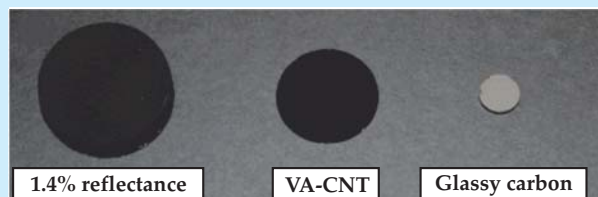


**Twitching and twanging rat whiskers.** Widely used as a model system for studying sensory processing, rat whiskers have been much studied in isolation or in anesthetized animals because the little beasts move very fast. But now a team of neuroscientists at MIT has analyzed the sensing behavior of free-ranging rats. And the researchers uncovered some important new details. If you draw one end of a stick across a wall, you can sense the wall's texture through the stick, but the stiffness of the stick matters. Similarly, a rat sweeps its whiskers across a rough surface, where they stick, then slip, then twang at a resonant frequency when they next get stuck. Even on smooth surfaces, the whiskers' elasticity allows for frictional stick-slip events, which are smaller and more regular than those from rough surfaces. The researchers, led by Christopher Moore, deduce that resonance is more than just an oscillation; it provides a filter for information transduced from the surface contact. Key to the work was the technology, developed by Jason Ritt, to acquire 3200 frames—about 1 gigabyte of data—per second at about 100-micron resolution and then track individual whiskers frame-by-frame through the deluge of images. The range and diversity of actual motions exceeded any seen in previous, more limited studies. The mechanical processes are transformed to neural processes through follicles at the whiskers' base. An important next step, “which is daunting,” says Moore, is to simultaneously monitor brain activity. (J. T. Ritt et al., *Neuron* **57**, 599, 2008.) —SCB

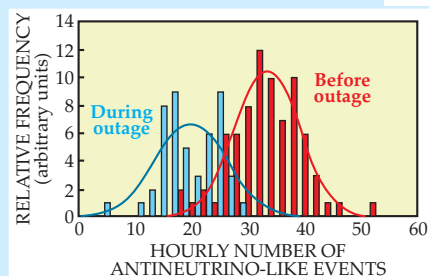
**The blackest material ever made** is a carpet of vertically oriented carbon nanotubes. The darkness or lightness of any object depends on the amount of light that gets reflected from it; as the object's index of refraction  $n$  approaches unity, less light gets reflected. An ideal black object, having  $n = 1$ , absorbs all colors of light and reflects none of them. Developed by physicists at Rensselaer Polytechnic Institute (RPI) in Troy, New York, the vertically aligned carbon nanotube array has  $n$  less than 1.02 and a reflectivity of only 0.045%. As seen in the flash photograph, the VA-CNT's reflectivity is 1/30 of the 1.4% NIST reflectance standard, three orders of magnitude lower than glassy carbon (a conventional black standard), and 1/3 of the previously darkest object (not shown). Shawn Lin and his colleagues grow the nanotubes on a prepared silicon wafer. The resulting mat, 10–800 microns thick, is lightweight (0.01–0.02 g/cm<sup>3</sup>) and can be peeled off to become a freestanding film. The spaces between the nanotubes act like long pores that trap incident light, and the rough surface provides diffuse scattering. Both effects combine to produce the strong absorption. Possible applications of the film include a revised darkness standard and soaking up stray radiation in astronomical detectors or in photovoltaic cells. (Z.-P. Yang et al., *Nano Lett.* **8**, 446, 2008.) —PFS



**One of the most precise measurements ever** comes from a new generation of atomic clocks that are based on optical transitions in single trapped ions. Like their cesium-based predecessors, optical clocks keep time by locking onto atomic resonances. The challenge is to trap an individual ion, cool it to a virtual standstill, and exactly count the number of oscillation cycles in a light source that is made synchronous with the natural oscillations of the single ion. Till Rosenband and his colleagues at NIST in Boulder, Colorado, used two atomic clocks—one based on an aluminum ion, the other based on a mercury ion—to meet the challenge. Direct comparison of the clocks is essential because uncertainties in the clock frequencies are smaller than the best Cs standards. Indeed, the ratio of the frequencies  $\nu_{\text{Al}^{+}}/\nu_{\text{Hg}^{+}}$  is accurate to within a mere  $5.2 \times 10^{-17}$ , an order of magnitude improvement in achievable measurement accuracy. To reach that precision, the team accounted for subtle effects—among them the tiny jiggling of the ion in the Doppler-cooled trap, blackbody radiation, and external RF fields—that shift the resonance frequency. Another group, publishing in the same issue of *Science*, reports significant accuracy gains in optical atomic clocks that use not single ions but large ensembles of strontium atoms held in optical lattices. In that work Andrew Ludlow and colleagues from NIST and the University of Colorado demonstrated an all-optical comparison of clock signals transmitted over kilometers. In addition to testing the invariance of fundamental constants such as the fine structure constant, applications for the new clocks might include long-distance entanglement networks and geodesy measurements. (T. Rosenband et al., *Science*, in press; A. D. Ludlow et al., *Science*, in press.) —RMW

**Antineutrinos and nonproliferation.** A simple, compact detector may help international inspectors peer inside a working nuclear reactor by directly measuring the flux of antineutrinos emerging from the core.

Typical nuclear reactors consume uranium-235 and both produce and consume plutonium-239, which could be diverted and fashioned into bomb material. Determining how best to monitor a working civil reactor is a large



part of nuclear nonproliferation efforts. The cubic-meter-scale detector proposed by Adam Bernstein of Lawrence Livermore National Laboratory and built by a team from Livermore and Sandia National Laboratories is well attuned to the number of antineutrinos produced over hourly, daily, and weekly intervals. Because fissile material can only be acquired while the reactor is shut down, those time scales are well suited to the needs of the International Atomic Energy Agency. In tests done at the San Onofre Nuclear Generating Station in southern California, a prompt shutdown that occurred over about an hour could be reliably detected with five hours of antineutrino data, collected remotely in real time. The figure shows the hourly antineutrino events before and during an outage. The detector operates unattended for long periods, is self-calibrating, does not affect plant operations, and can be made tamper-proof. Further, the antineutrino signature (the arrival of a positron followed 30 microseconds later by a neutron) is hard to mimic with surrogate neutron or gamma sources. (A. Bernstein et al., *J. Appl. Phys.*, in press.) —PFS