Physics Update

Dating water and tracing bones are two new applications of atom-trap trace analysis. Through the ATTA technique, researchers use lasers and magnetic fields to trap atoms of specific rare isotopes and then, with lasers, count them one at a time. In a pair of recent papers, Zheng-Tian Lu of Argonne National Laboratory worked with international collaborations to count krypton-81 atoms in ancient groundwater samples from beneath the Sahara Desert in Egypt and calcium-41 atoms released from human bones. The researchers found—using ^{81}Kr's half-life of 229 000 years—that the water trapped in the Nubian aquifer ranged in age from 200 000 to a million years old, depending on the sample location. In the biomedical application, ^{41}Ca was ingested by a female subject, and subsequent measurements of the isotope's abundance were used to monitor bone loss and retention rates. With ATTA, the researchers could detect one ^{41}Ca isotope per 10^8–10^{10} calcium atoms. With further improvements, the technique could be ideal for archaeological dating (^{41}Ca's half-life is 103 000 years) of ancient bones up to a million years old. (N. C. Sturchio et al., *Geophys. Res. Lett.* **31**, L05503, 2004; I. D. Moore et al., *Phys. Rev. Lett.* **92**, 153002, 2004.) —BPS

Parity violation in electron–electron scattering has now been seen. According to parity conservation, physics is the same in both ordinary and mirror worlds. Of the four known physical forces, only the weak nuclear force does not conserve parity. Since the 1950s, parity violation has been observed in several reactions, but never before in relatively low-energy electron–electron scattering: Electrons participate not only in electromagnetic interactions, but also in weak nuclear interactions via beta decay and related processes. The E158 Collaboration at SLAC scattered 50-GeV beams of longitudinally polarized electrons off electrons in a liquid hydrogen target and measured the fractional difference in scattering rates for the two polarizations. The observed asymmetry not only demonstrated parity violation, but also provided the first direct measurement of the electron's "weak charge." The value was in excellent agreement with predictions of the standard model of particle physics. (P. L. Anthony et al., *Phys. Rev. Lett.* **92**, 181602, 2004.) —PFS

Miser–slave symbiotic relations. In a number of natural associations, such as nitrogen-fixing bacteria in legumes, the host organism receives a significant benefit, but the symbiont partner gets little in return. Two researchers from New Zealand have recently suggested a simple model explaining such unequal relationships. Based on the Prisoner's Dilemma game, it allows both host and symbiont to adopt a cooperation strategy that is conditioned on the partner's actions. The asymmetry arises because the symbiont has a much faster reproduction rate than the host and therefore frequently engages in evolutionary struggles. If the host's cooperation strategy gives the symbiont greater net benefit with greater cooperation, then the symbiont will be driven to fully cooperate, even if that increased benefit is minimal. Over the longer time scale of their own battles for survival, hosts evolve to give the minimum level of cooperation that still induces full cooperation from their partners. (M. R. Frean, E. R. Abraham, *Phys. Rev. E* **69**, in press.) —SKB

A new high-pressure phase of a perovskite may solve some mysteries near the core–mantle boundary halfway to Earth's center. Just above that boundary, the so-called D″ layer exhibits a puzzling seismic discontinuity in which an elastic wave's speed varies significantly with direction. When scientists from the Tokyo Institute of Technology placed the perovskite form of $MgSiO_3$ in a diamond anvil cell and subjected it to temperatures and pressures similar to those of the D″ layer, the mineral changed to a new crystalline form. By running molecular-dynamics simulations, the researchers found that only a slightly denser and highly anisotropic crystalline structure, dubbed post-perovskite, could fit their x-ray data. Because perovskite is plentiful in the deep mantle, the researchers say that the newfound form can explain some of the seismic irregularities. Using the Tokyo x-ray data, a University of Minnesota group led by Renata Wentzcovitch ran independent simulations and presented similar conclusions at the March meeting of the American Physical Society in Montreal. (M. Murakami et al., *Science* **304**, 855, 2004; T. Tsuchiya et al., *Earth Planet. Sci. Lett.*, in press.) —PFS

Semiconductor nanocrystals can provide highly efficient carrier multiplication, which could lead to greatly improved solar cells. Usually, an incident photon striking a semiconductor solar cell produces both an exciton (an electron–hole pair), which generates the usable electrical current, and some excess heat. By using tiny (smaller than 10 nm) clusters of lead and selenium atoms, Victor Klimov and Richard Schaller of Los Alamos National Laboratory encouraged the absorbed photon—via a process known as impact ionization—to spawn a second exciton instead of the heat. Although they haven't yet built a working solar cell, the scientists say that the new process might provide efficiency gains of more than 35% in the conversion of light to current. (R. D. Schaller, V. I. Klimov, *Phys. Rev. Lett.* **92**, 186601, 2004.) —PFS ■