Physics Update

Ultranarrow luminescence lines from single quantum dots have been seen. The miniaturization of electronic devices, if carried far enough, can bring into play useful quantum phenomena, which can lead to greater efficiency and control in the switching of currents. For example, when electrons are confined in a two-dimensional quantum well, a plot of the density of the allowed electron states versus electron energy shows a series of steplike features. In a quantum wire, electrons are restricted to one dimension, and the density-of-states-vs-energy plot becomes spiky. When electrons are confined in all three dimensions, in a structure called a quantum dot, the allowable energies are completely quantized. Nanometer-size dots have been studied for several years. (See PHYSICS TODAY, January 1993, page 24, and June 1993, page 56.) It has been difficult, however, to measure the discrete nature of electron energies in dots because they are often studied in ensembles whose average properties are not precisely the same as those of any one dot. Now a Berlin–Halle–Saint Petersburg collaboration has observed high-spatial-resolution cathodoluminescence from single dots. The light from a 7-nm InAs dot appears as ultranarrow lines, monoenergetic to less than 150 μeV, an upper limit set by the resolution of the experimenters' instrument. The lines remain that sharp at elevated temperatures, says Marius Grundmann, proving the absence of thermal broadening effects. The researchers claim that this is the first direct evidence of the expected quantization of the density of electron states in single nm-scale quantum dots. Wavefunction animations can be viewed at http://sol.physik.tu-berlin.de/. (M. Grundmannn *et al.*, *Phys. Rev. Lett.* **74**, 4043, 1995.)

Room-temperature ice. Microscopic images of water condensing and evaporating can now be obtained with an atomic force microscope operating in a novel mode. Normally it is difficult to study thin liquid films with an AFM, because capillary forces wet the probe tip, ruining the measurements. Miquel Salmeron and his colleagues at Lawrence Berkeley Laboratory avoid this problem by raising the conducting, platinum-coated tip to an altitude of 20 nm above the sample. When a voltage is applied to the tip, the electric field is concentrated around the sharp apex; this polarizes the atoms in the insulating substrate. By adjusting the height of the tip to keep the polarization force constant as the tip scans across the surface, a topographic map of a water layer on a mica substrate can be made. Because the dielectric constant of water at room temperature (at which the experiments were carried out) is more than ten times that of mica, the apparent height of the water monolayer is enhanced with this new technique, called polarization force microscopy. The LBL researchers found that below about 25% humidity, a uniform layer of fluid water forms. For higher humidity, water islands having polygonal shapes emerge; the cell shapes have angles of about 60° and 120° and their orientations are apparently determined by the underlying mica substrate. The water possesses crystalline structure and is, in effect, a type of ice. (J. Hu *et al.*, *Science*, **268**, 267, 1995.)

Solar neutrinos and solar wind: Is there a link between these two particle streams issuing from our local star? The neutrinos are a by-product of nuclear fusion reactions at the core of the Sun, while the solar wind is an outward gust of particles from the solar corona. Ralph McNutt, of the Johns Hopkins University Applied Physics Lab, compared neutrino data from the detector in Homestake, South Dakota, with hourly averaged solar wind data recorded by the IMP-8 satellite. Over the 19-year period for which available data overlapped, the neutrino flux and the flux of solar wind particles seemed to vary together; the significance of a Spearman rank correlation was 2.6%. (The low "significance" actually means a significant result.) He believes that the flux correlation helps validate what have been controversial claims of neutrino flux variability. There is no theoretical explanation that could link the two fluxes. McNutt reported his findings at the June meeting of the American Geophysical Union in Baltimore.

Imaging with an atomic beam has been accomplished by physicists at the University of Hannover in Germany. Past efforts to use focused atoms as an imaging source have been hampered by the velocity spread of the beam particles, which results in a long focal length and considerable aberration. The Hannover team uses laser-cooled, polarized cesium atoms to image a patterned mask. Those atoms transmitted through the mask are focused by a hexapole magnet lens (analogous to an optical gradient-index lens) which tugs at the atoms' magnetic dipole moments. Further downstream, at the designated image plane (whose distance determines the magnification), the atoms pass through a sheet of tuned laser light, causing them to fluoresce; the resulting image is recorded by a CCD camera. The researchers expect that if a solid substrate were positioned at the image plane, this whole process could be useful in submicron lithography—the atoms would be deposited in the pattern of the mask. (W. G. Kaenders *et al.*, *Nature*, **375**, 214, 1995.)

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