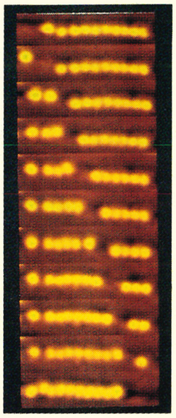
Physics Update

A nanotube has now been used as a microscope probe. Richard Smalley and his colleagues at Rice University have glued single carbon nanotubes (several micrometers long but only 5–20 nm wide) to the tips of scanning tunneling microscopes and scanning force microscopes. These long, slender tips are reproducible, conductive, inexpensive and useful for mapping rugged terrain, even the bottoms of trenches. Unlike a standard, pyramidal probe, a nanotube-tipped probe easily survives "catastrophic" crashes with the surface—it simply bends, then springs back to its original straight shape when withdrawn. (H. Dai *et al.*, *Nature* **384**, 147, 1996.) —PFS

Astrophysics may help the solar neutrino problem after all. The widely accepted standard solar model (SSM) calls for more neutrinos, especially arising from electron capture by beryllium-7 and boron-8, than are actually observed. (See PHYSICS TODAY, July 1996, page 30, and April 1995, page 19.) This shortfall has led to a search for new particle physics, such as neutrino oscillations. But what if the Sun really produces fewer neutrinos than called for? Wick Haxton of the University of Washington and Andrew Cumming of the University of California, Berkeley, have reexamined the SSM, particularly the role of helium-3 mixing. They looked at various perturbations of the SSM, subject to three constraints: All standard nuclear and atomic microphysics was retained, the known solar luminosity could not change and the resulting model must be steady-state. An intriguing solution emerged in which ^{3}He was rapidly transported deep into the Sun's core, in localized plumes, then returned to the outer core in a slow, broad, buoyant outflow. The altered balance between ^{3}He's production and consumption would then nudge the expected neutrino fluxes much closer to the observed values. While stressing that this idea is speculative, they point out that such ^{3}He mixing could have testable consequences for helioseismology, stellar evolution and ^{3}He ejection by red giant stars. (A. Cumming, W. C. Haxton, *Phys. Rev. Lett.* **77**, 4286, 1996.) —PFS

The quantum/classical border has gotten a bit sharper. Ideally, when a macroscopic measuring device is coupled to a microscopic system like an atom, the result should be a quantum superposition of the "device + atom" system. However, that is not observed. Instead, an irreversible reduction process seems to take place in which the macroscopic, coherent entanglement quickly dissipates. Now, Serge Haroche, Jean-Michel Raimond, Michel Brune and their coworkers at the Ecole Normale Supérieure in Paris have created such an entangled system and measured its progressive decoherence. They sent individual rubidium atoms—each of which was in a superposition of two Rydberg states—through a cavity containing a microwave field. Each of the two quantum states shifted the phase of the microwave field by a different amount—so the field also became a superposition of two states. As the cavity field exchanged energy with its surroundings, the superposition collapsed into a single definite state. The researchers monitored the decoherence by measuring correlations between the energy levels of pairs of atoms sent through the cavity with various time delays between the atoms. (M. Brune *et al.*, *Phys. Rev. Lett.* **77**, 4887, 1996.) —BPS

Counting on nanotechnology, researchers have demonstrated a molecular abacus. Scientists at IBM's research laboratory in Zurich have used a scanning tunneling microscope probe to reposition carbon-60 molecules along the "rails" of a stepped copper substrate, making a room-temperature device capable of storing and manipulating numbers at the single molecule level. The big, sturdy buckyballs can be pushed back and forth many times. The photo shows a single row of ten buckyballs configured separately for the numbers zero through ten. "The device is slow," says James Gimzewski, "but we may soon see arrays of hundreds and even thousands of STM probes for simultaneously imaging, and repositioning, many atoms and molecules." (M. T. Cuberes, R. R. Schlittler, J. K. Gimzewski, *Appl. Phys. Lett.* **69**, 3016, 1996.) —PFS



Ultrashort hard x-ray pulses have been produced at Lawrence Berkeley National Laboratory by shooting terawatt, 100-femtosecond bursts of infrared laser light at right angles across a beam of relativistic electrons. A highly collimated, 30 keV x-ray pulse (generated by 90° Thomson scattering) traveled in the direction of the electrons. The pulse duration—300 fs—was set by the transit time of the initiating laser pulse across the electron beam. A more tightly focused electron beam will lead to a shorter burst of x rays. These pulses are ideal probes for glimpsing ultrafast structural phenomena in condensed matter and biological systems. For example, the LBNL researchers are using the x-ray pulses to study melting silicon. (R. W. Schoenlein *et al.*, *Science* **274**, 236, 1996.) —PFS ■