ACOUSTIC RADIATION IS IMPORTANT in dynamic friction. Studies of sliding friction are often carried out at modest relative speeds, with moving surfaces typically sliding past each other at 1 cm/s. At such speeds, deformations of the surface asperities seem to dominate the friction; that is, they are the main energy sink. (See PHYSICS TODAY, September 1998, page 22.) However, at higher velocities, such as the 1 m/s motions of tectonic plates during an earthquake, that simple explanation has seemed inadequate. Now, Anders Johansen and Didier Sornette (UCLA) have performed and analyzed friction experiments for relative velocities of up to 0.35 m/s. Near the high end of their velocity range, the researchers noted that the data were very well fit if they included a radiation damping force proportional to the time derivative of the acceleration. The significantly increased production of sound waves from colliding asperities (largely neglected in past analyses) proved to be the dominant energy sink in that velocity regime. This finding suggests that the generation of sound waves between two sliding fault surfaces during an earthquake may mitigate the quake's effects, by greatly attenuating the fastest motions. (A. Johansen, D. Sornette, *Phys. Rev. Lett.* **82**, 5152, 1999.) —BPS

OPTICAL AND RADIO FREQUENCIES can now be compared to a few parts in 10^{17} or better. Because of the reciprocal relationship between time and frequency, a very short pulse of laser light (for example, a femtosecond wavepacket) contains a very wide range of frequencies. Within the lasing cavity, each frequency, or mode, is reflected separately. When the phases of all the modes match, then the entire wavepacket sloshes back and forth coherently, and the spectrum of the train of output pulses resembles a comb, with the regularly spaced teeth separated by the reciprocal bounce time of the cavity. Researchers at the Max Planck Institute for Quantum Optics (Garching, Germany) have now demonstrated that the output "teeth" of such a mode-locked laser are distributed uniformly in frequency to within three parts in 10^{17} over a range spanning 20 THz. In addition, using a comb with 244 000 teeth as a kind of ruler, they have now measured the frequency of the cesium D_1 line with unprecedented accuracy. This work may open a new chapter in metrology, and could lead to the replacement of atomic clocks (which are stable to about two parts in 10^{15}) by optical clocks. (Th. Udem *et al.*, *Phys. Rev. Lett.* **82**, 3568, 1999, and *Optics Lett.* **24**, 881, 1999.) —RJF

ZERO-POINT MOTION in a Bose–Einstein condensate (BEC) has now been studied. A group of MIT researchers measured the momentum distribution of a trapped sodium BEC, taking advantage of the fact that atoms absorb light at slightly lower (higher) frequencies if they are moving away from (toward) the light. In Bragg scattering, an atom absorbs a photon from a laser beam and is stimulated by a second laser to emit a photon at a different frequency. For the most efficient stimulation, the emitted frequency is also shifted upward or downward depending on the atom's motion. Measuring the width of this resonance allowed the researchers to determine the range of momentum values for the atoms in the condensate. Multiplying the measured momentum spread by the size of the condensate gave an answer of approximately $\hbar$—the minimum value allowed by Heisenberg's uncertainty relation—demonstrating that the BEC is maximally coherent. Previous measurements of momentum spreads in BECs were made on expanding condensates, typically having energies hundreds of times larger than the zero-point energy. According to Wolfgang Ketterle, "The trapped condensate has no entropy and behaves like matter at absolute zero." (J. Stenger *et al.*, *Phys. Rev. Lett.* **82**, 4569, 1999.) —BPS

THE SPEED OF LIGHT is frequency independent to within a factor of 6×10^{-21}. Bradley Schaefer of Yale University bases this estimate on the observed arrival of gamma rays from distant explosive events in the cosmos, such as gamma-ray bursters. If the speed of light varied slightly for different frequencies, then light of different frequencies emitted at the same time would arrive at our telescopes at different times. But this is not the case. The best previous effort to locate a frequency dependence for *c* was made in 1969; using light coming from the Crab pulsar, a limit at the 5×10^{-17} level was deduced. Thus, Einstein's special theory of relativity now seems vindicated over an additional four orders of magnitude. By the way, the prefix for anything as small as 10^{-21} is "zepto." (B. E. Schaefer, *Phys. Rev. Lett.* **82**, 4964, 1999.) —PFS

LONG-BASELINE NEUTRINO OSCILLATION experiments have now gotten under way. On 19 June, the Super Kamiokande detector in Japan recorded the arrival of a neutrino launched in its direction from the KEK proton accelerator, located 250 km away. Last year, Super Kamiokande provided strong evidence that neutrinos oscillate from one type to another on their way through Earth (see PHYSICS TODAY, August 1998, page 17). In the new experiment (dubbed "K2K"), physicists are attempting to confirm the oscillation phenomenon by allowing neutrinos made artificially at KEK to pass through both a nearby detector and the distant Super Kamiokande detector, aligned to receive the same neutrino beam. If, for example, muon neutrinos oscillate into another type of neutrino, adjusted event rates would be different for the two detectors. (See PHYSICS TODAY, February 1996, page 17.) The Sudbury Neutrino Observatory in Canada has also now seen its first events (see page 18, this issue). —PFS