Physics Update

A single-electron memory, operating at room temperature, has been developed at the University of Minnesota. In electronics, "smaller" usually means faster response, less power consumption and more components per chip. In the tiny Minnesota transistor, a bit of information is stored in the form of a single electron, resident on a dot of silicon (acting as a "floating gate") and having the ability to influence the current flow in a silicon channel. The dot is about 7 nm square by 2 nm thick, and the channel is about 10 nm wide—much less than the 70 nm Debye screening length for a single electron. The device is orders of magnitude smaller than, but otherwise similar to, the kind of metal oxide semiconductor (MOS) transistor used in conventional computer memories. (L. Guo, E. Leobandung, S. Y. Chou, *Science* **275**, 649, 1997.) —PFS

The Hipparcos star catalog will be published in June, with new measurements of the positions of and distances to a myriad of stars. Operating from late 1989 until June 1993, the European Space Agency's Hipparcos satellite recorded 1000 gigabytes of data, which had to be analyzed *en masse* to determine the positions of more than 100 000 stars with milliarcsecond accuracy (a 100-fold improvement over present catalogs) and the positions of a million more stars with an accuracy between 20 and 30 milliarcseconds. This greater knowledge of star locations is quickly being put to use, as was revealed on 14 February at a meeting of the Royal Astronomical Society in London. Of special interest are the distances to certain variable stars—Cepheid-, RR Lyrae– and Mira-types—whose luminosity changes can be used to deduce the distances to various clusters in the Milky Way as well as to faraway galaxies. For example, very preliminary revisions of stellar ages and distances suggest that globular cluster stars, thought to be the oldest stars in our Galaxy, may be only 11 (not 15) billion years old. Further, other galaxies may be perhaps 10% farther from us than earlier studies implied. Meanwhile, resolution of the embarrassing dilemma caused by the oldest stars appearing to be older than the universe itself still awaits peer review. (More on Hipparcos can be found in *Science* **275**, 1064, 1997, and *Science News* **151**, 101, 1997.) —PFS

Sonoluminescing bubbles collapse at more than Mach 4, new experiments have shown. Previous experiments could establish only that the bubble collapsed faster than the speed of sound in the gas within the bubble. Sonoluminescence (SL) is the still-mysterious process in which sound waves cause bubbles in a water tank to collapse and generate ultrashort light flashes, which represent a trillionfold concentration of the original sound energy. (See PHYSICS TODAY, September 1994, page 22; December 1995, page 9; November 1996, page 9.) Now, UCLA researchers have determined the speed of bubble collapse—about 1500 m/s—by measuring the amount of light scattered from ultrashort (100 fs) laser pulses impinging on a bubble at different times during its implosion. The amount of scattered light is proportional to the square of the bubble radius. The work provides the best evidence yet for the shock-wave model—the leading explanation for SL. But the experiment does not rule out competing explanations because all experiments to date have probed only the outer surface of the bubble, not what is happening inside. The UCLA team also found that the SL flash occurs within 300 ps of when the bubble reaches its minimum radius of less than 1 μm; at that time the bubble's surface is accelerating by at least $10^{11}\,g$, yet amazingly remains intact. (K. R. Weninger, B. P. Barber, S. J. Putterman, *Phys. Rev. Lett.* **78**, 1799, 1997.) —BPS

Atom-interferometer gyroscopes, though still lacking long-term stability, are now at least as sensitive as the best commercial laser gyroscopes, new experiments have demonstrated. By sending two beams of atom waves along different paths and then recombining them, an interference pattern of light and dark fringes can be created. Rotating the interferometer while the atom waves travel freely through the device makes the fringes shift from their usual positions—known as the Sagnac effect—and enables researchers to detect rotation rates. In one recent experiment, David Pritchard and his coworkers at MIT passed a beam of sodium atoms through a series of nanofabricated diffraction gratings and achieved a sensitivity of 3×10^{-6} rad/s. Meanwhile, Mark Kasevich and his colleagues at Stanford University used laser beams for diffraction gratings to realize a sensitivity of 2×10^{-8} rad/s. For comparison, the Earth's rotation rate is 15° per hour, or 7.3×10^{-5} rad/s. Both experiments sought short-term sensitivity in their one-second observations, not the long-term stability that must still be demonstrated for most real-world applications, such as sensing rotational effects in autos and tanks or making inertial guidance systems for aircraft. The intrinsic sensitivity of atom interferometers could surpass that of laser interferometers by a factor of 10^{10}: Atom wavelengths are much shorter than those of visible light, potentially making them more sensitive to smaller changes, and their speeds are much slower than that of light so the interferometer has more time to rotate while the particles travel through the device, producing larger fringe shifts. (A. Lenef *et al.*, *Phys. Rev. Lett.* **78**, 760, 1997. T. L. Gustavson, P. Bouyer, M. A. Kasevich, *Phys. Rev. Lett.*, in press.) —BPS