Physics Update

Plasma instabilities in tokamaks have been greatly brought under control in two separate experiments. Physicists at the TFTR tokamak at Princeton University and at the DIII-D tokamak at General Atomics in San Diego have shaped the magnetic fields inside their fusion reactors into a "reversed magnetic shear" configuration, by producing and maintaining a hollow current density profile. This profile in turn suppresses certain pressure-driven instabilities and turbulence often found in tokamak plasmas with peaked current profiles. The experiments generated central ion temperatures of 20 keV and higher, and highly peaked density, temperature and pressure profiles that indicated significantly enhanced plasma confinement. The peak pressure exceeded 10^5 pascals. Controlling and maintaining a high plasma density and high temperature are important parts of the long-term effort to develop power plants based on thermonuclear fusion reactions. There is no complete theory as yet that matches the experiments, but calculations had predicted improved stability and confinement in a reversed magnetic shear configuration. Although the ultimate significance of the experiments is not yet known, the fusion community is greatly excited by them. (F. M. Levinton *et al.*, *Phys. Rev. Lett.* **75**, 4417, 1995; E. J. Strait *et al.*, *Phys. Rev. Lett.* **75**, 4421, 1995.) —PFS

Acoustic time-reversal mirrors for detecting flaws in solids have now been demonstrated by a team at the University of Paris VII. TRMs are devices that record a sound wave emanating from a source and generate a new one that behaves as if the original were traveling backward in space and time. For example, shouting "too" at the device would yield a reversed acoustic wave (sounding something like "oot") that would converge back toward the speaker's mouth. Previously, TRMs had been rigorously tested for sound in fluids such as water or air, where only longitudinal waves propagate. Demonstrating TRMs in solid objects has been more difficult because both longitudinal and transverse sound waves can exist, resulting in two wavefronts that travel at different speeds. The Paris researchers first used the TRM to send an ultrasonic wave into the solid sample, and detect any echoes from defects such as cracks. The TRM both records the incoming echo and broadcasts a time-reversed version. The new signal, in turn, reflects from the defect, an echo returns to the TRM and so forth, in an iterative process that leads to a clearer location of the defect. There is no such iterative focusing if there are no defects. TRMs have potential applications for detecting tiny cracks in airplanes and nuclear reactors, and for locating and destroying kidney stones (the stones are "defects" in an essentially liquid medium). (Paper 1pPA5, Acous. Soc. of Amer. Mtg., St. Louis, 1995.) —BPS

Chemistry at high pressures can change unexpectedly. Oxygen and hydrogen usually react explosively to form water in a process that helps to put astronauts in orbit. But in experiments carried out at the University of Paris VI, a mixture of H_2 and O_2 in a diamond anvil press at room temperature was found to remain stable at a pressure of 7.6 GPa (75 000 atm). The researchers, whose lab sustained a damaging explosion in one test, believe the high-pressure alloy that is formed instead of water might lead to a new form of energy storage, such as for rocket fuel, and could serve as a model for the interiors of Jupiter-like planets. (P. Loubeyre, R. LeToullec, *Nature* **378**, 44, 1995.) —PFS

Problems with big bang nucleosynthesis? Two research groups have recently addressed this question and the jury is still out. A prominent artifact of the big bang is the synthesis of several species of light nuclei, namely ^{2}D, ^{4}He, ^{3}He and ^{7}Li, only minutes after the explosion. Cosmologies that predict this early nucleosynthesis must account for the present-day abundances of these nuclei, allowing for the primordial inventory as well as any nuclei that may have been manufactured or destroyed in the cores of stars. Measurements (particularly of ^{4}He; see PHYSICS TODAY, October, 1995, page 19) have improved to such an extent that both cosmological theories and various features of the standard model of particle physics can now—or soon will—be put to the test. For example, the more species of "light" neutrinos (with masses less than 1 MeV) there are, the faster the early universe would have expanded, leaving behind more neutrons, which in turn would lead to a larger amount of ^{4}He. Particle theory and experiment suggest three light species: electron, muon and tau neutrinos. Both of the new analyses agree that, for N_ν (the number of light species) to be three, the abundance of primordial ^{4}He inferred from observations may have been severely underestimated, although the Chicago group gets around this by rethinking the Galactic evolution of ^{3}He. The Ohio–Pennsylvania group suggests that although the data might be at fault, the value of N_ν is actually consistent with 2, perhaps indicating an unstable tau neutrino with considerable mass. The Chicago group suggests that, within the uncertainties, the data and the standard theory are still consistent with each other and there is no need to invoke new physics. (N. Hata *et al.*, *Phys. Rev. Lett.* **75**, 3977, 1995; C. J. Copi *et al.*, *Phys. Rev. Lett.* **75**, 3981, 1995.) —PFS

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