pole moment. The inversion breaks the ice rule in neighboring tetrahedra and creates two magnetic charges $\pm q_m$, a nearest-neighbor monopole–antimonopole pair represented by the large colored balls in the figure; one monopole represents a state in which three spins point out and one in, while the other represents a state in which one spin points out and three in. The monopoles can be separated from each other without further violations to charge neutrality by flipping a chain of adjacent dumbbells. Indeed, one can envision monopoles in spin ice as magnetic analogues of electrically charged defects H_3O^+ and OH^- in water ice.

Deconfined monopoles migrate independently around the bulk crystal. A pair separated by a distance r experiences a Coulombic potential $-\mu_0 q_m^2/(4\pi r)$, where μ_0 is the vacuum permeability. Because they are embedded in a crystal with a fluctuating magnetization **M**, the monopoles can act as sources and sinks of the magnetic field **H** while still preserving a zero divergence in the magnetic flux density **B**, in accord with Maxwell's equations.

Finding monopoles

At least conceptually, detecting the presence of a monopole is straightforward. The magnetic flux measured in a superconducting quantum interference device wrapped around a wire of spin ice should change as a monopole drifts down the wire and through the SQUID. Practically, the experiment is tough. The charge on a spin-ice monopole is tiny, roughly 1/8000 the charge of an elementary Dirac monopole, so the measured change in a SQUID would be 1/8000 the flux quantum $h/2e$. Moreover, the monopoles must be dilute enough that just one or two of them diffuse through the SQUID at any one time. The temperature required to guarantee that is so low that other issues become more worrisome—in particular, the dynamics become very slow.

Castelnovo and colleagues take a different approach to building confidence in their theory. By applying a magnetic field along a crystallographic direction in spin ice, they argue, one can essentially tune the density of monopoles. Varying the magnetic field at different temperatures maps out the system's phase diagram.

Five years ago, researchers observed[4] a line of first-order phase transitions in the spin ice dysprosium titanate below a critical temperature of about 0.36 K in an applied magnetic field around 0.9 T. How to interpret the transition has remained mysterious until now, says Moessner. By accurately reproducing the phase diagram, the new spin-ice model accounts for the transition as the condensation of a dilute gas of monopoles into a dense liquid.

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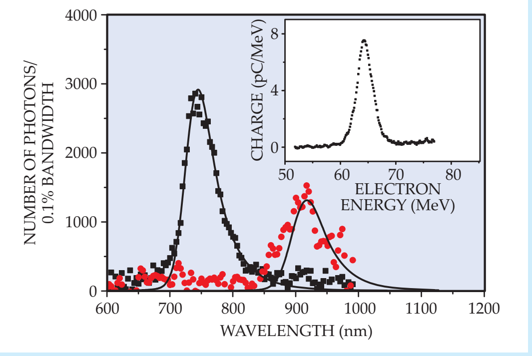
polarizability for Pb. Designing simple electromechanical materials using chemical substitution could greatly decrease costs and increase utility of ultrasonic and other actuators. (M. Ahart et al., *Nature* **451**, 545, 2008.) —SGB

Synchrotron radiation from a plasma wakefield accelerator. A mainstay of the materials-science and bioscience research communities, the synchrotron light source provides a powerful, though large and expensive, probe of substances from the exotic to the mundane. To shrink those synchrotrons from



today's giant user facilities to something that can fit in a basement room is the goal of a multinational team led by Dino Jaroszynski (University of Strathclyde, Glasgow, UK). In a first step, the physicists coupled a high-intensity femtosecond laser, a plasma, and an undulator—a series of magnets through which electrons wiggle—to generate bursts of narrowband visible light. The intense field of a laser pulse produces waves in the plasma and rapidly accelerates electrons in a very short distance. Those high-energy electrons then navigate the undulator, radiating as they go. In the figure, the black dots show the light from the electron pulse depicted in the inset, while the red dots are from a different shot. In these early experiments, only about 1 in 10 laser pulses produced monoenergetic electron bunches, but the researchers think improvements can greatly increase the reproducibility and stability of the shots. Because laser-wakefield synchrotrons would be compact, inexpensive, and able to radiate from x rays down to microwaves, Jaroszynski says they could enable a wide range of applications in research, medicine, and industry. (H.-P. Schlenvoigt et al., *Nat. Phys.* **4**, 130, 2008.) —SGB

Saxophonists tune vocal tracts. Saxophone great John Coltrane had a sound that is instantly recognizable to an experienced listener. His distinctive style arose in part from resonances in the frequency-dependent acoustic impedance (proportional to sound pressure) of his throat and mouth. Of course, the saxophone, which typically has a sharp impedance peak near the frequency of the note being played, also makes an important contribution. For some 25 years, acousticians and musicians alike have debated the vocal tract's influence on an instrument's sound. Now, Jer Ming Chen and colleagues at the University of New South Wales in Sydney, Australia, have addressed the question quantitatively—at least for the tenor saxophone, whose innards are big enough to house the researchers' measuring equipment. The Sydney group determined that in the tenor's lower range, resonances in the saxophone's impedance are much stronger than those in a musician's vocal tract. So the tract resonance need not be, and typically is not, tuned to the note sounded. But the strength of the instrument's resonances decreases as the frequency of the note increases. To play a note in the so-called altissimo range, which comprises notes higher than the instrument was designed to play, the vocal-tract resonance needs to be significantly stronger than the instrument's. And to tune the tract resonance to those super-high frequencies is a challenge—one met by the professional saxophonists but not by the amateurs in the study. (J. M. Chen, J. Smith, J. Wolfe, *Science* **319**, 776, 2008.) —SKB ■