PHYSICS UPDATE

A single-photon light-emitting diode has been created. At the May CLEO/QELS meeting in Long Beach, California, scientists from Toshiba Research Europe Ltd described a nanometer-scale indium arsenide quantum dot integrated into a conventional gallium arsenide LED structure. Using a pulse of electric current, the researchers could induce a single electron and a single hole to recombine in the dot, thus generating a single photon. Because the exciton's lifetime was 1.0 ns and the equipment had subnanosecond time resolution, the physicists could verify that photons were emitted singly. The researchers believe this is the first electrically driven single-photon source. Such single-particle–emitting sources could offer a potentially inexpensive and convenient component for quantum cryptography and other applications. (Paper QTuG1 at the meeting; see also Z. Yuan et al., *Science* **295**, 102, 2002.) —BPS

Microsatellite plasma propulsion. Thanks to new MEMS (microelectromechanical systems) technology, the development of low-mass spacecraft—less than 20 kg—has gone well, with one notable exception: suitably miniaturized thrusters, the minirockets that steer the craft and make other flightpath adjustments. John Foster, a researcher at NASA's Glenn Research Center in Cleveland, Ohio, has now built a tiny propulsion system that develops thrust from a pressurized gas of xenon that is ionized by energetic electrons as it escapes through 0.18-mm apertures. Foster boiled the electrons off a filament and used a cusp in a magnetic field to focus them onto the apertures. The resulting ions were then accelerated to the 50–200 eV range to generate thrust. Only about 50 mm across, the device is extremely fuel-efficient: 88% of the fuel is successfully turned into ions. The new compact plasma accelerator could also be used for modifying surface chemistry and making thin films. (J. E. Foster, *Rev. Sci. Instrum.* **73**, 2020, 2002.) —PFS

Bright solitons in a Bose–Einstein condensate. A soliton is a localized wave that, because of nonlinear effects, can travel for long distances without spreading out or losing its original shape. Solitons can occur in all kinds of waves, including sound and light. In fact, solitons are regularly used in telecommunications in optical fibers. Essentially a macroscopic matter wave, a BEC can also form solitons. Usually, however, a BEC quickly spreads after it is released from the trap in which it was created. Now, groups at Rice University in Houston and at the Ecole Normale Supérieure in Paris have been able to form BEC solitons with lithium-7 atoms. Both groups used a tunable magnetic field to adjust the interatomic interactions from repulsive—necessary to form a stable condensate—to weakly attractive. The attractive interactions provided a self-focusing nonlinearity that exactly compensated for wavepacket dispersion. After releasing the atoms into a 1D potential, both groups observed solitons that propagated without changing shape for more than a millimeter—a truly macroscopic distance. The Rice experimenters formed a train of up to 10 individual solitons, which appeared to repel each other as they oscillated in a weakly harmonic potential. The Paris group set up an open waveguide and accelerated a single soliton. Matter-wave solitons may prove useful for eventual technological applications of BECs, such as for gyroscopes for ultraprecise navigation, very accurate atomic clocks, or other devices that use atom interferometry. (K. E. Strecker et al., *Nature* **417**, 150, 2002; L. Khaykovich et al., *Science* **296**, 1290, 2002.) —BPS

A nanoscale, nonmagnetic read-head sensor, based on extraordinary magnetoresistance (EMR), has been developed. Today's state-of-the-art magnetic recording delivers about 15 gigabits per square inch of recording medium. To achieve that result, the read head uses magnetic metals in a layered structure with either the giant magnetoresistance (GMR) or tunneling magnetoresistance (TMR) effect to convert the field orientation (up or down) of tiny magnetic domains into changes in electrical resistance. Both effects make use of electrons' spin and are subject to magnetic noise. By contrast, EMR makes use of electrons' orbital degrees of freedom; the magnetic fields deflect a current from a conducting shunt attached to the semiconductor and thereby produce resistance changes. A group led by Stuart Solin of NEC Research Institute in Princeton, New Jersey, has now used nonmagnetic, silicon-doped indium antimonide to build a mesoscopic read head (see the scanning electron micrograph) that operates on the EMR principle. According to Solin, GMR and TMR will ultimately have a noise-limited areal density of about 150 Gb/in^2, whereas EMR could reach 1 Tb/in^2 and has a fast enough response time to utilize that density. The researchers fabricated their 116-Gb/in^2 device using a multistep electron-beam lithography process that required excruciating accuracy: Features needed to be aligned to within 10 nm. Although free of magnetic-noise limitations, the device needs to sense magnetic fields that are 10 times stronger than those sensed with current technologies, which could limit its practical application for the time being. (S. A. Solin et al., *Appl. Phys. Lett.* **80**, 4012, 2002.) —PFS