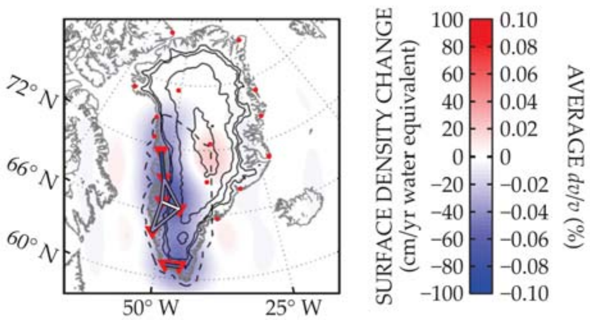
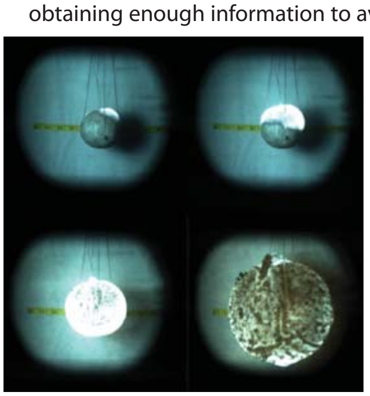


travel. The scientists reasoned that the seasonal loading and unloading of the annual snowpack would repeatedly close and reopen pores and cracks in the rock beneath it. By cross correlating the signals from select pairs of seismometers (red inverted triangles) in western Greenland between 2012 and 2014, they retrieved a continuous record of the waves propagating between the sensors. A comparison of each daily correlation function to a reference standard yielded the relative seismic-velocity changes (dv/v) from season to season; those results, averaged over the summer of 2012, are shown on the map as connecting lines against the blue background of GRACE data. The team then developed a poroelastic model to infer the volume of ice lost or gained. Reassuringly, the model results agree with those taken by GRACE to within 91% accuracy. (A. Mordret et al., *Sci. Adv.* **2**, e1501538, 2016.) —RMW

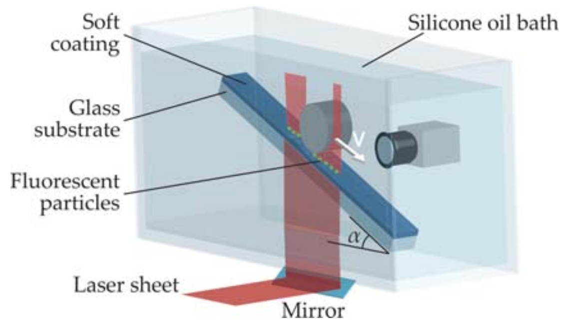
GETTING UP CLOSE AND PERSONAL WITH MILITARY EXPLOSIVES

Plenty of people have been lured into science after watching an explosion or perhaps blowing up something themselves. US Army chemists routinely perform both those activities in an effort to determine how to trigger more effective explosions and to protect soldiers from unexpected blasts. The challenge is to analyze explosions up close, preferably within a few meters, while obtaining enough information to avoid the costly task of repeating the test detonation multiple times. Kevin McNesby, from the US Army Research Laboratory at Aberdeen Proving Ground in Maryland, and his colleagues have developed a multisensor apparatus that can simultaneously probe the temperature, pressure, chemical species, and energy deposition of an explosion. During detonations of subkilogram samples of TNT and C-4, a spectrometer paired with cameras shooting at up to 40 000 frames per second mapped the temperature of the expanding fireballs and tracked the corresponding shock waves. Rapid bursts of bright 510 nm laser light enabled cameras to peek inside the comparatively dark fireballs; the researchers exploited the technique to determine that an unlucky manikin placed 2 m from the detonation of 600 g of pentolite experienced 25 psi of overpressure, which is usually fatal to humans. Crucially, images such as the ones here reveal that despite engineers' best efforts, explosions always exhibit some degree of asymmetry, which affects how energy is released. Information-rich diagnostic tests by McNesby and others could help military engineers develop explosive devices that emit immediate, more evenly distributed bursts of energy. (K. L. McNesby et al., *Rev. Sci. Instrum.* **87**, 051301, 2016.) —AG



SOFT SURFACES LIFT HARD OBJECTS

Two decades ago theorists began to investigate how objects move through viscous fluids when pulled close to a soft, springy surface. They predicted that objects would experience a counterintuitive lift force, even at low speeds. One of those theorists, L. Mahadevan of Harvard University, recently joined Baudouin Saintyves, Theo Jules, and Thomas Salez in devising and running an experiment to test that and other predictions. Depicted here, their setup consists of a glass tank filled with silicone oil. Inside the tank is the test surface: an inclined pane of glass coated with a layer of soft polymer that is embedded with fluorescent particles.

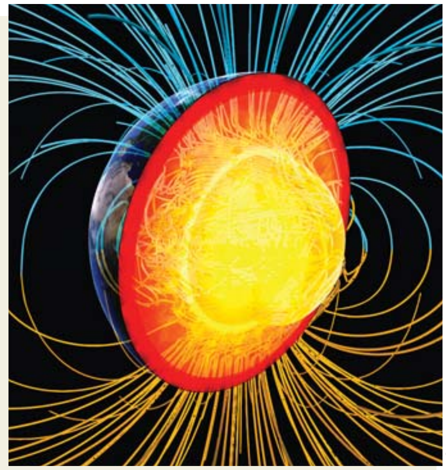


When the test object, an aluminum cylinder, rolls or slides down the layer, the combination of a sheet of laser light and a video camera monitors the cylinder's motion and the layer's response. As the cylinder moves, it's expected to push down on the soft layer in front of it and pull back on the layer behind it. The resulting asymmetric pressure distribution should exert a net upward force on the cylinder. The asymmetric deformation was indeed observed, as was the emergence of a low-friction, self-sustained motion of the object at constant speed, consistent with predictions. Mahadevan and his colleagues intend to apply their newfound understanding to cartilaginous joints, the flow of soft particles, and other soft-matter settings. (B. Saintyves et al., *Proc. Natl. Acad. Sci. USA* **113**, 5847, 2016.) —CD

HOW THE BACTERIUM *PSEUDOMONAS SYRINGAE* INDUCES WATER TO CRYSTALLIZE

Ice-nucleating bacteria can catalyze ice formation in supercooled water stored in plant tissue. That ability enables them to rupture plant cell walls and release the nutrients the plants contain. Bacterial catalysis also provokes water in clouds to freeze; ice-nucleating bacteria may thus have a significant impact on weather and climate. Invoking molecular simulations, scientists conjectured that the surface of a bacterial protein organizes the liquid near it to promote crystallization. That hypothesis has now received experimental confirmation in work led by Tobias Weidner at the Max Planck Institute for Polymer Research. Weidner and colleagues studied the bacterium *Pseudomonas syringae*, whose ice-nucleating protein is called inaZ. They used sum-frequency generation (SFG) spectroscopy, in which IR and visible laser pulses aimed at an interface return a strong signal only if the interface is

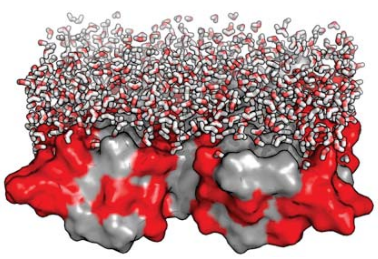
EXPERIMENTS RELATING TO EARTH'S INNER CORE RAISE QUESTIONS ABOUT ITS AGE


DESY

Earth's magnetic field (illustrated here) is sustained by liquid iron that is continuously churning in the planet's outer core. Iron that crystallizes onto the solid inner core releases latent heat, which powers convection that drives Earth's dynamo (see the article by Daniel Lathrop and Cary Forest, PHYSICS TODAY, July 2011, page 40). But lately scientists have questioned whether that set of mechanisms has always provided the energy for Earth's magnetic mojo. Simulations from a 2012 study suggested that iron has surprisingly high thermal conductivity under the extreme conditions that prevail in the core. The finding hinted that the core may export heat to the rocky mantle much faster than previously thought. If the core truly does lose heat so quickly, then it would have taken less than a billion years for the inner core to reach its current size. Some other process, then, would have had to power the dynamo for a significant interval of Earth's 4.5-billion-year history.

Now two research teams have heated diamond-anvil cells with lasers to determine iron's thermal conductivity at core-like temperatures and pressures. Kenji Ohta and his colleagues crushed iron wires and determined their electrical resistance, which is inversely proportional to thermal conductivity. The team estimated a conductivity of 90 W/(m·K), a measurement that is roughly in line with the simulation predictions and sets an upper age limit for the inner core of about 700 million years. Zuzana Konôpková and her colleagues measured the propagation of laser-delivered heat through an iron sample. Her collaboration obtained a value of about 30 W/(m·K), which supports the more traditional view of a gradually cooling core with an early-forming solid center. David Dobson, who was not affiliated with either study, notes that the Konôpková result is more dependent on modeling than Ohta's, and any unnoticed melting of the iron could have skewed the measurement.

Follow-up experiments, perhaps ones that capture electrical and heat-propagation measurements simultaneously on a single sample, could resolve the discrepancy between the two teams' results. Even in the absence of a solid core, theorists can devise exotic mechanisms, such as the wobble of Earth's axis, to explain how the planet could have maintained a magnetic field a few billion years ago. (K. Ohta et al., *Nature* **534**, 95, 2016; Z. Konôpková et al., *Nature* **534**, 99, 2016.) —AG



populated with ordered molecules. The observed signal increased as the researchers reduced the temperature, a manifestation of inaZ's ever more effective water ordering at its surface. Complementary molecular simulations revealed an unanticipated subtlety. The surface of inaZ, shown in the figure with water molecules above it, alternates the hydrophilic regions (red) responsible for the enhanced SFG response with hydrophobic regions (gray). Close to the hydrophobic regions, the water resembles a liquid–vapor interface, but experimental and theoretical studies suggest that such an interface can boost nearby ice nucleation. The hydrophobic regions of inaZ may thus actually facilitate ice formation. Further SFG studies revealed another of inaZ's tricks—it arranges the water molecules so that vibrational energy transfer effectively whisks away the latent heat released when water crystallizes. (R. Pandey et al., *Sci. Adv.* **2**, e1501630, 2016.) —SKB

CHAOS LIMITS PREDICTABILITY OF HURRICANE INTENSITIES

Weather is the archetypical example of a chaotic system. Indeed, it was his calculations of weather models that led Edward Lorenz to his landmark 1963 paper that helped launch modern chaos theory. (See the article by Adilson Motter and David Campbell, PHYSICS TODAY, May 2013, page 27.) Lorenz famously gave a 1972 talk titled "Predictability: Does the flap of a butterfly's wings in Brazil set off a tornado in Texas?" Chanh Kieu and Zachary Moon at Indiana University Bloomington now report on a related question: How well can we forecast the intensity of a hurricane? For steady conditions, Kerry Emanuel has shown that thermodynamic arguments yield a wind speed—the standard measure of hurricane intensity—that's a reasonable upper bound for a majority of observed storms (see Emanuel's Quick Study, PHYSICS TODAY, August 2006, page 74). Using a minimal dynamic model, Kieu and Moon found that the limiting speed is stable: Simulated hurricanes approach that equilibrium value regardless of their initial conditions. Yet the errors in forecasts of hurricane intensity don't go away as one might expect; rather, speed errors level off at about 8 m/s (18 mph) after four to five days in real-time intensity forecasts. Through full-physics simulations, the pair discovered that those errors arise from a so-called chaotic attractor at the maximum potential intensity limit. That finding implies that improvements in intensity forecasts are more likely to come from better modeling of the large-scale environment than from better knowledge of the storm's initial state. Even so, the researchers note, the maximum range of predictability is only about three days, and likely shorter for mature hurricanes. (C. Q. Kieu, Z. Moon, *Bull. Amer. Meteorol. Soc.*, in press, doi:10.1175/BAMS-D-15-00168.1. Hurricane Ike image courtesy of NOAA Environmental Visualization Laboratory.)

—RJF PT