OPTICS & PHOTONICS NEWS

JANUARY 2013

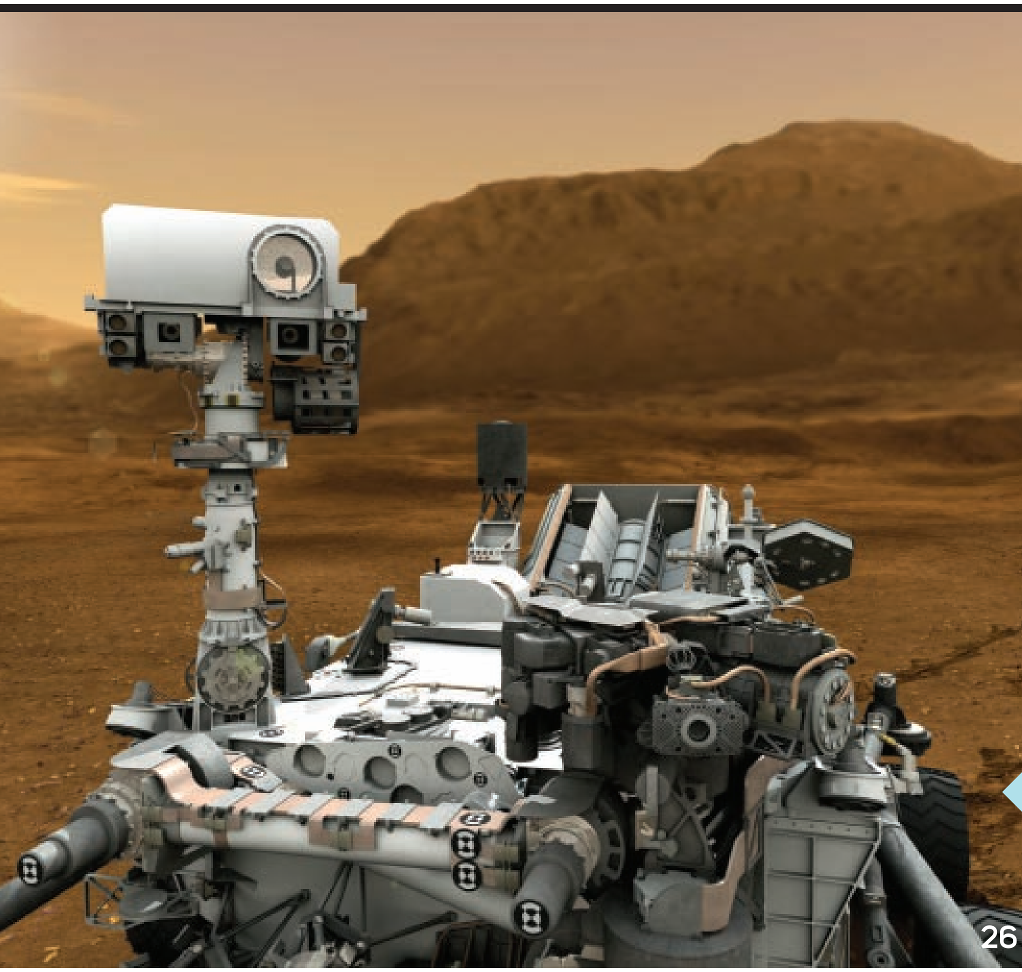
ADOLPH LOMB'S LEGACY 34

SNOW SPARKLE 42

LASERS DETERMINE RED PLANET'S CHEMISTRY

Zapping Mars

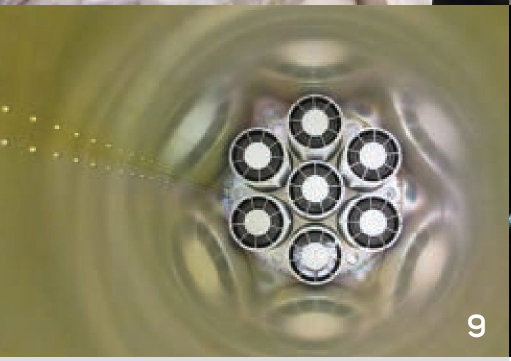
OSA®



The *Curiosity* is using laser-induced breakdown spectroscopy to detect nearly all chemical elements on Mars.

OPTICS & PHOTONICS NEWS

DEPARTMENTS



COVER: Artist's concept of the ChemCam instrument aboard the *Curiosity* rover in operation. NASA/JPL-Caltech

Scatterings

Pulses

Backscatter

President's Message

OSA's global activities continue to expand to keep up with our increasingly diverse membership. Today more than half of our members reside outside the United States. The fastest growing community is that of the student chapters: 75 percent are now in non-U.S. countries.

Although new technologies have made communications easier than ever, I still believe that meeting face to face is the best way to learn about global issues and perspectives. As an OSA officer, I have already met with OSA members and the officers of our peer societies in Korea, Mexico, China, Brazil and Australia. As OSA President, I look forward to more opportunities to meet members all over the world.

“Although new technologies have made communications easier than ever, I still believe that meeting face to face is the best way to learn about global issues and perspectives.”

A significant component of OSA's global growth is in Latin America. In just over 12 months, I have visited Mexico once and Brazil twice. At the 22nd General Congress of the International Commission for Optics (ICO-22) in Puebla, Mexico, I met a number of students from the region at an OSA student member lunch. Although ICO-22 was an international meeting, it was still an excellent chance to learn more about optics and photonics in Latin America.

Then, in July of 2012, I made my first visit to Brazil when I spoke at the Advanced School of Optics and Photonics in São Carlos, Brazil, organized by the OSA student chapter at the University of São Paulo (IFSC). Both the quality of the program and the organization were excellent, so it was no surprise to me that the IFSC Chapter won the 2012 Student Chapter Excellence Award. I made a second trip to Brazil in November, and I had the opportunity to attend IONS SA-2 at Unicamp in Campinas. The Unicamp chapter is proud to be the first Latin American student chapter. It was fascinating to hear reports from a number of Latin American student chapters about the range of their activities—from designing crossword puzzles to conducting outreach in local schools.

While in Brazil, I also attended the Latin American Optics & Photonics (LAOP) conference in São Sebastião. Sponsored by OSA and Sociedade Brasileira De Física (SBF), LAOP is a biennial conference that started in 2010. It featured about 200 presentations from researchers in 26 countries—mostly in Latin America.

One of the speakers was Carlos Henrique de Brito Cruz, scientific director of the São Paulo Research Foundation, who discussed the growth of science and technology in Brazil. From the conference talks and visits to labs in both São Carlos and Campinas, I saw firsthand the results of this development—and it is certainly not confined to Brazil. It's an exciting time for the community, and OSA is eager to play a supporting role. The next LAOP conference is scheduled for Mexico in fall 2014. I'm already planning to attend.

—Donna Strickland
OSA President

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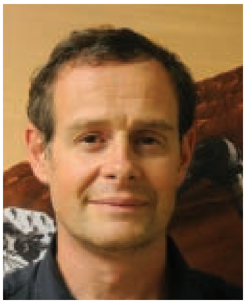
Wiens

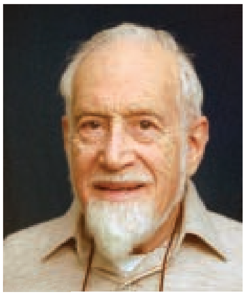

Horton


Maurice

The landing of the Mars *Curiosity* was one of the biggest science stories of the past year—and many of the rover's capabilities derive from optics, from high-tech cameras to spectrometers to lasers. Our cover article examines how the rover is using laser-induced breakdown spectroscopy to probe the surface of the red planet. "The laser technology currently operational on Mars is different from any previous one used for space exploration," says lead author **Noureddine Melikechi**. "For the first time ever, laser-induced breakdown spectra of the surface of a planet other than Earth are being measured and analyzed." Melikechi wrote the article in collaboration with colleagues **Roger Wiens**, **Horton Newsom** and **Sylvestre Maurice**.

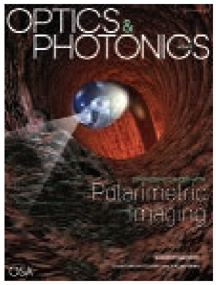
Although one of OSA's most prestigious awards is named after Adolph Lomb, the man behind the medal is a mystery for many of us. Perhaps that's because he was a shy man who preferred supporting the work of others to producing his own. Nevertheless, he had a profound influence on optics and OSA. "Adolph Lomb is a prime example that not just elite politicians, newsmakers and scientific wunderkind influence the course of history," says science historian **Victoria Meyer**. "His patronage and contributions to the field of optical science demonstrate the necessity of exploring all aspects of society and culture in the past and the unlimited potential of the individual."


Meyer


Cann

When it comes to optics in nature, it seems that rainbows, haloes and glories get all the, well, glory. But the sparkles we see in snow, diamonds and glitter are just as fascinating and far more ubiquitous. Retired engineer **Alfred Cann** decided to delve into the physics of sparkles and was surprised to learn that very little was known about them. "Around 1999, I became intrigued by sparkles on snow, figured out how they worked, and wrote a little paper about it for my grandchildren," he says.

Polarized light and cancer



Thank you for the interesting article on polarimetric imaging for cancer diagnosis (OPN, October 2012).

The experimental setup and results are quite interesting, but the article does not appear to correctly connect scattering and polarization theory. The authors' claim for small scatterers is that "backscattered light is less depolarized when the incident light is linearly rather than circularly polarized."

Size really has nothing to do with the greater circular depolarization. For backscattering, all randomly oriented particles depolarize more in circular polarizations regardless of particle size (Appl. Opt. **47**, 3795 [2008]). This is a result of integrating a single particle's scattering matrix over all possible azimuthal orientations.

Within the Rayleigh regime, depolarization generally increases with particle size. For example, nitrogen molecules are aspheric, but due to their small size, they are only weakly depolarizing at visible wavelengths. However, the amount of asphericity and index contrast also play a role in determining the particle's depolarization (Opt. Lett. **20**, 1356 [1995]). Perhaps a more likely reason that the researchers can discount larger scatterers such as cell nuclei from the depolarization signals is their being nearly spherical. (Spherical particles do not depolarize within the single scattering approximation.) Size alone certainly does not rule out depolarization, or greater circular depolarization, by larger cellular structures.

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THE AUTHOR REPLIES: We appreciate Matthew Hayman's opinion about our article. His comments might be relevant for single scattering by independent particles. Both of his cited references deal with a single scattering regime, which is quite common in lidar or radar polarimetric experiments.

However, biological tissue is a multiply scattering medium. In such media, we have to solve the problem of radiative transfer in order to find the coefficients of the tissue's Mueller matrix.

Measurements of diffuse backscattering Mueller matrices of highly scattering media and corresponding Monte Carlo simulations showed the variation of M44 values with the size of scatterers (Opt. Exp. **1**, 441 [1997]); Appl. Opt. **39**, 1580 [2000]). The characteristic length of depolarization in multiply scattering media depends on the initial state of polarization (linear or circular) and on size of particles (Phys. Rev. E **49**, 1767 [1994]).

The researchers Xu and Alfano described the mechanism of circular depolarization due to multiple scattering by particles of a large size or high refractive index in 2005 (Phys. Rev. E **72**, 065601). So, the claim that size has nothing to do with greater circular depolarization is not correct in our case.

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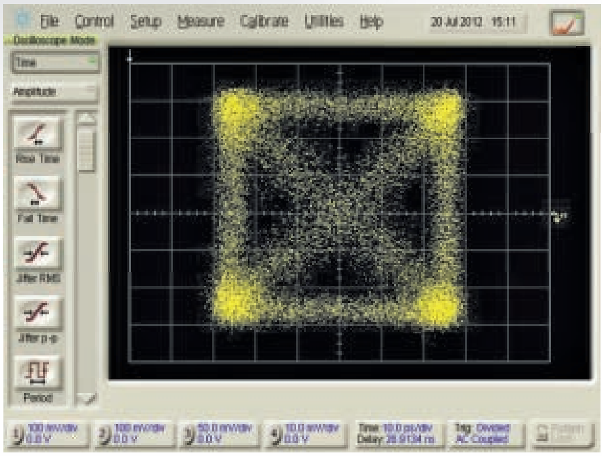

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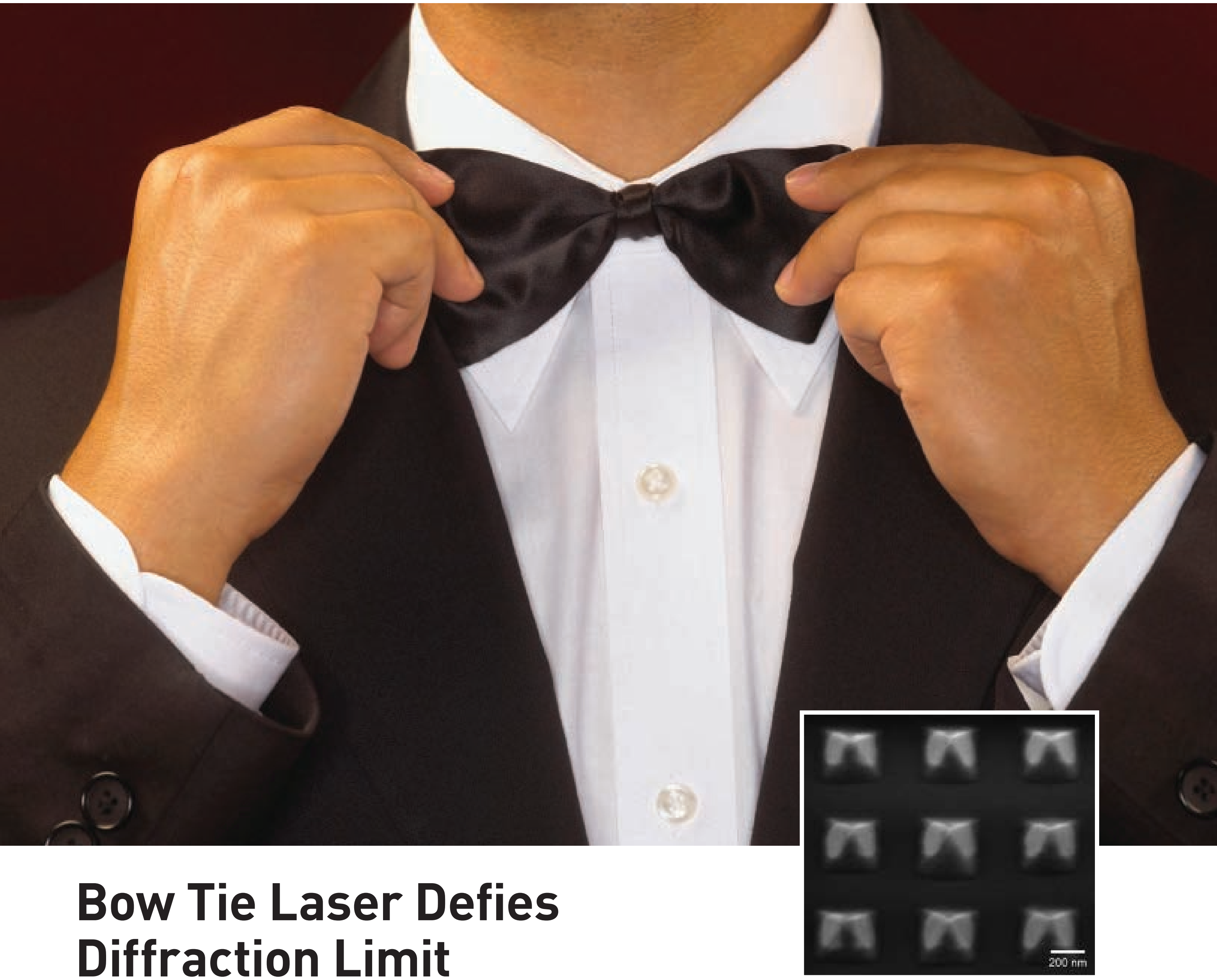


Bow Tie Laser Defies Diffraction Limit

A popular shape for a tuxedo accent may be revolutionary for laser cavities.

A virus-sized single-laser device could function below the diffraction limit, thanks to lasing cavities made of 3-D metallic nanoparticle dimers shaped like bow ties. Transient absorption measurements confirmed ultrafast resonant energy transfer between photoexcited dye molecules and gap plasmons on the picosecond time scale (Nano. Lett. **12**, 5769).

The plasmonic nanolaser designed at Northwestern University (U.S.A.) operates at room temperature and could be used with silicon-based photonic devices, all-optical circuits and nanoscale biosensors—increasing storage and processing capabilities. The metalic nanostructures support localized surface plasmons, which have no fundamental size limits when confining light.

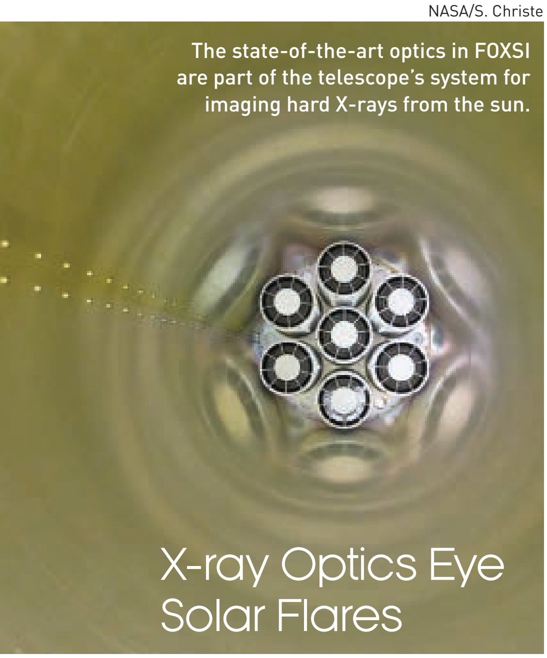
Why the bow-tie shape? For one reason, it produces an antenna effect that provides a well-defined electromagnetic hot spot in a nanosized volume. In addition, a bow tie's discrete geometry has minimal metal "losses." —*Sarah Michaud*

(Inset) Gold lasing cavities shaped like bow ties.

Courtesy of Teri Odom

Solar energy currently generates **<1 percent** of the electricity in the United States, but it is predicted to increase to **10 percent** by 2025.

NASA/S. Christe



The state-of-the-art optics in FOXSI are part of the telescope's system for imaging hard X-rays from the sun.

X-ray Optics Eye Solar Flares

Nanoflares—relatively faint eruptions from the sun's surface—were the target for the focusing optics X-ray solar imager (FOXSI) launched aboard a sounding rocket on 2 November from White Sands, N.M. (U.S.A). The six-minute flight provided a brief window for observation that will hopefully give us insight into what causes nanoflares and why the atmosphere of the sun is so much hotter than the surface.

The iridium-coated nickel/cobalt mirrors in FOXSI successfully reflect glancing X-rays toward the imager. Several of these mirrors in combination help collate the X-ray light before funneling it to the detector. The mirrors were made using a replication technique whereby a surface is perfectly polished, and mirrors are created off of that surface by nickel-plating it. This process can be repeated, thus saving time and money. *—Yvonne Carts-Powell*

Human Eye **Inspires New Lens**

Researchers turn to nature for visionary lens design.

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Fabricated lens image.

Drawing heavily on nature for inspiration, a team of researchers has created artificial lenses that are nearly identical to the lenses in the human eye (Opt. Express, **20**, 26746). These new, multilayered lenses could be a more natural replacement than current substitute lenses for damaged or diseased ones in the human eye; they may also lead to advanced surveillance technology.

This work, conducted by researchers at Case Western Reserve University, the Rose-Hulman Institute of Technology, the U.S. Naval Research Laboratory and PolymerPlus (U.S.A.), also provides a new material approach for fabricating synthetic polymer lenses.

The technology behind the new lens is called gradient refractive index optics (GRIN). In GRIN, light is bent by varying degrees as it passes through a lens or other transparent material. This is in contrast to traditional lenses, which use their surface shape or single index of refraction to bend light.

The team's approach was to follow nature's example and build a lens by stacking thousands of nanoscale layers, each with slightly different optical properties, to produce a lens that gradually varies its refractive index.

GRIN optics may be used in miniaturized medical imaging devices or implantable lenses. Current intraocular replacement lenses, such as those used to treat cataracts, use their shape to focus light, much like contacts or eye glasses. Unfortunately, they never achieve the same performance as natural lenses because they cannot incrementally change the refraction of light. GRIN also enables optical systems with fewer components, which is important for vision products and military surveillance equipment.

This technology has already moved from research to commercialization. Prototype and small-batch fabrication has begun, and the team is identifying early adoption applications in commercial devices. *—Patricia Daukantas*

tweeted

@DrMRFrancis (Matthew R. Francis)

My life is full of family and music and particle physics today.

@DiscoverMag (Discover Magazine) Disappointed physicists: This Higgs we found is so...normal. :'(

@vihartvihart (Vi Hart)

If calculus makes physics education harder rather than easier, you're doing it wrong.

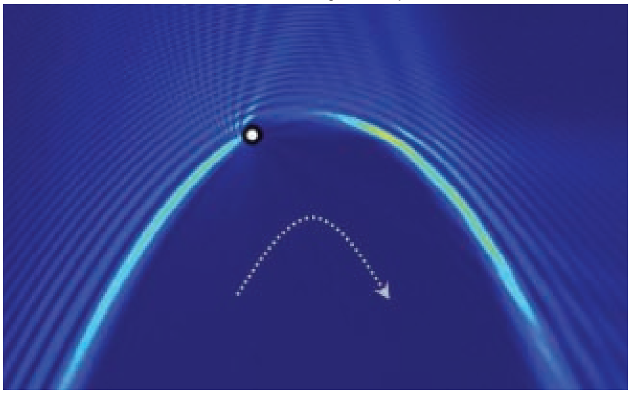
Two New Classes of
Accelerating Light Beams

For five years, scientists have studied Airy beams—a curious class of light beams that resist diffraction and appear to bend in a parabolic arc as they propagate. An international team has found two new types of curving light beams that may lend themselves to nanotechnology applications (Phys. Rev. Lett. **109**, 193901).

Airy beams work only in a narrow zone limited by the paraxial approximation, so they break or disperse too fast for some applications. The research group at the University of California at Berkeley (U.S.A.) discovered two categories of beams that are nonparaxial, so they not only bend to larger angles than Airy beams, but they are much more controllable for practical tasks.

One of the types of beams, called a Mathieu accelerating beam, comes from solving the Helmholtz equation in elliptical coordinates. The nonparaxial circular accelerating beams that other groups have found recently represent a special case of Mathieu beam. Likewise, the team found that the Weber accelerating beams result from an exact solution of the Helmholtz equation in parabolic coordinates, and Airy beams are simply the paraxial approximation of Weber beams.

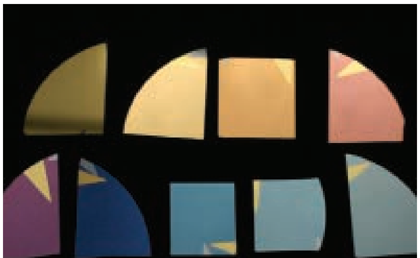
P. Zhang et al. Phys. Rev. Lett. **109**, 193901 (2012).



Numerical simulation of the self-healing property of a Weber accelerating beam. The white dotted arrow indicates the direction of beam propagation.

To generate the beams, the researchers sent 532-nm laser light through a holographic mask. They used a tank filled with a watery suspension of polystyrene nanoparticles to view the curving beams from the side.

The group would like to use the new beam types to guide microparticles and steer surface plasmon polaritons. They also want to try to curve the beam back on itself, creating an "optical boomerang" effect that is still purely theoretical.
—*Patricia Daukantas*



Optical Coatings for Science & Art

Solar cells, photodetectors and even jewelry could benefit from a new type of absorptive semiconductor-film optical coating developed by researchers at Harvard University (U.S.A.) (Nature Mater., doi:10.1038/nmat3443). A layer of this coating, which is just a few atoms thick, can change the color of the underlying material.

This group modified the usual reflectivity of gold surfaces by spraying them with electron-beam-evaporated germanium to create layers between 7 and 25 nm deep—a fraction of the wavelength of visible light. The variation in film thickness gave the gold pieces different colors. Unlike conventional coatings, the germanium coatings have a low sensitivity to the angle of incidence of the impinging light, so the materials will appear to have the same color to observers at different positions.

Unlike femtosecond laser ablation, the Harvard group's method is reversible. Also, these films take less semiconductor material than other coatings, thus resulting in cost savings. —*Patricia Daukantas*

(Above) Gold films colored with germanium films.

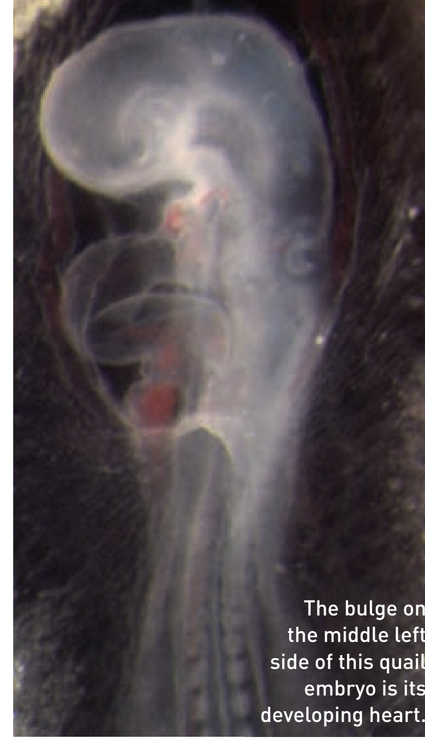
Courtesy of Mikhail Kats, Romain Blanchard and Patrice Genevet

Unlocking Secrets to the **Heart**

3-D stress map of embryonic heart sheds light on why defects form.

Development of the heart is mostly controlled by genes, but the organ also matures in response to the stresses of pumping blood. Researchers have visualized in 3-D the stresses induced by flowing blood in an embryonic heart. The technique promises to provide new insight into how and why heart defects develop (Biomed. Opt. Express, **3**, 3022).

Researchers from Case Western Reserve University (U.S.A.) used quail embryos to examine the stress caused when blood rushes past cells in a developing heart. This stress helps to control and regulate heart development, but tiny aberrations in the heart beat can alter blood flow patterns and cause congenital heart defects.



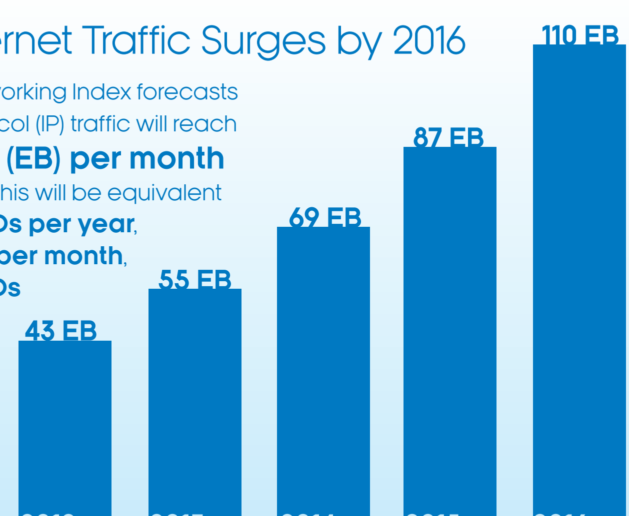
The bulge on the middle left side of this quail embryo is its developing heart.

OSA

The group developed a new imaging method map by modifying Doppler optical coherence tomography (OCT)—similar to radar or ultrasound. They collected data on the heart's structure and blood flow and used it to create 3-D movies, which showed that the areas experiencing high sheer stress corresponded with areas of future valve formation. This work will hopefully be used to develop a tool that doctors can use to decide if early intervention could prevent heart defects. —*Sarah Michaud*

Global Internet Traffic Surges by 2016

Cisco Visual Networking Index forecasts that Internet Protocol (IP) traffic will reach **110 Exabytes (EB) per month** by 2016. Globally, this will be equivalent to **331 billion DVDs per year**, **28 billion DVDs per month**, or **38 million DVDs per hour**.



Cisco VNI Global Forecast 2011-2016

New LED-based solid-state devices convert **over 90 percent** of the energy they consume into visible light, while the traditional incandescent light bulbs convert only 25 percent.

whitehouse.gov

United States Capitol

POLICY

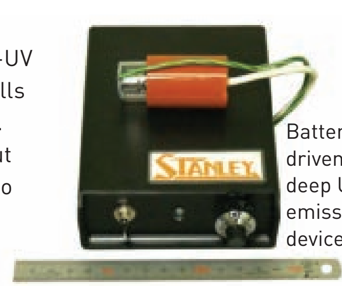
Scientists Win and Lose in 2012 U.S. Congressional Elections

The U.S. House of Representatives added a physicist to the chamber when former Rep. Bill Foster (D) defeated Rep. Judy Biggert (R) in the 11th district of Illinois. Foster, who represented the district that was home to Fermilab from 2008 to 2011, decided to run against Biggert after district lines were redrawn. Biggert has spent her seven-term congressional career as a member of the House Science, Space and Technology Committee and is co-chair of the Congressional Research & Development Caucus along with Rep. Rush Holt (D-N.J.), the only other Ph.D. physicist in Congress.

House Science Committee member Roscoe Bartlett (R-Md.), who holds a doctorate in physiology, lost his bid for reelection, as did Rep. Robert Dold (R-Ill.), one of the congressional supporters of the Golden Goose Awards, which honor innovation in federally funded research projects. Rep. Brian Bilbray (R-Calif.), co-chair of the Congressional Biomedical Research Caucus, was also defeated. Rep. Jeff Flake (R) won a tight Senate race in Arizona against former Surgeon General Richard Carmona. Flake has targeted federal research in his push for cutting government spending. He was one of the architects of an amendment that would have prohibited the National Science Foundation from funding political science research. Other new members who hold undergraduate science or engineering degrees include Mazie K. Hirono (D-Hawaii) in the Senate; and Tony Cardenas (D-Calif.), Alan Lowenthal (D-Calif.), Ted Yoho (R-Fla.), Susan W. Brooks (R-Ind.), Thomas Massie (R-Ky.), John Delaney (D-Md.), Joseph P. Kennedy III (D-Mass.), Brad Wenstrup (R-Ohio) and Suzan DelBene (R-Wash.) in the House. —*Sarah Michaud*

Efficient Deep UV Emitter

Researchers in Japan fabricated a compact deep-UV emission device by combining AlGaN quantum wells and graphene nanoneedle field electron emitters. The device demonstrated a 20-mW deep UV output power and 4-percent power efficiency. It is likely to find applications in the point-of-care analysis of body fluids, as well as water purification and air and food sterilization. —*Sarah Michaud*

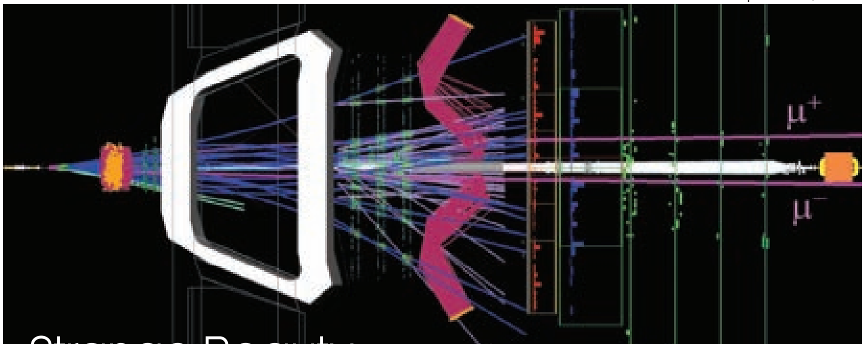


Battery-driven deep UV emission device.

Matsumoto et al. Opt. Express **20**, 24320 (2012).

"It pays to keep an **open mind**, but not so open your brains fall out." *–Carl Sagan*

LHCb experiment, CERN



Strange Beauty Researchers from CERN's Large Hadron Collider observed one of the rarest predicted particle decays—a strange beauty quark (B^0_s) decaying into a muon and antimuon—which is only expected to occur three times in every billion decays. This observation supports theories for the Higgs boson particle and the accuracy of the Standard Model—the prevailing particle physics theory.

INDUSTRY

Applied Nanotech and Universal Display Corp. Nab Small Business Grants

The U.S. Department of Energy Office of Science has awarded two Small Business Innovation Research grants in solid-state lighting (SSL) technology to Applied Nanotech (Austin, Texas, U.S.A) and Universal Display Corporation (Ewing, N.J., U.S.A.). The awards will explore the technical merit and feasibility of innovative concepts in SSL technology.

Applied Nanotech's project, entitled "CarbAlTM Based Board for Power LED Packaging," seeks to develop a unique thermal management solution for its novel CarbAl-based, high-power LED circuit board. The project by Universal Display Corporation, entitled "Novel Low-Cost Single Layer Outcoupling Solution for OLED Lighting," proposes organic LEDs with external quantum efficiencies of more than 42 percent—twice the efficiency in light extraction compared to the highest-efficiency phosphorescent white organic light-emitting diode (WOLED) with no outcoupling enhancement. *—Valerie Coffey*

WOLED lighting panels.

Universal Display Corp.

FLIR Wins U.S. Army Contract for Sensor Kits

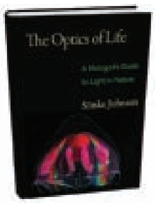
Sensor system manufacturer FLIR Systems (Portland, Ore., U.S.A.) has been awarded a U.S. Army contract for up to $88.3 million to support the procurement of domestic response capability kits for the National Guard Weapons of Mass Destruction Civil Support Teams. The kits include advanced sensors and support equipment used to detect and decontaminate chemical warfare agents.

The three-year contract will provide an initial order for $26.9 million by December 2013. FLIR will produce the DRC kits at its facility in Elkridge, Md., incorporating sensors from several FLIR operations. *—Valerie Coffey*

BOOK REVIEWS

The Optics of Life: A Biologist's Guide to Light in Nature

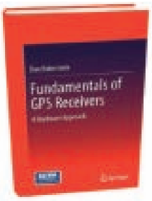
Sönke Johnsen, Princeton University Press, 2011; $99.50 (hardcover).



Johnsen guides the reader through a fascinating area of applied optics that has been very active in recent decades. The book contains examples drawn from nature and everyday life. It will be of interest to a variety of readers, from undergraduate students in biology to curious researchers looking for a greater understanding of nature.
— Christian Brosseau

Fundamentals of GPS Receivers: A Hardware Approach

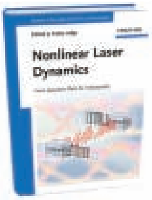
Dan Doberstein, Springer, 2012; $119.00 (hardcover).



The author wants to make the basic operation and hardware of GPS understandable to a larger group than those actively working in this area. While he has simplified the workings of the GPS, he expects readers to have some knowledge of radio receivers, digital electronic circuits, algebra and trigonometry—so the book is not for everyone. *— Albert C. Claus*

Nonlinear Laser Dynamics: From Quantum Dots to Cryptography

Kathy Lüdge, ed., Wiley-VCH, 2012; $135.00 (hardcover).



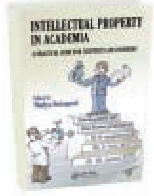
This outstanding reference focuses on recent advances in nonlinear laser dynamics. The

Patricia Daukantas, Yvonne Carts-Powell and Valerie Coffey are freelance science writers who specialize in optics and photonics. Sarah Michaud is OPN's associate editor.

book includes papers on laser devices, synchronization and cryptography, and nanostructured devices. Readers will find experimental and computational results that are based on nonlinear systems with feedback, time delay and stochastic bifurcation methods.
— *Axel Mainzer Koenig*

Intellectual Property in Academia: A Practical Guide for Scientists and Engineers

Nadya Reingand, ed., CRC Press, 2011; $49.95 (hardcover).



Reingand tries to provide a complete source of intellectual property (IP) information for academic researchers. The book is a valuable guide to business and market estimation, employment legislation and invention priority estimation. It will become a standard reference for IP issues and help to stimulate interactions between academics and entrepreneurs.
— *Christian Brosseau*

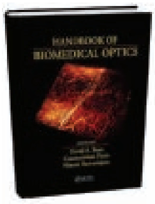
Physics of Nanostructured Solid State Devices

Supriyo Bandyopadhyay, Springer, 2012; $119.00 (hardcover).

This textbook introduces the basic concepts of quantum mechanics that are needed to understand nanostructured solid-state devices. There are several examples in each chapter that should help students to comprehend the material. This book is suitable for first-year graduate students of electrical engineering and applied physics as well as researchers in the field. — *Abdolnasser Zakery*

Handbook of Biomedical Optics

David A. Boas, Constantinos Pitris and Nimmi Ramanujam, eds., CRC Press, 2011; $149.95 (hardcover).



This handbook provides comprehensive coverage of recent developments in biomedical optics. It is a great resource for scientists and graduate students in biomedical engineering and optics. In addition to providing background information on classical optics, irradiation guidelines and tissue optical properties, this book offers a thorough treatment of tomographic and microscopic imaging technologies. — *Axel Mainzer Koenig*

ONLINE EXTRA

Visit www.osa-opn.org for additional book reviews.

Christian Brosseau is a professor of physics at the Université de Bretagne Occidentale in Brest, France. Albert C. Claus is with the physics department at Loyola University, Chicago, Ill., U.S.A. Axel Mainzer Koenig is CEO, 21st Century Data Analysis, a division of Koenig & Associates, Inc., Portland, Ore., U.S.A. Abdolnasser Zakery is a member of the physics faculty of Shiraz University, Iran.

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OPTICS INNOVATIONS

Thorlabs: *Swimming in the Fast Lane*

Alex Cable and Laurie Morgus

Thorlabs is taking a series of swift, precise strokes to meet its goals for aggressive growth.

Like many technology companies, Thorlabs has never been content with merely treading water. In 2011, the company's growth was a healthy 18 percent over the previous year, and revenue broke through the $200-million-per-year mark. Last year was slightly slower, but the company still expects double-digit growth for 2012. Although Thorlabs' legacy products represent the major portion of its revenue, new product development is also key to its sustained rapid growth. Here's how the company compresses its time to market.

Incubating ideas. Thorlabs has built an idea depository that has evolved into an online product incubator called BrainWave. It provides an internal space to post product and technology ideas. The tool then encourages comments from any of Thorlabs' roughly 850 employees and industry friends. As ideas gain support (measured in votes), BrainWave monitors a number of parameters to push high-potential ideas forward. Currently there are 7,421 active product ideas at various stages of development. BrainWave gathers estimates on resource allocation from marketing, engineering, manufacturing and other groups as the ideas pass through the system, and staff conversations move from unstructured dialogs into formal interdepartmental product meetings. In the near future, BrainWave will also act as a full-lifecycle management tool. Company leaders ultimately hope to make large portions of it available to the entire industry.

Going local. As many companies extend the length of their supply chains by seeking the lowest-cost batch production methods, Thorlabs has taken the opposite approach—building local manufacturing facilities and synchronizing production with customer demand. This strategy conveys a multitude of benefits: Worldwide, more than 93 percent of roughly 20,000 products ship on the day a customer places the order. The team at Thorlabs can take product improvement ideas and produce an updated product within days or weeks, since there's no need to purge its inventory channel.

Customer-driven design. Thorlabs is also successfully synchronizing design with demand. For example, in the first half of 2012, the company released 1,012 new products, over a third of which were inspired by customers. This milestone has been many years in the making, as Thorlabs has invested heavily in building the infrastructure that can sustain bringing 500 new products to market per quarter.

Investing and restructuring. The leaders at Thorlabs invested in both the personnel and capital equipment needed to streamline design, manufacturing, marketing and fulfillment processes. There have been a few strategic restructurings to allow engineers more time to actually engineer. On the manufacturing side, to keep up with increased production, Thorlabs added new CNC optics fabrication equipment, machine tools and metrology capabilities.

Integrating processes to promote quick development. The various business units within Thorlabs use what company personnel refer to as "swim lanes." These are processes that allow a design to move unimpeded through the various stages of product development outlined in the BrainWave incubator. During the initial stages, 3-D printers as well as dedicated machines and optics shop tools are used for prototyping. Then the design is modified as needed. Finally, manufacturing, marketing and warehousing occur, and the product is released for sale on the company's e-commerce website. Thorlabs also learned to use the swim-lane manufacturing infrastructure to build initial inventory.

Although Thorlabs' legacy products represent the major portion of its revenue, new product development is also key to the company's sustained rapid growth.

Creating a high-speed culture. Regardless of whether a project makes it into a swim lane or stays in normal development channels, there is a sense of urgency throughout the company. Engineers and key members of the manufacturing team engage in short, twice weekly meetings. This streamlines the flow of new products by having everyone on the same page, with the same priorities, and swimming in the same direction. BrainWave also ensures that others who are not present at the face-to-face meeting are kept informed of individual projects as well as the overall future demand for their services. This is especially important for the marketing staff.

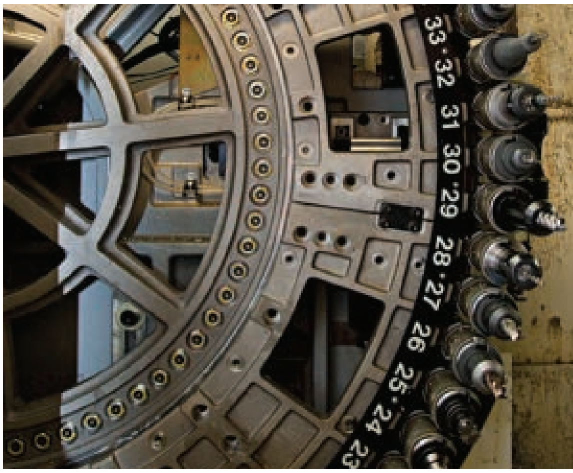
Without careful flow management, projects tend to bunch up, creating bottlenecks. The guiding principle at Thorlabs is "touch it, finish it."

In 2013, the company is expecting to achieve two milestones: One is attaining a new product rate of 600 per quarter, and the other is to realize more than $15 million in revenue growth from market extensions that reach outside its core scientific and product R&D segments. For example, the Microscopy Tools division based in Sterling, Va.—which represented 22 percent of the company's growth in 2012—is expected to accelerate to 30 percent for 2013. This group is a purely green-field initiative that has established its ability to build from scratch a new division that serves a new-to-Thorlabs market.

For 2014 and beyond, there are other substantial green-field projects in the BrainWave incubator mixed in with several thousand incremental ideas. With Thorlabs' average compounded annual growth rate of 20 percent and ambitious future plans, it seems the company was built for life in the fast lane. OPN

Alex Cable (acable@thorlabs.com) is the founder and CEO of Thorlabs. Laurie Morgus is the marketing communications manager.

Laura Field



Haas EC400 Pallet Pool Horizontal Mill has a 72-tool selection.

URL
www.thorlabs.com

HEADQUARTERS
Newton, N.J., U.S.A.

PRODUCT TYPES
Optomechanical, motion control, optics, fiber, light sources, light analysis, imaging

FOUNDED
1989

PRESIDENT & CEO
Alex Cable

NUMBER OF EMPLOYEES
850

AVERAGE CAGR
20 percent

GLOBAL OPTICS

Optics at Peking University

Kebin Shi

Peking University, one of the most reputable universities in China, has boosted its optics research—which spans from fundamental physical optics to application-orientated areas such as nanophotonics, silicon photonics, optical communications and quantum optics.

Boya Pagoda, one of the campus landmarks.

Thinkstock

Peking University is one of China's earliest national universities. It was established in 1898, during the late Qing dynasty in the 19th century. Nestled in a historic neighborhood in northwest Beijing, the university's scenic main campus now hosts about 12,000 undergraduate students, 13,000 graduates, 2,000 international students and 4,000 academic staff. It has long been known as one of the top-tier comprehensive universities in China, and it holds a state reputation for its leading position in both natural and social science.

The university is organized into 47 schools and departments covering 211 doctoral and 253 masters programs. As a national key university, it is primarily supported by the Chinese central government as well as various state funding agencies. For example, under State Project 985, which was initiated by former Chinese President Zeming Jiang at the 100th anniversary of Peking University in 1998, the university was allocated 1.8 billion RMB to strengthen its infrastructure.

As the Chinese government increasingly emphasizes the development of innovative research and technology, the number of research grants to the university has steadily risen over the past decade. In the 2011 fiscal year, the National Natural Science Foundation of China (NSFC) granted Peking University's record-breaking funding of 385 million RMB, which was raised by 40 percent over the amount in the previous year.

Research in optics is one of the areas that has expanded rapidly during the past few years. It has benefitted from substantial support by the university and state funding agencies such as the NSFC, the Ministry of Science and Technology and the Ministry of Education.

As an enabling field, optics cuts across many disciplines. Not surprisingly, then, optical research at Peking University is distributed among research groups at various schools, including the schools of physics, electronic engineering and computer science, life sciences, and engineering. The research scope spans from fundamental atomic, molecular and optical physics to application-orientated programs such as nanophotonics, biophotonics, optical communication and quantum optics.

Affiliated with the school of physics, the Institute of Modern Optics carries the most comprehensive optical program at Peking University.

The Institute of Modern Optics

Affiliated with the school of physics, the Institute of Modern Optics (IMO) carries the most comprehensive optical program at Peking University. It is directed by Cheung Kong Distinguished Professor Qihuang Gong and has 20 faculty members and 70 graduate students. Most of them are members of the mesoscopic optics and femtophysics creative group (MOFCG) supported by the NSFC.

In May 2012, IMO successfully hosted the Sixth International Conference on Nanophotonics in Beijing. Roughly 350 researchers attended the conference, which was sponsored by OSA. It included five plenary talks and 39 invited presentations.

Besides nanophotonics, the work of the MOFCG covers quantum optics, opto-electronic devices and photovoltaics, photonic crystals, cavity photonics and plasmonics.

A nanofabrication facility in the institute is equipped with cutting-edge systems such as focus ion beam and e-beam lithography equipment. The work of MOFCG members on surface plasmon polaritons, high-Q microcavities and low-threshold nonlinear photonic crystal devices has been featured in high-impact journals, including *Nano Letters*, *Physical Review Letters*, *Nature Photonics* and *Advanced Materials*.

Recently, the MOFCG demonstrated a new type of deformed whispering gallery microcavity that supports both highly unidirectional emission and an ultrahigh-Q-factor of 10^8. This work makes it possible to investigate strong light-matter interaction using a free-space-coupled ultrahigh-Q microcavity. Using a combination of plasmonics and quantum optics in ultra-small-mode volume, MOFCG researchers used plasmonic nanostructures to demonstrate a quantum interference effect in the spontaneous emission spectrum of an atomic system at the subwavelength scale. Their work was published in *Nano Letters*.

Several subgroups of MOFCG members are working on femtophysics, including femtosecond laser fabrication, ultrafast dynamics of biomolecules, atomic and molecular dynamics and nonlinear spectroscopy and imaging. Research achievements were reported regularly in *Physical Review Letters*, *Optics Letters*, *Physical Review A* and *Optics Express*.

For example, MOFCG researchers are currently carrying out a study of protein dynamics using femtosecond lasers. Their COLTRIMS (cold target recoil-ion momentum spectroscopy) system is integrated with intense femtosecond lasers. It was first demonstrated in

PEKING UNIVERSITY BY THE NUMBERS

Area
2,743,532 m²

Graduate students
13,000

Undergraduates
12,000

Academic staff
4,000

International students
2,000

Master's programs
253

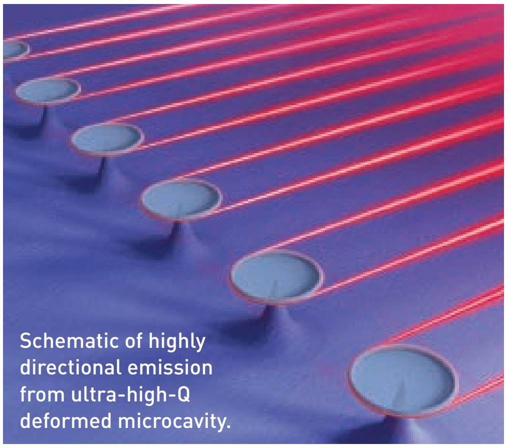
Doctoral programs
211

Members, Chinese Academy of Sciences
53

Schools and departments
47

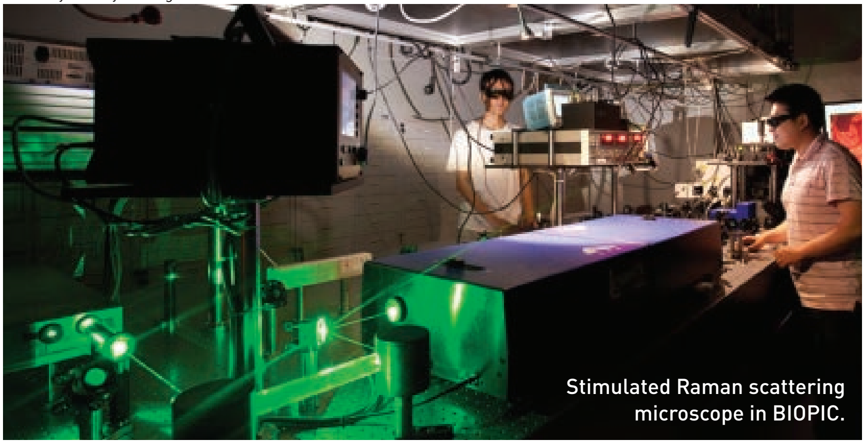
Members, Third World Academy of Sciences
14

Members, Chinese Academy of Engineering
7


Schematic of highly directional emission from ultra-high-Q deformed microcavity.

Courtesy of Yun-Feng Xiao

Courtesy of Yanyi Huang



Stimulated Raman scattering microscope in BIOPIC.

China through a collaborative effort by MOFCG members.

Another MOFCG study is focusing on *ab initio* simulations of strong field processes that were developed by numerically solving the full dimensional time-dependent Schrödinger equation for few-electron atomic and molecular systems.

MOFCG scientists are also working on cutting-edge research that merges femtophysics with mesoscopic optics. They developed a novel technology for achieving high spatiotemporal resolution by integrating femtosecond lasers with scanning near-field optical microscopy.

In 2011, MOFCG members Qihuang Gong, Xiaoyong Hu, Shufeng Wang and Hong Yang were awarded the 2nd Class of the State Natural Science Award—a highly prestigious national award—for their project on the nonlinear optical properties of a charge-transfer molecular system and ultrafast all-optical switch.

Optical communication and integrated photonics

Optics research in the school of electronics engineering and computer science is mainly related to the State Key Laboratory of Advanced Optical Communication Systems & Networks. With the emphasis on photonic applications in communications and photonic integration devices, the State Key Laboratory organizes diverse interdepartmental collaborations that are primarily categorized into four strategic fields:

- Next-generation optical networks.
- Ultra-high-speed optical communication technology.
- Integrated opto-electronics devices.
- Optical sensing and information processing.

There are several groups conducting internationally recognized research. Recently, Peking University researchers reported the highest repetition rate of the femtosecond Yb:fiber ring laser and the shortest pulse from a femtosecond Er:fiber laser, as demonstrated by Zhigang Zhang's group in the department of electronics. The newly developed lasers are especially desirable in applications that require large-mode-spacing frequency comb sources.

Biophotonics

Biophotonics research at Peking University has grown recently due to the enthusiastic support from the university and state funding agencies. In December 2010, Peking University officially launched the Biodynamic Optical Imaging Center (BIOPIC). Founded by X. Sunney Xie, who pioneers the interdisciplinary research of biology and optics, BIOPIC's strategic research plan is to develop and apply the most advanced bio-imaging and sequencing techniques to address fundamental biological and compelling medical problems at the molecular and cellular levels. Equipped with state-of-the-art facilities, BIOPIC members focus on single molecule observation and manipulation, super-resolution cellular imaging, high-throughput sequencing, single-cell analysis and label-free biomedical imaging.

Future outlook

Both the Chinese government and Peking University launched a series of programs to recruit talented young scientists around the globe. With ample support for resources and infrastructure, the optical science community at Peking University aims to recruit more top-tier researchers and make a strong commitment to research excellence. OPN

Kebin Shi (kebinshi@pku.edu.cn) is a professor in the school of physics in the Institute of Modern Optics in Peking University in Beijing, China.

To Learn More ...

- Peking University: www.pku.edu.cn.
- Institute of Modern Optics: www.phy.pku.edu.cn/~optics/.
- BIOPIC: http://biopic.pku.edu.cn.
- State Key Laboratory of Advanced Optical Communication Systems & Networks: http://ofcl.pku.edu.cn.

CONVERSATIONS

Network Architect

Nick McKeown is building the Internet of tomorrow.

McKeown is known for developing software-defined networking (SDN), which challenged the vertically integrated approach to the switch-and-router design of the past 20 years. At Stanford University, he leads a research group—including SDN's inventor, Martin Casado—focused on SDN and shaping the architecture for the Internet of the future. He will be a plenary speaker at OFC/NFOEC 2013, 17-21 March in Anaheim, Calif., U.S.A.

Courtesy of Nick McKeown

Q. Did you face skepticism for SDN?

New ideas are always questioned—we dealt with intense skepticism for several years. This is the classic case of the innovator's dilemma: The incumbents just couldn't afford to see its potential.

Q. What have you learned from your entrepreneurial experiences?

I co-founded two companies, Nemo Systems and Nicira Networks (co-founded with Casado and Scott Shenker), which were purchased by Cisco Systems and VMWare, respectively. I have learned that, in order to create a successful venture, you must choose a problem that: 1) is intellectually interesting; 2) will change the practice; and 3) is not favored by industry (yet). If the industry loves it, they'll do it themselves—they have more resources and a greater urgency than you. Next, you need to spend time actually bringing about the change in practice, which could include giving ideas away (I don't patent anything) or creating a company to make the ideas easier to transfer.

Q. What can improve Internet architecture?

Internet architecture has been essentially unchanged for 30 years. This is in part because of the great vision of the original architects, but it's also because the Internet is difficult to change. If we can programmatically control the network in an open and standard way, then the Internet can and will evolve rapidly. Once it's possible to quickly introduce new functionality, we will see a thousand ideas bloom, and the good ones will prevail.

Q. What topics will you cover in your OFC/NFOEC plenary session?

I will focus on the pressing need for companies that build transport equipment or networks to invest in SDN so they aren't left behind. At first blush, there is no change of functionality with SDN—functions have simply been moved around. In practice, however, it leads to profound changes to the way networks will be built and operated. SDN will eventually simplify and improve every network we build and use: WiFi, home networks, WANs, enterprise networks and optical transport networks. OPN

Brielle Day (bday@osa.org) is OSA's public relations specialist.

CAREER FOCUS

Learning to TEACH

Arti Agrawal

Some instructors are naturals, but for most of us teaching is an acquired skill. Here's why you can and should learn to do it.

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As a young academic who is predominantly focused on research, I was terrified when I was asked to lecture at my university. Aside from the fact that I lacked experience, I was apprehensive about the tremendous amount of work involved—which would mean time away from my research.

At the same time, I was excited about the prospect of inspiring students. Despite my misgivings, I wanted my students to like me and to enjoy my classes. I recalled some of my favorite teachers and the impact they had had on me.

It seems that some people are natural-born teachers: They instinctively pause when students need them to and explain complicated concepts in a simple, easy-to-understand way. They know when their students don't understand something. In short, they know how to engage their audience!

For those of us who lack this innate talent, the prospect of facing a few hundred students waiting to devour discrete Fourier transform like hungry lions is not very enticing.

Fortunately, there is help out there.

Questions to consider

The first thing to do is to break down the task of teaching into its individual elements. This will make it seem less overwhelming and scary. Think about:

- **What is the learning culture?**
  Some students are so-called strategic learners; they are mostly only interested in doing what they need to (in tutorials, labs, coursework) to get a good final grade. For others learning is the main motivation, and grades are merely an outgrowth of that. (Sadly, the former seem to be much more common than the latter, at least in my classroom.)

- **How can you engage and motivate students?**
  Each class is composed of people with vastly different temperaments and interests. Think about what might motivate each personality type, and how you could create elements of your curriculum that appeal to each.

- **How will you discipline students?**
  Disruptive students are an unfortunate reality in many classroom settings, so dealing with them has to be part of your game plan.

- **What's the best approach to assessment?**
  You'll need to come up with a system that can fairly and objectively assess each student and provide feedback that aids in their development.

Despite my misgivings, I wanted my students to like me and to enjoy my classes.

Arti Agrawal

Teaching tips

Universities often offer courses on academic practice.

These classes deal with various aspects of teaching: theories on learning and teaching in higher education, curriculum development, teaching techniques, the design of learning environments, and much more.

I went to a two-day teaching workshop where we were taught how to design lectures, including preparing slides, handouts, assignments, etc. We delivered practice lectures that were video-recorded and played back to us. With feedback on very practical issues, we could see how we appeared to students: Were our voices carrying across the room? Were our notes on the board legible? Did we fidget or appear nervous?

Many professional and technical societies also have resources for educators.

Usually they will be subject-specific and thus a great place to find material, teaching tips and activities for your area. They can often suggest appropriate individual projects and group activities for students of differing ability levels.

You can find support from experts who specialize in various teaching techniques.

Some specific methods include e-learning, peer instruction, learning development and just-in-time teaching. Many such techniques reflect new technologies and shifting social norms. Getting input from these sources can make a big difference in engaging students.

Consider this example: I found that that my class was not solving tutorial questions, and it seemed that no amount of exhortation from me could convince them to do it. The Learning Development Centre team suggested that I divide the class into groups and assign the questions to each one. Then the groups would have to answer them on the board before the entire class. Each team had to prepare a question to challenge other groups, with the best question winning. Peer pressure and some healthy competition gave the students the incentive they needed to get through the questions.

Like most things, teaching gets better with practice.

With a lot of hard work and practice, you can come to seem like a natural yourself.

As for me, I found my reward in one of my recent lectures. While I taught, my class was attentive—there was no yawning, talking or texting. My students asked me questions and responded to mine. They even laughed at my jokes. It doesn't get much better than that. OPN

Arti Agrawal (arti_agrawal@hotmail.com) is a lecturer in the department of electrical and electronic engineering, School of Engineering and Mathematical Sciences, City University London, United Kingdom. To follow her personal blog, visit http://artiagrawal.wordpress.com.

UNIVERSITY UNIVERSALS

Lecturing at a university has its own set of challenges that set it apart from teaching in a secondary school. At university, you can expect:

Larger classes

Some lecture halls can fill 300 seats or more.

Students from different backgrounds and abilities

Some students will not have knowledge you think essential, while others are more advanced.

Cultural diversity

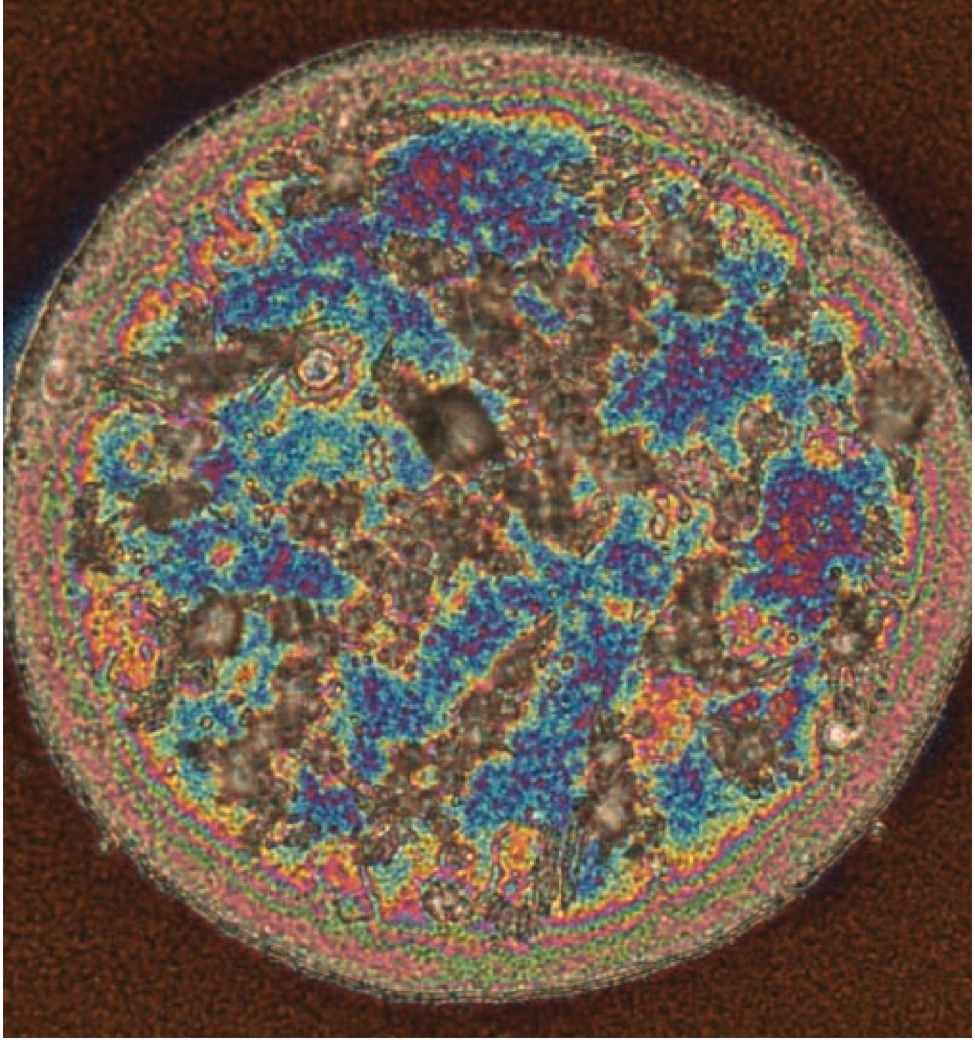
Expect varying cultural norms and degrees of fluency in your native language.

Non-attendees

No-shows are common at the university level, and many schools expect you to prepare your lecture slides and handouts for download.

Member Lens

Cool optics images from our readers



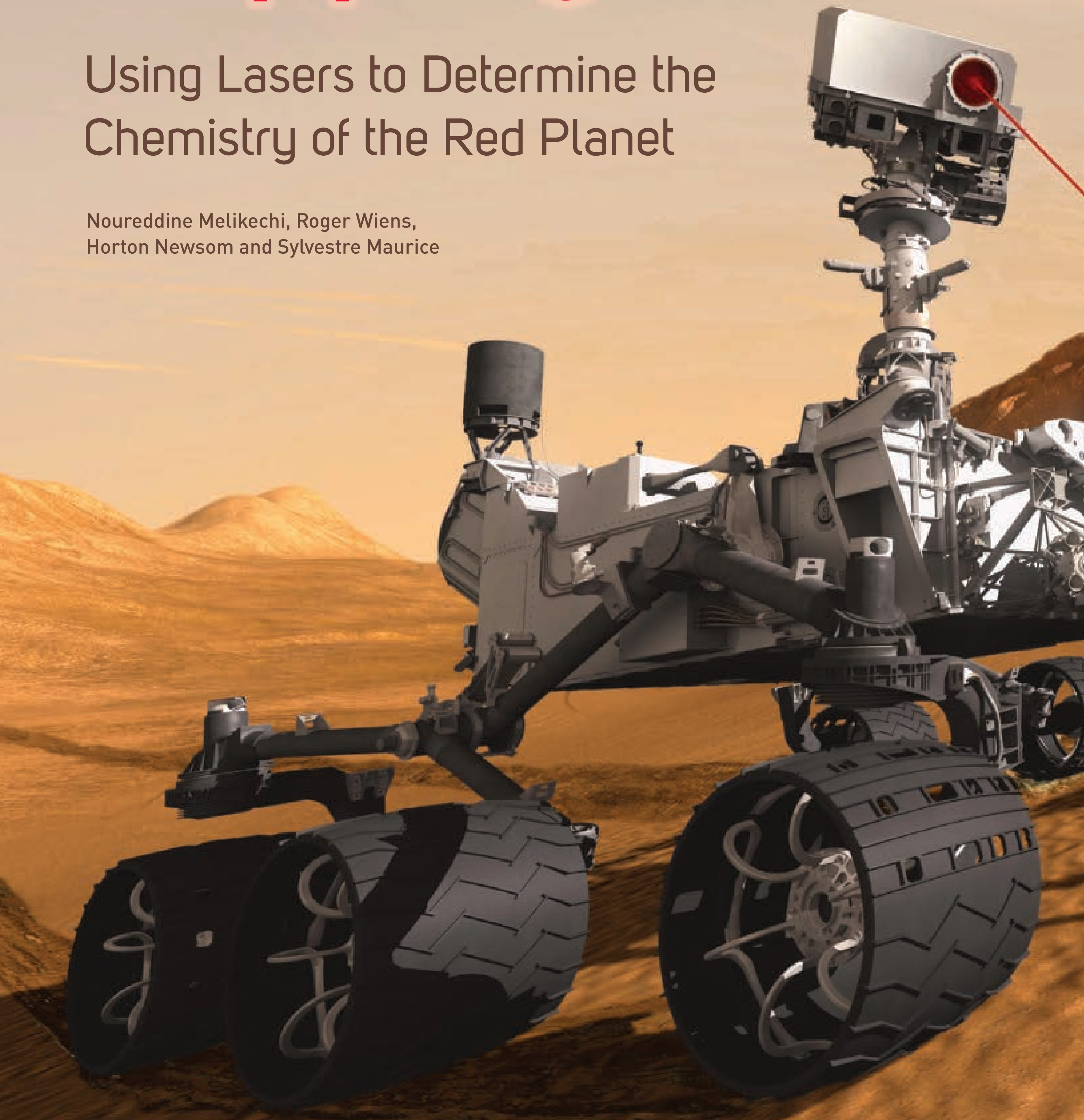
Silica sol-gel creates a 2-D Earth globe on a silicon chip.
—Simin Mehrabani, University of Southern California, U.S.A.

Perfect reflection at Badwater Basin, Death Valley, Calif., U.S.A.
—*Philipp Jester*

Zapping Mars

Using Lasers to Determine the Chemistry of the Red Planet

Noureddine Melikechi, Roger Wiens, Horton Newsom and Sylvestre Maurice



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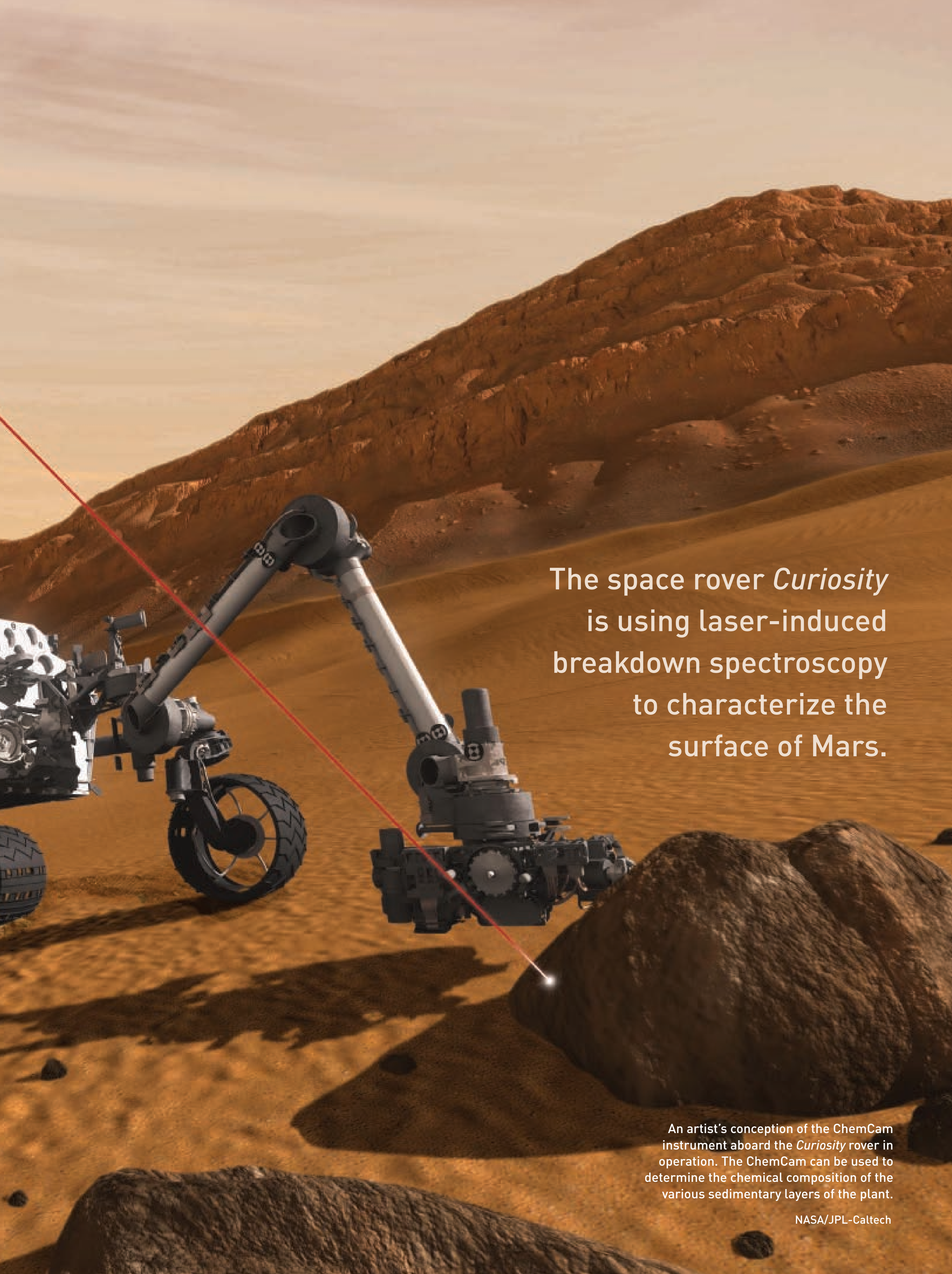


The space rover *Curiosity* is using laser-induced breakdown spectroscopy to characterize the surface of Mars.

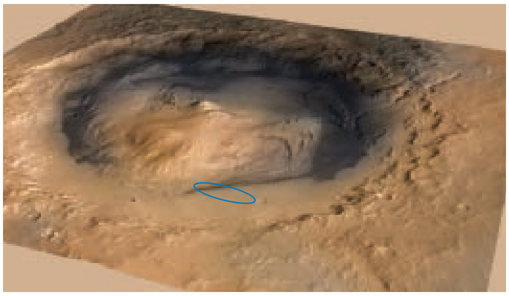
An artist's conception of the ChemCam instrument aboard the *Curiosity* rover in operation. The ChemCam can be used to determine the chemical composition of the various sedimentary layers of the plant.

NASA/JPL-Caltech

When NASA's rover *Curiosity* landed successfully on Mars last August, it opened a new chapter in space exploration: the use of laser-based instruments to probe the surface composition of other planets. Otherwise known as the Mars Science Laboratory (MSL), the nearly one-ton rover was designed to be a laboratory on wheels, capable of doing sophisticated analyses on rough terrain on the red planet.

The *Curiosity* mission is expected to reveal a rich portrait of Martian history, particularly since the decision was made to land the vehicle in the 150-km Gale crater, which was formed about 3.6 billion years ago during a humid period on Mars. With the tallest stack of accessible sedimentary rock layers in the solar system (taller than the Grand Canyon is deep), the crater may contain details of a climate change from the wetter, warmer past to the cold, dormant conditions today.

NASA/JPL-Caltech/ESA/DLR/FU Berlin/MSSS



NASA's *Curiosity* rover landed in the Gale crater. The rover landed well within its targeted landing ellipse (20 km x 6.4 km), outlined in blue. Mount Sharp with an elevation of about 5.5 km above the floor of the crater is located in the center.

A laser in the *Curiosity* toolbox is "zapping" rock samples along the rover's path to determine their composition.

A laser in the *Curiosity* toolbox is "zapping" samples along the rover's path to determine their composition. One of MSL's overarching goals is to determine if the area was or is potentially habitable—that is, whether or not it could have sustained liquid water in the presence of other chemicals necessary for life, such as carbon, hydrogen, nitrogen, oxygen, phosphorus and sulfur.

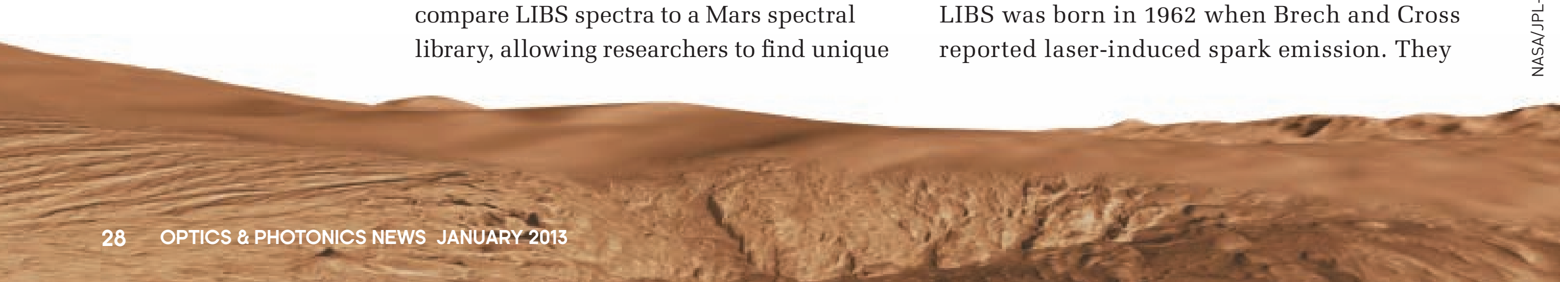
The laser is part of an instrument called ChemCam (chemistry and camera), which analyzes samples through a process called laser-induced breakdown spectroscopy (LIBS). ChemCam includes a remote LIBS spectrometer and a remote micro-imager (RMI).

ChemCam's mission is to perform:

- *Rapid rock classification*: ChemCam will compare LIBS spectra to a Mars spectral library, allowing researchers to find unique signatures that will identify the types of rocks, thereby indicating which samples are worth studying with more time-intensive *Curiosity* instruments.
- *Quantitative composition*: This will be done for major, minor and trace elements using multiple analysis points, along with a spectral training set.
- *Depth profiling*: ChemCam can remove dust and drill through layers of rock and soil by repeatedly directing laser pulses on a specific location. These data could provide important clues to climate and weather conditions over the history of the sample. The lasers can profile up to one millimeter in rock and several millimeters in soil.
- *Context imaging*: RMI provides high-resolution images for analyzing LIBS targets. This is important for investigating the 350- to 550-µm LIBS observation pits and mineral grain sizes.
- *Passive spectroscopy*: ChemCam's spectrometers have a passive setting for collecting data on, for example, the iron content of samples. This capability extends beyond the 7-m limit of the laser interaction.

A new era for space exploration: LIBS on Mars

LIBS was born in 1962 when Brech and Cross reported laser-induced spark emission. They



NASA/JPL-Caltech/Malin Space Science Systems

NASA's *Curiosity* rover used the Mars Hand Lens Imager (MAHLI) to capture 55 high-resolution images, which were stitched together to create this full-color self-portrait. The ChemCam, two mast cameras and four navigation cameras can be seen at the top of the remote sensing mast.

sarcastic tweeting from Mars

For live updates about what the *Curiosity* is up to on Mars, be sure to follow @MarsCuriosity on Twitter—the NASA Twitter feed covering the rover. But for a glimpse into *Curiosity*'s snarky alter ego, check out @SarcasticRover, the unofficial Twitter presence not associated with NASA. Here's a sampling of what our Martian friend has to say:

@SarcasticRover I've got a nuclear-powered laser and control of an entire planet... so I'm essentially a Bond villain. #suckit007

@SarcasticRover I used my ATOMIC LASER to vaporize some rocks and the fumes kinda made me high... so SEND SOME CHEETOS and DILLY BARS - ASAP!!

@SarcasticRover How many rocks do I have to laser open before I stop expecting there to be a prize inside?

@SarcasticRover OMG! I found life on Mars... also, I found out what happens when you crush life with a 1 ton atomic-robot! SCIENCE!

@SarcasticRover My nuclear-laser can VAPORIZE ROCKS... so I suggest you don't step to me. LOL JK, I long for personal contact.

focused a ruby laser beam onto metallic and non-metallic solid materials to generate vapors that were subsequently excited with an electric spark to generate emission spark spectra.

LIBS consists of focusing a pulsed laser onto a target to create a plasma plume and analyzing the optical spectra made up of emission lines generated as the plume decays. The unifying feature of all LIBS experiments is the formation of a laser-generated plasma plume from the target, which can be a solid, a liquid or a gas. The fundamental processes that create the plasma are very complex and depend on the characteristics of the target and its surrounding atmosphere, as well as the features of the laser.

As a spectrochemical analytical technique, LIBS can provide the elemental composition of a sample in a solid, liquid or gaseous phase without sample preparation. It relies on the spectral analysis of atomic, ionic and potentially molecular bands emitted by the plasma plume initiated above the surface of the sample. Due to its versatility and simplicity, LIBS has been used for a wide range of analytical applications, including simultaneous multi-elemental analyses of metals and biological samples.

LIBS experiments are usually conducted under standard Earth atmospheric conditions. About 20 years ago, Blacic et al. suggested using LIBS for the remote analysis of planetary surfaces. This year, on the 50th anniversary of the technique, LIBS was used on the red planet, more than a hundred million kilometers away from where it was first developed. LIBS experiments on Mars are particularly challenging because researchers have to deal with atmospheric conditions significantly different than those in a laboratory on Earth, including:

- An atmospheric pressure of 7 Torr (100 times lower than that on Earth).

As a spectrochemical analytical technique, LIBS can provide the elemental composition of a sample in a solid, liquid or gaseous phase without sample preparation.

Objectives of the Mars Science Laboratory

NASA's rover *Curiosity* provides an unprecedented opportunity for space exploration using a variety of technologies, including optical ones. *Curiosity*'s four primary science objectives are to:

Assess the habitability potential of at least one target environment by determining the nature and inventory of organic carbon compounds, searching for the chemical building blocks of life and identifying features that may record the actions of biological processes.

Characterize the geology of the rover's field site at various spatial scales by investigating the chemical, isotopic and mineralogical composition of surface and near-surface materials, and by interpreting the processes that have formed rocks and soils.

Investigate processes that may indicate past habitability by assessing long-timescale atmospheric evolution and determining the present state, distribution and cycling of water and carbon dioxide.

Characterize the broad spectrum of surface radiation, including galactic cosmic radiation, solar proton events and secondary neutrons.

- Surface temperatures that range from –125 °C during polar night to 27 °C at the equator during midday.
- An atmosphere composed of 95.9 percent carbon dioxide, 1.9 percent nitrogen, 1.9 percent argon, 0.14 percent oxygen and 0.06 percent carbon monoxide.
- A surface typically covered with dust or other debris.
- High surface winds of 10 m/s, with gusts up to 40 m/s.

Habitability on Mars

Mars is considered potentially habitable because it has abundant water and a thin atmosphere; billions of years ago it had a climate more similar to Earth. Our study of habitability on Mars is buoyed by an explosion of findings related to microscopic organisms on Earth that thrive in extreme environments—including those characterized by high pressure, heat or radiation—indicating that life might have a chance on the surface of Mars, which is subject to relatively high radiation doses compared to Earth. Some of these terrestrial “extremophiles” obtain their energy from surprising sources such as the oxidation or reduction of manganese on rock surfaces.

The search for evidence of past or present life on Mars requires a better and broader understanding of the geochemistry of Martian rocks and soils and a characterization of their biological potential or biosignatures. While a number of scientific approaches have been explored to investigate the likelihood of biosignatures on planets, ChemCam provides an almost complete elemental composition of selected targets, including elements important to life on Earth.

Recent investigations have demonstrated that LIBS can be used in quantitative molecular analysis to characterize complex biosamples, including organic carbon in soils, and to obtain hydrogen composition of high-molecular-weight proteins.

ChemCam: A high-res camera and spectrometer

To meet the MSL objectives, the ChemCam laser had to satisfy a number of challenging requirements: an output intensity of more than 10 MW/mm^2 during each pulse, environmental conditions characterized by a minimum of 670 diurnal thermal cycles for the nominal mission duration, and compactness and weight not to exceed 140 cm^3 and 600 g.

Laser-Induced Breakdown Spectroscopy

The entire LIBS process lasts up to tens of microseconds.

1 Laser/absorbtion

A pulsed laser is focused on a target (rock). An irradiance threshold of 1 GW/cm^2 is needed to obtain a plasma representative of the target composition. Part of the laser’s energy is absorbed by the target and generates ions and free electrons, which gain kinetic energy.

2 Heating

The free electrons collide with the lattice phonons on the rock’s surface, leading to avalanche ionization and thermal energy (red spot on rock) in the target.

3 Melting/evaporation

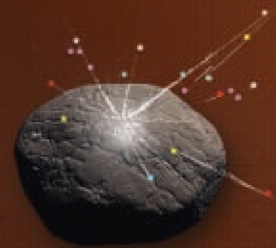
A small portion of the target rich in free electrons, ions and neutrons is vaporized and ablated (white cloud and divot); the ablated region expands at a velocity faster than the speed of sound and generates a shock wave.

4 Plasma

As the vapor expands, it continues to absorb optical energy from the laser and becomes a luminous plasma plume (white cloud) with temperatures that can reach 10^4 K.

5 Emission

The laser pulse ends. The plasma plume collides with the surrounding species and begins to cool, emitting radiation through emission and recombination processes that can be collected to analyze the target (white cloud).

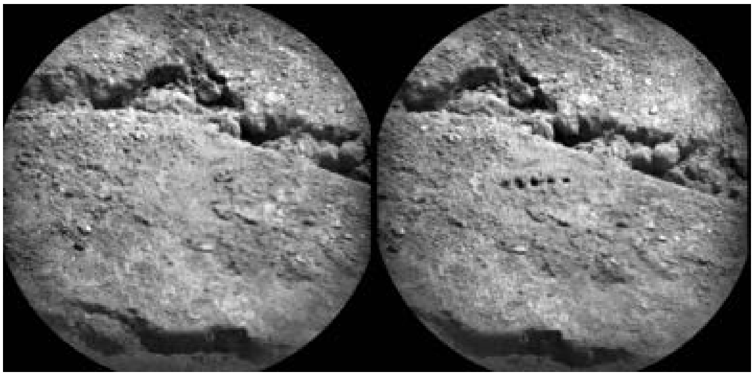


6 Species formation

The radiative and non-radiative (post-plasma) processes may yield high-density neutral species, clusters of nanometer and micrometer sized particles (multicolored dots).

Phil Saunders

NASA/JPL-Caltech/LANL/CNES/IRAP/LPGN/CNRS



On day 19 of the mission, *Curiosity* sent RMI images of the "Beechey" target (a sample of Martian soil) taken before (left) and after (right) laser ablation. The image on the right shows five laser-ablated regions generated by using 50 laser pulses with an irradiance of about 30 MW/mm^2 in each pulse.

The ChemCam laser consists of a diode-pumped, rubidium titanium phosphate Pockels cell Q-switched, neodymium-doped potassium-gadolinium tungstate (Nd:KGW) linear oscillator and two amplifiers. The oscillator and amplifiers are pumped individually by a 700-W diode stack. Nd:KGW was selected as the operating medium because it provides small absorption variations over a broad temperature range. It yields a stable power output without cooling, even in an environment characterized by large daily temperature variations.

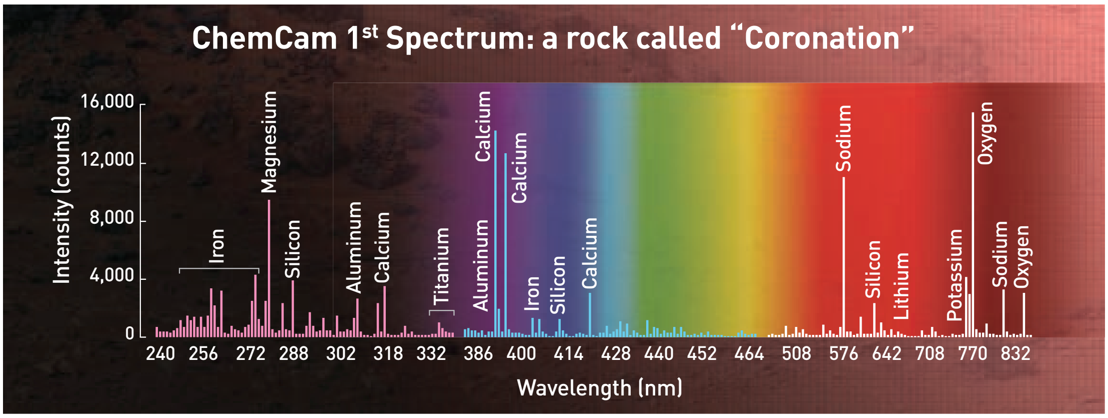
The ChemCam laser operates at temperatures between –30 °C and 30 °C and generates about 30 mJ of 1,067-nm radiation in about 5-ns long pulses with an M^2 of less than 1.6 over most of the operating thermal range, a beam diameter of 2.5 to 3.5 mm, a pointing stability and a pointing direction of less than 0.3 mrad, and a shot-to-shot energy stability with less than 2 percent root mean square variation. The oscillator provides an output energy of about 10 mJ. The two amplifiers give a three-fold gain per pulse.

A key feature of ChemCam is its ability to use LIBS to detect nearly all chemical elements—including light elements that previous Mars rovers couldn't measure.

The oscillator and amplifiers are housed inside a hermetically sealed titanium box filled with dry air and a getter. This setup protects the laser from environmental conditions, reducing the risk of self-contamination and absorbing potential pollutants. The laser was tested under the expected conditions on Mars—particularly in terms of thermal, radiative and mechanical constraints—before its integration with the rest of the ChemCam instruments. It was space qualified by Thales Optronique in France; France's Centre National des Etudes Spatiales; and Los Alamos National Laboratory and the Jet Propulsion Laboratory in the United States. To measure the emission lines of LIBS signals, ChemCam uses three spectrometers that operate in UV, visible and visible-to-near-IR spectral regions.

A key feature of ChemCam is its ability to use LIBS to detect nearly all chemical elements—including light elements that previous Mars rovers couldn't measure: hydrogen, lithium, beryllium, boron, carbon, nitrogen and oxygen. Before the launch of *Curiosity*, researchers demonstrated that the ChemCam laser could quantify most major elements in geological samples to ±10 percent relative accuracy. The ChemCam team is working to realize this accuracy on Mars samples. In view of the LIBS spectra being generated by ChemCam, current data indicate that the laser is performing to a level that satisfies all the requirements of the mission and promises to zap more than one million laser pulses on Martian rocks and soils.

The ChemCam also houses the remote micro-imager—a high-resolution camera that it inherited from the European Space Agency project Rosetta. The RMI provides geomorphology and textural data of Martian rocks and soils as well as context images of the LIBS targets. With a field of view of 20 mrad and a capability to identify a 1-mm feature from 10 m, the RMI can also visualize features within the 0.35 to 0.55 mm diameter ablated regions before and after laser zapping. Five ablated regions, enlarged



ChemCam's first Martian laser-induced breakdown spectrum was obtained remotely on day 13 of the MSL mission. It is the result of a laser hitting "Coronation," a fist-sized rock located 2.6 m away from the ChemCam.

Phil Saunders/Adapted from NASA/JPL-Caltech/LANL/CNES/IRAP

further by the laser shock wave, are clearly visible in the image on the facing page.

In the figure above, we show the first LIBS spectrum of a Martian rock named "Coronation." This spectrum, sent to Earth on 19 August 2012, represents the average of 30 LIBS spectra measured at a single location. For this specific measurement, the hydrogen peak was only present on the first laser shot, indicating that hydrogen was only present on the top surface of the rock.

Machine learning for LIBS signal analysis

One of the goals of ChemCam is to analyze LIBS signals coupled to RMI images. These data can be used to rapidly extract compositional information of Martian rock and soil samples, which can then be classified using a database of well-characterized samples. The classifications are then used to determine if a more in-depth analysis with other *Curiosity* instruments is appropriate. The amount of data generated with LIBS is large compared to the number of elements contributing to its signal.

As a result, it is necessary to reduce the dimensionality of the data before a classification algorithm can be applied. To suppress unimportant data and highlight useful information, ChemCam researchers have explored a number of dimensionality reduction techniques based on multivariate analyses. These include principal component analysis, independent component analysis, partial least squares, soft independent modeling of class analogy and non-linear Sammon's map projection. These complementary methods provide physical meaning to the independent components retrieved and a fast and easy way to visually demonstrate the accurate classification of zapped Martian rocks and soils.

What's next?

As of November 2012, ChemCam has directed over 12,000 laser shots at rocks and soils on Mars, and the interpretation of the LIBS analyses of Mars are under way. Time will tell how useful LIBS is in helping *Curiosity* in its search of habitable environments on our neighboring planet. With good fortune, ChemCam's team will have a very rewarding future. Pulsed lasers have entered an era where they too can contribute to answering one of the oldest question humans have ever asked: Are we alone in the universe? OPN

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Adolph Lomb,
circa 1915.

Childhood home of Adolph Lomb.

Bausch + Lomb Archives

Adolph Lomb

Patronage, Industry and Optics in Early 20th-Century America

Victoria N. Meyer

Adolph Lomb did not make any major discoveries or publish original works; yet his influence on early 20th-century optics was monumental. Reminiscent of the wealthy princes and patrons of the Renaissance and Enlightenment periods, he advanced optics by generously supporting the field—and the Society devoted to it.

Courtesy of Bausch + Lomb Archives

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Bausch + Lomb Archives

The Bausch + Lomb family and employees in the early 1890s. (Bottom row, left) Captain Henry Lomb, J.J. Bausch and E.E. Bausch; (top row, left) William Bausch, Henry Lomb, Henry Bausch, Edward Bausch, Carl Lomb, Adolph Lomb and William Drescher.

Most OSA members are familiar with the name Adolph Lomb due to the medal awarded annually by the Optical Society in his name. Some may also know him as a charter member of the Society and the eldest son of Bausch + Lomb Optical Company's co-founder, Captain Henry Lomb.

But beyond that, details may seem scarce. When we peel back some of the mystery surrounding Lomb, we discover that he was a patron and philanthropist whose support enabled the development of early American optics as well as the fledgling Optical Society of America. Most of the tributes to Lomb—from the award to the library bearing his name—would have embarrassed the shy man. However, they serve as important reminders of his authority in optics at the turn of the century, as well as the role of science and patronage in American society.

A scholar and captain of industry

Lomb was born in 1866, after a period that many historians characterize as the "launching" of American science. He was part of the first generation to come of age with science occupying a central place in American society and everyday life. His evolution into a man of science and industry thus was a product of his age as much as his family circumstance.

Like many others of his generation, Lomb envisioned science to be at the core of progress. As a result, he expanded the opportunities available to him from his father's position

To achieve progress, Lomb's "man of science" had to use his education and knowledge to advance the concerns of humanity.

and wealth. These prospects began with his early education. As the elder Lomb headed the sales division of the Bausch + Lomb Optical Company, Adolph spent his boyhood in the bustling center of New York City, as well as a year abroad in Europe in 1878-1879.

His early interest in optics was stimulated by his experiences in the family company after the Lombs moved back to Rochester, N.Y., in 1880. He began on a course of practical education, serving as an apprentice in the various divisions of the B+L factory. There, Lomb became fascinated with the more intricate operations of optics, as well as the complex theories and history behind their application.

Lomb was so invested in his practical education that he delayed his university studies until 1888, when he entered the University of Rochester at age 22. He studied mathematics and physics for two years before transferring to the Massachusetts Institute of Technology. He earned a degree in mechanical engineering from MIT in 1893. Lomb thoroughly enjoyed his studies and was sent for advanced academic work in theoretical optics at European centers of science: the University of Berlin, the Royal Technical College of Berlin, and the University of Paris.

The additional education not only provided Lomb with an unsurpassed grounding in theoretical and applied optics, but also had benefits for B+L. After his return to the United States around 1897, Lomb officially began work as a B+L employee. He took an interest in management, quickly rising in rank and responsibility.

Although Adolph had not technically been a B+L employee while studying abroad, he spent considerable time in various workshops, including those of the leading optical firm, Carl Zeiss Works in Jena, Germany. The personal relationships he cultivated there were essential in formalizing a later alliance among Carl Zeiss, B+L and Saegmuller in 1908. By 1916, Lomb was assistant secretary of the company and on the board of directors. He would rise to be the first vice president of the company, an office he retained until his death.

Science and a brighter future

As Lomb continued to rise within B+L, American society underwent a transformation that can help us better understand Lomb's priorities and historical significance. In the wake of the negative consequences of the first industrial revolution—such as pollution and poor working conditions—and widespread popular discontent, a new reforming spirit emerged in the 1890s, launching the Progressive Era in American history.

An early component of this was the shift in American philanthropy—from the vague desire to "do good" to large, well-funded reform movements. Crucial to this change were the captains of American industry, including Andrew Carnegie and John D. Rockefeller.


60 Petzval. Bericht über dioptrische Untersuchungen.

Um die Liebhaber der Photographie an entfernten Orten in den Stand zu setzen, eine ähnliche Camera obscura, wie die vorgezeigte, sich verfertigen zu lassen, folgt hier noch eine Abbildung dieses Instrumentes, ausgeführt nach einer Photographie.

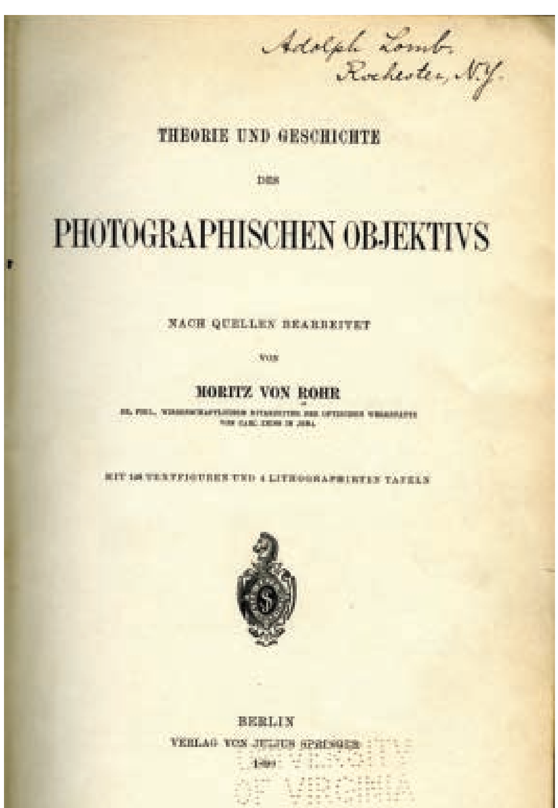
Illustration from Joseph Petzval's *Bericht Über Optische Untersuchungen* (1857).

Historical Collections & Services, Claude Moore Health Sciences Library, UVa.

OSA's aims aligned with Lomb's focus and work **in both theoretical and applied optics, indicating his likely influence in the direction and formation of the Society.**

Carnegie published an essay titled "Gospel of Wealth" in 1889 that laid out the duty of the emerging class of the self-made wealthy. His argument was essentially that the rich are only entrusted with wealth in order to fulfill their moral duty to advance the welfare and happiness of the general public. Carnegie asserted that the best way to do so was through private organizations. So by the dawn of the 20th century, these philanthropic robber barons were establishing large private foundations to enact their philanthropy efficiently.

The Lomb family had been at the forefront of this shift, as Captain Henry Lomb was already using his industrial position to fund philanthropic reforms in Rochester in the 1880s. He not only helped to establish the Rochester Institute of Technology in the 1880s, but he also introduced kindergarten to Rochester public schools and formed institutions of public health in the city. His actions established a model for his two sons on how they should be leaders in business and society, emphasizing social innovation and philanthropy. Adolph continued on this path, dedicating his learning and skills to the responsibilities of citizenship. As a shy individual, he chose the most inconspicuous means to participate in public and social life and to help people.


Adolph Lomb.
Rochester, N.Y.

THEORIE UND GESCHICHTE

DES

PHOTOGRAPHISCHEN OBJEKTIVS

NACH QUELLEN BEARBEITET

VON

MORITZ VON ROHR

BERLIN

VERLAG VON JULIUS SPRINGER

Lomb's signature on the title page of his edition of *Thoerie und Geschichte des Photographischen Objektivs* by Moritz von Rohr (1899).

Historical Collections & Services, Claude Moore Health Sciences Library, UVa.

Adolph's aims diverged from his father's because of Adolph's absolute focus on science as the path towards progress. According to his close confidante and memorialist, James P.C. Southall, Adolph "devoted his life to the advancement of science, in the firm conviction that enlightenment and knowledge went hand in hand with virtue and religion for the promotion of the welfare of mankind." We can understand then that, for Lomb, scientific and technological developments alone did not define progress. Instead, they were the means towards achieving grander social and political goals. He was dedicated to what historian Leo Marx calls an Enlightenment belief instead of a technocratic concept of progress. To achieve progress, Lomb's "man of science" had to use his education and knowledge to advance the concerns of humanity. The utilitarian focus comes directly from the Enlightenment in the 18th century, when thinkers emphasized the application of science to everyday life for the benefit of mankind.

By the start of the 20th century, we can clearly see the influence of this vision in the practices of B+L. A pamphlet celebrating the 1908 alliance with Zeiss and Saegmuller proclaimed the new industrial spirit. It stated: "While it does not lose sight of or neglect the success of the individual, aims to subserve the good of mankind as a whole. To give to

Wikimedia Commons

The UVa Rotunda, which was the original library building at the head of Jefferson's Academical Village. A collection of Lomb's volumes is housed at UVa.

science the best instruments … is surely to advance the welfare of humanity." The goals and success of science, industry and mankind were linked together in one monumental project.

Lomb was not alone in his devotion to science. For many in the Progressive Era, science became an enlightened problem-solving tool. Men like Rockefeller and Carnegie emphasized scientific philanthropy. In other words, they envisioned science as pivotal to a reformed America. This required ensuring future scientific experts as well as scientific management. Carnegie, for example, founded the Carnegie Institution of Washington in 1902, to "show the application of knowledge to the improvement of mankind."

OSA and Lomb's model for science

Before the U.S. Civil War, the American scientific community had begun to establish core institutions of science as well as professional ideals. But by the 1890s, it entered a new phase of institutionalization, professionalization and specialization funded and led by these philanthropic foundations in what some have deemed a second age of scientific revolution. Philanthropic aims overlapped with the increasing emphasis on and celebration of science in American society in a way particularly suited to Lomb's views and goals.

One of these new professional, discipline-specific associations was the Optical Society of America. It is not surprising that Lomb was an eager collaborator and charter member of the Society when it was founded in 1916. OSA sought to combine theory and application and become an authority in the emerging area of industrial research. OSA's aims aligned with Lomb's focus and work in both theoretical and applied optics, indicating his likely influence in the direction and formation of the Society.

OSA elected Lomb as its first treasurer. He filled that office until his death in 1932, despite initial restrictions to one-term appointments. Yet in most records on the early history of the society, Lomb is barely mentioned. Hilda Kingslake's in-depth study of OSA in 1966 was one of the few to acknowledge his role. Yet his authority and status is clear when one examines the statements made about him by his contemporaries.

While Lomb's impact was great, it was often unseen, and the full extent of his patronage is unknown. He was an extremely shy, lifelong bachelor who supported the works of others rather than producing his own. Most information about him comes only second-hand, in particular from his dear friend, physics professor and former OSA President James P.C. Southall. Because Lomb shunned publicity, after his death, Southall took pains to emphasize the man and his deeds. As Southall described him, Lomb was OSA's own Macaenas: unseen but never unfelt as a patron and advisor.

By surveying OSA's early records, one can see just how essential Lomb was to the very existence of the society. He not only eagerly gave his time, but he also liberally donated his money. He put his beliefs about the philanthropic value of science into practice through his patronage of OSA as a whole, as well as of individual members and projects. As treasurer, Lomb knew first-hand the usually dire straits of the Society through the 1920s. So he would quietly make up the deficit with his own money. In 1917, he donated over $1,000 in addition to his own dues. This was a large sum of money at the time, equal to the annual salary of most professors.

During the 1920s, OSA's annual deficit continued, and Lomb donated somewhere between $2,000 and $3,000 each year. Quite simply, the Society would have gone under without Lomb. Lomb's beneficence extended to other projects, including the celebrated translation in 1924–1926 of von Helmholtz's *Physiological Optics*, which Lomb personally bankrolled after the costs exceeded the original estimate of $10,000.

Lomb regularly made significant contributions to the Society in addition to his other philanthropic activities. His patronage remained consistent during the economic devastation of the Great Depression. His backing was so vital to the organization that OSA formally acknowledged his influence in October 1923, recognizing him as its patron. By the 1940s, three organizations would come to be designated as patrons of OSA. However, Adolph Lomb was the only individual ever to hold that title.

While OSA was not the only scientific organization of which Lomb was a member, it was the one to which he was most dedicated. Fittingly, his last acts were for the association. He literally signed a check for the Society on his deathbed with the help of his younger brother Henry. Although he was a man of industry, he funneled his wealth back into the advancement of science—not for profit, but for the advancement of knowledge. For it was knowledge, he believed, that would help mankind.

The Adolph Lomb Optical Library

The Adolph Lomb Optical Library at the University of Virginia (UVa) is a unique resource for anyone interested in optics. It contains some rare works that are not easily available elsewhere in the United States.

In many ways, it is a reflection of the man whose name it bears. A collection of more than 1,400 volumes at the time it was donated, Lomb's tastes and interests were the driving force behind the library. Since he was primarily interested in theory, design and construction of optical instruments, the strengths of the collection are in geometrical and applied optics, physiological optics and ophthalmological optics, including optometry.

It includes many original editions of works, copies of key articles, primarily in English, French and German, as well as some works in Latin and other European languages. Lomb's love for the volumes of his library is visible by the notes in the margins of some works.

Although there is not yet a searchable guide of the contents of the collection, UVa and many other libraries do have a printed copy of *The Catalogue of the Adolph Lomb Optical Library*, which was published in 1947. Much of the collection, in particular the rare works, is housed in Historical Collections of the Claude Moore Health Sciences Library.

To access works from the Lomb Optical Library, contact the staff through their website www.hsl.virginia.edu/historical/.

The rest of the collection is spread throughout the UVa library system, so it is best to search through the online catalog Virgo, found at www.lib.virginia.edu/.

(Above) Sample of works in the Adolph Lomb Optical Library housed at the University of Virginia, U.S.A.

Historical Collections & Services, Claude Moore Health Sciences Library, UVa

ONLINE EXTRA

Visit www.osa-opn.org/home/multimedia to view two videos that highlight the legacy of optics in the Rochester region—including the contributions of Bausch + Lomb.

During the 1920s, OSA's annual deficit continued and Lomb donated somewhere between $2,000 and $3,000 each year. Quite simply, the Society would have gone under without Lomb.

Building a mecca for optics

Lomb's other great love was his optics library, collected by him and his brother since their youth. When he died suddenly from pneumonia in 1932 without a will, his brother Henry sought to honor Adolph's memory by donating their library in his name to a university. Entrusting the collection to an institution suited the progressive and philanthropic example set by their father, as well as Adolph's own Enlightenment understanding of progress through science.

At the time of his death, it was recognized as the first library of its kind in the United States and the finest collection of works on modern optics. Henry had wanted to fulfill his brother's legacy and vision by creating a "mecca to which students of optics would come from all parts of the United States." Southall suggested his own alma mater, the University of Virginia (UVa), as the ideal spot because of its geographic location, giving increased and equal access to students of optics in both the North and the South. He also knew of both Lomb brothers' admiration for UVa's founder, Thomas Jefferson, an Enlightenment figure who had been dedicated to science and the progress of man.

The donation of the library to UVa was quickly arranged, and it was officially presented to the Physics Library during the 1933–1934 academic session. Henry had intended to set aside funds to endow the library in order to keep it up-to-date, but he died suddenly in 1934. Support for the library then fell primarily to Southall, as OSA had decided to honor the memory of Lomb rather by saving funds for the medal bearing his name.

Southall continued through the 1940s to promote the library in hopes of gaining publicity and therefore funding for its support. An article in *Science* in May 1945 detailed that the library had already declined in the past decade because it lacked an endowment. Indeed, the whole purpose of publishing the catalogue of the library in 1947 was to advertise the library's holdings with the hope of gaining funds to maintain and develop the collection as the Lomb brothers would have desired. Unfortunately, it seems that once those who had personally known Lomb died, so too did the support for his collection of optics books. The library's invisibility by the second half of the 20th century also sadly mirrors that of Adolph himself.

Many of the works mentioned in this catalogue are no longer in UVa's possession—a fact that underscores the continued problems of the unendowed library, as well as the more general challenges raised in the age of digitalization.

Visions of progress

Lomb's Enlightenment belief in progress through science persists. Although recent history has revealed the risk in holding absolute faith in science, modern industrialized society still privileges science as the means of all knowledge and progress. Science, though, is not only a creation of those whose names are recorded as inventors and authors. Lomb's life exemplifies the collaborative nature of scientific production, and his historical collection is his enduring legacy. By bringing this quiet man from the shadows and throwing open the doors of his collection, we can better understand the past and inspire future scholars. OPN

Special thanks to the staff at the archives of Bausch + Lomb and to Historical Collections, Claude Moore Health Sciences Library, UVa Library.

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Alfred Cann

All about Sparkles

Thinkstock

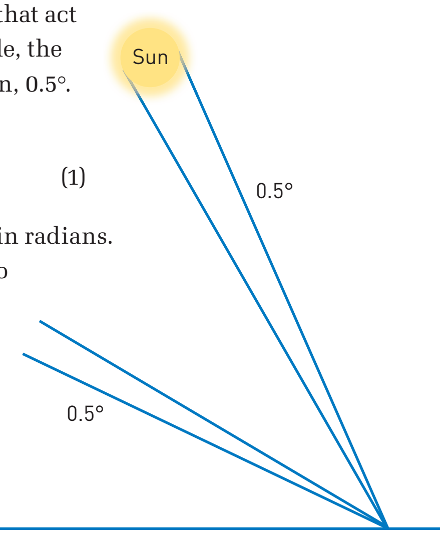
Sparkles are a magnificent manifestation of optics in nature, and nowhere are they as abundant as on freshly fallen snow. Because they evade our depth-perception mechanism, sparkles have an otherworldly quality that makes them seem to float indeterminately rather than appearing on any surface or at any altitude.

Whether they're caused by snow, diamonds or glitter, sparkles are always dazzling to behold. The glittering, ephemeral effect they have is caused in part by their rapid appearance and disappearance. But that is not the whole story—or even most of it. The startling impression they induce is caused by the inability of our depth-perception mechanism to process them. Snow crystals have flat surfaces that act as tiny mirrors, reflecting the sun. Considering the mirror width negligible, the beamwidth of these reflections is equal to the angular diameter of the sun, 0.5°. The width of the illuminated spot at the eye is given by

$$w = r\theta, \qquad (1)$$

where r = the distance from the mirror to the eye and θ = the beamwidth in radians.

This can be much smaller than the typical distance between our two eyes. For example, at 3 m (10 ft), the spot width is about 2.5 cm (1 in.). Consequently, each sparkle is generally seen by only one eye, and thus the two eyes see different sets of sparkles. That prevents the depth perception system from fusing the two images and determining the distance to any one sparkle.



MIRROR REFLECTION: Snow crystals have flat surfaces that act as tiny mirrors, reflecting the sun. Considering the mirror width negligible, the beamwidth of these reflections is equal to the angular diameter of the sun, 0.5°. The width of the illuminated spot can be much smaller than the typical distance between the two eyes.

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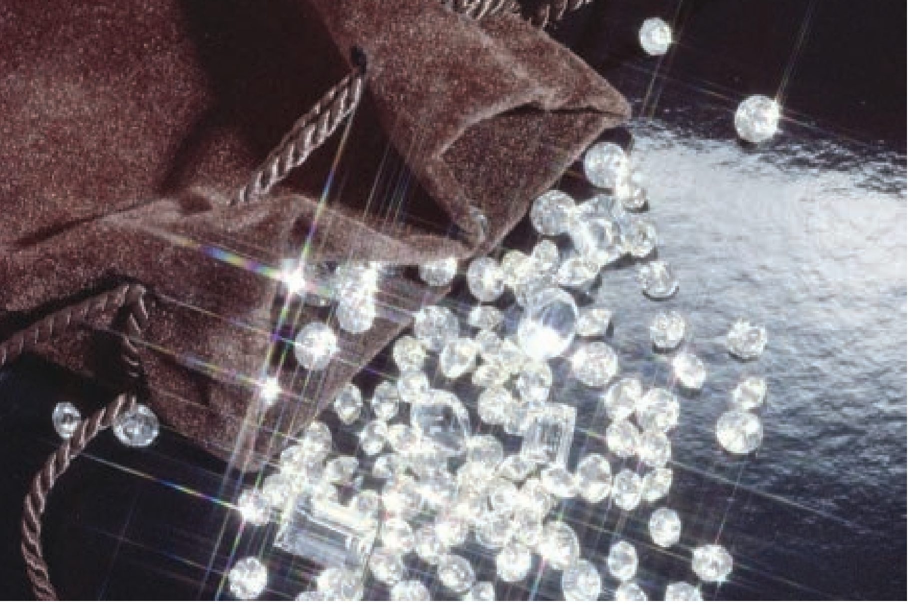
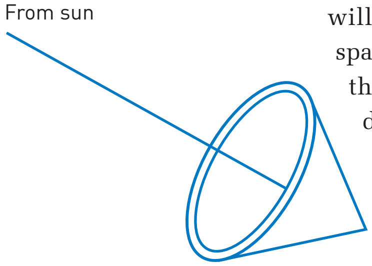


Thinkstock

The ethereal quality of the sparkle stems largely from its appearing to float indeterminately, neither totally above nor below nor on the surface—where we "know" it to be. It will usually appear to float above the surface. Interestingly, the illusion disappears at once when the unstimulated eye is closed. Apparently, the brain knows not to expect stereopsis when one eye is closed.

The ethereal quality of the sparkle stems largely from its appearing to float indeterminately, neither above nor below nor on the surface—where we "know" it to be.

The same effects can be seen at night by moonlight or artificial light, provided the light is sufficiently small and far enough away. Occasionally, light will be refracted into a crystal and dispersed on its way out. In that case, you will see colored sparkles. Occasionally, two sparkles will happen to be close enough that their images can be fused. In that case, a definite depth will be perceived. However, the fused image will generally not lie on the surface, thus again providing a peculiar appearance.



Glitter, gems and dewdrops

Sparkles can also be seen with the glitter dust that young girls like to put on their faces or that is sometimes used to depict snow on Christmas cards. The effect can also be seen with sequins and faceted gems. Jewelers have learned by experience that diamonds show the most sparkle under small bright lights mounted fairly high. This binocular effect helps to explain why the diamonds in photographs, no matter how artfully lit, never sparkle like the real thing. (It's not just the limited dynamic range.)

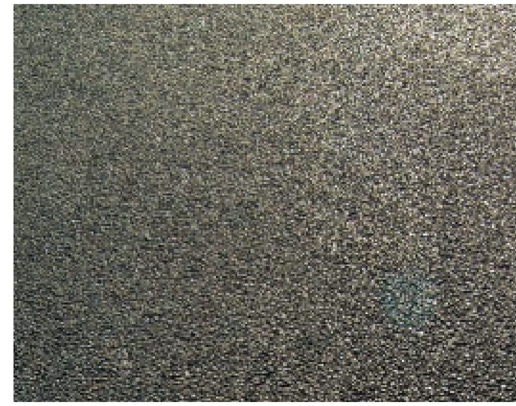
It is curious that the sparkle effect appears to have escaped notice until now, while much rarer phenomena such as the green flash and the glory have been known for centuries and understood for years. I propose reserving the term "sparkle" for this narrow-beam effect, leaving such terms as "glint," "glisten," "gleam" and "shimmer" for the broad-beam reflections from curved surfaces such as icicles, ice-covered twigs and ripples on water.

Dew drops can also produce the sparkle effect—but by a different mechanism. Sparkles will generally be found only in the "dewbow"—an ellipse or arc on the ground along which the dew sparkles in color. (The rest of the dew merely glistens white.) They are caused by the same mechanism that cause rainbows. To simplify somewhat, a spherical drop emits an annular conical beam with a half angle of 41°, and a thickness of 2°, as shown in the figure to the left. The color varies from red to violet across the thickness. When an eye is within the thickness of the sheet beam, it receives just a narrow bundle of rays from this beam of one color; let us call this a "ray." It also receives rays from different parts of the cones of other drops. The locations of these drops trace out a bow in the sky (rainbow) or on the grass (dewbow).

It is more difficult to observe sparkle with dewdrops because the line connecting the two

DEWDROP REFLECTION: A spherical water drop emits an annular conical beam with a half angle of 41° and a thickness of 2°. The color varies from red to violet across the thickness. When an eye is within the thickness of the sheet beam, it receives just a narrow bundle of rays from this beam, of one color, or a "ray." It also receives rays from different parts of the cones of other drops. The locations of these drops trace out a bow in the sky (rainbow) or on the grass (dewbow).

It is more difficult to observe sparkle with dewdrops than with snow because the line connecting the two eyes must be more or less perpendicular to the sheet beam, and the greater beam thickness of 2° requires the observer to be closer to a dewdrop than to a snow crystal.



Thinkstock

eyes must be more or less perpendicular to the sheet beam, and the greater beam thickness of 2° requires the observer to be closer to a dewdrop than to a snow crystal. When both eyes are within the sheet beam and seeing different colors, the effect is interesting but does not seem to prevent fusion. Some simple experiments with different-colored dots have confirmed that they can be fused and indicate a definite distance. It might be interesting to explore whether it is more difficult to achieve fusion in such a case.

A white dewdrop can sparkle if it is hidden from one eye by a blade of grass.

Once you know how to recognize them, you may start noticing sparkles everywhere—on granite, sand and even on asphalt, mostly arising from bits of mica. Many more spots glisten but do not exhibit the sparkle effect; their beams are too broad, probably because they have curved surfaces; a thin flake of mica is easily bent. The sparkle effect can also be observed with a glitter-coated card. Use the sun or any other small-angle light source. Tilting the card makes the sparkles appear and disappear rapidly.

Part of the impact of laser speckle is from the sparkle effect, a binocular difference caused by narrow-beam scattering. But aside from that, laser speckle is a much more complex phenomenon involving interference.

Capturing sparkle

Hopefully these insights will help diamond photographers to realize that stereo photography is needed to capture sparkle. This does not mean that a 3-D viewer must be packed with each jewelry catalog; two photos can be printed side-by-side as a stereogram for cross-eyed viewing. Even so, the dynamic range will be severely limited in print; slides are much better, as are LCD displays.

Once you know how to recognize them, you may start noticing sparkles everywhere—on granite, sand and even on asphalt, mostly arising from bits of mica.

Because sparkles have not been understood until now, theaters probably have not been able to make realistic snow sparkles in their productions—only glistens (which are equally bright to both eyes). The reason is that theater light fixtures typically have lenses several inches in diameter. Trying to use those with sequins or the like to make sparkles results in excessive reflected beamwidth except maybe for patrons in the first few rows. The beams can be narrowed by removing all lenses and mirrors from the fixtures, using very compact lamps, and hanging them far back from the stage.

Knowing about and looking for the ethereal nature of sparkles can make you more aware of them and enjoy them more—I know it has for me. OPN

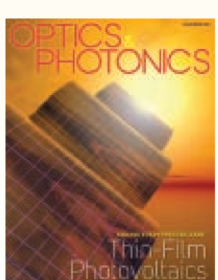
Alfred Cann (sesame@ieee.org) is a retired electronics engineer from BAE Systems (formerly Sanders Associates).

PUBLICATIONS

Welcome New Editors

We are happy to announce that **Xiaoyong Hu** of Peking University, China, has been appointed as a new topical editor for *Optics Letters*. We also welcome new topical editor **Martin Schnaiter** of Karlsruhe University of Technology, Germany, to the editorial board of *Applied Optics*. Finally, **Shining Zhu** of Nanjing University, China, has agreed to serve as a topical editor for JOSA B.

We'd also like to thank the following associate and topical editors who have agreed to serve second three-year terms: **Christophe Dorrer**, University of Rochester, U.S.A.; **Yoonchan Jeong**, Seoul National University, Korea; **Paul Murphy**, QED Technologies, U.S.A.; **Thomas Sudmeyer**, University of Neuchatel, Switzerland; and **Limin Tong**, Zhejiang University, China, for *Optics Express*; and **Vasudevan Lakshminarayanan**, University of Waterloo, Canada, for *Optics Letters*.



Optics & Photonics News welcomes three new members to its editorial advisory committee: **Dmitry Dylov**, Global Research, U.S.A.; **Nicholas Frigo**, U.S. Naval Academy; and **Vasudevan Lakshminarayanan**, University of Waterloo, Canada. We thank these members of the optics community for their support of OSA publications.

Tamar Loladze

Werner presents at the Medical University of Armenia.

GLOBAL NEWS

Werner Travels with OSA Grant

OSA Fellow **John S. Werner**, University of California, Davis, U.S.A., was awarded an OSA Fellow travel grant to visit Azerbaijan, Georgia, and Armenia in September 2012. He and his gracious hosts enthusiastically discussed vision science and medical optics. However, he found that research facilities and opportunities for young scientists in these countries were limited.

LAOP Conference Held in Brazil

The Latin America Optics & Photonics Conference (LAOP) took place in São Sebastião, Brazil, from 10-13 November 2012. Sponsored by OSA and Sociedade Brasileira De Física (SBF), LAOP is a biennial conference started in 2010. The plenary speakers were **Carlos Henrique de Brito Cruz**, FAPESP, Brazil; **Philip Russell**, Max Planck Institute for the Science of Light, Germany; and OSA President **Donna Strickland**, University of Waterloo, Canada.

OSA Partners with CIOMP

Following the success of the 2011 program, OSA and the Changchun Institute of Optics, Fine Mechanics and Physics (CIOMP), China, will partner for a 2013 Summer Session Program on optical engineering, design and manufacturing from 4-9 August 2013 in Changchun, China. The application deadline is 19 April 2013. Confirmed speakers include **Pierre H. Chavel**, Inst. d'Optique Lab, Fabry, France; **Juan C. Miñano**, Universidad Politécnica de Madrid, Spain; **Jannick P. Rolland**, University of Rochester, U.S.A.; **Kevin P. Thompson**, Synopsys, Inc., U.S.A.; and **James C. Wyant**, University of Arizona, U.S.A. For more information, visit www.osa.org/summersession.

Asia Communications on Photonics

The Asia Communications on Photonics Conference (ACP) was held 7-10 November in Guangzhou, China. Sponsored by OSA, SPIE, the IEEE/Photonics Society, the Chinese Optical Society and the China Institute of Communications, ACP is the largest event that OSA sponsors in China.

STUDENT NEWS

Unicamp Hosts Second IONS South America Conference

The second IONS meeting in South America was held on 9-10 November 2012 at the Unicamp campus in Campinas, Brazil. About 30 students were joined by three invited speakers: **Masud Mansuripur**, University of Arizona, U.S.A.; **Newton Frateschi**, Unicamp, Brazil; and OSA President **Donna Strickland**, University of Waterloo, Canada. The event also featured student talks, a poster session and presentations about the IONS chapters.

OSA/Kari Apter

IONS-SA II attendees.

HONORS AND AWARDS

Kyle J. Myers **Named U of A Alumna of the Year**

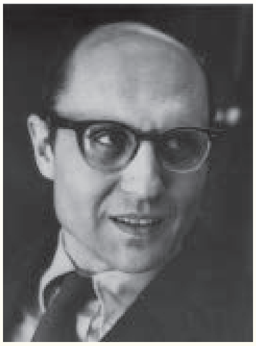
Kyle J. Myers

OSA Fellow **Kyle J. Myers**, U.S. Food and Drug Administration, has been selected by the University of Arizona Alumni National Board as the 2012 Alumna of the Year for the College of Optical Sciences. Myers, who received her Ph.D. in 1985, has made great contributions to the science that enables medical imaging systems to diagnose serious diseases.

IN MEMORY

Richard G. Brewer

Quantum Optics Pioneer



AIP Emilio Segrè Visual Archives, Physics Today Collection

Richard G. Brewer, an OSA Fellow known for his contributions to atomic physics, laser spectroscopy and quantum optics, passed away on 22 July 2012, following a long illness. He was 83.

Brewer was an instructor at Harvard University and an assistant professor at the University of California, Los Angeles, before joining the research staff at IBM, Almaden, in 1963, where he remained until his retirement in 1994. He became an IBM Fellow in 1973 and a consulting professor of applied physics at Stanford University in 1978.

An OSA member for 35 years, Brewer was elected as an OSA Fellow in 1977. He received the Albert A. Michelson Gold Medal of the Franklin Institute in 1979. In 1997, he endowed the Brewer prize at Caltech, which is awarded annually to a freshman who is deemed the best at overcoming two "hurdles" (i.e., complex word problems) for admission into an independent research program.

In 2000, Brewer received the OSA Charles Hard Townes Award for his outstanding contributions to the field of quantum optics. Some of his contributions include the first observation of stimulated Brillouin scattering in liquids; the invention of the optical Stark-switching technique allowing studies of novel coherent optical transients; an experimental test of the optical Bloch equations for solids; a fundamental theorem on coherent optical or NMR transients; and a QED quantum jump theory of a single trapped ion.

With Aram Mooradian, he initiated the highly successful International Conference on Laser Spectroscopy, a conference that continues to be held in worldwide venues.

If you would like to make a memorial donation to the OSA Foundation in honor of Richard G. Brewer, please visit www.osa-foundation.org/give.

HISTORY

Happy Birthday **Satyendra Nath Bose**

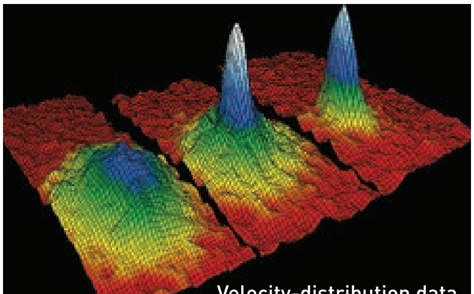
Quantum physicist and namesake of the boson particle

The year 1894 got off to a brilliant start: Satyendra Nath Bose was born on the first of January in Kolkata, India. He had a wide range of interests, including languages, mathematics, biology and fine arts, but he's best known for his incredible contributions to quantum mechanics.

Wikimedia Commons

Bose began his career as a physicist in 1916, a pivotal time for the field: Einstein's theory of general relativity was published in 1915, and evidence supporting the new quantum theory was starting to accumulate. Bose wrote a manuscript in 1924 showing how he derived Planck's quantum radiation law by using a new technique for counting states with identical particles. After it was rejected for publication, he sent the paper to Albert Einstein for review. Einstein appreciated the importance of the work and submitted it on Bose's behalf to a well-respected German physics journal. This paper was integral to creating the field of quantum statistics and opened the door for Bose to collaborate with other science luminaries, including Louis de Broglie, Marie Curie and Einstein.

NIST/JILA/CU-Boulder



Velocity-distribution data of a gas of rubidium atoms, confirming the discovery of a new phase of matter, the Bose–Einstein condensate.

His revolutionary way of viewing photon behavior and photon statistics provided the foundation for Bose-Einstein statistics and the theory of the Bose-Einstein condensate. Recently, his namesake particle—the boson, a class of particles that obey Bose-Einstein statistics—has been popping up all over the world with the recent (probable) discovery of the Higgs boson in July 2012. Although his work was never recognized by a Nobel Prize, Bose was undoubtedly one of the most important figures in 20th century science.

Got News? OPN is interested in sharing the achievements of your colleagues. Please help us celebrate careers, awards and other accomplishments. Send news to opn@osa.org.

Hannah Bembia (hbembia@osa.org) is OSA's publications administrative assistant. Sarah Michaud is OPN's associate editor.

CALENDAR

OSA Optics and Photonics Conferences and Meetings

2013

Optical Fiber Communication Conference and Exposition/National Fiber Optic Engineers Conference (OFC/NFOEC)
17–21 March 2013
Anaheim, Calif., U.S.A.
www.ofcnfoec.org

Optics in Life Sciences Congress
14–18 April 2013
Kona, Hawaii, U.S.A.
www.osa.org/Life_Sciences_Congress

- Bio-Optics: Design and Application (BODA)
- Novel Techniques in Microscopy (NTM)
- Optical Molecular Probes, Imaging and Drug Delivery (OMP)
- Optical Trapping Applications (OTA)

Digital Holography and 3-D Imaging (DH)
21–25 April 2013
Kohala Coast, Hawaii, U.S.A.
www.osa.org/dh

European Conferences on Biomedical Optics (ECBO)
12–16 May 2013
Munich, Germany
www.osa.org/ecbo

International Photonics and Opto-Electonics Meetings (POEM)
25–26 May 2013
Wuhan, China
http://poem.wnlo.cn/

- Nanophotonics, Nanoelectronics and Nanosensor
- Advanced Optoelectronics for Energy and Environment

CLEO: 2013—Laser Science to Photonic Applications (CLEO)
9–14 June 2013
San Jose, Calif., U.S.A.
www.cleoconference.org

Optical Interference Coatings
16–21 June 2013
Whistler, British Columbia, Canada
www.osa.org/oic

Imaging and Applied Optics Congress
23–27 June 2013
Arlington, Va., U.S.A.
www.osa.org/Imaging_Congress

- Imaging Systems Applications (IS)
- Applied Industrial Optics: Spectroscopy, Imaging & Metrology (AIO)
- Hyperspectral Imaging and Sounding of the Environment (HISE)
- Adaptive Optics: Methods, Analysis and Applications (AO)
- Computational Optical Sensing and Imaging (COSI)
- Fourier Transform Spectroscopy (FTS)

Advanced Photonics Congress
14–19 July 2013
Rio Grande, Puerto Rico, U.S.A.
www.osa.org/en-us/meetings/optics_and_photonics_congresses/advanced/

- Integrated Photonics Research, Silicon and Nano-Photonics (IPR)
- Optical Sensors (SENSORS)
- Photonic Networks and Devices (NETWORKS)
- Signal Processing in Photonics Communications (SPPCom)

Nonlinear Optics
21–26 July 2013
Kohala Coast, Hawaii, U.S.A.
www.osa.org/nlo

Frontiers in Optics 2013/ Laser Science XXIX (FiO/LS)
6–10 October 2013
Orlando, Fla., U.S.A.
www.frontiersinoptics.com

Advanced Solid-State Lasers Congress
27 October–1 November 2013
Paris, France
www.osa.org/assl

- Application of Lasers for Sensing & Free Space Communication (LS&C)
- NEW! Mid-Infrared Coherent Sources (MICS)

Renewable Energy and the Environment Congress
4–7 November 2013
Tucson, Ariz., U.S.A.
www.osa.org/Renewable_Energy

- Optics for Solar Energy (SOLAR)
- Solid State Organic Lighting (SOLED)
- Optical Nanostructures and Advanced Materials for Photovoltaics (PV)
- Optical Instrumentation for Energy & Environmental Applications (E2)

Support the Siegman International Summer School

Dr. Tony Siegman served on the organizing committee for OSA's first international summer school program, the International Summer Session on Lasers and Their Applications. This school, hosted in China, provided more than 100 students from 13 countries with world-class lectures, interactive sessions and networking events.

The OSA Foundation will carry on Tony's work by endowing a summer school dedicated to educating tomorrow's leaders in laser technology.

Your contribution will inspire the next generation, providing students from all walks of life and around the world with the opportunity to participate in this once-in-a-lifetime learning experience.

How You Can Help

Visit **www.osa.org/foundation/siegman** to learn more and make a donation.

OSA FOUNDATION

Upcoming **Call for Papers** Deadlines

Digital Holography and 3D Imaging (DH)

OSA Topical Meeting

21–25 April 2013
Kohala Coast, Hawaii, USA

Submissions Due:
14 January 2013, 12:00 EST (17:00 GMT)

www.osa.org/dh

European Conferences on Biomedical Optics (ECBO)

Co-Sponsored by OSA and SPIE

12–16 May 2013
Munich, Germany

Submissions Due:
16 January 2013, 17:00 GMT

www.osa.org/ecbo

CLEO: 2013 – Laser Science to Photonic Applications (CLEO)

9–14 June 2013
San Jose, California, USA

Submissions Due:
30 January 2013, 17:00 GMT

www.cleoconference.org

Exchanging Breakthroughs in Optics and Photonics
Submit your research today!

OSA
The Optical Society

For more information, visit www.osa.org/meetings

What's New

Product Profiles

Nextrom Fiber Optics Day

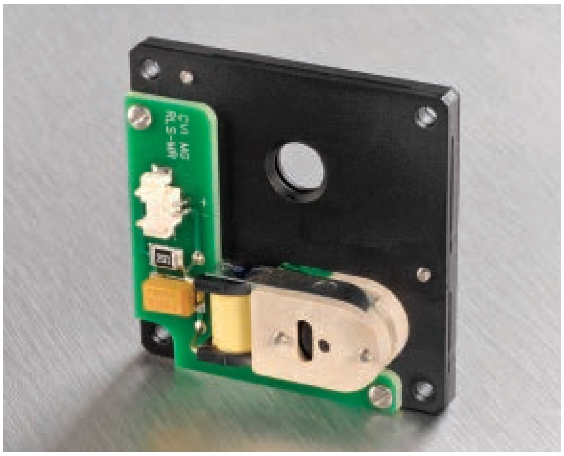
The Fiber Optics Day event took place at the Nextrom plant in Finland 22–23 May 2012. This was the third time this event had been held. The event was a great success and was very well received by partners and customers from the optical fiber and fiber optic cable industry, bringing together over 100 guests from various different companies from around the world. **Nextrom Oy** www.nextrom.com

UV-Visible Achromatic Wave Plates

Thorlabs has announced the release of its new line of achromatic wave plates, which are designed for use in the 260 – 410 nm range, making it one of the first to offer a high performance wave plate capable of reaching into the UV wavelength range. To manufacture an achromatic wave plate for use into the UV, Thorlabs utilized a compound plate design of quartz and sapphire; this plate design is advantageous for its manufacturability, high durability, and unparalleled wide field of view (FOV). **Thorlabs** www.thorlabs.com

TECHSPEC Optical Cage System

Edmund Optics introduces new TECHSPEC Cage System Linear Translation Assemblies. Offering a high precision alternative to complex optical alignment systems, these versatile opto-mechanical systems are designed for modularity and flexibility. TECHSPEC Optical Cage Systems consist of precision rods and plates, allowing the user to construct custom, adaptable opto-mechanical component systems with limitless options for modification. **Edmund Optics** www.edmundoptics.com



New SafeClose Shutters for Laser Applications

CVI Melles Griot introduces SafeClose laser shutters, based on the proven rotor drive actuation technology modified to close on power down. The proprietary Rotor Drive actuator provides a reliable, multimillion-cycle operation and ability to withstand harsh environmental conditions, including wide temperature variations (from –40 °C to +70 °C), high shock, and vibration in a clean environment. **IDEX Optics & Photonics** www.idexcorp.com

There is a charge of $150 for nonmembers to run a corporate press release in OPN Magazine and on the OPN website at www.osa-opn.org. Corporate Members and advertisers may run their press releases at no charge. The Product Profiles section is based on information supplied by manufacturers. *Optics & Photonics News* assumes no responsibility for its accuracy. Only a few products can be highlighted in each issue. High quality art is taken into account in the selection process, as are newsworthiness and relevance to the optics and photonics industry. For more information contact Regan Pickett at +1.202.416.1474 or email rpickett@osa.org.

CLEMSON UNIVERSITY

The Clemson University Department of Materials Science and Engineering, in conjunction with the Center for Optical Materials Science and Engineering Technologies (COMSET), is soliciting applications and nominations of Full or Associate Professors for the Sirrine Endowed Chair in Optical Fibers.

Supported by an endowment in excess of $7.3M, the Sirrine Chair will be a pre-eminent scholar with an international reputation for research relating to optical fiber materials, advanced structures and applications. The endowment resulted from funding by the J. E. Sirrine Textile Foundation and the South Carolina Research Centers of Economic Excellence Act, both of which stipulated that the chaired professor encourage knowledge-based economic development and academic excellence.

The Sirrine Chair will be a dynamic, innovative leader with a distinguished record of accomplishment of scholarship. The Chair will have an earned doctorate in materials science or related discipline and have 10-plus years of relevant industrial and/or academic experience. The candidate will have strong ties to professional societies and be active on national and international committees relating to research, education, or professional development in optics and materials. In addition to being a proven leader and mentor, the Sirrine Chair will have extensive industrial and governmental contacts, a solid history of international, interdisciplinary research, support and outreach activities, and a proven innovation record as evidenced by patents and licensed/commercialized technologies. Ideally, the candidate will be entrepreneurially minded having either created or consulted with new firms or have quantifiably contributed to business development or technology entrepreneurship. As a faculty member within the School of Materials Science and Engineering with additional affiliations within the University where warranted, the candidate will assume responsibilities associated with his/her academic appointment, including development and teaching of undergraduate and graduate courses, establishment of a strong and sustained research program, and demonstration of service to the University.

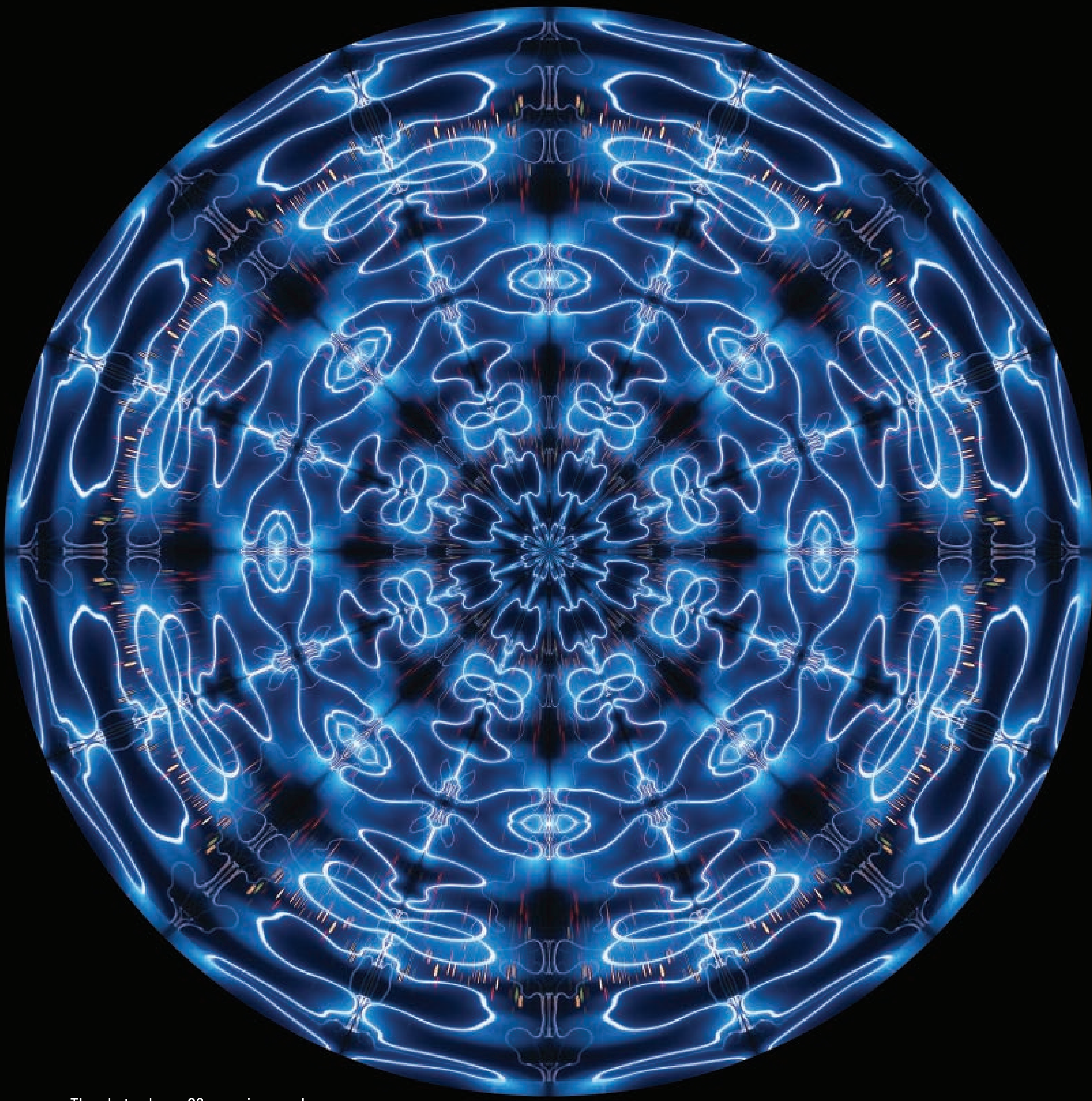
Applicants should submit a cover letter, their resume, curriculum vitae, and a list of five references. Electronic submission required and should be sent to Dr. John Ballato, Search and Screen Committee Chair, at: jballat@clemson.edu. Informal inquiries may also be directed to this e-mail address. Application materials should be received by March 1, 2013 to receive full consideration; however the search will remain open until the position is filled.

Clemson University is an AA/EEO employer and does not discriminate against any person or group on the basis of age, color, disability, gender, national origin, race, religion, sexual orientation or veteran status.

ADVERTISER INDEX

For advertising information, please contact Regan Pickett, OPN's Advertising Sales Manager, at **+1.202.416.1474** or **rpickett@osa.org**.

After Image



The photo shows 32 superimposed images of plasma discharging in a tube, which were then subjected to a polar coordinate transformation. The initial plasma discharging was recorded at the Swiss Science Center Technorama.

—Dan Curticapean, University of Applied Sciences Offenburg, Germany