concentration more precisely.

A typical experimental run at low dynamin concentration appears in figure 3. Micrographs are at the top, a plot of the tube radius versus time is at the bottom. Fluorescently tagged PIP_2 (top, red) delineates the GUV and the tube. Fluorescently tagged dynamin (top, green) shows up only when the tube is at its lowest radius, 10.4 nm.

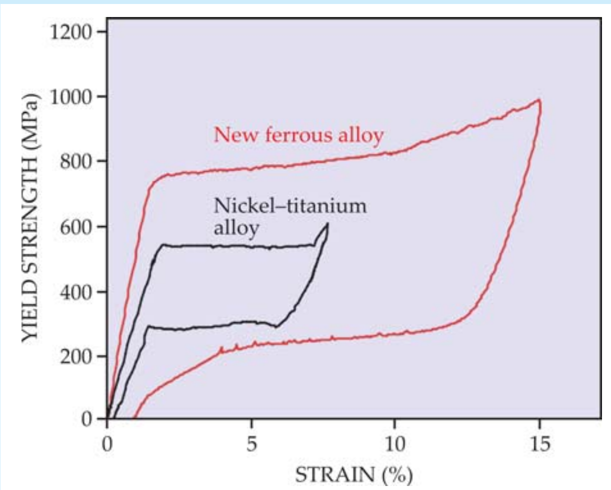
By taking measurements over a range of concentration and radii, Roux and his coworkers could map a phase diagram of dynamin's polymerization. Below a critical concentration c_1, dynamin never polymerized. At c_1, dynamin polymerized only on tubes whose radius matched dynamin's. As the concentration increased, dynamin polymerized on tubes of a widening range of radii. The lower limit of the range decreased weakly with concentration; dynamin couldn't polymerize on tubes that were too thin. The upper limit increased rapidly with concentration. Evidently, the vigor of dynamin polymerization was enough to deform ever thicker tubes.

A simple mathematical model that balances polymerization energy, which depends on concentration, and the elastic energy, which depends on concentration and tube radius, could reproduce the phase diagram. The molecular picture that emerges from the experiment is of matching geometries. Curved monomers slide around on a curved surface and readily link if the two curvatures match. If they

physics update

These items, with supplementary material, first appeared at http://www.physicstoday.org.

Stretchy metals recoil. In materials, as the axiom goes, structure follows function: A metal's tightly bonded atomic crystal lattice gives it strength, and a polymer's mesh of macromolecular chains makes it elastic. Medical implants, electronic components, and other similar devices call for multifunctional materials



that are both strong and stretchy. One such material is the shape-memory alloy (SMA), a polycrystalline arrangement of assorted metals that, when stressed, undergoes a structural phase transition from high to low symmetry. The transition is reversible, and above a critical temperature SMAs are superelastic—they fully recover after being stretched well beyond the reversible-deformation strain values of pure metals. Now, materials scientists at Tohoku University in Sendai, Japan, have presented evidence for an iron-based SMA that is 35 times as elastic as pure metals. The new alloy, which also features nickel, cobalt, aluminum, tantalum, and boron, has an elastic strain of 13%, as shown in the figure, almost double the value of the more expensive commercial-standard nickel–titanium alloy. Furthermore, the material's yield strength, 800 MPa, is 1.5 times that of the nickel–titanium SMA. The researchers say that microstructured precipitates similar in composition to the bulk matrix and interspersed through it are a key to the improved mechanical strength. The greater elastic strain and strength could be exploited for mechanical damping in building materials. Also, the ferrous SMA's magnetism is phase dependent, which makes it potentially useful for electromechanical sensing applications. (Y. Tanaka et al., *Science* **327**, 1488, 2010.) —JNAM

An unexpected cosmic current. According to cosmological theory, the expanding universe has no preferred direction. Thus, the cosmos may be likened to a rising loaf of raisin bread, with the raisins playing the roles of galaxies. Viewed from Earth (or anywhere else), the motion of a distant galaxy should be determined by the overall cosmic expansion. Now, following on their earlier work presented in 2008, Alexander Kashlinsky of NASA's Goddard Space Flight Center and colleagues report that superimposed on the cosmic expansion is a universal flow along the line from Earth to the Centaurus and Hydra constellations. The "dark flow," as the authors call it, was revealed in the cosmic microwave background by minuscule temperature fluctuations that arise when x-ray-emitting gas from galaxy clusters scatters off CMB photons. A catalog of more than 1000 x-ray-luminous galaxy clusters told Kashlinsky and company where in the *Wilkinson Microwave Anisotropy Probe*'s five-year data set they should look for those fluctuations. The researchers had to average over ensembles of clusters to see evidence for the dark flow, which persisted unabated to the furthest measurable reaches, 2.5 billion light-years away. It's as if—and this is a literal possibility—matter beyond the edge of the visible universe is pulling the entire cosmos toward it. (A. Kashlinsky et al., *Astrophys. J. Lett.* **712**, L81, 2010.) —SKB

Prototype for a new astronomical detector. Much of the light emitted from stars and other astrophysical objects is absorbed by dust and reemitted at far-IR or submillimeter wavelengths—radiation that is notoriously difficult to detect. Last year researchers from the Jet Propulsion Laboratory proposed a new type of detector for that regime, with an eye toward future, more sensitive space missions. The team has now built a prototype microdevice (see figure), called a quantum capacitance detector (QCD), which would be one pixel in an eventual array. The detection chain goes like this: Photons are received at an antenna and fed into a superconducting absorber where they break Cooper pairs and generate quasiparticles. A superconducting island, called a single Cooper-pair box (SCB), is connected to the absorber in such a way that, at most, one quasiparticle at a time can tunnel onto it; that changes the island's capacitance, which is so small that the charging energy of a single electron has a large effect. With a resonant circuit, the physicists monitor the frequency of capacitance changes from which they can determine the density of quasiparticles in the absorber and thus the photon flux at the antenna. The device's performance is already comparable to that of other superconducting detectors. The advantage of the QCD, say the researchers, is the ease with don't match, the linking can force a match, provided enough monomers are present.

Roux could also measure the polymerization force, which was manifest as a reduction in the force required to hold the bead in place. In general, the polymerization force depends on dynamin concentration and membrane tension. At a concentration of 12 μmol/L, the force is 18.1 ± 2.0 pN.

Interestingly, Roux's results imply that dynamin cannot exert enough force to overcome the higher membrane tensions measured in real neurons. However, certain membrane proteins appear in a nascent pit to reduce the tension and regulate the onset of endocytosis.

In the final stage of endocytosis, polymerized dynamin obtains energy from molecules of GTP (guanosine triphosphate, a common cellular fuel), twists into a tighter spiral, and garrotes the neck. When Roux was a postdoc in Pietro De Camilli's lab at Yale University, he, De Camilli, and their coworkers had verified the GTP-fueled twisting.[4] Now, Roux plans to measure the twisting force.

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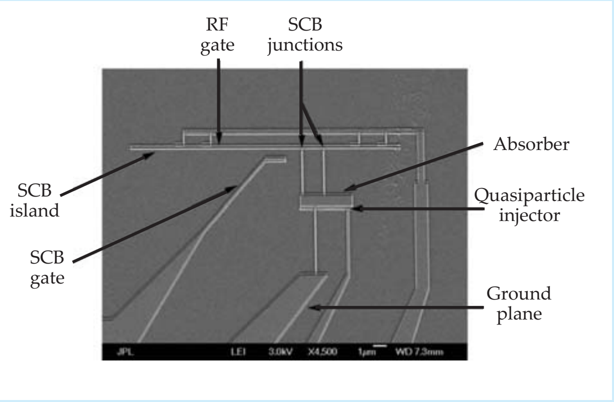
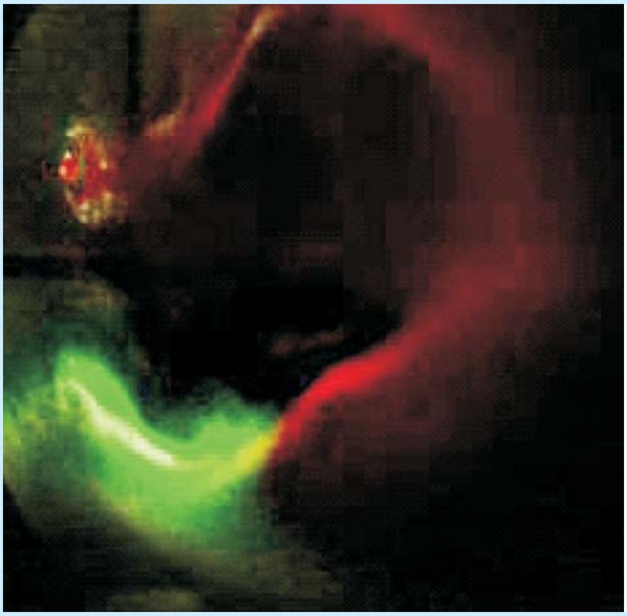


which it can be read out from an array of detectors. For example, each pixel detector could be fabricated with a different resonance and simultaneous readout could be done with a frequency comb. (J. Bueno et al., *Appl. Phys. Lett.* **96**, 103503, 2010.) —SGB

The intrinsic limits of quantum cascade lasers. One of the hallmarks of lasing is a dramatic narrowing of the light's frequency spread. In 1958 Arthur Schawlow and Charles Townes deduced that the laser linewidth is fundamentally limited by unavoidable spontaneous emission. (Thanks to other sources of noise, a real laser's linewidth is usually considerably broader.) Semiconductor diode lasers required a revision of the intrinsic linewidth formula to account for additional inherent broadening, but quantum cascade lasers (described in Physics Today, May 2002, page 34) had been thought to obey the original limit. Now Saverio Bartalini and colleagues at Italy's National Institute of Optics–CNR, the European Laboratory for Non-linear Spectroscopy, and the Second University of Naples have confirmed a recent theory predicting that QCLs can in fact beat the Schawlow–Townes limit and yield significantly improved spectral purity. Key to the 2008 theory by Masamichi Yamanishi and coworkers at Hamamatsu Photonics was the recognition that nonradiative transitions in QCLs strongly suppress spontaneous emission. To test the prediction, the Italian researchers tuned their IR QCL to be halfway down a carbon dioxide absorption peak at 4.33 μm (69.3 THz). Thanks to the steep slope of the absorption curve there, frequency fluctuations were converted into detectable intensity variations. That technique enabled the team to measure the noise spectrum over seven decades of frequency and to extract the intrinsic QCL linewidths for various pump currents. The obtained widths, in the range of 500 Hz, agreed well with the new theory and were three orders of magnitude smaller than predicted by the venerable Schawlow–Townes formula. (S. Bartalini et al., *Phys. Rev. Lett.* **104**, 083904, 2010.) —RJF

Astrophysical jets and solar loops in the lab. At the center of many an active galaxy lies an exceedingly powerful engine that, among other things, shoots out collimated jets of fast-moving plasma. Such jets can extend well beyond the galaxy's luminous boundary, ending in vast lobes that light up the intergalactic medium in the radio band. Closer to home, the Sun's atmosphere has many a plasma-filled magnetic loop, the dynamics of which are somewhat mysterious. In February, at the joint meeting of the American Physical Society and the American Association of Physics Teachers, Paul Bellan (Caltech) reported on his group's recent experiments that shed light on both systems. The experimenters used the large currents and magnetic fields of spheromak technology to create plasma jets in a very large vacuum chamber, which ensured that the plasma configurations were unaffected by walls. With a preexisting magnetic field "frozen in," the physicists puffed some gas through an electrode, switched on a current, and watched as a plasma jet formed, self-



collimated, underwent a kink instability, and then detached when the electric current was strong enough. In a different magnetic-field geometry, the figure shows counterpropagating collimated plasma jets—red hydrogen from the cathode and green nitrogen from the anode—colliding head-on within an arched magnetic loop, much like those seen in the Sun's corona. Bellan also developed a physical model for the self-collimation and a dusty-plasma dynamo mechanism suitable for generating actual astrophysical jets. (P. M. Bellan et al., invited APS/AAPT talk H3.2, 2010. Preprint available from the author.) —SGB