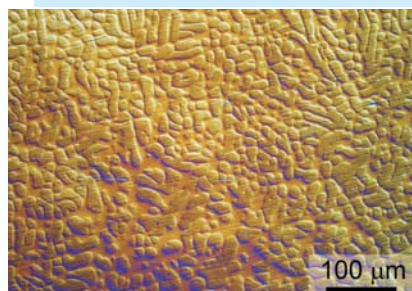


from the University of Khartoum, led by professor Muawia Shadad, gathered 47 of the meteorites, one of which was studied in detail. That remnant's high porosity and dark carbon-rich material are peculiar. Those anomalies may, in time, help physicists understand the processes that took place in the solar nebula in the region where Almahata Sitta and its spectral classmates formed. (P. Jenniskens et al., *Nature* **458** 485, 2009. Photo courtesy of NASA/Peter Jenniskens.) —SKB

Confining cracks in metallic glass. Lightness, strength, and moldability are among the most desired material properties for aircraft, sporting equipment, and many structural applications. Those sometimes opposing properties converge in bulk metallic glasses—supercooled amorphous metal alloys that can be cast into complex shapes and are resilient under large elastic strains. However, their toughness is suspect: Under repeated stress, BMGs fatigue and develop fatal cracks much more quickly than crystalline metal alloys do. To control crack propagation, Caltech's William Johnson, Lawrence Berkeley National Laboratory's Robert Ritchie, and their collaborators focused on controlling



the microstructure of a particularly tough BMG composite made of zirconium, titanium, and other metals. Its finger-like crystalline dendrites (67% by volume) are surrounded by an amorphous matrix, as seen in this optical micrograph. By heating the precursor alloys between their melting points then rapidly quenching the solution, the researchers were able to control dendrite size and the spacing between the glassy and crystalline phases. The width of the glassy region between the much-tougher dendrite fingers was tailored to be short enough to serve as a "microstructural arrest barrier" for just-formed cracks. Compared with existing dendrite-containing BMGs, the new material holds up under three times more stress cycles and is comparable in toughness to high-strength steel or aluminum. (M. E. Launey et al., *Proc. Natl. Acad. Sci. USA* **106**, 4986, 2009.) —JNAM

ates capillary waves. The calculations don't, however, show any indications of splashing; the researchers suggest that other parameters, such as the droplet viscosity and thermal transfer, must become important after the initial spreading phase. (S. Mandre, M. Mani, M. P. Brenner, *Phys. Rev. Lett.* **102**, 134502, 2009.) —RJF

Making a splash. In his "Milkdrop Coronet," strobe-photography pioneer Harold Edgerton famously captured the splash produced by a milk droplet falling into a saucer. But our understanding of the underlying physics remains poor. It's known that before a liquid droplet splashes upward from a surface, a thin sheet of liquid spreads out from the impact point. Four years ago experiments by Sidney Nagel and colleagues at the University of Chicago showed, surprisingly, that splashing on a dry surface can be suppressed by reducing the ambient air pressure. The researchers concluded that compressible effects in the air are responsible for the splashing (L. Xu, W. W. Zhang, S. R. Nagel, *Phys. Rev. Lett.* **94**, 184505, 2005). Now Michael Brenner and coworkers at Harvard University have further looked into the air's role in how droplets splash on a dry surface. Taking into account the compressibility and viscosity of the gas and the surface tension of the liquid, they modeled the behavior of the approaching droplet as it reaches the surface. They find that instead of spreading out over the surface, the liquid spreads over a very thin film of air. When the droplet nears the surface, pressure builds beneath it and the bottom of the droplet deforms by flattening and then becoming dimpled. The droplet's bottom perimeter develops a kink that, still over a layer of air, moves out and cre-

Engineering a faster battery. Today's laptop computers, cell phones, hybrid vehicles, and other technologies rely on rechargeable batteries. As discussed in *PHYSICS TODAY*, December 2008, page 43, batteries—in particular, the popular lithium-ion batteries—typically have a high energy density but a low power density: They can't deliver their stored energy particularly quickly. Often the limiting step in Li^+ batteries is not getting the ions through the electrolyte and electrode structure but getting them into the active electrode material itself. Using nanoscale materials in the electrodes and doping the materials are among present techniques to improve battery rates. Now Byoungwoo Kang and Gerbrand Ceder of MIT have shown that using particles of a common electrode material, lithium iron phosphate (LiFePO_4), covered with a glassy coating of iron-doped lithium phosphate can significantly increase the charging and discharging rates. Moreover, the particles and coating can be formed together in a single step. In test experiments, the researchers obtained discharge rates 100 times as fast as today's commercial Li^+ batteries. The researchers suggest that the amorphous coating may improve Li^+ transport across the surface of the electrode particles; uncoated LiFePO_4 , in contrast, conducts ions poorly except in a narrow range of directions. Additionally, they say that the coating may modify the surface potential and provide adsorption sites for a range of ion energies. (B. Kang, G. Ceder, *Nature* **458**, 190, 2009.) —RJF

Plasma waves and cosmic rays. With energies exceeding 10^{20} eV, the highest-energy cosmic-ray protons are as energetic as well-hit tennis balls. How does a proton become so energetic? Recent cosmic-ray data disfavor the notion that these ultra-energetic protons have exotic origins such as the decay of very massive particles as yet unidentified. So one must seek the proton acceleration mechanism in familiar astrophysical environments. The conventional suggestions—acceleration by relativistic shocks, spinning black holes, or flares on hypermagnetized neutron stars—each have problems accounting for the highest observed energies. Shock acceleration, for example, becomes increasingly inefficient at high energy because the inevitable trajectory bending causes severe synchrotron energy loss. Now theorist Pisin Chen (SLAC and National Taiwan University) and coworkers have demonstrated analytically and by computer simulation that so-called magnetowaves—electromagnetic waves with unusually strong magnetic components in magnetized plasmas—can drive plasma waves in their wake much as laser pulses in the laboratory drive plasma wakefields in experimental plasma-based accelerators (see *PHYSICS TODAY*, March 2009, page 44). The mechanism avoids synchrotron loss, and it provides strong accelerating gradients even at very high energy. Chen and company show that a proton surfing a stochastic succession of such plasma wakes can, with luck, be accelerated to 10^{21} eV. Magnetowaves are believed to be produced in the relativistic jets emanating from active galactic nuclei. And the "luck" required for the proton to catch just the right sequence of plasma waves in an AGN jet accords with the observation that ultra-energetic cosmic rays are extremely rare. That's why the detector arrays that study them cover thousands of square kilometers. (F.-Y. Chang et al., *Phys. Rev. Lett.* **102**, 111101, 2009.) —BMS ■