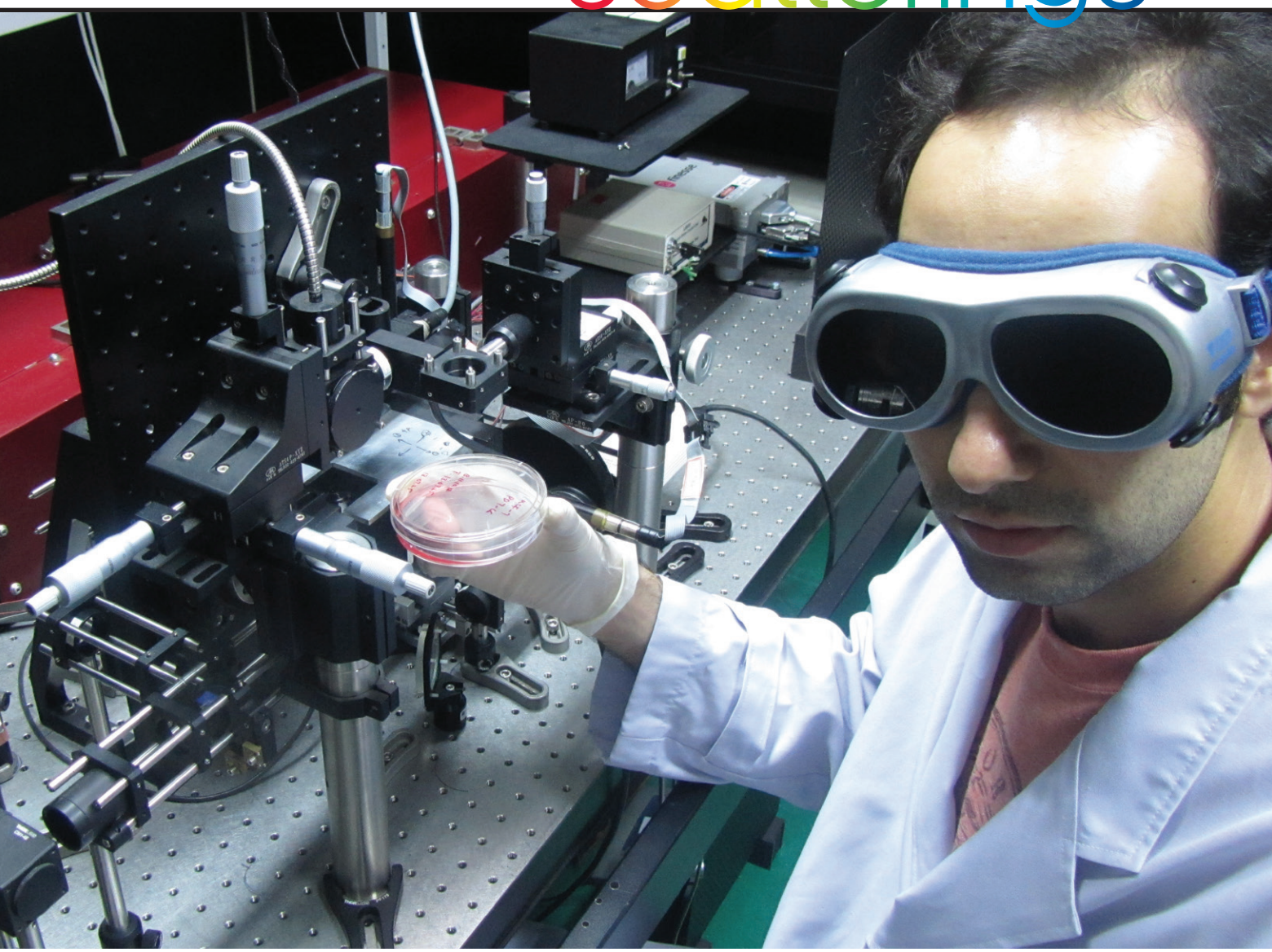


Muhammad Waleed prepares a cell sample for optical transfection.

GIST, South Korea

BIOMED

Precision Bio-Optics

New tool enables the gentle insertion of DNA into single cells.

Researchers in South Korea have used light to insert a strand of DNA into a single cell without damaging the cells nearby (Biomed. Opt. Express **4**, 1533). They employed femtosecond lasers and optical tweezers to introduce foreign genes into living cells via a process called optoporation—the generation of transient holes in cell membranes. This breakthrough may enable new forms of gene therapy and genetic engineering of individual cells.

Yong-Gu Lee and colleagues at the Gwangju Institute of Science and Technology developed the method in order to have better control over cell transfection (the introduction of nucleic acids into cells). Other single-cell transfection methods such as microinjection can damage surrounding cells and introduce foreign substances into target cells.

During the experiment, the researchers injected a single cell with a plasmid-coated microparticle that fluoresces under UV excitation to produce a green fluorescent protein; the signal helps the scientist to identify the cell membrane for DNA insertion and confirms successful transfection. The surrounding untreated cells act as a control.
—*Valerie C. Coffey*

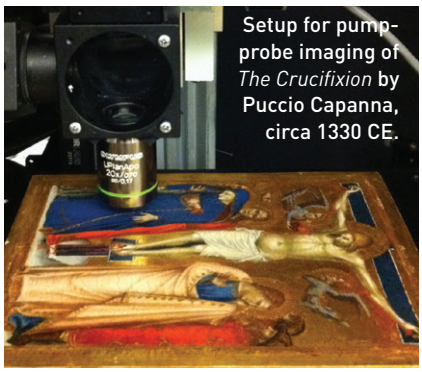
Moonlighting **at the Museum**

Using medical lasers to inspect artwork.

A near-IR pump-probe imaging technique originally designed to detect melanoma now has a completely different use: identifying pigments in priceless artwork.

Researchers at Duke University (U.S.A.) who developed the pump-probe microscopy technique are collaborating with the North Carolina Museum of Art to characterize pigments without defacing historical paintings and sculptures. OSA Fellow Warren S. Warren says he got the idea for the project three years ago when he saw an exhibit on scientific methods of forgery detection. He noticed that the techniques were several decades old and wondered if the art world could benefit from recent research in biomedical imaging.

The pump-probe technique incorporates two near-IR femtosecond lasers and works on substances that absorb light but do not fluoresce. The pump pulse excites molecules in the target substance, and the probe pulse creates more or less signal than it would have without the first pulse. The signals from the pump-probe delay provide clear signatures for different pigments. Last year, Warren and his team distinguished the types of blue pigments used in historical paintings (Opt. Lett. **37**, 1310). —*Patricia Daukantas*



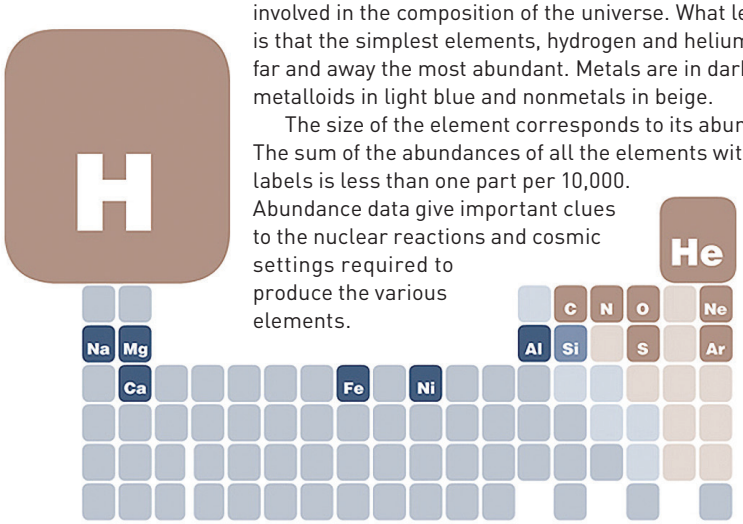
Setup for pump-probe imaging of *The Crucifixion* by Puccio Capanna, circa 1330 CE.

William Brown, North Carolina Museum of Art

The Chemical Universe

To illustrate the connection between chemistry and astronomy, NASA has converted the familiar periodic table of elements to reflect the major elements involved in the composition of the universe. What leaps out is that the simplest elements, hydrogen and helium, are far and away the most abundant. Metals are in dark blue, metalloids in light blue and nonmetals in beige.

The size of the element corresponds to its abundance. The sum of the abundances of all the elements without labels is less than one part per 10,000. Abundance data give important clues to the nuclear reactions and cosmic settings required to produce the various elements.



Source: Chandra X-ray Observatory (NASA)

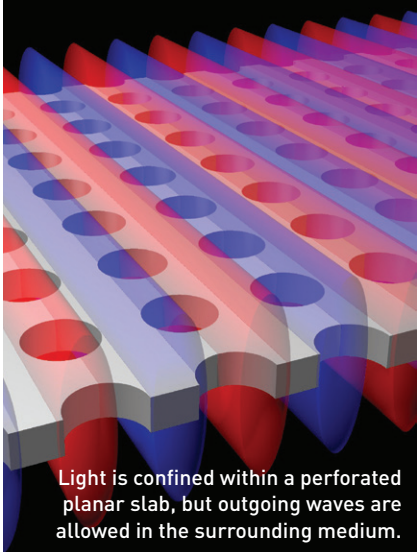
NASA began operations **55 years ago**, in October 1958.

LIGHT

Embedded Eigenvalue

Researchers from Harvard University and MIT (U.S.A.) used a photonic crystal to trap a beam of light without restricting its passage. This new phenomenon is a realization of the bound state in the continuum (embedded eigenvalue) predicted by John von Neumann in 1929. Their findings are expected to enable new optics and photonics applications, such as large-area lasers and chemical and biological sensors.

The trap works by destructive interference in a 180-nm–thick dielectric slab patterned with an array of cylindrical channels (Nature **499**, 159). A supercontinuum laser beam produces light at an angle normal to the photonic crystal surface, which is submerged in a colorless liquid medium. At the slab-liquid interface, each wave is partly transmitted into the medium as an outgoing plane wave and partly reflected back into the slab. As the transmitted light emerges through different channels, waves of opposite amplitude interfere and cancel each other. The technique is also applicable to sound waves, electrons and water waves. —*Valerie C. Coffey*



Light is confined within a perforated planar slab, but outgoing waves are allowed in the surrounding medium.

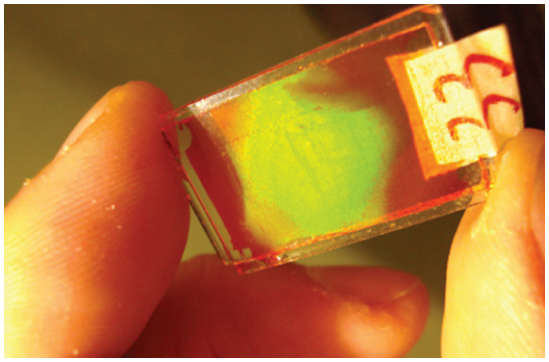
Chia Wei Hsu, MIT and Harvard

Margaret Thatcher, born 13 October 1925, worked as an X-ray crystallographer under Dorothy Crowfoot Hodgkin before entering politics.

Slowing Light to a Crawl

An international team of scientists has found a way to put a speed bump in light's path. Dye molecules embedded in a liquid crystal matrix throttle the group velocity of light back to less than one-billionth of its top speed (Opt. Express **21**, 19544). The researchers say that the ability to slow light in this manner may one day lead to new technologies in remote sensing and measurement science.

Dong Wei and his colleagues manipulated the properties of a crystal lattice to slow and temporarily stop light inside the medium. To do this, a liquid crystal similar to the ones used in LCD TVs is added to a chemical component that twists the crystal molecules into helices. Dye molecules are added and nestle into the crystal structures.



Mixture containing dye in a liquid crystal host.

Dong Wei

When irradiated, the dye molecules change their shape, altering their optical properties and hence changing the relative velocities of the different wave components of the light pulse as it travels through the mixture. The helical structure ensures longevity for the shape-shifted dyes, which makes it possible to "store" a light pulse in the medium and release it on demand. —*Sarah Michaud*

tweeted

@realscientists (guest tweeter Nick Bate) Paper Title of the Day: "Can the Higgs Boson Save Us From the Menace of the Boltzmann Brains?" I'd watch that movie.

@AstroKatie (Katherine J. Mack) My brain is in too many places at once. This is not conducive to productivity. I don't even subscribe to the many-worlds interpretation.

@mandaYoho (Amanda Yoho) Never fails. Me: "Here's a paper for editing!" Advisor: "I'm out of town for at least 4 days." I'm sure there's a PhD comic about this.

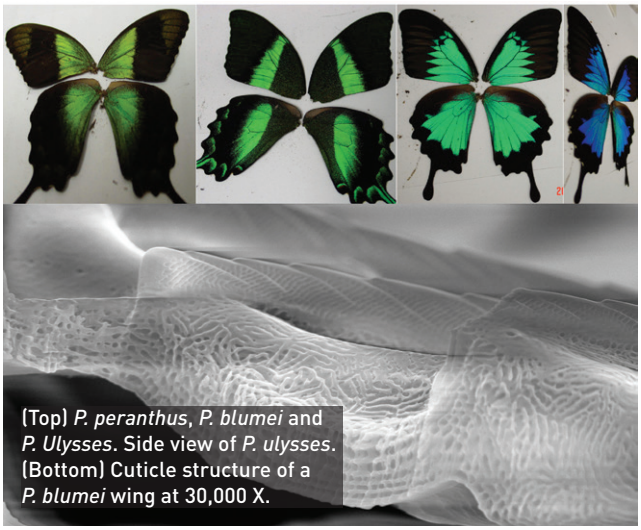
@drskyskull (Greg Gbur) My new analogy on state of cloaking physics: "We have a wheelbarrow and are thinking how cool an interstate highway system would be."

@Moochava (Kyle Marquis) Yearly reminder: Unless you're over 60, you weren't promised flying cars. You were promised an oppressive cyberpunk dystopia. Here you go.

@upulie (Blue Lotus) Grad Students! Made weak by time and fate, but strong in will. To strive, to seek, to find, and not to yield #melodramaticlabnotebook

MATERIALS

Butterflies Inspire **Designer Materials**



(Top) *P. peranthus*, *P. blumei* and *P. Ulysses*. Side view of *P. ulysses*. (Bottom) Cuticle structure of a *P. blumei* wing at 30,000 X.

Opt. Mat. Express

Physicists in Hong Kong have uncovered an iridescent structure in butterfly wings that could lead to new designer coatings and materials. Kok Wai Cheah at Hong Kong Baptist University and colleagues found that subtle differences in the crystalline structure of three closely related tropical butterflies create stunning variations of color (Opt. Mat. Exp. **3**, 1087). The discovery could lead to manufactured coatings that can be tuned to a specific color.

The team discovered that the wings contain specialized nanostructures of solid flat layers (cuticles) alternating with air layers (laminae). The laminae contain pillars of the cuticle material, which give the wings a repeating crystal-like structure similar to that of a Bragg reflector. —*Valerie C. Coffey*

Ancient Romans Were Nanotech Trailblazers

A 1,600-year-old Roman chalice changes colors with the help of nanotechnology engineering. Until recently, researchers have been stumped as to why the Lycurgus Cup changes from green to red when lit from behind. English scientists investigated fragments from the cup and discovered that the glass was impregnated with tiny particles of silver and gold that are about 50 nm in diameter (Archaeometry **32**, 33; 1990). The metallic particles vibrate when hit with light, which affects the perceived color. Using the same technology, scientists from the United States have made arrays containing billions of simulated Lycurgus Cups that can help determine the makeup of different liquids (Nanotechnology **22**, 365203; 2011). The arrays could be used in portable medical detectors to analyze saliva or urine for disease. —*Sarah Michaud*

The Lycurgus Cup is red when lit from behind and green when lit from the front.

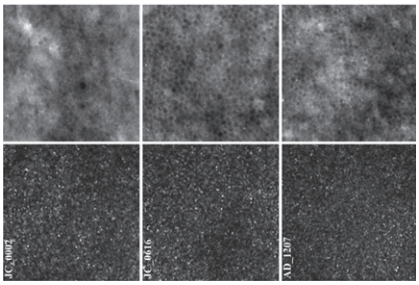
Wikimedia commons

A quantum mechanic? Tweet your conceptual **physics Halloween costume** ideas to @OPNmagazine.

IMAGING

Dark-Field Adaptive Optics **for the Eye**

U.S. researchers have developed a method for imaging eyes that is more comfortable for patients. The non-invasive reflectance imaging of the human retinal pigment epithelium (RPE) cell mosaic uses a modified confocal adaptive optics scanning light ophthalmoscope that requires less light than current techniques (Biomed. Opt. Exp. **4**, 1710). RPE dark-field imaging could be used to study the mechanisms of eye disease.



Confocal images (top) show the cone photoreceptor mosaic. Dark-field images (bottom) show the RPE cell mosaic.

Biomed. Opt. Express

The group's new aperture arrangement shows the RPE cell mosaic by dramatically attenuating the light backscattered by the photoreceptors. The mosaic was seen in seven study subjects at multiple retinal locations with varying degrees of contrast and cross-talk from the photoreceptors. The dark-field imaging required low-light exposures relative to light safety standards—which was easier for the subjects to tolerate than the traditional autofluorescence RPE imaging with visible light. —*Sarah Michaud*

INDUSTRY

Fiber Optics: Strong Growth Predicted Through 2017

Market research firm ElectroniCast Consultants (U.S.A) expects to see strong growth in the global market for fiber optics through 2017. In the case of fiber optic collimator lens assemblies, the firm's July report forecasts explosive growth of more than 50 percent per year through 2017, driven by optical communication applications. Such collimator lens assemblies are key indicators of the fiber-optic component market. —*Valerie C. Coffey*

Eyjafjallajökull eruption on 27 March 2010.

Wikimedia Commons

Michigan Gets Contract to Monitor Volcanic Ash

Michigan Aerospace Corporation (U.S.A.) announced the start of a NASA contract to develop an aircraft-based optical system for detecting airborne volcanic ash. Researchers will use UV lasers to monitor the velocity, direction, temperature and density of the ash.

Volcanic ash can cause damage to aircraft engines, windscreens and electronics. In 2010, air travel over Europe was disrupted for several weeks due to ash from Iceland's Eyjafjallajökull volcano, and this year flights to and from Mexico City were disrupted by Mexico's Popocatépetl eruption. Ash concentrations will be continuously monitored to provide advance warning of dangerous conditions so that flight crews can alter their course. —*Valerie C. Coffey*

SOLAR

Canadian Cathedral **Harnesses Light**

Not all of the sunlight falling on the stained-glass windows in a new Canadian cathedral escapes through to the congregation inside. Some of it generates electricity.

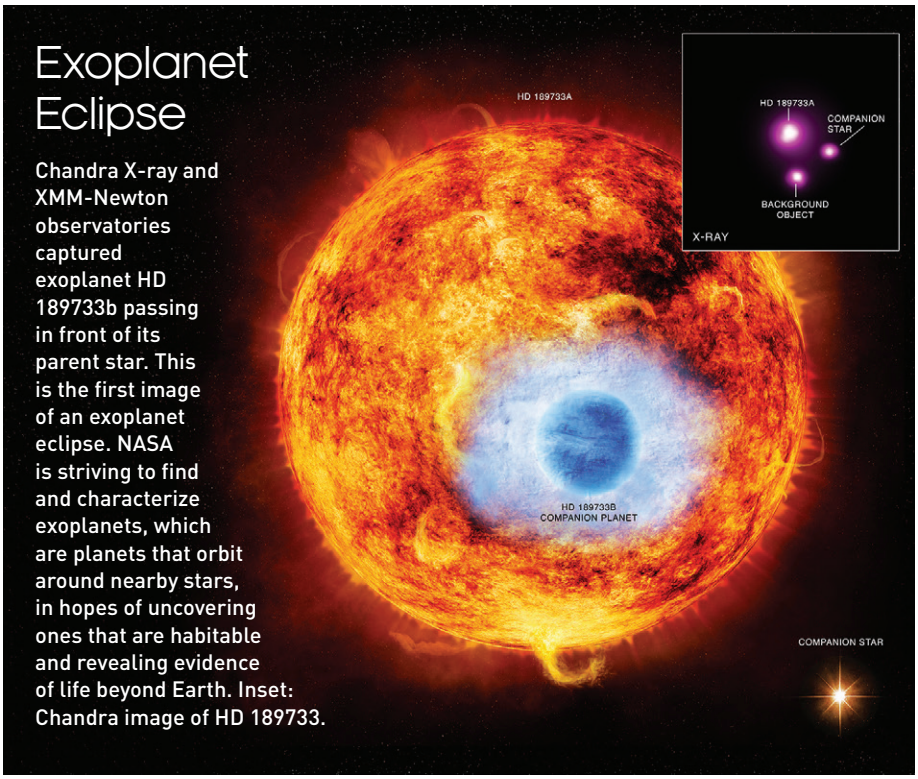
The Cathedral of the Holy Cross in Saskatoon is the first such structure to have photovoltaic cells integrated into three of its south-facing windows. The solar-powered windows feature modern designs by Canadian glass artist Sarah Hall of Toronto. Titled *Lux Gloria*, the tinted patterns are meant to evoke broad, sweeping prairies as well as religious symbols.

Lux Gloria solar windows from the interior of the Cathedral of the Holy Family in Saskatoon, Canada.

Grant Kernan

Hall says the project took three years, including one year of discussions with the Roman Catholic diocese of Saskatoon. They chose 1,113 silver-colored polycrystalline solar cells to complement the white panels of the building's facade. The largest of the three windows is 11.3 m high and 3.7 m wide.

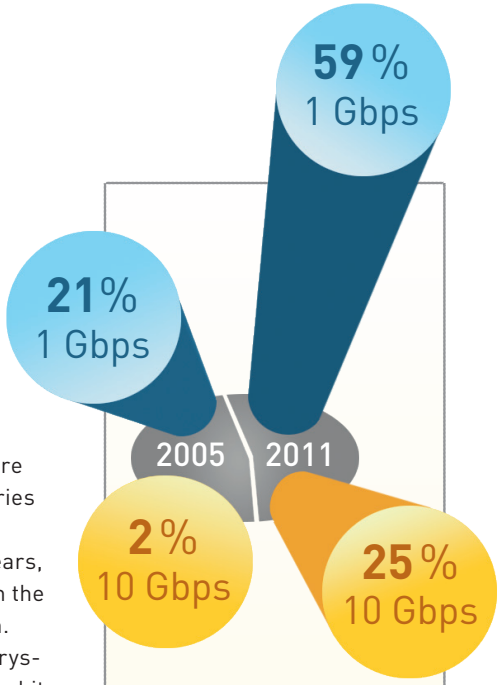
The windows are expected to yield about 2,500 kWh of energy annually. In addition to generating electricity, the stained-glass windows help shade parts of the cathedral's interior. —*Patricia Daukantas*



Exoplanet Eclipse

Chandra X-ray and XMM-Newton observatories captured exoplanet HD 189733b passing in front of its parent star. This is the first image of an exoplanet eclipse. NASA is striving to find and characterize exoplanets, which are planets that orbit around nearby stars, in hopes of uncovering ones that are habitable and revealing evidence of life beyond Earth. Inset: Chandra image of HD 189733.

NASA/CXC/M. Weiss. Inset X-Ray: NASA/CXC/SAO/K. Poppenhaeger et al.



Network Capacity Helps KNOWLEDGE ECONOMY

U.S. academic research institutions have seen a **jump in cyberinfrastructure from 2005 to 2011**, according to data from a recently released National Science Foundation survey. In 2011, **59 percent** of academic institutions reported bandwidth of at least 1 Gbps, compared with **21 percent** in 2005. The percentage with network connections of 10 Gbps or greater increased from **2 percent** to **25 percent** during this period.

Increased connectivity can positively influence international collaborations, access to data and quality of research—all important ingredients to a healthy knowledge economy.

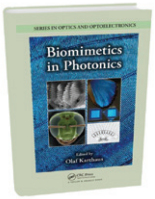
Source: NSF, National Center for Science and Engineering Statistics, FY 2011 Survey of Science and Engineering Research Facilities. Infographic by Alessia Kirkland.

Patricia Daukantas and Valerie C. Coffey are freelance writers who specialize in optics and photonics. Sarah Michaud is OPN's associate editor.

BOOK REVIEWS

Biomimetics in Photonics

Olaf Karthaus, Ed.
CRC Press, 2012; $119.95 (hardcover).



This book provides new insights into biomimetic photonics. The core material concerns the physical principles underlying nano- and microstructures found in fauna and flora. This application-driven account focuses on concrete phenomena. It explains how these physical principles can be used to produce structural colors and even metallic reflections from non-metallic multilayers. —*Christian Brosseau*

Modern Electrodynamics

Andrew Zangwill
Cambridge, 2012; $85.00 (hardcover).

Modern Electrodynamics gives a comprehensive introduction to the topic and covers more advanced material compared to similar volumes. The intended audience is engineers, but physicists will also find this book informative. The author presents relationships to quantum electrodynamics and covers historical and axiomatic themes. The reader will build physical intuition and develop technical skill through the numerous worked examples and applications boxes. —*Peter Enders*

Light-Matter Interaction: Physics and Engineering at the Nanoscale

John Weiner and Frederico Nunes
Oxford, 2012; $ 110.00 (hardcover).

Weiner and Nunes provide a clear and concise explanation of the classical electromagnetism and basic quantum mechanics needed to explore interactions between light and matter. Readers should look elsewhere if they are hoping to gain a broad understanding of nanoscience, but those who seek a good grounding in electromagnetics will find this text very useful. There are also a number of helpful supplements and appendices that provide added detail on diverse topics. —*K. Alan Shore*

Principles of Nano-Optics, 2nd Ed.

Lukas Novotny and Bert Hecht
Cambridge, 2012; $90.00 (hardcover).

Readers will appreciate the modern theoretical foundation on nano-optics that this second edition offers. It covers topics ranging from resolution and microscopy to metamaterials and optical antennas. The physical and mathematical rigor is high; the authors clearly state the approximations and limitations of the theory and the experimental devices. I highly recommend this book for a graduate course. —*Barry R. Masters*

Christian Brosseau is a professor of physics at the Université de Bretagne Occidentale in Brest, France, and a Fellow of OSA. Peter Enders is a software engineer at Nokia Siemens Networks, Germany. Barry R. Masters is a Fellow of AAAS, OSA and SPIE. K. Alan Shore is from Bangor University, school of electronic engineering, Bangor, Wales, United Kingdom.