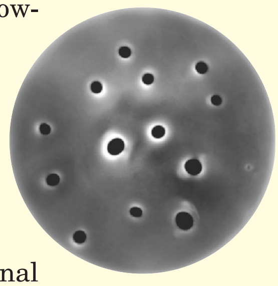
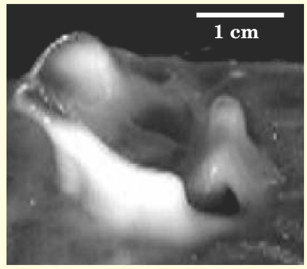
Physics Update

Temperature-induced magnetization of antiferromagnetic (AF) nanoparticles has now been explained. Because neighboring magnetic moments are antiparallel, a typical AF material has no net magnetization. And any magnetization should decrease as the thermal fluctuations of its spins increase with rising temperature. Yet experiments have shown that both of these behaviors can be violated in AF particles that are just a few nanometers across. Often, an AF material is modeled as two sublattices of oppositely directed magnetic moments. Two physicists at the Technical University of Denmark have now determined that the sublattices in AF nanoparticles precess in such a way that the moments are not strictly antiparallel to each other, which leads to a net magnetization that increases with temperature. The thermally induced magnetization is inversely proportional to volume and thus is apparent in nanoparticles but not in bulk material. The researchers say that the effect will be encountered more frequently as the field of nanotechnology continues to expand. (S. Mørup, C. Frandson, *Phys. Rev. Lett.* **92**, 217201, 2004.) —PFS

Our universe has no topological scale smaller than 24 gigaparsecs—about 75 billion light years—according to a new analysis of data from the *Wilkinson Microwave Anisotropy Probe*. Because of conceivable hall-of-mirrors effects of spacetime, the universe might be finite in size but give us the illusion of being infinite. For example, the cosmos might be tiled with some repeating shape, around which light rays might continuously wrap themselves, somewhat like a video game in which an object might disappear off the left side of the screen and reappear on the right. In the new study, researchers looked for signs of such "wrapped" light in the form of pairs of circles, in opposite directions in the sky, that exhibit similar patterns of cosmic-microwave-background temperature fluctuations. If the universe were finite and smaller than the distance to the "surface of last scattering" (the place in deep space where the cosmic microwaves originate and that constitutes the edge of the visible universe), then multiple images should show up in the microwave background. But no such correspondences appeared in the analysis. The researchers turned the lack of recurring patterns into a lower limit of 24 Gpc on the scale of cosmic topology, a factor of 10 larger than previous observational bounds. (N. J. Cornish et al., *Phys. Rev. Lett.* **92**, 201302, 2004.) —PFS

Persistent holes have been observed in a shaken non-Newtonian fluid. Normally, a fluid takes the shape of its container and any puncture of the surface quickly fills. However, in an experiment performed at the University of Texas at Austin, stable holes appeared in a cornstarch–water mixture that was vertically vibrated at frequencies above 120 Hz, with accelerations between 12 and about 20 times the gravitational acceleration. Holes did not form spontaneously; but if a puff of air poked a hole in the fluid, the hole could persist indefinitely. As seen from above in the top photograph, the holes had diameters comparable to the 5-mm depth of the fluid and extended to the bottom of the container, which was 9.4 cm across. The researchers attribute the holes' stability to shear thickening—an increase of viscosity with shear rate. At higher accelerations, as shown in the side view (bottom) of a single hole, the rim grew fingerlike protrusions that rose 2 cm above the surface and undulated erratically. (F. S. Merkt et al., *Phys. Rev. Lett.* **92**, 184501, 2004.) —PFS





Neutrino oscillation has now been seen in the long-distance travel of a beam of muon neutrinos (ν_μ) created at an accelerator. Since 1998, the international K2K collaboration has been directing a ν_μ beam from the KEK 12-GeV proton synchrotron in Tsukuba, Japan, to the Super-Kamiokande detector 250 km away. The study of neutrinos created in the atmosphere by cosmic rays has already yielded strong evidence that a ν_μ can metamorphose into a tau neutrino (ν_τ). But the new K2K result, reported in June by Tsuyoshi Nakaya (Kyoto University) at a meeting in Paris, is a reassuring confirmation of the oscillation mechanism. With an accelerator beam, one can directly compare the neutrino spectrum at birth with what's left over after the journey. In five years of running, 108 ν_μ particles from KEK were seen in Super-Kamiokande. In the absence of oscillation, one would have expected 151 ± 11. Both that shortfall and the measured energy spectrum agree well with the oscillation parameters from the atmospheric data. For example, the difference between the squared masses of the relevant neutrino eigenstates comes to about 2.7×10^{-3} eV^2 from K2K and, when combined with the atmospheric data, yields a joint result of 2.5×10^{-3} eV^2. (See http://neutrino.kek.jp.) —BMS