Physics Update

Ice changes from a molecular solid to an ionic solid when squeezed hard enough. In normal ice, each hydrogen atom is bonded strongly to the oxygen atom in its H_2O molecule, and is bonded weakly to the oxygen in a neighboring molecule. Recently, physicists at the Carnegie Institution of Washington used a diamond anvil cell to subject ice to pressures as high as 210 gigapascals. As the molecules approached each other under pressure, the hydrogens became more egalitarian in their alignment with the surrounding oxygens. At 60 GPa, a phase transition to symmetrical hydrogen bonding occurred. The same transformation took place at 70 GPa for D_2O ice. (A. F. Goncharov *et al.*, *Science* **273**, 218, 1996.) —PFS

Laser-induced transparency for isotope discrimination has recently been proposed and demonstrated by Athos Kasapi of Stanford University. Isotopes of an element absorb light at slightly different energies because the electron–nucleus interaction depends subtly on the spin of the nucleus, which is different for each isotope. In principle, for any two atomic species with transition frequencies that are only slightly displaced or split with respect to each other, one species can be made highly transparent and the other highly opaque by using a pair of carefully tuned laser pulses. To demonstrate the technique for trace-element isotope discrimination, Kasapi used a gas composed of 99.97% lead-208 and 0.03% lead-207. By allowing a "probe" laser (tuned to a ^{208}Pb transition from the ground state to an excited state) and a "coupling" laser (tuned to a ^{208}Pb transition from an intermediate metastable state to the same excited state) to interfere, the ^{208}Pb becomes unable to absorb any of the light. Meanwhile, by adjusting the coupling laser's intensity, the trace isotope ^{207}Pb was rendered highly absorbing and was detected by its photoabsorption. This technique represents an interesting application of "laser-induced transparency," a new tool in quantum optics that was previously used to create "lasing without inversion" (PHYSICS TODAY, September 1995, page 19). (A. Kasapi, *Phys. Rev. Lett.* **77**, 1035, 1996.) —BPS

Extremely high energy cosmic rays show a slight preference in their directionality. Researchers look to cosmic rays for the highest-energy particles, far above what can be attained with accelerators. A new study of 36 cosmic-ray events with primary energies greater than 4×10^{19} eV (40 EeV), recorded with the Akeno Giant Air Shower Array in Japan between 1990 and 1995, shows that most of the cosmic rays' arrival directions are uniformly distributed across the sky. Six of the events, however, occurred in three pairs, with an angular separation within each pair of less than 2.5°. The probability of this distribution occurring by chance is 2.9%. Of these three pairs, two are located within 2° of the supergalactic plane—defined originally by the agglomeration of bright nearby galaxies in the Northern Hemisphere—with a chance probability of 0.7%. Furthermore, when the Akeno scientists included events from other sites around the world published so far, one of their pairs became a triplet and a fourth pair turned up. The researchers suggest that some celestial accelerators lie in the directions of the collimated pairs. (N. Hayashida *et al.*, *Phys. Rev. Lett.* **77**, 1000, 1996.) —PFS

The electrical resistance of a single xenon atom has been measured. Normally, resistance involves a huge number of atoms. In recent years, it was realized that, for ballistic electrons in mesoscopic structures, resistance is quantized in units of $h/2e^2$—about 12.9 kilohms. (See PHYSICS TODAY, July, page 22.) Now, physicists at IBM have shown how conductivity through a single atom (or a chain of a few atoms) can depend on the atomic orbitals. They attached one xenon atom to the tip of a scanning tunneling microscope above a nickel surface, and measured its resistance to be $10^5\ \Omega$. Two xenon atoms in series had a resistance of $10^7\ \Omega$. Says Ali Yazdani, "Our calculations are also a pretty reliable way of predicting these atomic resistances." (A. Yazdani, D. M. Eigler, N. D. Lang, *Science* **272**, 1921, 1996.) —PFS

Individual carbon nanotube properties, both electrical and mechanical, have now been measured. Because of their nanometer diameters and micrometer lengths, nanotubes are difficult to study singly. Nevertheless, a team of scientists at the NEC Research Institute (Princeton, New Jersey) and the University of Illinois at Urbana-Champaign deduced the Young's modulus (indicative of a material's elasticity) of 11 nanotubes by noting the amount by which the free tips of the anchored tubes were blurred by thermal vibrations in microscopic images taken at various temperatures. The researchers found that the fibers had an average modulus of 1.8 terapascals, higher than that of either steel or normal carbon fibers. This extreme stiffness, along with their low density, might make carbon nanotubes an excellent ingredient for composite materials. Electrical properties are potentially no less important. Another NEC experiment, this time in conjunction with Micrion Europe (Munich, Germany), successfully connected four tungsten probes to individual nanotubes, affording a more controlled study of conductivity than was possible in previous two-probe experiments. The four-probe tests on nine nanotubes showed a wide range of resistivities, from metallic to semiconducting. The researchers conclude that each tube's electronic properties depend strongly on its own unique structure. (M. M. J. Treacy *et al.*, *Nature* **381**, 678, 1996. T. W. Ebbesen *et al.*, *Nature* **382**, 54, 1996.) —PFS ■