Physics Update

Triple photoionization of lithium, a rare process in which a single photon removes all three electrons simultaneously from the atom, has been detected for the first time by a Japan–US collaboration. At the KEK Photon Factory in Tsukuba, Japan, an intense beam of extreme-ultraviolet (EUV) photons broadsided a beam of neutral lithium atoms, and Li^{3+} ions were collected. In the simplest picture of the process, an EUV photon transfers virtually all of its energy to a single electron; any multielectron processes must then arise from correlation effects among the electrons. Auger (autoionization) processes play no role because they would leave behind at least one bound electron. Other groups have previously observed triple photoionization of heavier atoms, such as neon, but those events do involve Auger-type internal rearrangements of other electrons in the atom at photon energies well above the triple ionization threshold. (R. Wehlitz *et al.*, *Phys. Rev. Lett.* **81**, 1813, 1998.) —BPS

Lithography with carbon nanotubes has been demonstrated on silicon by Hongjie Dai (Stanford University) and his colleagues. Ordinary graphite pencils write by wearing themselves down, but the researchers showed that a stiff, capped nanotube pencil can be very robust—a real boon to nanofabrication. The nanotube writes by means of an electric field emanating from the tip; the field removes atoms from a layer of hydrogen atop a silicon base. The exposed silicon surface then oxidizes, leaving 10 nm-wide SiO_2 tracks. According to Dai, such lines, spaced 100 nm apart, can readily cover a 100 μm^2 area in 100 s. He concludes that such nanotubes, "derived from bottom-up chemical synthesis may become the workhorse for top-down nanofabrication." (H. Dai, N. Franklin, J. Han, *Appl. Phys. Lett.* **73**, 1508, 1998.) —PFS

An improved value of Planck's constant has been obtained by physicists at the National Institute of Standards and Technology in Gaithersburg, Maryland. The new value for h of $6.62606891 \times 10^{-34}$ J s, with an uncertainty of 89 parts per billion, instantly improves the accuracy of values for related fundamental constants (such as electron mass, proton mass, elementary charge and Avogadro's number) and paves the way for a quantum-based definition of mass. The experiment, first proposed by Brian Kibble of the UK's National Physical Laboratory in 1976, used a moving-coil watt balance—an apparatus with a kilogram mass connected to a metal coil in a magnetic field—that makes use of the Josephson and quantum Hall effects. First, the researchers allowed the coil to move downward, measuring its velocity and the voltage it generated. Next, they sent a current through the coil, which created an upward magnetic force that exactly balanced the downward force of gravity on the mass. The researchers were able to extract the value of h from their data, in which factors such as the geometry of the setup canceled out. (E. R. Williams, R. L. Steiner, D. B. Newell, P. T. Olsen, *Phys. Rev. Lett.* **81**, 2404, 1998.) —BPS

Quantum error correction has now been experimentally demonstrated. Skeptics have maintained that quantum computers would crash before carrying out a useful calculation because the proposed devices rely on fragile, easily corrupted quantum states. But the new proof-of-concept experiment, using liquid nuclear magnetic resonance techniques, may change their minds. The researchers aimed radio-frequency pulses at a liquid of either alanine or trichloroethylene molecules, which spread a single bit of quantum information onto three nuclear spins, using entanglement. The bit of information was a superposition of the values 0 and 1, and spreading it out made it possible to recover the information if one of the nuclei got corrupted. Measuring the spins directly would have destroyed the superposition and forced the bit to become either a 0 or a 1. So the researchers instead compared the states of spins two at a time, without actually learning what the states were, to see if any differences arose between them. This approach allowed the experimenters to detect an error, and correct it, without ever knowing what the "message" was. (D. G. Cory *et al.*, *Phys. Rev. Lett.* **81**, 2152, 1998.) —BPS

Kaons behave strangely in dense nuclear matter. Recently, experimenters at the GSI lab in Darmstadt, Germany have looked for kaons in violent collisions (1 GeV/nucleon) between gold nuclei. During such an energetic reaction, the nuclear matter is compressed to about three times normal nuclear density for a very short time—about 3×10^{-23} s. During this hot and dense phase, strange mesons—mostly positively charged kaons—are created. Then the nuclear fireball explodes. At polar emission angles of 90° in the center-of-mass frame, nucleons and pions emerge preferentially out of the plane of the collision. Kaons, however, are expected to emerge isotropically, due to their long mean free path. But they don't. They accompany the nucleons in a joint escape from the plane. This unexpected finding could indicate that the effective mass of the kaon is altered in the extreme nuclear environment, which in turn could have important implications for the astrophysics of supernovae and neutron stars. (Y. Shin *et al.*, *Phys. Rev. Lett.* **81**, 1576, 1998.) —PFS ■