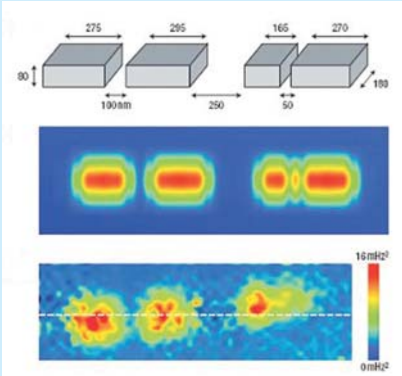
onto the cantilever tip. The image shows a schematic (top), a simulation (middle), and the experimental result (bottom). Separa-



tions of 100 nm could be clearly resolved. Previously, the same group of physicists had used a similar setup to detect the magnetic resonance of a single unpaired electron in a sample (see PHYSICS TODAY, September 2004, page 21). But now they are detecting much weaker nuclear spins. The nuclear advantage lies in its generality: Many materials have nuclear magnetic moments, but relatively few have unpaired electron spins. The nuclear MRFM experiment effectively explored a 650-zeptoliter volume, some 60 000 times smaller than the best conventional magnetic resonance imaging capability. Rugar thinks that their current apparatus can now detect 200 nuclear spins, which brings the group closer to their ultimate goal of imaging molecules at the single nuclear spin level. (H. J. Mamin et al., *Nat. Nanotechnol.* **2**, 301, 2007.) —PFS

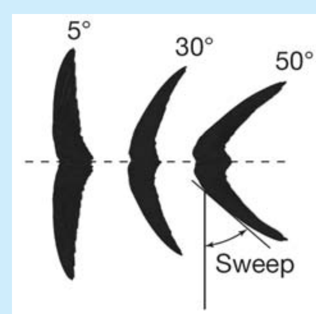
Newton's second law of motion passes another test. Physicists at the University of Washington used a swiveling torsion pendulum (shown here), in which the restoring force is provided by a very thin twisting tungsten wire. The pendulum, which had a natural period of 795 seconds and an amplitude decay time of 15 days, is inside a vacuum chamber that was installed on an air-bearing turntable. Newton's law implies that for small oscillations, the pendulum's frequency should be independent of

the amplitude. Looking for slight departures from that independence, the Washington researchers operated the pendulum for 20 days at various amplitudes, some as small as 13 nanoradians; at such tiny twists, Brownian excitation of the pendulum was a considerable factor in interpreting the results. The researchers found the second law to be valid down to accelerations as small as 5×10^{-14} m/s^2. That is a 1000-fold improvement in sensitivity over the best previous test, carried out back in 1986. The new result tightens the constraints on speculative modifications of Newtonian dynamics that, for example, try to account for the rotation curves of galaxies or for the ongoing mystery surrounding an apparently unaccounted-for acceleration in the trajectory of the two very distant Pioneer spacecraft. (J. H. Gundlach et al., *Phys. Rev. Lett.* **98**, 150801, 2007.) —PFS

***Gravity Probe B* (*GP-B*)** has measured the geodetic effect—the warping of spacetime in the vicinity of and caused by Earth—with a precision of 1%. The tiny effect was observed via the precession of gyroscopes onboard the craft, which is in a polar orbit around Earth. The observed precession rate, 6.6 arcseconds per year, is consistent with the prediction of general relativity and with the only other measurement of the effect, which used the Earth–Moon system orbiting the Sun. Once certain subtle disturbance torques on the gyroscopes are better understood, *GP-B* scientists expect the precision of their geodetic measurement to improve to 0.01%. The first results were reported at the April meeting of the American Physical Society by Francis Everitt (Stanford University). The other major goal of *GP-B* is to measure frame dragging: When Earth rotates, general relativity predicts that it drags space and time around with it,

causing a different gyroscopic precession, perpendicular to and 1/170 as strong as the geodetic precession. Everitt said that *GP-B* saw "glimpses" of frame dragging in the early analysis of the data; the researchers expect to report a credible, thoroughly cross-checked measurement at the final results presentation now scheduled for December 2007. The four gyroscopes are the most spherical objects ever made: The ping-pong-ball-sized orbs are out of round by no more than 10 nm. They are electrostatically suspended in a small case (shown here) spun up to speeds of 4800 rpm, and held in a vacuum of 10^{-14} torr. Coated with niobium, the balls are rotating superconductors at a few kelvin, and develop tiny magnetic dipole moments that can be read out to fix the spheres' instantaneous orientations. (See http://meetings.aps.org/Meeting/APR07/Event/64567 for the abstract.) —PFS

Morphing wings help birds control gliding. With an articulated skeleton under muscular control, birds are able to change the amount their wing feathers overlap and accordingly alter their wings' shape and size, independent of whether the wings are flapping. To learn more, researchers in the Netherlands did wind-tunnel studies of the common swift (*Apus apus*), which spends most of its time in the air—even roosting on the wing—and has an extensive



gliding repertoire. They found that wings fully extended outward are optimal for slow glides, lazy turns, and low metabolic cost. Indeed, swifts actually roost at a sedate 8–10 m/s with their wings outstretched. Wings swept backward toward the tail (see the figure) improved not only gliding at higher speeds but also agility. In particular, swept wings can bear a higher load and thus can tolerate the increased centripetal acceleration during high-speed turns at up to 30 m/s. The researchers used their data to develop a semiempirical model that correlated well with radar measurements on roosting swifts in the field. Wing morphing could help control the flight of future aircraft. (D. Lentink et al., *Nature* **446**, 1082, 2007.) —SGB ■