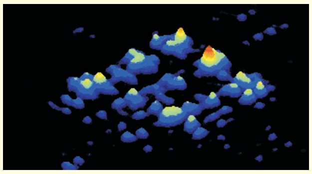
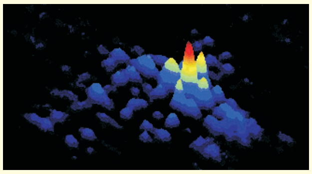
Physics Update

Tuning optical fibers with microfluidics. Optical fibers are a fundamental part of optical sensing, optical telecommunications, and many medical applications. One way to make the fibers even more efficient and versatile is to hand over some of the switching, tuning, and reconfiguring chores to the fibers themselves, rather than to rely on separate devices. Researchers at OFS Laboratories in Murray Hill, New Jersey, have now developed a tunable optical grating in a microstructured optical fiber. Their fiber has a hexagonal array of tiny air holes running its length, surrounding the 8-μm core where the light actually propagates. They created a tapered region, about 7 cm long, in the fiber so that the light field could expand beyond the core and interact with the air holes. With a vacuum applied at one end of the fiber, they alternately drew fluid plugs and air into the microchannels in the tapered region. The resulting periodic structure of fluid plugs was, in effect, a photonic crystal that caused resonant coupling of modes and wavelength-dependent attenuation. (C. Kerbage, B. J. Eggleton, *Appl. Phys. Lett.* **82**, 1338, 2003.) —PFS

Salt: the movie. Solid, liquid, melting, and freezing are concepts that refer to bulk matter, not to individual atoms. But what about a small cluster of atoms or molecules? Louis Bloomfield and Andrew Dally (University of Virginia) looked at a pulsed beam of clusters of a salt; each cluster contained dozens of molecules that each had four cesium atoms and three iodine atoms. An ordinary salt grain has more than a million atoms along each side of its cubical structure. The Cs_4I_3 molecule can take on three different shapes or "isomers": a cube, ladder, or ring. The researchers sent the salt clusters through a laser interaction region, where the cubic isomer was depleted. Using probing lasers downstream, the researchers watched at a cinematic 30 "frames" per second as the population of the cubic form was restored at the expense of ladders and rings. The interconversion, known as isomerization, happened more quickly with higher temperature. In fact, at about 500 K, the molecules spent only enough time in any one shape to convert into another, the signature of a phase transition from solid to liquid in a bulk system. Interestingly, the melting temperature of bulk cesium iodide is about 900 K. (A. J. Dally, L. A. Bloomfield, *Phys. Rev. Lett.* **90**, 063401, 2003.) —PFS

Two-dimensional lattice solitons. Through a balance between linear and nonlinear processes, periodic nonlinear systems can produce a self-localized state: a lattice soliton. Such systems include, for example, "breather" states in biological α-helixes and quantum vortex pairs in linear arrays of current-driven Josephson junctions. Now, Mordechai Segev (Technion–Israel Institute of Technology), Demetri Christodoulides (University of Central Florida), and their colleagues have created such a system in two dimensions. The physicists used light both as the means for creating the lattice—by interfering pairs of plane waves within a photorefractive, anisotropic crystal—and as the "probe" beam to form the optical lattice soliton. The degree of nonlinearity was set by a tunable electric field and by adjusting the ratio between the probe beam and the lattice waves. At a low voltage, the probe propagated linearly through the 6-mm-long crystal and showed a "discrete diffraction" pattern (left image, above). At a higher voltage, however, self-trapping occurred and a soliton formed (right image). When the probe intensity was lowered, even at the high voltage, the diffraction reappeared. The researchers say that their methods allow them to dynamically reconfigure the lattice into various geometries, and that further possibilities include studying lattice solitons with angular momenta, vortex lattice solitons, and 3D collisions of lattice solitons. They also say that these ideas can be implemented in other media, such as atomic lattices for Bose–Einstein condensates. (J. W. Fleischer et al., *Nature* **422**, 147, 2003. See also J. W. Fleischer et al., *Phys. Rev. Lett.* **90**, 023902, 2003.) —SGB





Less than 100 zeptojoules (100×10^{-21} joules, or 0.6 eV) to operate a molecular switch. That is some 10^{-4} of the energy needed by transistor switches in current high-speed computers. The porphyrin-based molecule Cu-TBPP (structure shown at left) was in the "on" position when one of its four legs was perpendicular to the copper surface on which it sat, and "off" when the leg was parallel. In a recent experiment, scientists from the University of Basel and IBM Zurich in Switzerland, and from the CEMES-CNRS lab in Toulouse, France, used an atomic force microscope tip not only to rotate the leg but also to measure the required force, from which they determined the energy. The authors suggest that a machine made from 10^{12} such interconnected nanodevices, operating at 1 GHz, would consume less than 100 W of power. (Ch. Loppacher et al., *Phys. Rev. Lett.* **90**, 066107, 2003.) —PFS