physics update

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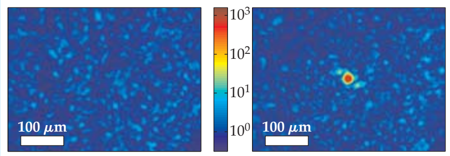
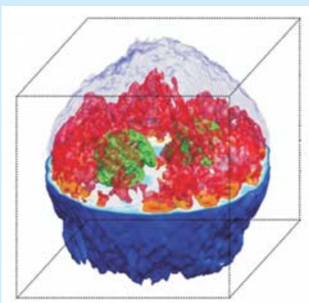
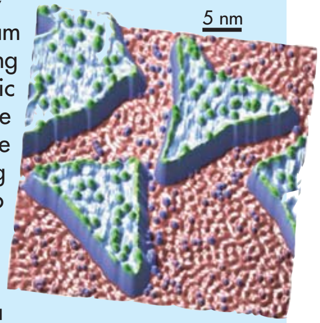
Opaque lens. Some materials such as milk, paint, and biological tissues strongly scatter any light that penetrates them. For thin samples, the transmitted light is both dim and diffuse; adaptive optics cannot unscramble the emerging light. Thicker samples are visually opaque. (For more on diffusing light, see PHYSICS TODAY, March 1995, page 34.) Two physicists at the University of Twente in the Netherlands have now focused a beam of coherent light passing through such a strongly scattering medium. Ivo Vellekoop and Allard Mosk first sent the light through a 10-μm-thick sample of paint tinted with rutile (TiO_2) and, with a CCD camera, recorded the highly attenuated light that emerged (left image). Next, in front of the sample, they inserted a phase modulator that had more than 3000 adjustable segments. By fine tuning each segment to get the brightest transmission at a target spot behind the sample, the physicists constructed a scrambled *incident* wavefront that interfered constructively—in phase—within the sample and emerged focused into a spot 1000-fold brighter than the diffuse background (right image). The researchers also obtained focused enhancements using 40-μm daisy petals, 430-μm chicken eggshells, and 1.5-mm human tooth samples. (I. M. Vellekoop, A. P. Mosk, *Opt. Lett.* **32**, 2309, 2007.) —PFS



Tomographic phase microscopy. Seeing inside cells usually requires the use of stains, fluorescent markers, or other contrast agents, and the cells themselves typically have to be fixed, or killed. But now Michael Feld and colleagues at MIT have developed a technique that allows three-dimensional mapping of unperturbed, live cells and tissues in their native state. In the new method, the sample is placed in one arm of an interferometer, and the 2D interference pattern is recorded while the angle of the light through the sample changes and the frequency of the reference beam is modulated. From the resulting quantitative phase images, the team reconstructs a 3D map of the refractive index using algorithms similar to those used in medical x-ray computed tomography (CT) scans. In less than 10 seconds, the MIT researchers could record 100 2D phase images and obtain a 3D tomogram, like this one of a cervical-cancer cell, with a resolution of about 0.5 μm. The technique can resolve internal cell structures, including parts in the nucleus, as well as various structures in tissues and multicellular organisms. (W. Choi et al., *Nat. Methods* **4**, 717, 2007.) —RJF



Observing spin polarization in single atoms. Understanding the behavior of individual atomic spins in condensed-matter environments is important for the development of spintronics, quantum-information systems, and other novel applications. In a new advance toward that understanding, physicists from the University of California, Berkeley, and the US Naval Research Laboratory have now directly observed the spin polarization of individual magnetic iron and chromium atoms adsorbed on a surface. Such measurements have proved challenging in the past because of the low energy barrier for spin fluctuations. The team overcame that difficulty by sprinkling atoms on islands of ferromagnetic cobalt; the image here shows Fe adatoms as green protrusions on the triangular Co islands. The coupling between the adatoms and the Co kept the adatom spins stationary at the experiment's low temperatures. The researchers probed the spin orientation of adatoms using a scanning tunneling microscope outfitted with a magnetic tip. When the tip was over an adatom, the tunneling current depended on the relative polarization directions of the Cr tip, adatom, and Co island. The Fe and Cr adatoms were found to exhibit opposite coupling behavior, in agreement with theoretical calculations: The Fe atoms aligned ferromagnetically (spins parallel) with the Co island, and the Cr atoms aligned antiferromagnetically (spins antiparallel). (Y. Yayon et al., *Phys. Rev. Lett.* **99**, 067202, 2007.) —PFS



Gamma rays from thunderclouds. During thunderstorms, atmospheric electric fields can be strong enough to accelerate charged particles to tens of MeV and produce bursts of radio, x-ray, and gamma-ray emissions. The bursts are separated from lightning in time and often in location as well. Although the x rays can last for a minute or more, the radio and gamma-ray burst durations typically lie in the micro- or millisecond range. Some unusual, longer-duration gamma events last tens of seconds or even minutes. A collaboration of researchers from four institutions in Japan has now described one such event that took place during a winter thunderstorm over the Sea of Japan on 6 January 2007. Specialized detectors atop a nuclear power station recorded about 40 seconds of gamma rays, followed some 70 seconds later by a lightning stroke. The photons had energies that reached and exceeded 10 MeV and were unambiguously determined to have come from the sky. The figure shows the spectra from two counters in one of the detectors. Knowing that winter thunderclouds in that location have a three-layer vertical charge structure of positive-negative-positive, the scientists suggest the following scenario: Cosmic rays generated energetic electrons that were further accelerated, both groundward and skyward, in the ambient electric fields. An avalanche of runaway electrons ensued that produced relativistically beamed bremsstrahlung radiation. The events are rarely seen because the narrow radiation cones almost never intercept an appropriate detector. To learn more about the mysteries of lightning and the role of cosmic rays and runaway electrons, see PHYSICS TODAY, May 2005, page 37. (H. Tsuchiya et al., *Phys. Rev. Lett.*, in press.) —SGB ■