

Refraction at the atomic level. In general, the speed of light in a dense medium is determined by the medium's refractive index, which can vary significantly from that in vacuum. A highly dispersive medium—one in which the index of refraction varies rapidly with frequency—can allow greatly slowed or even speeded up group velocities for light. Now, researchers from the University of Tokyo (Japan) and NIST (Maryland) have altered a light pulse's speed in a microcavity with a medium—less than 10 rubidium atoms—whose density scarcely differs from vacuum. The secret to the effect is a long dwell time. The 70- μm -long cavity was so reflective (its “finesse” was high) that the pulse reflected many times before leaking out. Thus the light interacted repeatedly with the handful of atoms, which makes the macroscopic concept of refractive index meaningful. The pulses used in the experiment were themselves quite ephemeral, amounting to only an average of four-tenths of a photon in the cavity at any one time. The researchers plan to look for single-atom effects in the cavity. (Y. Shimizu et al., *Phys. Rev. Lett.* **89**, 233001, 2002.) —PFS

Icicle ripples. The ridges that embellish the surfaces of most icicles are similar regardless of variations in air temperature, humidity, icicle thickness, or growth rate. An icicle grows when thin sheets of water flow down the ice shaft. A portion of the flowing water freezes and the rest drips from the icicle tip. The ice that's left behind forms ringlike ridges stacked along the icicle's length. Those ridges always measure about 1 cm from peak to peak, although



their heights can vary from one icicle to another. Researchers at Hokkaido University in Japan have developed a model that explains the surprisingly universal structure of icicles: The preferred periodicity arises from a competition between two effects. The Laplace instability, which entails the diffusion of heat from the water sheath into the colder air, amplifies the ripples by promoting ice buildup in convex regions. Flow in the thin water layer, however, tends to even out the temperature distribution and thus inhibit the Laplace instability. The theory also predicts that the ripples should migrate down an icicle at about half the speed that the icicle grows—a prediction the researchers hope will soon be observed. In addition, they expect that their model will help explain the structures of mineral stalagmites commonly found in limestone

caves. (N. Ogawa, Y. Furukawa, *Phys. Rev. E* **66**, 041202, 2002.) —JRR

The photonic de Broglie wavelength of entangled photon pairs has been directly measured. In the early days of quantum mechanics, Louis de Broglie argued, and it was soon demonstrated, that if waves could act like particles (as in the photoelectric effect), then particles could also act like waves. By now, the wave nature of molecules as large as buckyballs (carbon-60) has been demonstrated. For composite objects, the de Broglie wavelength depends fundamentally on the object's internal structure. For an ensemble of photons taken collectively, the de Broglie wavelength is λ/N , the wavelength of an individual photon divided by the number of photons. This was verified in 1999 for a two-photon wavepacket in a double-slit experiment. Physicists at Osaka University in Japan have now demonstrated that the relation still holds for spatially separated, entangled photons. Through parametric down-conversion, they transformed a photon of wavelength λ into an entangled pair of photons (a biphoton) of wavelength 2λ . Those photons were then sent along different paths through an interferometer. When the single-photon interference for either member of the pair was measured, it showed a wavelength of 2λ . However, the measurement that preserved the entanglement yielded λ . The physicists also showed that the coherence length of the biphoton was much longer than for the 2λ single-photon case. They say that the concept remains valid for more than two entangled photons. Eventually, it may be possible to generate entangled photons from nonentangled photons of the same wavelength, a process called hyperparametric scattering. (K. Edamatsu, R. Shimizu, T. Itoh, *Phys. Rev. Lett.* **89**, 213601, 2002.) —PFS

Cooling by adiabatic magnetization has been seen in NaFe_6 ferric wheels. The spins in an ensemble of molecules constitute a system all by themselves and can be “cooled,” without heat flowing in or out, by decreasing the strength of an applied magnetic field. Some of the heat of molecular motion can then be transferred to the spins, which lowers the molecular temperature. Such adiabatic demagnetization was once routinely used to achieve the low temperatures needed for studying helium-3. Surprisingly, physicists at Erlangen-Nürnberg University in Germany have demonstrated the inverse effect: cooling molecules by increasing the applied field. The adiabatic magnetization was achieved with ring-shaped molecules featuring six iron atoms plus a few ligand hangers-on. The mechanisms of heat transfer are not yet fully explained. (O. Waldmann et al., *Phys. Rev. Lett.* **89**, 246401, 2002.) —PFS ■