Physics Update

A SUPERCONDUCTING TRANSISTOR-LIKE DEVICE has been fabricated and tested. A group led by Norman Booth (University of Oxford) and Antonio Barone (University of Naples) stacked together two tunnel junctions to build a device having three metallic layers separated by two insulating barriers. A signal current or voltage applied to the superconducting injector junction breaks some of the bound Cooper pairs of electrons. One of the resulting two electronic excitations (called quasiparticles) tunnels into the middle layer—actually a bilayer composed of superconducting niobium followed by normal aluminum. There, it gives up its energy to many of the free electrons in the normal metal; these electrons can then tunnel through the second junction. The highly directional current gain can be as high as a factor of 70. The device operates at 4.2 K—a temperature at which conventional transistors perform poorly—on a power of about 1 μW and voltages of mV. By reversing the bias polarities, this quasiparticle trapping transistor, which the researchers call a "quatratran," becomes the superconducting analog of both the pnp and npn transistors. Furthermore, by reversing only one polarity, a new device results that has negative current gain. (G. P. Pepe *et al.*, *Appl. Phys. Lett.* **77**, 447, 2000.) —PFS

EVIDENCE FOR A SOFT DIPOLE RESONANCE has been found. In neutron-rich light nuclei, the extra neutrons can constitute a "halo" around the core nucleus. According to predictions dating back to the mid-1980s, if such nuclei are properly excited, the core and halo should oscillate. Yet the very existence of this "soft dipole resonance" has remained controversial, both experimentally and theoretically. Now, a group in Japan led by Shintaro Nakayama (University of Tokushima) may have seen it in helium-6. The physicists bombarded a lithium-6 target with a beam of $^7Li^{3+}$ and acquired data on the energy and angular distributions of the ^7Be ejecta. After subtracting the effects of the spin dipole and giant dipole resonances, a feature remained whose properties were consistent with the long-sought soft dipole resonance. (S. Nakayama *et al.*, *Phys. Rev. Lett.* **85**, 262, 2000.) —PFS

TWO-DIMENSIONAL TURBULENT FLOWS leak significant energy to their surroundings, new experiments have confirmed. All 2D laboratory fluids are immersed in their 3D environments and thus can dissipate their turbulent energy through either the fluid's internal viscosity or its friction with its surroundings. The same holds true for atmospheric flows, which are often modeled as 2D even though they couple to Earth's surface. For such flows, modelers have used the 2D Navier–Stokes equation with a linear drag term, but the validity of this approach had not been quantitatively tested—until now. In a new experiment, Michael Rivera and Xiao-Lun Wu (University of Pittsburgh) created turbulence in a salt-based soap film by sending electric and magnetic fields through it. They then monitored the turbulence for 30 minutes (and measured 1000 vector fields) by tracking lycopodium particles (mushroom spores) in the film. They found that the familiar, simple model applied but that energy transfer to the surrounding air molecules was often greater than the energy dissipated to internal viscosity. That result demonstrates that an interaction with the surroundings is essential for maintaining a steady state in such a 2D system, and implies that ideal 2D fluids are unlikely to be found in our observable world. (M. Rivera, X. L. Wu, *Phys. Rev. Lett.* **85**, 976, 2000.) —BPS

QUANTUM SUPERPOSITION of distinct macroscopic states has been demonstrated. In general, a large, complex system can show quantum effects only if it is completely decoupled from the environment. Hence, experimental realizations of quantum superposition have involved a very few individual particles, whether electrons, ions, or photons. Now, however, physicists at SUNY Stony Brook, led by James Lukens and Jonathan Friedman, have broken the macroscopic barrier using a carefully isolated superconducting quantum interference device (SQUID) operating at 40 mK. The SQUID could accommodate either zero or one magnetic flux quantum, corresponding to a few μA of current flowing either clockwise or counterclockwise around the device. The experimenters used microwaves to induce coherent tunneling between the two flux states, thereby putting the states into a quantum superposition. The magnetic moments of the two states differ by about $10^{10}\ \mu_B$, which is truly macroscopic. Such a large coherent quantum state might find a use in quantum computing. (J. R. Friedman *et al.*, *Nature* **406**, 43, 2000.) —PFS

A SIMPLE QUANTUM REFRIGERATOR MODEL has been formulated. The third law of thermodynamics says essentially that nothing can be reversibly cooled to absolute zero in a finite time. That seemingly inviolate law, first stated in 1906 by Walther Hermann Nernst, predated quantum mechanics; yet, near absolute zero, quantum-mechanical effects dominate over classical ones. Now, Jeffrey Gordon (Ben-Gurion University, Israel), and Ronnie Kosloff and Eitan Geva (Hebrew University, Israel) have analyzed a steady-state, three-energy-level quantum refrigeration cycle, which incorporates both a hot and a cold bath, and in which coherent radiation provides the input power. The researchers found that the maximum cooling rate vanishes linearly with the temperature of the cold bath, which is the weakest functional dependence commensurate with the third (and second) law. The result is model-independent, but the authors note that in real molecular systems, the fundamental irreversible limit may prove elusive due to, for example, spontaneous emission. (R. Kosloff, E. Geva, J. M. Gordon, *J. Appl. Phys.* **87**, 8093, 2000.) —SGB ■