Physics Update

Nonexponential decay of a quantum system has been observed for the first time. Unstable systems are known to decay exponentially in all fields of science, but quantum mechanics predicts deviations from this law at both very short and very long times in a system's evolution. Physicists at the University of Texas at Austin have now devised a scheme to study the tunneling rate of trapped sodium atoms at very early times. They found a decay rate that was initially flat, followed by one that was steeper than the final decay rate. After 10–15 μs, the usual exponential decay took over. The researchers think that tunneling can be suppressed during the early times. For more on quantum transport, see last month's PHYSICS TODAY, page 30. (S. R. Wilkinson *et al.*, *Nature* **387**, 575, 1997.) —PFS

Unusual properties of cubane. First synthesized in 1964, cubane (C_8H_8) is a molecule with eight carbon atoms arranged at the corners of a cube plus single hydrogen atoms sprouting symmetrically from each carbon. Thus the C–C–C bond angle is 90°, rather than the 109.5° customary in other hydrocarbon molecules. A great deal of strain energy is therefore stored in the chemical bonds—150 kcal/mole or 6.5 eV per molecule. Replace all the Hs with NO_2 groups and you get a terrific fuel or explosive, with nearly twice the power of TNT. Replacing the Hs with other chemical groups results in potentially more salubrious derivatives, some of which are currently undergoing tests for fighting the AIDS virus, bone marrow cancer and Parkinson's disease. For all its potential, however, solid cubane is not well understood. Like other molecular solids (such as solid C_{60}), in which molecules rather than atoms make up the underlying lattice, cubane exhibits a "plastic phase" close to its melting point in which the molecules start to swivel about one or more of their axes. Recently, a University of Chicago–NIST collaboration has experimentally worked out the structure of this plastic phase, using x-ray powder diffraction. Surprisingly, unlike most other molecular solids, the plastic phase of cubane is not face-centered cubic. It's rhombohedral. The researchers' work shows that cubane undergoes a large volume expansion of 5.4% at the first-order phase transition temperature of 394.3 K. (T. Yildirim *et al.*, *Phys. Rev. Lett.* **78**, 4938, 1997.) —PFS

Gamma rays from a free-electron laser. Physicists at Duke University used ultraviolet photons, Compton backscattered from 500 MeV electrons inside a storage-ring free-electron laser (FEL), to produce a beam of 12.2 MeV gamma rays. The emittance and divergence of the electron beam were so low that by collimating the gamma beam, a nearly monoenergetic beam of gammas (with an energy spread of about 1%) resulted. The intensity of the gamma beam is expected to be 1000 times greater than that produced with non-FEL systems. A beam like this will be useful for high-resolution nuclear gamma-ray spectroscopy and cancer therapy. It can also be used for high-precision gamma-ray transmission radiography. Other facilities that use Compton backscattering in FELs to produce gammas are UVSOR and NIJI-IV in Japan and Super-ACO in France. (V. N. Litvinenko *et al.*, *Phys. Rev. Lett.* **78**, 4569, 1997.) —PFS

Proton pairs ejected from nuclei have now been studied in enough detail to begin to probe short-range correlations within the nucleus. At the National Institute for Subatomic Physics (NIKHEF) in Amsterdam, The Netherlands, a beam of electrons was directed at oxygen nuclei. For just the right collision energy, a single electron can knock two protons out of the nucleus. The experimenters showed that the two protons (which are detected in coincidence with the scattered electron) emerge primarily in an S state, in which their relative angular momentum is zero. Such protons would have been within 10^{-15} m of each other—and strongly correlated—in the nucleus just before being struck by the electron. The NIKHEF experiment was the first to obtain clean enough spectra to see the ejected S-state proton pairs, thereby leaving the residual carbon nuclei in the ground, or a low-excited, state. (C. J. G. Onderwater *et al.*, *Phys. Rev. Lett.* **78**, 4893, 1997.) —PFS

A sonoluminescing bubble of air may change to argon. In sonoluminescence, an air bubble repeatedly collapses, producing ultrashort flashes of light. Recently, a German–US team proposed that such a collapsing air bubble, with its imploding shock waves, becomes hot enough to dissociate the air's nitrogen and oxygen molecules, which then react with hydrogen and oxygen radicals from dissociated water vapor. The compounds thus formed are water soluble and, after a few collapse cycles, only inert gases (mainly argon) are left to produce the light. At the Acoustical Society of America meeting in June, William Moss of Lawrence Livermore National Laboratory reported simulations from a rigorous fluid dynamics code (originally developed for imploding fusion pellets) that includes the physics of partially ionized plasmas. Moss and his colleagues simulated sonoluminescing bubbles of both pure argon and pure nitrogen. Their argon spectrum closely matched the experimental spectrum from a collapsing air bubble, but their nitrogen spectrum did not, lending strong support to the notion of shock-driven chemistry being important. (D. Lohse *et al.*, *Phys. Rev. Lett.* **78**, 1359, 1997. W. C. Moss, D. B. Clarke, D. A. Young, *Science* **276**, 1398, 1997.) —BPS