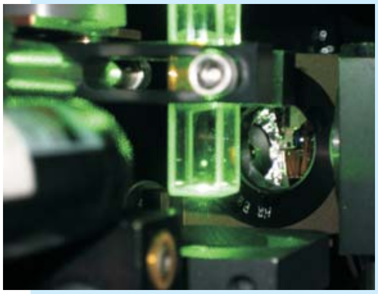
equilibrium depends solely on temperature—the classic definition of Brownian motion. Einstein then concluded that the instantaneous velocity of such particles would be impossible to physically measure, and for more than a century, it seemed that he was right. But now, Mark Raizen and his colleagues at the University of Texas at Austin have used optical tweezers in a vacuum chamber to trap a 3-μm-diameter silica bead, observe its ballistic



(inertial) motion at short time scales, and determine its instantaneous velocity. The bead is held at the focal point of two noninterfering laser beams, similar to the setup in the image. When the bead makes a random move, it deflects the beams, which allows its position to be traced and the instantaneous velocity to be measured. From those measurements, the researchers calculated root mean square velocities. Even when obtained at varying air pressures, the results agreed with each other and with the theoretically predicted value, proving that in the ballistic regime, the bead's mean velocity is solely dependent on temperature and not on pressure or the inertial effects of the surrounding air molecules. Raizen says they will next attempt to cool the particle's motion to the quantum ground state and confirm that the kinetic energy will be nonzero even at 0 K. (T. Li et al., *Science*, in press, doi:10.1126/science.1189403.) —JNAM

Casimir force, antennas, and salt water. As famously predicted by Hendrik Casimir in 1948, parallel conductors in a vacuum will attract each other because the conductors impose boundary conditions that affect the vacuum energy of the electromagnetic field (see the article by Steve Lamoreaux in PHYSICS TODAY, February 2007, page 40). In general, the Casimir force depends on the shape of the conductors and its value is notoriously difficult to calculate, but research groups worldwide have been developing increasingly applicable computational techniques. Now a team at MIT has shown how tabletop measurements might provide the key information needed for the general calculation. The Casimir force may be expressed as an integral over frequency (ω) of correlation functions that involve electric and magnetic fields. In principle, those frequency-dependent correlations can be obtained in a suitably scaled tabletop experiment from measurements of how an antenna at one point responds to a current generated at a distant point. In practice, such measurements won't work because the integrand oscillates wildly with ω. The integrand becomes well behaved—it decays and doesn't oscillate—if the integration is performed in the complex plane, but real antennas respond to real frequencies. The key observation made by the MIT team is that their mathematical expressions always involve ω in the combination $\varepsilon\omega^2$, where ε is the permittivity. Thus, the researchers predict, a force integral with real vacuum permittivity and complex contour can be calculated from a tractable number of antenna measurements made at real ω in a medium of complex permittivity—for example, salt water. (A. W. Rodriguez et al., *Proc. Natl. Acad. Sci. USA* **107**, 9531, 2010.) —SKB

Quantum teleportation through open air. A central tenet of quantum information processing asserts that an unknown qubit cannot be cloned (see PHYSICS TODAY, February 2009, page 76). But the unknown state of one qubit can be transferred to another qubit in a process termed quantum teleportation. The first experimental demonstrations succeeded in teleporting a qubit state a meter or so (see PHYSICS TODAY, February 1998, page 18). Subsequent experiments with photons, whose polarizations form a convenient basis for quantum information, have used fiber optics to achieve teleportation over hundreds of meters. But practical quantum communication will require teleportation over much greater distances. Jian-Wei Pan, Cheng-Zhi Peng, and coworkers at the University of Science and Technology of China and Tsinghua University have now transferred a qubit state through free space over a distance of 16 km, from "Alice" in the Beijing suburb of Badaling, across towns and roads, to "Bob" in Huailai, on the other side of Guanting Reservoir. The experiment employed a standard teleportation protocol: Alice and Bob each receive one of a pair of entangled photons; Alice measures hers in combination with an unknown qubit and sends the result, by classical means, to Bob; armed with that result, Bob projects his photon onto the state of the unknown qubit. The new work, though, adds many refinements, including novel telescope designs for open-air transmission, active feedback control for increased stability, and synchronized real-time information transfer. The resulting teleportation fidelity was nearly 90%. Such high-fidelity transmission, say the researchers, could help enable quantum teleportation to orbiting satellites. (X.-M. Jin et al., *Nat. Photon.* **4**, 376, 2010.) — RJF

Using noise to map Earth's deforming crust. Earth is awash in vibrations—literally. Interference between ocean waves near a coastline excites faint ambient noise throughout the planet. Thanks to a recent innovation in seismic imaging, long time sequences of the ambient noise can be used to reveal details about Earth's interior hundreds of miles inland. The technique, ambient noise tomography, involves looking for correlations between the diffuse seismic surface waves recorded at pairs of closely spaced seismometers and then extracting the group and phase velocities from the correlated signals. By tapping high-frequency wave components, which are typically lost to scattering and attenuation in signals from distant earthquakes but strong in ambient noise, seismologists can probe the roughly 30-km-thick continental crust, whose rheology differs from that of the deeper mantle. Using the technique, Michael Ritzwoller and his colleagues at the University of Colorado, Boulder, have now found evidence for widespread crustal deformation in the western US, a region long thought to have suffered strain from extension ever since the Cenozoic era began 65 million years ago. Ritzwoller's team processed waveforms captured between 2004 and 2007 by the USArray Transportable Array, which comprises some 400 broadband seismometers on a 70-km² grid, and extracted the radial anisotropy—the differences in speed of vertically and horizontally polarized surface waves, plotted here. The anisotropy, a proxy for strain in crustal rock, is consistent with the lattice orientation of minerals found in surface outcrops and constrains models of how continents are built. (M. P. Moschetti et al., *Nature* **464**, 885, 2010.) —RMW