PHYSICS UPDATE

AN EXCITED ATOMIC STATE WITH A TEN-YEAR lifetime has been observed in an ytterbium ion, raising hopes for atomic clocks a thousand times more accurate than now possible. According to the Heisenberg uncertainty principle, the longer a system can be observed, the smaller is the uncertainty in its energy. Therefore, it is extremely desirable to tune an atomic clock to a long-lived excited state because of the precision with which the transition frequency can be known. Researchers at the National Physical Laboratory in the UK used a laser photon to boost a single cooled and trapped ytterbium ion's outermost electron to the long-lived, metastable $^2F_{7/2}$ state. Rather than waiting ten years, the researchers subsequently boosted the electron to a yet higher state, from which it then decayed to its ground state. From the characteristics of the laser and the rate at which it drove the transitions, the researchers determined a 3700-day lifetime for the metastable state. In addition to being the most durable excited energy state yet detected in an atom, this is the first time a rare electric octupole transition—in which the electron changes its angular momentum by a relatively large amount of three units—has been driven. An atomic clock based on this transition would be very precise but would require much additional development. (M. Roberts *et al.*, *Phys. Rev. Lett.* **78**, 1876, 1997.) —BPS

DISCRETE ELECTRONIC STATES in a metal quantum dot have been investigated by physicists at Harvard University. In general, reducing an object's dimensionality makes its quantum nature more manifest. In a semiconductor, for example, confining mobile electrons to a two-dimensional plane, a one-dimensional wire or a zero-dimensional dot enforces an ever sharper limit on the allowed energies, and this effect can be exploited in producing compact and highly controllable electronic devices. Michael Tinkham, Dan Ralph (now at Cornell University) and Charles Black (now at IBM's T. J. Watson Research Center) succeeded in attaching leads to a 10 nm aluminum particle to make a tunneling transistor. The spectrum for "electron-in-a-box" energy levels for the interacting electrons inside the particle was measured from the current–voltage curves. Unlike a semiconductor dot, a metal nanoparticle can be made superconducting or ferromagnetic, and knowledge of the individual energy levels can provide a detailed view of the forces that govern these properties. Indeed, in such a speck of aluminum, the group observed the electron spectrum while an applied magnetic field broke up the superconducting state by flipping one electron spin at a time. Nonequilibrium excitations were also detected and characterized. (D. C. Ralph, C. T. Black, M. Tinkham, *Phys. Rev. Lett.* **78**, 4087, 1997.) —PFS

AN ACOUSTO-OPTIC DEVICE has been developed at the University of Munich, bringing about a new method for processing and storing light signals on a chip. In the new device the storage is accomplished by first sending a pulsed surface acoustic wave (SAW) along a piezoelectric semiconducting quantum-well structure. A laser pulse is then converted into a splash of excitons (electron–hole pairs), which are caught in the electric fields of the leisurely propagating SAW. In effect, photons become spatially separated electrons and holes that surf along on different parts of the guiding acoustic wave, like on a conveyor belt. Later, and in a different location on the device, the electron–hole pairs are made to recombine, reproducing the photons, which are then detected. The signal has essentially been converted from a speed-of-light wave into a speed-of-sound wave, and back again. According to Achim Wixforth, the strong lateral electric fields in a SAW can be exploited to combine the large absorption of a direct-gap semiconductor with the long radiative lifetimes of an indirect system. Typical excitons live for mere nanoseconds before recombining; in this experiment, they have survived for microseconds. (C. Rocke *et al.*, *Phys. Rev. Lett.* **78**, 4099, 1997.) —PFS & BPS

AN AMORPHOUS SOLID CAN BEHAVE LIKE A CRYSTAL. For a quarter-century, all amorphous solids have been found to damp out low-energy vibrations quickly. Put another way, they all have had comparable, relatively high values of "internal friction." By contrast, if you shake a pure silicon crystal, chilled to cryogenic temperatures, it will ring for an hour or more at various frequencies. Now a collaboration of physicists from Cornell University and the National Renewable Energy Laboratory in Golden, Colorado, has incorporated a small, judicious amount of hydrogen into amorphous silicon, greatly improving the electronic stability of the material by "tying down" some of its dangling bonds. In the process, the group found something unexpected: The low-energy vibration modes persisted for an hour, just as in the material's crystalline counterpart. This as-yet-unexplained property gives the researchers an experimental tool for exploring the role of hydrogen in these solids and for studying amorphous solids in general. For example, one can observe what happens to these low-energy excitations as impurities are added to the material. Amorphous silicon is a low-cost rival to crystalline silicon for photovoltaic applications. (X. Liu *et al.*, *Phys. Rev. Lett.* **78**, 4418, 1997.)—PFS