS BEEN DOING BUSINESS in China for three decades, it requires a special license to ship EUV systems to customers in the country. The key difference between EUV and older lithography equipment is that the latest semiconductor chip patterning systems are covered by the Wassenaar Arrangement.

That international agreement, first signed by participating countries in The Netherlands in 1995, restricts exports of “dual-use” technologies that can be used in either civilian or military applications—largely to stop them getting into the hands of terrorists.

As ASML’s CEO Peter Wennink told reporters, ASML is able to sell its equipment to any of the 42 countries signed up to Wassenaar. However, China is not a signatory, meaning that the company has to apply for a license from the Dutch government to complete the shipment of any EUV kit ordered by a customer in China.

The vast majority of ASML’s EUV shipments are destined for the US, Korea, and Taiwan to key customers like Intel, Samsung, and the Taiwan Semiconductor Manufacturing Company (TSMC) foundry.

Although Wennink would not confirm the identity of ASML’s Chinese EUV customer, it is widely believed to be another foundry, Shanghai-headquartered Semiconductor Manufacturing International Corporation (SMIC).

The CEO said that ASML had applied to the Dutch government for a new export license to ship an EUV tool to a customer in China after an existing license expired in June 2019—adding that he was surprised to have had to wait so long for it to be renewed.

The reason for that delay appears to be the pressure put on Dutch authorities by US officials worried about China acquiring EUV systems, although whether that is because of their potential for military use or simply to hamper China’s development of technologies like 5G communications is unclear.

But China cannot get the equipment from anywhere else: after spending around $13 billion on their development, ASML is the only company capable of making the hugely complex $130 million-plus pieces of equipment. The company also insists that complicated equipment is virtually impossible to copy.

According to a report last week in the Dutch business newspaper Het Financieele Dagblad, the US ambassador to the Netherlands Pete Hoekstra confirmed that the US did not want what it considers to be a “particularly sensitive technology” to ship to China. The vast majority of the parts that make up an EUV system originate in Europe, meaning that the US cannot directly block such sales, but diplomatic pressure does appear to have been applied.

That came after the same newspaper spoke to Hoekstra’s Chinese counterpart Xu Hong, who is said to have made it clear that there may be consequences if the EUV export license is refused.

The geopolitical crossfire has put both the Dutch government and ASML into a difficult position—although Wennink insists that if shipments of EUV to China are blocked, the company’s plans will be largely unaffected as the systems will simply be shipped elsewhere to meet growing global demand for the latest cutting-edge devices.

“If we can’t ship to country ‘A,’ we’ll ship to country ‘B, C, or D’ instead,” he said.

Signs of that growing demand can be seen at all ASML’s key locations across Europe, with the company spending billions of euros on a new EUV logistics center at its Veldhoven headquarters, and investing heavily in key partner Zeiss’s development of the high-numerical aperture (high-NA) optics that will be needed to shrink the dimensions of critical features in future devices.

This article originally appeared on optics.org.
A SCIENTIST’S GUIDE TO
Testifying before Congress

YOU’VE SEEN IT IN THE MOVIES or on the news: leaders or subject matter experts testifying at a hearing before US Congress. The purpose of these hearings can be to inform an investigation, review proposed legislation, or vet a nominee before they are passed to the floor for full consideration. There are dozens of congressional committees that regularly hold these hearings; they are an important aspect of Congress and committee work, and scientists and engineers are often asked to testify.

Juan Torres, the Associate Laboratory Director for Energy Systems Integration at the National Renewable Energy Laboratory (NREL) in Golden, Colorado, is an electrical engineer by training and has testified before Congress twice. In October 2018, he testified before the Senate Committee on Energy and Natural Resources on the subject of blackstart, which refers to restarting the power grid after a system-wide blackout. Then, in July 2019, he testified on the subject of power grid modernization and security for the House Committee on Science, Space, and Technology.

Witnesses, such as Torres, are asked to submit written testimony before the hearing, and then to deliver five minutes of oral testimony and respond to questions during the hearing. In preparing his testimony, Torres made a point to consider its potential impact on his home office, NREL, its parent office—the Department of Energy, Office of Energy Efficiency and Renewable Energy—and other interested sponsor offices.

“I was sure to get my written testimony reviewed in advance, both internal and external to NREL, to make sure they were aware of what I was going to say and if they had any concerns or suggestions on rewording,” he says. He also practiced his oral testimony out loud, timing it to ensure that it fit within the firm five-minute window allowed for opening statements.

Torres says that testifying requires you to “communicate on a level where you know you’re speaking to an intelligent audience; however, they may not have a technical background or depth of knowledge in the area,” and that means adapting the message for the audience. He recommends having somebody outside your area of technical expertise read your testimony in advance to ensure that a nonexpert can understand it, and to ask questions. “It’s one thing to be able to plan your statement in writing... but when somebody asks you a question on the fly about artificial intelligence or quantum computing, you have to be able to respond in a way that the audience will grasp what you’re saying.”

As a witness, Torres also emphasized the importance of context when testifying. This means paying attention to both the politics of the moment and the politics of the committee members themselves. “Your topic may not be controversial, but there might be something else controversial going on,” says Torres. In his case, Torres testified not long after the contentious nomination hearings of Supreme Court Justice Brett Kavanaugh, and many of the Senators he was testifying before had also served in those hearings.

And while Torres’s testimony on blackstart was noncontroversial, he cautioned that “not everybody who may be on the...
committee will be a big fan of the technology that you’re working on, so it’s good to do a little bit of homework in advance to understand where they are coming from.”

For example, two of the Senators on the Energy and Natural Resources Committee had very different interests when it came to energy generation. One was from a state with a strong incentive to increase renewable energy, and another came from a state whose economy depends on the coal industry. “We as technical experts have to be agnostic to the politics,” says Torres, emphasizing the importance of delivering scientific facts in a neutral fashion under such circumstances.

Being up to date on current events related to the hearing topic is also valuable context. There was an attack on the power grid the month before Torres testified on grid security, and he was asked a question about the incident during the hearing.

Knowing who else is testifying can also inform oral testimony. Coordinating with other witnesses can help to prevent repeating information and use hearing time more effectively. Regarding his grid security testimony, Torres says, “Once the written testimonies were submitted...there were a couple of us [witnesses] that connected, and we shared each other's testimony.” This allowed them to support and complement each other during the hearing, and convey a more cohesive message.

If you are a leader or a prominent subject matter expert in your field, it is possible that you might one day be called upon to testify before Congress. Congressional staff could invite you to testify based on your publications or your position at a university or federal agency. Whether or not that day comes, the lessons of knowing your audience, understanding the context of a moment, practicing, and having others review your message before you deliver it, will make you a more effective communicator wherever you choose to speak.

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WHEN YOU SPREAD A THIN LAYER of oil on a metal frying pan, did you know that you’re half way to a photonic crystal that can be used as a quantum emulator?

In the past few decades, photonic crystals have revolutionized our understanding of light–matter interaction. While solid materials are naturally employed as key building elements for construction of photonic crystals due to their structural stability, new research shows that liquids also hold promise.

Researchers from University of California, San Diego, proposed a way to create tunable liquid metasurfaces. In their theoretical study, they leverage surface tension properties of liquid thin films to demonstrate that interfering optical surface waves can induce periodic deformation of the gas–liquid interface, leading to a periodic refractive index, e.g., a liquid photonic crystal.

In the presence of a gain media like a dye, the periodic deformation of the liquid thin film can even lead to formation of resonators, capable to support lasing modes that can be controlled by modifying the symmetry of the photonic liquid crystal.

Since oils are nearly nonvolatile liquids and can form stable thin liquid films on metal surfaces, it’s not unreasonable to end up with a quantum emulator on a common metal frying pan. (S. Rubin and Y. Fainman, Adv. Photon. 2019 doi: 10.1117/1.AP.1.6.066003.)

ULTRASOUND IS A NONRADIATIVE AND NONINVASIVE METHOD for imaging inside the human body, but it requires firm contact between the probe and the skin. For burn victims and others with skin sensitivity, touch is a problem. But MIT researchers have developed a noncontact method of ultrasound that uses lasers to remotely image—from half a meter away—inside of a person’s body down to about 6 cm below the skin.

Their method is part of the field of photoacoustics, which uses a pulsed laser tuned to a particular wavelength to penetrate skin, thereby creating mechanical vibrations as sound waves that travel back up and are detected by transducers on the skin. However, traditional photoacoustic methods still require a detector in direct contact with the body. And, because light can’t travel very far into the body, only structures near the surface can be detected with this method.

However, sound waves, which require a medium through which to propagate, can travel farther into the body. The researchers used an infrared 1550-nm laser—a wavelength readily absorbed by water, skin’s primary component—and sent a pulse wave into the skin to generate a sound wave. A second continuous laser, also tuned to 1550 nm, detects the reflected sound waves by measuring the resulting vibrations on the skin’s surface that result from sound waves bouncing off muscle, fat, and tissue. That surface motion causes the detecting laser to change frequency, which can be measured to generate an ultrasound image. Without any contact, anywhere.

The group hopes to miniaturize their setup so that the device could someday be used as a portable in-home imaging unit. (X. Zhang et al., Light: Sci. Appl. 2019 DOI: 10.1038/s41377-019-0229-8. Foundational research was presented at SPIE Medical Imaging.)
CANCEROUS CELLS have unique molecular markers, and doctors often look for those markers as the first indications of the presence of tumor cells in the body. But beyond a few types of cancer cells, not many molecular indicators have been identified. Detection is difficult because they appear in such tiny amounts in samples, and they usually involve a combination of different compounds belonging to all of the different types of cells, including fats, proteins, and sugars. Up to now, there hasn’t been a method versatile or sensitive enough to define a broad range of molecular signatures.

Ferenc Krausz and a team at the Laboratory for Attosecond Physics in Munich and the Max Planck Institute for Quantum Optics have developed a laser-based system to accomplish this task. Their instrument emits pulses of broad-spectrum infrared laser light, which create vibration among the bonds that link atoms together. These vibrating molecules emit light at specific wavelengths that give away the identity of all of the compounds in the sample.

The system can detect very low concentrations of molecules and produce highly precise molecular fingerprints, enabling molecular analysis via infrared light illumination on living tissue. The team hopes their technique could lead to advances in early detection of disorders. (I. Pupeza et al., Nature 2020 DOI: 10.1038/s41586-019-1850-7. Foundational work presented at SPIE Photonics West.)

Making a Molecular Mark

World’s Tiniest Particle Accelerator

AT THE SLAC NATIONAL ACCELERATOR LABORATORY, bursts of microwave radiation move a stream of electrons through nearly two miles of copper pipe in a vacuum until they reach the speed of light. Recently, scientists at Stanford and SLAC swapped the microwaves for infrared waves and the copper pipe for silicon channels to create a much smaller particle accelerator—so small that it fits on a nanoscale chip.

The shorter wavelength of infrared light makes it an ideal accelerator for a nanoscale circuit, but certainly complicates the chip’s tiny design. To meet the challenge, the team eschewed traditional chip design approaches and instead used inverse design algorithms. Their approach tasked software with suggesting how to build the nanoscale structures to accomplish the most efficient flow of photons and electrons that will result in particle acceleration.

The resulting prototype looks pretty weird according to the standards of conventional lithography, but it does what the team set out to do. Bursts from an infrared laser propel electrons forward at increasingly faster speeds through the silicon channels. The group intends to achieve acceleration to 94 percent of the speed of light, which is a powerful enough particle flow for some medical purposes. To accomplish that speed, the group will need to pack thousands of these acceleration stages into a chip, which will increase its size substantially—to maybe an inch. (N. Sapra et al., Science 2020 DOI: 10.1126/science.aay5734. Foundational research was presented by Jelena Vuckovic at SPIE Photonics West and SPIE Optics + Photonics.)

Sources

[Image and text]
Something's a-Foote with Climate Science History

John Tyndall, Eunice Foote, and the greenhouse effect

JOHN TYNDALL IS OFTEN CREDITED with discovering the greenhouse effect, but the real history is more complex. In the 1820s, French mathematician Joseph Fourier calculated that sunlight alone could not keep the Earth at its present temperature. In 1856, Eunice Foote, an American scientist and inventor, experimentally showed that sunlight heated carbon dioxide and water vapor more than air, and suggested that changes in gas concentrations might explain evidence of past warm periods. Starting in 1859, Tyndall analyzed radiation transfer and heat absorption of gases, the physical basis of the greenhouse effect.

Born of well-educated protestant Irish parents around 1820, Tyndall worked as a surveyor, then moved to Britain when a railroad boom made surveying a lucrative profession. He also briefly taught, then studied physics at the University of Maxberg in Germany. In 1833, he joined the Royal Institution in London, headed by Michael Faraday.

The following year, Tyndall gave a series of lectures on heat. In one, he shone a bright light along a jet of water flowing from a tank, with total internal reflection guiding light through the arc of liquid, delighting the audience. His later description of the effect in a popular book led some to credit Tyndall with inventing light guiding that ultimately led to fiber optics. Yet Tyndall’s notes reveal Faraday suggested the idea, which Swiss physicist Daniel Colladon had published in 1842 but whom Tyndall never credited.

Tyndall also never credited Eunice (Newton) Foote, born in 1819, whose father was a Connecticut farmer named Isaac Newton, no known relation to the English physicist. Educated at the Troy Female Seminary, she took science courses at what is now the Rensselaer Polytechnic Institute. She married Elisha Foote, a lawyer, judge, and inventor, and the couple settled in Seneca Falls, New York, where both of them were early signers of a pioneering statement of women’s rights in 1848.

Both Footes had papers on heating by sunlight presented at the 1856 annual meeting of the American Association for the Advancement of Science, but only Elisha spoke; Eunice’s paper was read by Joseph Henry, head of the Smithsonian Institution. Her paper described how the temperature of damp air and “carbonic acid” (carbon dioxide) exposed to sunlight rose much more than that of dry air. She wrote that such elevated moisture and CO₂ could account for the high temperatures geologists thought the Earth had in prehistoric times. It was the first time anyone had suggested changes in the atmosphere could change climate. Her idea made *Scientific American* and the *New York Daily Tribune*. The *American Journal of Science and Arts* printed both her and Elisha’s papers, but that success was forgotten after she went on to other things.

Tyndall began studying heat absorption in gases in the spring of 1859, and never cited either of the Footes’ papers. Yet John Perlin, a visiting scholar at the University of California in Santa Barbara, believes Eunice’s paper inspired Tyndall’s efforts. Perlin says Tyndall should have had access to her paper because he was an editor of the British *Philosophical Magazine*, which reprinted Elisha’s paper from the *American Journal*, but not Eunice’s closely related shorter paper which was published in the same issue.

Support from the Royal Institution and an expertise in measurement allowed Tyndall to conduct more sophisticated experiments than the Footes could as amateur scientists and independent inventors. Whereas the Footes measured temperatures by reading thermometers in sealed glass cylinders illuminated by direct sunlight, Tyndall used “radiant heat” from a Leslie cube containing water at the boiling point—a simple blackbody source. He built a differential spectrometer to measure light absorbed by gas passing through a 30-inch tube.

Tyndall first reported heat absorption in gases to the Royal Society on 25 May 1859, followed by a 10 June talk to the Royal Institution. His written summary mentions only “coal gas,” a mixture of hydrogen, methane, and other gases produced by heating coal then used for lighting and heating. He concluded, “the atmosphere admits of the entrance of the solar heat, but checks its exit, and the result is a tendency to accumulate heat at the surface of the planet.” To bolster his claim to the discovery, he sent papers to three European journals as well as publishing his work in England.

Sickness and a frenetic schedule interrupted Tyndall’s work on radiant heat until June 1860, when he began measuring absorption of other gases. Only on 20 November 1860, did he finally measure moist air, finding that its absorption was comparable to that of CO₂, but less than coal gas. With hindsight, we can recognize the greenhouse effect in Tyndall’s early data, but the “radiant heat” he was measuring included both visible and infrared light.

Not until 1864 did Tyndall begin to study the differences between visible light and the infrared, which he called “black” or “obscure” heat because it was invisible to the eye. He found solar radiation reaching the ground was mostly visible, but the “heat” radiated by the Earth and hot surface objects was largely infrared. That infrared light had up to 25 times the heating power of visible light, and could heat platinum to incandescence, an effect he called “negative fluorescence” because it converted long wavelengths into shorter ones. Physicists spent years debating its nature and its relationship to fluorescence.
We don’t know exactly why Tyndall never credited Eunice Foote with inspiring his work. His attitude toward women very likely contributed. Tyndall—like many other men at the time—thought women were inferior to men and lacked their scientific originality, so he might have ignored a discovery claimed by a woman. He was also ambitious, an Irishman seeking acceptance by British scientists. He also failed to credit discoveries by men like Colladon, and quarreled over priority with some other prominent scientists of his time.

After a second paper on electrical excitation in 1857, Eunice Foote faded away from the world of physics. She was the first American woman to publish on physics (not counting astronomy), which wouldn’t happen again until 1889. She may have felt unwelcome in science, or may have chosen to focus on the more practical world of invention and technology. In 1857, a court awarded Elisha Foote a small fortune for infringement of his 1842 patent on stoves. In 1860, Eunice patented a new filling that stopped shoe soles from squeaking. Later she developed an improved paper-making machine.

Others built on Tyndall’s work as he had built on Eunice’s. In 1896, Swedish scientist Svante Arrhenius calculated how much atmospheric carbon dioxide warmed the Earth. In 1938, English engineer and inventor Guy Callendar calculated that the increase in CO₂ levels over the previous 50 years was enough to explain the rise in global temperatures. Many others who followed them stood on their shoulders to build modern climate science.

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Astronomers Feel the Animal Heat

Photo Credit: Liverpool John Moores University
Astronomers help ecologists locate at-risk animals using imaging techniques honed from decades of hunting for stars.

By Mara Johnson-Groh
HIDING WITHIN THE VIRGIN RAINFOREST of Malaysia, there lives a troop of Bornean orangutans. These fruit-eating great apes, who spend the majority of their lives in trees, are widely under threat from deforestation. Today, only around 100,000 remain in the wild. Last spring, they were tracked by a group of unlikely hunters: British astronomers equipped with drone-mounted infrared and visible wavelength cameras.

The astronomers, accompanied by a few ecologists, were taking a field trip far from their telescopes to help find new ways to save some of the world’s most at-risk animals. Combining off-the-shelf equipment with data-processing techniques and machine-learning algorithms gleaned from astrophysics, the researchers are combining astronomy with ecology to pioneer a new synergistic field: astro-ecology.

CONSERVATION ECOLOGY RESEARCH relies on finding and monitoring animals to understand the factors vital to their conservation—no easy task when the animals in question have had thousands of years to perfect their camouflage. Consequentially, conservational ecologists have readily adopted new technology over the years, such as camera traps and DNA sequencing.

In the last decade, conservation ecologists have also begun using drones equipped with optical cameras to survey parks and wilderness areas. Drones can quickly survey large areas, but deciphering all the data is time consuming. Small animals in particular can be hard to spot from a distant aerial viewpoint.

Infrared cameras, which pick up the animals’ warm-blooded heat signature, can be much more reliable for identification. Until recently, infrared cameras were prohibitively expensive. But advances in technology reduced camera size and weight, and also decreased the price, opening up their usage in conservation.

By combining infrared cameras with drone technology, conservation ecologists have gained a huge advantage in surveying large areas.

Back in 2014, one such conservation ecologist, Serge Wich, a researcher based at Liverpool John Moores University (LJMU), was working with infrared cameras but had trouble analyzing the large volume of data. One evening, Wich mentioned his struggle in passing to his seatmate as they rode the train home after work. That person happened to be his neighbor, astrophysicist Steven Longmore, who is also a professor at LJMU.

For decades astronomers have been using infrared cameras to study the births of stars and planetary systems. They’ve perfected techniques to remove background noise and image artifacts, as well as developed systems to automatically identify sources.

Longmore himself has been working with infrared data for 15 years. He got started with a thermal camera mounted on the Gemini North 8-meter telescope in Hawaii where he observed star-forming regions to understand how gas clouds collapsed to form high-mass stars. He realized that looking for endangered animals wasn’t that different from identifying young stars in gas clouds and offered Wich his help.

“[The animals’] glow is exactly the same as the kind of glow stars and galaxies have in astronomical images,” said Claire Burke, an astro-ecologist at LJMU who was one of the first researchers to start on the project. “The idea was we could use techniques from astronomy to find them.”

Longmore and Wich began a collaboration that has since expanded into a multidisciplinary team of astronomers, ecologists, computer scientists, and engineers. Their single serendipitous conversation has since launched a flood of new research.
IN INFRARED ASTRONOMY, TELESCOPES are typically equipped with high-resolution CCD cameras cooled to reduce internal noise. For conservation purposes, the researchers instead must use microbolometers, which are cheaper and light enough to fly on a drone. The microbolometer commonly used by the LJMU group—a FLIR Tau 2 640 long-wave thermal infrared camera—weighs only 72 grams, and lighter ones, like the FLIR Boson come in at just over 7 grams. The downside is that these lightweight cameras are low resolution, only 640 x 512 pixels.

“That’s sort of industry standard for a top-of-the-range [infrared] camera, and that’s not a lot of pixels,” Burke said. “That’s like a smartphone 10 years ago.”

As a result, the cameras have to be flown close enough to their targets for identification. While this isn’t prohibitive when searching for elephants on the African plains, it’s challenging when searching for smaller animals in a forest environment.

Furthering the issue, pixels in microbolometers can bleed into one another. As a result, one data point might contain a heat signature from both an orangutan and the tree it’s occupying. If the orangutan’s shape doesn’t cover enough pixels, its true temperature can’t be distinguished—something known as the spot size effect. The astronomers calculated they’d have to fly no higher than 90 meters above an orangutan to resolve it—a height just above the trees’ crowns, some of which reached 65 meters.

The lower flying heights required to combat the spot size effect limits the coverage area for smaller animals, but the data can still be valuable. In 2017, the group flew at a height of just 20 meters as they searched for riverine rabbits—one of the most endangered mammals in the world—in South Africa. They ended up with five sightings, which is remarkable considering their entire population is estimated at just 1,500 individuals.

In order to see fainter and smaller astrological objects, astronomers maximize their signal-to-noise ratio by extending observations over hours, sometimes even stacking exposures with the cumulative time of days. Unlike celestial bodies, animals don’t tend to stay in one place, so improving the likelihood of finding an animal requires other techniques.

Instead of taking longer images, astro-ecologists increase their signal by choosing the time when they observe. At night, the ground environment is coolest, increasing the temperature difference between object and background. Some countries and many conservation areas have laws restricting drone usage at night, so the group often chooses to observe in the morning just after dawn, when the ground is still relatively cool.

Longmore wondered about the efficacy of detecting animal heat signatures in the warm humid environment of a jungle. “We were a bit worried,” he said. “But we are happy to see that even in these very hot, humid environments the orangutans are still detected by the thermal cameras.”

Of course infrared data doesn’t guarantee detec-
Astronomers are used to working with infrared cameras specifically tailored to their needs. But commercially available infrared cameras are often designed for industry work, such as in glass and plastics manufacturing—not for the intent of tracking endangered animals. The microbolometer used by the LJMU group was specifically designed to measure the spectral band from 7.5 to 13.5 micrometers, with a scene temperature range spanning nearly 600 degrees Celsius. As a result, certain calibrations need to be made for use in astro-ecology.

“The cameras are optimized to work over a very large [temperature] range,” Longmore said. “We’re trying to find the ways to optimize the camera to work for the purposes that we’re doing in conservation.”

To identify different species by their thermal image, the data needs to resolve differences as small as 0.5 degree Celsius. Additionally, since wide-angle lenses are used for infrared imaging, the researchers also have to account for the drop in sensitivity of the microbolometer around the edges due to imperfect optics. The FLIR cameras have autocorrections and calibrations preprogrammed, but additional adjustments were needed to enhance the data for animal tracking.

The optimizations they developed were largely drawn from three concepts taken from astronomical imaging: flat fielding, stacking, and binning. Flat fielding allows the researchers to characterize the sensitivity of each element of the array. By additionally stacking multiple images of a uniform temperature source, the researchers can average the images and account for stable noise. Binning, or averaging neighbor pixels, can also help reduce spatial noise in the images. By adding these techniques to their data processing, the group found they could correct most of the large structure noise, improving image quality. However, issues of nonuniform noise are still challenging to correct.

So far one camera has been optimized, and the group is working to see if they can develop a generic calibration applicable to other instruments. The astro-ecology group has also adjusted how frequently calibration images should be taken to optimize their data for their aerial applications.

Ambient temperature, for example, can affect camera sensitivity. “If you’re flying a drone, then you’ve got wind that’s keep keeping your camera cool,” Longmore said. “You might need to do fewer [calibrations] than if you had a different environment.”

The cameras in the orangutan study were flown aboard a Tarot X4 drone, a type of drone with four rotors designed for aerial photography. These types of drones are useful in testing as they can hover and allow for controlled movement. The group has also used fixed-wing drones, which have much better battery life. Fixed-wing drones, which look like small airplanes, are advantageous when covering large areas, but also require constant forward motion and an open area for takeoff and landing.

The LJMU group has taken their instruments around the world. The first proof-of-concept tests were done over an English cow pasture. Since then, they have flown in Mexico looking for spider monkeys, South Africa to find riverine rabbits, Tanzania to spot poachers, Madagascar in search of bamboo lemurs, and Brazil to find river dolphins, in addition to the work with orangutans in Malaysia.

“We’ve discovered that different species of animal have a unique thermal profile as well as being different shapes and sizes,” Burke said. “And we’re training a machine-learning algorithm to recognize different species of animal automatically.”

Automatic identification and large data sets are both things astronomers are familiar with. The Pan-STARRS survey, which continually looks for moving and variable objects, has created over 1.6 quadrillion bytes of data, and the upcoming Square Kilometer Array is expected to produce even more—a quintillion bytes of data every day. With this data deluge, automated systems are necessary to reduce data and flag potential objects of interest.

Animals are found in environments with nonuniform background temperatures, making them hard to identify through thresholding—a common technique in astronomy that flags objects above a certain contrast level. Instead, the LJMU group has adapted machine-learning algorithms from more complex astronomical identification programs to better identify animals and distinguish them from other false sources, like a hot rock warming on a sunny day.

The programming for the calibrations and machine learning is done in Python and entirely open source. The hope is that game wardens and other conservationists will be able to use such setups to easily find and monitor animals. The drones and cameras are also all modified from off-the-shelf units, making them affordable and accessible.
The group is also exploring beyond conservation to issues related to climate change and safety. They’re looking at applying the same technology to search and rescue planning, monitoring wildfires, and identifying underground peat fires.

“None of the stuff we’re doing in and of itself is hugely groundbreaking,” Longmore said. “It’s the piecing together of lots of different bits from different areas.”

Groundbreaking or not, the synergy of astronomy and ecology is steadily expanding the scope of environmental monitoring. And with an increasing number of possible applications, both in ecology and astronomy, the technology seems bound only by the imagination.

MARA JOHNSON-GROH is a freelance science writer and photographer who writes about everything under the Sun, and even things beyond it.
Far-infrared sensors will play an important role in overcoming some of the problems that plague sensor platforms on autonomous vehicles

By Mark Venables

THE RACE IS ON TO CAPTURE THE LUCRATIVE autonomous vehicle (AV) market: traditional auto-makers such as Volvo, Mercedes, BMW, Audi, Toyota, GM, and Ford are vying with new market entrants Apple, Uber, Waymo, Oxbotica, and Baidu. To meet the definition of a fully autonomous vehicle it must be able to navigate without human intervention, to a predetermined destination, over roads that have not been adapted for its use. The prize at the end of the day is massive. According to New York-based Kenneth Research, the global self-driving car market will expand at an annual rate of 36.2 percent, leading to global revenue of $173.15 billion by 2023.

Self-driving car systems utilize vast amounts of data from image-recognition systems, along with machine learning and neural networks, to build systems that can drive autonomously. The race for the fully AV continues, but the current state of sensing technology is hampering its commercialization. Sensor problems have been blamed for several accidents in recent years.

In March 2018, an Uber autonomous Volvo SUV killed a woman in Tempe, Arizona, in what was the first reported crash involving an AV and a pedestrian. A year earlier, Uber suspended tests after one of its autonomous vehicles was involved in a multivehicle collision, although on this occasion there were no serious injuries. In 2016, the California Department of Motor Vehicles ordered all Uber AVs off the road after several were filmed running red lights.

Uber is not the only company to suffer problems with AV technology. Also in 2016, the first death attributed to an AV occurred in Florida when the autopilot sensors on a Tesla Model S failed to detect an 18-wheel truck and trailer; the driver was killed in the collision.

TRADITIONALLY, FOUR TYPES OF SENSORS form the AV toolkit—video cameras, radar, ultrasonic sensors, and lidar. Radar uses radio waves to detect objects, while lidar uses light waves. Because of the shorter wavelengths, lidar is more accurate than radar, although the latter is used in applications where detection distance is critical, but not the exact size and shape of an object. Each type of sensor has its limitations, whether it be glare that distorts video, radar's poor vision abilities, ultrasonic's distance challenges, or lidar's inability to cope with poor weather. For the autonomous vehicle to be roadworthy, its perception must be accurate enough to enable the classification of any object at a variety of distances.

The answer could be in far infrared (FIR) thermal sensors, which give vehicles complete reliable detection of the road and its surroundings. Numerous companies have been developing FIR camera systems that can see people and objects in extremely challenging conditions. It is a solution that meets the approval of Tesla CEO Elon Musk, who recently proclaimed that he does not have the right sensor suite available, and FIR could be the answer.
Israel-based startup AdaSky is one such company with an infrared solution. Their Viper thermal sensing camera passively collects heat signatures from nearby objects, and converts them into a VGA video, and computer vision algorithms detect and classify the objects.

“Unlike other sensing options, thermal sensors do not require any light to accurately detect, segment, and classify objects and pedestrians and are therefore well suited to improve AV systems safety drastically,” Raz Peleg, AdaSky sales director, explains. “Far-infrared sensors can deliver reliable, accurate detection in real time and in any environmental condition because they access an additional layer of information that the other sensors do not. While radar and lidar sensors transmit and receive signals, a FIR camera passively collects signals by detecting the thermal energy that radiates from objects.

By sensing this infrared wavelength that is far longer than visible light, FIR cameras access a different band of the electromagnetic (EM) spectrum than other sensing technologies do.”

Infrared radiation operates at the lower end of the EM spectrum and is therefore invisible to the human eye. The infrared section of the electromagnetic spectrum is found between the visible waves and the microwaves. The infrared wavelength is between 0.75 and 1000 µm and is separated into three regions: near-infrared from 0.75 to 3 µm, mid-infrared from 3 to 8 µm, and far-infrared above 8 µm—although there is some disagreement about these ranges in the literature. The infrared window that is commonly used in low-cost thermal imagers spans 8–14 µm wavelengths, also known as LWIR (long-wave infrared). Thus, the FIR camera can generate a new layer of information, making it...
an all-weather solution that enables AVs to detect objects that may not otherwise be perceptible to radar, cameras, or lidar.

“It’s also worth noting that FIR’s passivity offers another advantage to autonomous vehicles: no interference,” Peleg adds. “Because lidar and radar are active, energy-emitting modalities, the lidar and radar installed and functioning on one vehicle may interfere with and upset that of another passing vehicle. Conversely, as a passive technology, FIR can work to detect a vehicle’s surroundings without ever upsetting the sensors of other vehicles.

INTEGRATING INFRARED technology into autonomous or standard road cars is the task of tier one suppliers, such as Sweden-based Veoneer, who put together a complete sensing platform with the software algorithms required to combine the data from the range of sensors with GPS information. Although these sensor systems will be the brain of future autonomous cars, they are also very much part of today’s cars, delivering advanced driver assistance systems. Veoneer has sensor systems on BMW, Audi, Mercedes, Bentley, Rolls Royce, Peugeot, Cadillac, Porsche, and Lamborghini, and is working with new market entrants as well.

Veoneer’s thermal sensing system uses an infrared camera mounted in the front grille of the vehicle that senses heat differences as sensitive as a tenth of a degree to create a highly detailed thermal image of the world out in front of the vehicle. An onboard computer runs custom algorithms to detect animals, pedestrians, and cyclists up to 100 meters ahead of the vehicle and reacts in less than 150 milliseconds to detect and highlight them on an in-car display. Thermal sensing systems help drivers see objects three to four times farther than the vehicle headlight range and improve visibility in fog, smoke, and oncoming headlight scenarios.

“When the carmakers that we work with recognize that they need thermal imaging,” Stuart Klapper, senior director at Veoneer, explains. “Vision at night is clearly a problem with 69 percent of all pedestrian traffic fatalities occurring at night, over 4,000 a year. Now, as we enter into autonomous vehicles, the problem becomes even greater because when you have a human in the loop, they could react to critical use cases that are not easy to experience if you’re in an autonomous vehicle.”

This means AVs must have more information and better redundancy to continually be able to handle all those situations. Night driving is particularly problematic. “Vision cameras do not have enough resolution in clarity at night,” Klapper adds. “Shadows on the road and oncoming headlight glare add to the complexity, making it difficult for a vision camera to be able to detect objects. With radar, sometimes you can get information that there is something ahead, but you cannot classify what that object is. The same is valid with lidar; it is excellent at 360-degree awareness, but there are many vital situations where it cannot classify an object.”

The only technology capable of reliably seeing objects at night, especially humans and animals, is a far infrared camera system. There is much discussion about why the Uber vehicle hit the pedestrian at night in Arizona, but one thing that most agree on was that if there had been a thermal device on the vehicle, there would have been a better chance to avoid the accident.

THE BIGGEST CHALLENGE FACING AV MANUFACTURERS right now is safety. “Many of the manufacturers are making systems that are very effective in normal roadway conditions; however, where these systems struggle is what we call corner cases and challenging lighting,” says Paul Clayton, general manager at FLIR OEM and Emerging division.

The current AV sensor suite has a performance gap in low light and darkness. Corner cases refer to those relatively uncommon, but genuine scenarios that human drivers can typically negotiate but pose significant problems for AV systems. “At the moment, the industry is focusing on solving those complex and less common roadway scenarios, which require more sensor technology and better algorithms,” Clayton adds.

The general feeling from the automotive industry is that the existing suite of sensors deployed on autonomous vehicles today has proven to be insufficient for all conditions and roadway scenarios. “That is why automakers and suppliers have begun to examine complementary sensor technology, including thermal cameras, or what we call long-wave infrared cameras,” Clayton says.

“FLIR sees thermal imaging as a complementary technology that improves upon the prevailing sensors by offering a parallel and redundant dataset to help improve the automated decision making on the vehicle system while also adding new data that the prevailing sensor system cannot detect—heat energy,” Clayton adds. “That heat energy, or infrared radiation, constitutes a different part of the electromagnetic spectrum that the other sensors do not capture, be it lidar, visible, ultrasonic, or radar sensors.”

In essence, thermal imaging enables the autonomous car to see warm objects, which is everything above ~273 degrees Celsius. Thermal cameras allow the AV to see the things we least want to hit, no matter if the vehicle is in complete darkness, in cluttered city environments, facing the direct sun, or headlight glare.

To bring AVs to the mass market, the consensus amongst developers is that each vehicle will need to be fitted with a multisensor platform. In order to deliver the complete detection capabilities required, carmakers are leaning towards adopting multiple FIR sensors that will deliver the highest possible levels of safety. FIR is seen as the enabling sensor for full autonomy because, in addition to its impressive sensing capabilities, the technology is also uniquely affordable for mass market deployment. Many within the industry are predicting that it could be the final piece in the AV puzzle, hastening the advent of an autonomous future for driving.

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A handful of biological species can detect infrared radiation. Envious of this evolution-honed sensory superpower, researchers with technological visions are working to emulate it.

Photo Credit: Volker Steger/Science Photo Library
GANG HAN HAD A GREAT 2019. In September, he was promoted to full professor at the University of Massachusetts Medical School in Worcester. And in April, he and a team of colleagues at several Chinese research institutions published a sensational paper in the journal *Cell* that earned them extensive media attention and even a shoutout from Francis Collins, the longtime director of the National Institutes of Health. Referring to a preprint version of the *Cell* paper in a March posting of his NIH Director’s Blog, Collins wrote, “In a dramatic advance that brings together material science and the mammalian vision system, researchers have just shown that specialized lab-made nanoparticles applied to the retina, the thin tissue lining the back of the eye, can extend natural vision to see in infrared light.”

Not human infrared vision. Not yet, anyway. So far, Han said in December in a dark meeting room in Boston at the Materials Research Society meeting, his team has bestowed IR vision on what Han referred to as “supermice.” In a subsequent interview, Han acknowledged that the plan is to take necessary steps, through a series of primate studies and then by navigating relevant ethical and regulatory challenges, to develop a safe technology that would modify peoples’ eyes to directly see IR without any bulky goggles or other optical gadgetry. It’s the sort of superpower that brings soldiers and first-responders to the mind’s eye. If the researchers succeed in delivering this human vision-enhancement technology, then people will join what always has been a rarefied and enviable club of the living kingdom that can see infrared (IR) radiation.

**CONSIDER SEVERAL SHRIMP SPECIES**

that thrive at pitch-dark depths up to two miles in the Mid-Atlantic Ridge. That’s where they feed on sulfur-metabolizing microorganisms that for eons have been making a living near hydrothermal vents that spew sulfur-rich water at searing temperatures of 350 degrees Celsius. In this utter darkness, the arthropods avoid becoming flash-boiled shrimp by virtue of an evolution-honed sensory innovation: a retina-like patch on the shrimps’ backs enables the animals effectively to see plumes of lethally hot water from a distance far enough that the animals can steer clear of them.

“They can see the edge of the hot water,” says Tom Cronin, a sensory biologist at the University of Maryland, Baltimore County. “The water comes out in a lamellar flow so there is a hard border between the really hot water and the colder surrounding water.” To the shrimp, the hot plumes of water might appear like gaudy illuminated fountains in a background of profound blackness.

For most people who have heard about IR vision in animals, it’s usually in the context of snakes, most likely pit vipers such as rattlesnakes, copperheads, and bushmasters. It was only in the 1930s that scientists began to get an inkling of the biological roles played by what were then still mysterious apertures on the faces of these and certain other snakes. It was in 1935 that Margarete Ros noticed that her pet African Rock Python paid special attention to warm objects she placed in its terrarium but would lose some interest in the same objects when she clogged her pet’s facial pits—later to be called “pit organs”—with petroleum jelly.

Since Ros’s pioneering observations, a lineage of pit-organ researchers has teased out much about how these master examples of natural infrared sensing technology work and how these IR sensors equip their serpentine owners with vision specialized for hunting. The pit organs differ in structure among the three groups of snakes known to have them. They range from nearly pitless infrared sensory areas on the faces of boas, to the broad pits with retina-like sensory floors of pythonid snakes like Ros’s pet, to the suspended in-pit sensory membranes of the pit vipers. The latter’s pit organs, the most sensitive of all among snakes, work like pinhole cameras and probably enable a kind of IR imaging, states University of Geneva herpetologist Andrew Durso in his blog *Life is Short, but Snakes are Long*.

Neurophysiological recordings have revealed that the pit organs respond most vehemently at IR wavelengths of about 8–12 microns, the wavelengths emitted by living mice and other potential meals. The IR-triggered neuronal signals originating in pit organs combine downstream in the snake’s brain.
with signals from the reptiles’ laterally located eyes into integrated optical/IR visual perception. In this way, even in dark and complex settings snakes with pit organs can track mice and other warm prey.

The pit organs’ structural and material details embody the engineering brilliance that evolutionary forces can yield. Among these are arrays of depressions less than a micron deep and few microns across that, as the late Richard Goris, who had been a herpetologist and neuroanatomist at Yokahama City University in Japan, explained it the Journal of Herpetology, “efficiently disperse wavelengths centered at 500 nm, while allowing free passage of longer infrared wavelengths.” Tiny dome-like details in some pit organs prevent infrared rays from scattering back out of the pit organs thereby preserving information about the environment that otherwise would literally escape the animal. “For maximum efficiency,” Goris noted, “the pit organs must be able to fend off, weaken, or dissipate all extraneous wavelengths.”

The Members of Biology’s IR Club that perhaps have inspired the most technological ambition are collectively known as fire-loving or pyrophilous insects, mostly beetles. These insects show up by the thousands at forest fires as the conflagrations burn themselves out. These insects also have been assumed to follow the heat to fires at chemical plants and oil refineries, a less biologically profitable behavior that nonetheless provided some of the evidence of these insects’ IR sensitivity.

Scientists have identified at least 17 pyrophilous beetle species among the roughly million known insect species. For pyrophilous beetles, trees freshly killed by fire serve as safe havens that further the cause of procreation. “The freshly burnt area serves as a meeting place for both sexes and, after copulation, the females start to deposit their eggs under the bark of burnt trees,” Helmut Schmitz, a longtime researcher of pyrophilous beetles at the Institute of Zoology at the University of Bonn and his colleagues, state in one of their papers. Subsequently, the larvae feed on the wood and emerge in a year or two as the next generation of fire beetles. For their part, the adult beetles rely on their exquisitely sensitive IR sensors to locate forest fires many kilometers away.

Found in the various but related anatomies of the IR-sensing beetle species are at least three different types of receptors. Little ash beetles (Acanthocnemus nigricans), for one, sense IR with a pair of sensilla-lined discs in their prothoracic segment, which is adjacent to the head. Australian fire beetles (Merimna atrata) sport their trough-shaped IR organs in the cuticles of their abdominal regions. In a 2018 paper in PLOS One, Schmitz and coworkers reported experiments that revealed these beetles apparently use their IR organs to avoid depositing the eggs in what would be lethally hot spots in freshly burned wood. For 11 species collectively known as black fire beetles (Melanophila
A microscopic view of the pit viper infrared receptor organ.

genius), a single IR organ comprises about 70 tiny dome-shaped sensilla (each one with an accompanying pore-riddled wax gland) in a pit structure in the metathorax (a shoulder-like location). This is the type of sensor that Schmitz and coworkers have been aiming to emulate. Each individual sensillum has a complex, fluid-filled interior pressure chamber that includes the dendritic end of a single sensory neuron feeding neurodata about IR in the environment into the insect’s central nervous system.

The current view on how a sensillum works is that it behaves like mechanoreceptor. When infrared radiation impinges on a sensillum’s stiff dome, it heats it up. This has the effect of raising the interior pressure of each liquid-filled sensillum’s microanatomy and consequently puts a squeeze on the more compliant neuronal dendrite that innervates each structure. This, in turn, activates receptors on each neuron that act as gateways for ions. The changing ionic traffic leads to the firing of these neurons and thereby a relay of signals about the IR environment into the insect’s brain. Data from years of research, much of it by Schmitz and various colleagues, portray this mechanoreceptive system as one of astonishing—though still undetermined—IR sensitivity, including in the infrared wavelength range of 2.8 to 3.5 microns.

THE WAVELENGTHS THE SENSILLA respond to map onto the IR emissions of forest fires and that has inspired Schmitz and others with technological visions. A combination of experimental measurements, modeling, and calculations indicate a sensitivity that could be 500 microwatts per square centimeter or possibly an even much lower threshold. The more conservative sensitivity is good enough, Schmitz and colleagues calculate, to detect a 20-ha forest fire—with areal dimensions comparable to the height of the Empire State Building (about 450 meters)—from 12 kilometers away. It’s possible the beetles can detect fires from ten times that distance.

This detection range would be an improvement over commercially available uncooled bolometer infrared sensors currently used for fire detection. In a 2018 paper published in the journal Micromachines, Schmitz and his colleagues outline their vision for building wide-area fire detectors using what they call “beetlecopters”—drone-mounted sensors that mimic the IR-sensing ways of Melanophila beetles.

In a warming world ever more wrecked by forest fires, the disaster prevention and response communities surely could benefit from better and widely deployable fire-detection systems, but Han has his sights on human beings with what he calls “the superpower of IR vision.” At the MRS meeting, he wowed his audience with videos of the IR-seeing “supermice” his team has created. At the heart of the achievements are so-called “photoreceptor-binding upconversion nanoparticles” (phUCNPs). These nanoantennae particles are made with rare-earth ingredients that absorb invisible infrared light and convert it into visible green light. To the same nanoparticles, the researchers also attach organic components that effectively glue the nanoparticles to the outer segments of retinal photoreceptor cells. When the researchers injected these tiny IR nanoantennae into the eyes of mice (using standard clinical optical injection techniques, Han assured his audience), the nanoantennae bound like Christmas-tree decorations to the rods and cones of the animals’ retinas.

Physiological and behavioral tests comparing the eye-modified mice with unmodified cohorts were telling. The pupils of the “supermice” dilated when the researchers shined IR light into them, while the pupils of unmodified mice showed no response in the same test. Moreover, given a choice to occupy either a dark compartment or one “lit” up with infrared light, the supermice consistently opted for the dark compartment. Mice prefer dark places. Mice with untreated retinas randomly explored both compartments, which suggests both compartments appeared equally dark to them. These results indicate that the nanoparticles enable the mice to see IR as light.

In an interview, Han said he is working on organic dye molecules that he thinks will smooth the way to tests with people, who he expects will one day join biology’s infrared-seeing club. “These should be safer and brighter” than the nanoparticles, Han said, noting that the technology could open the way to soldiers with IR-sensing retinas and IR-seeing first responders who might be able to spot survivors of collapsed buildings. More uplifting, however, was Han’s musings about looking up at the night sky with eyes modified to see infrared radiation. “This could let us see a more beautiful view of the universe for us,” he said.

IVAN AMATO is a writer, editor, podcaster, and science cafe organizer in Hyattsville, Maryland.
ONE OF THE TRUE JOYS OF BEING AN SPIE OFFICER IS VISITING WITH student chapters around the world. When traveling we often try to add an SPIE Student Chapter visit or two. The students we meet are always incredibly welcoming, excited, and proud to share their research and stories. You can’t come away anything but impressed, reinvigorated, and certain that the future of our field is in good hands.

SPIE has often relied on our Student Chapters to provide much of our community outreach, especially for K–12 schools, and they do a wonderful job. In many cases, the Student Chapters also organize the social activities of the students. However, there is a realization that the SPIE Student Chapter program is not doing enough for the professional development of the students in the time leading up to the biggest professional transformation in their careers—leaving school and getting a job.

One of my goals is that SPIE develop materials or programs for students to help prepare for this transition while they are still in school. How can we help them hit the ground running? Can we help instill the values of what it means to be a professional and the associated work habits? Perhaps we need to help faculty with these tasks.

Once a student has graduated, their primary focus must be to establish successful careers. It is perhaps natural that they step away from the broader professional society, but it may not be wise. A new support network and resource group is needed. To this end, SPIE has established a reduced-rate voting membership for Early Career Professionals (ECP). It allows continued participation through this transition period and the interaction with potential mentors and collaborators.

Just as important for ECPs is to try to attend and present at conferences. Volunteering to serve on a conference committee can further expand your professional network and can possibly lead to future conference or committee leadership opportunities.

I believe that my career has greatly benefited by being a Society volunteer. I have met and become friends with people who I would never have met without being a participant. So, I give the following advice to anyone at any level, but especially to ECPs:

Get involved, be involved, stay involved!

JOHN E. GREIVENKAMP
2020 SPIE PRESIDENT, president@spie.org
# SPIE Deadlines and Events

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SPIE Awards Announced

SPIE Early Career Achievement Award–Academic
Vivian Ferry, assistant professor in the Department of Chemical Engineering and Materials Science at the University of Minnesota, in recognition of her contributions to the understanding of light-matter interactions in solar energy conversion, and the development of optical materials for plasmonics, metamaterials, and nanocrystals.

SPIE Early Career Achievement Award–Academic
Gordon Wetzstein, assistant professor of electrical engineering at Stanford University and leader of the Stanford Computational Imaging Lab, for his outstanding contributions to computational imaging and display technologies at an extremely early stage of his career.

SPIE Early Career Achievement Award–Government/Industry
SPIE Member Sona Hosseini, early-career planetary scientist at the NASA Jet Propulsion Laboratory (JPL), in recognition of her innovative optical design work on ultraminiature heterodyne spectrometers.

SPIE Early Career Achievement Award–Government/Industry
SPIE Senior Member Nishant Mohan, vice president of the Optical Coherence Tomography (OCT) Division at Wasatch Photonics Inc., for his innovative work in improving vision and eye health by development of novel contact lenses and OCT instrumentation.

SPIE María J. Yzuel Educator Award
SPIE Fellow Kathleen Richardson, Pegasus Professor of Optics and Materials Science and Engineering at CREOL/College of Optics and Photonics, in recognition of her sustained contributions to global research, education, and training in optical materials.

SPIE Maria Goeppert Meyer Award in Photonics
John H. Lehman, physicist and head of the Sources and Detectors Group in the Physical Measurement Laboratory’s Applied Physics Division at NIST, in recognition of the development of innovative tools for laser power and energy measurements spanning ultraviolet to THz wavelengths and from sub-micro-Watt to multi-kiloWatt power levels.

See the entire list of SPIE Award Winners at spie.org/2020awards
2020 Prism Awards

On 5 February at the annual Prism Awards, held during SPIE Photonics West in San Francisco, SPIE and Photonics Media honored the best groundbreaking light-based innovations on the market in nine categories.

COMMUNICATION

Innolume
The CW Datacom Laser, a high-power, distributed feedback (DFB) laser features up to 180 mW at 100 °C. It can provide 100 mW at the fixed current in the 25–100°C temperature range, making it an attractive light source for uncooled operation. By enabling lower channel costs, CW Datacom Laser will increase the ability of data centers to handle burgeoning demand.

ENERGY

Prisma Photonics
Electrical overhead power lines constitute a global six-million-kilometer network. Monitoring this massive network for predictive and preventive maintenance, safety, and security, is certainly valuable, but installing thousands of sensors is impractical. PrismaSense offers a monitoring solution of electrical transmission lines based on pre-existing optical communication cables. A single PrismaSense system can monitor 100 km of transmission lines, without the need to install any sensor on lines or towers.

HEALTHCARE

PhotonicCare
The TOMi™ Scope uses light to see through the eardrum and directly visualize fluid in the middle ear for correct diagnosis and treatment. It enables users to objectively determine the presence and density of fluid in the middle ear, providing 90 percent diagnostic accuracy, nearly doubling that of the gold standard of otoscopy (50 percent). Exam results can quickly and easily be shared with patients or placed into the EMR.

LIFE SCIENCES

TERA-print
The TERA-Fab E Series is a desktop nanoprinter based on beam pen lithography, which enables rapid prototyping and fabrication of millimeter-scale nanostructured patterns and devices with a diffraction-unlimited resolution for electronics, photonics, metamaterials, soft robotics, and biomedical applications. The platform integrates ‘state-of-the-art’ structured light illumination with ultra-precise optomechanics to enable rapid printing of millimeter-scale arbitrary designs with a diffraction-unlimited (sub-250 nm) resolution using massively parallel arrays of hundreds of thousands of independently actuatable near-field probes.

MANUFACTURING

Inspekto
The Inspekto S70 is a plug-and-play system for visual quality assurance (QA) inspection. This out-of-the-box and ready-to-go QA system can be installed in about 30 to 45 minutes without an external systems integrator or any machine vision expertise. The Inspekto S70 QA system is suitable for any handling method, product type, and material and can be installed at any point on a production line, and is easily moved from one line to another.

QUALITY CONTROL

CloudMinds
The Smart MEMs Handheld Raman X1² is a cloud AI MEMs Raman device specifically designed for area sampling. The X1² is built upon CloudMinds’ 2019 PRISM Award-winning handheld Raman X1™, but is also equipped with a MEMs scanning mirror. The design of the X1² minimizes the exposure of the laser beam to samples, so it can be used for samples that tend to be burned or ignited by lasers.

SAFETY & SECURITY

Pendar Technologies
The Pendar X10 is a rugged, handheld, point-and-shoot system that can identify almost any material from up to a meter away without the need for eye protection. The Pendar X10 allows for rapid chemical identification, including highly fluorescent, dark, and sensitive materials. No sample contact is required; measurements can be taken through plastic bags or windows.

TRANSPORTATION

Outsight
The 3D Semantic Camera combines two hardware and software breakthroughs: a new broadband high-power laser source (SWIR band) with embedded software that provides classification and object detection without requiring machine learning. The camera uses hyperspectral analysis and simultaneous localization and mapping (SLAM) technology to identify surrounding objects and analyze road conditions.

VISION TECHNOLOGY

WaveOptics
With its waveguide technology, WaveOptics seeks to solve three of the biggest challenges in scaling AR wearables: design, optical performance, and low-cost mass manufacture. This technology features a large eye-box and patented 2D pupil expansion methods for binocular viewing with a wide field of view. Images are clear, crisp, and high contrast, and text is undistorted. Waveguides transfer the light waves from the light source and project them into the user’s eye, enabling the digital image to be overlaid onto the real world. The waveguides are lightweight and designed specifically to integrate into AR wearables.
SPIE Offers Child Care Grants to Give Parents Equal Opportunity to Attend Its Meetings

TRAVELING TO MEETINGS or conferences can present challenges to parents of young children. As part of SPIE’s commitment to family-inclusive support, the Society has created grants to give parents equal opportunity to share their research at SPIE meetings.

The SPIE Childcare Grants are designed to supplement the cost of childcare for SPIE Members who are registered to attend one of our annual meetings. Grants of up to $500 will be made in the form of reimbursements for expenses related to childcare of children under the age of 13 during the duration of the meeting. The grant can cover costs for childcare at the conference or at home.

“It is vitally important for researchers with young children to be able to participate in the scientific community,” says Michelle Povinelli, of University of Southern California. “For junior faculty on the tenure track in particular, there is an urgent need to promote and share results at conferences. This early-career period often coincides with the birth of young children. These grants will help ensure that parents can continue to travel to conferences during a vital period in their career development.”

The application system for the 2020 SPIE event cycle is now open: spie.smapply.io/prog/2020childcare

2020 DCS Rising Researchers Announced

THE RISING RESEARCHER PROGRAM recognizes early-career professionals who are conducting outstanding work in product development or research in the areas of defense, commercial, and scientific sensing, imaging, optics, or related fields. This year’s recipients are presenting papers at SPIE Defense + Commercial Sensing (DCS) 26–30 April in Anaheim, California.

“The work of these young scientists—from across academia and government–industry hybrids—represents a high level of excellence that we are proud to showcase at our symposium,” says SPIE Director of Science and Technology, Bob Hainsey. “This year’s winners reflect the diversity of the SPIE DCS constituents as well as the breadth of the related technical content, with our Rising Researchers covering disciplines that include infrared optics, single photon counters, biomedical sensors, metamaterials, and cubesats.”

The 2020 DCS Rising Researchers, their affiliations, and conference paper titles are:

» Jonathan Fan, Stanford University
  “Data-driven design of metasurface systems”

» Tian Gu, Massachusetts Institute of Technology
  “High-performance reconfigurable meta-optics based on optical phase change materials”

» Sevgi Gurbuz, University of Alabama
  “Cross-frequency training with adversarial learning for radar micro-Doppler signature classification”

» David Haefner, US Army CCDC, C5ISR Center, NEVSD
  “High throughput thermal camera characterization”

» Gillian Kyne, Jet Propulsion Laboratory
  “Single photon counting detectors: TRL advancement of EMCCDs”

» Howard (Ho Wai) Lee, Baylor University
  “Extreme epsilon-near-zero on-chip and on-fiber photonic devices”

» Beiwen Li, Iowa State University
  “Similarity evaluation of 3D topological measurement results using statistical methods”

» Nicole Pfiester, Ohio State University
  “Optical properties of III-V superlattices for the design optimization of antenna-coupled detectors”

» Matthew Smith, Jet Propulsion Laboratory
  “ASTERIA: Technology and Science Advances from a Nanosatellite Space Telescope”

» Christopher Valenta, Georgia Institute of Technology
  “Towards single aperture RF/EO/IR systems: multi-spectral sensing and communication”

» Paul Williams, Stellenbosch University
  “Classification of game meat with NIR hyperspectral imaging”

» Sheng Xu, University of California, San Diego
  “Hybridized electronics for wearable healthcare: from the skin to below the skin”

» Cunjiang Yu, University of Houston
  “Rubbery electronics: electronics made fully out of rubbery materials”
SPIE Endowment Matching Program Establishes Graduate Scholarship at CREOL

AT PHOTONICS WEST 2020, SPIE announced the establishment of the SPIE-Glebov Family Optics and Photonics Graduate Scholarship Fund for the University of Central Florida (UCF) College of Optics and Photonics (CREOL). The $325,000 in funding from SPIE will be matched in full by the College’s Research Foundation and the Glebov family to create scholarships for graduate students at CREOL in Orlando.

“We are delighted to join with the Glebovs in creating a scholarship fund that will exist in perpetuity to help support the next generations of scientists and engineers who will create the future using optics and photonics,” said SPIE CEO Kent Rochford.

“With the matching funds from SPIE, the Glebov family’s gift creates a fully endowed scholarship for our graduate students. The scholarship will have immediate impact for our current students and will help us recruit the brightest minds in optics and photonics. SPIE support magnifies the impact of the gift and advances the future of this exciting field,” said Dr. David Hagan, Interim Dean of UCF CREOL.

The SPIE Endowment Matching Program, established in 2019, is a $2.5 million, five-year, educational-funding initiative designed to increase international capacity in the teaching and research of optics and photonics.

LUKE LONG RECEIVED THE $10,000 Nick Cobb Memorial Scholarship for his potential contributions to a field related to advanced lithography.

The Nick Cobb scholarship recognizes an exemplary graduate student working in the field of lithography for semiconductor manufacturing. The award honors the memory of Nick Cobb, who was an SPIE Senior Member and chief engineer at Mentor. His groundbreaking contributions enabled optical and process proximity correction for IC manufacturing.

“As we in the community recognize, photolithography has enabled immense technological innovation, overcoming many scientific and technological barriers along the way,” says Long, who is pursuing his PhD degree in the physics department of the University of California at Berkeley. “Now, as device scale approaches the nanometer regime, the quantized nature of light-matter interaction poses significant new challenges to future device scaling. It is an honor to win the Nick Cobb scholarship in recognition of my work on understanding EUV stochastics and serves as motivation going forward for furthering our understanding of this challenging subject. I am excited to utilize the support to continue my research, and to present my results at SPIE conferences in the coming year.”

Long received his award certificate at the SPIE Advanced Lithography Symposium in February in San Jose, California.

SPIE Senior Members

DID YOU KNOW that SPIE Senior Membership is a prerequisite to becoming an SPIE Fellow? SPIE Senior Members are Members of distinction honored for their professional experience, their active involvement with the optics community and SPIE, and/or significant performance that sets them apart from their peers. Nominate your colleague for SPIE Senior Membership and put them on a path of recognition. Senior Membership nominations are due 15 March 2020. Learn more at spie.org/seniormember
Reflections

These star trails were photographed in the Maranjab Desert of Iran. The dot effect of the star trails is achieved through multiple timed exposures. As a result of light interference from the repeated stripe pattern, a Moiré pattern appears in the bottom center of the image.

Photo by Nima Asadzadeh, @nima.asadzadeh
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