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Watching nematodes swim the channel

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physics update

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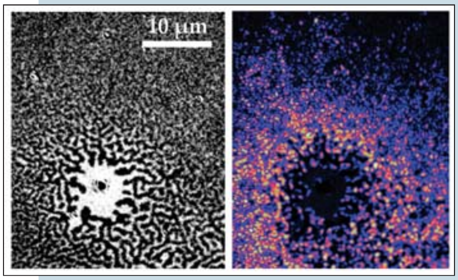
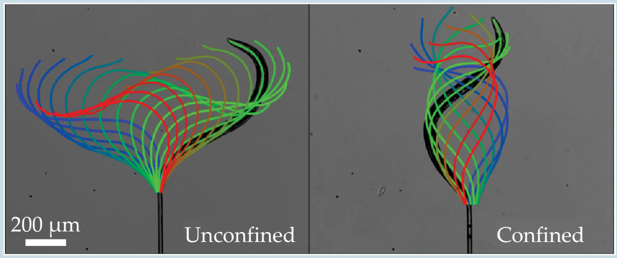
Spontaneous fluctuations in a ferromagnetic film. A close-up look at the hysteresis loop of a ferromagnet often reveals a series of sudden magnetization jumps. The so-called Barkhausen jumps come from domain-wall fluctuations, whose distributions in size and duration follow a power law and can be analyzed for scaling behavior and critical exponents. But the physics in those critical exponents is a complex mix of disorder, magnetic anisotropy, and dipole–dipole interactions. Andrew Balk and colleagues of NIST's Center for Nanoscale Science and Technology (Balk is also with the University of Maryland) set out to simplify the problem. They nudged the magnetic domain walls in a platinum-cobalt-platinum multilayer into spontaneously fluctuating, even without an external magnetic field. Roughening the interfaces between the different layers with argon ion milling drove the film close to a transition that reorients the cobalt magnetization from perpendicular to parallel orientation relative to the film plane. That trick reduced the magnetic anisotropy and domain wall pinning energies enough to allow spontaneous thermal fluctuations of the domain walls. The group used Kerr microscopy, which detects the change in polarization when light reflects off a magnetic sample, to make videos of the changing magnetic domain patterns. The figure's left panel shows one video frame, in which light and dark areas represent oppositely oriented domains; the right panel maps the number of fluctuations summed over a one-minute period—brighter colors indicate more fluctuations. As with field-driven domain-wall motion, the size distribution of the fluctuating areas showed a power-law behavior. (A. L. Balk, M. D. Stiles, J. Unguris, *Phys. Rev. B* **90**, 184404, 2014.) —SC

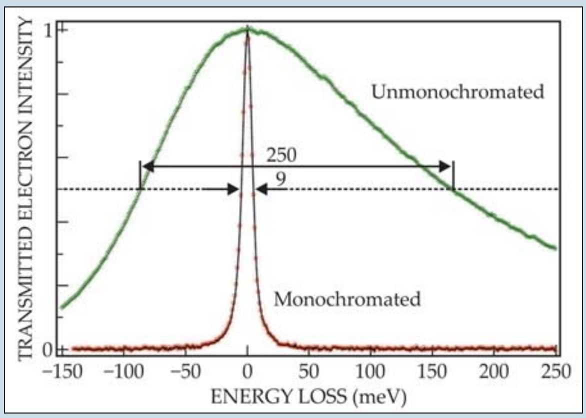


Watching nematodes swim the channel. For microbes, it's not always open-water swimming. Sperm negotiate narrow reproductive tracts, infectious bacteria navigate thin layers of mucus, and many other microbes live life confined to thin biofilms. Now researchers led by Kari Dalnoki–Veress (McMaster University, Hamilton, Ontario, Canada) have devised a way to probe how confinement affects a microswimmer's stroke. The researchers capture undulating nematodes by the tail, one at a time, with a cantilevered micropipette. The forces the roundworms generate as they wriggle can then be determined with subnanonewton precision by measuring tiny deflections of the pipette. In one setup, the tethered worms swim near a glass plate; in another, they swim in the narrow channel between two plates. In both cases, the undulating motion lies in the plane parallel to the plates—that way, although the boundaries increase the viscous resistance that a worm feels, they don't constrict its range of motion. In the experiments, the nematodes adapt by summoning super strength. They generate nearly three times as much propulsive and lateral force when they're within a couple of



body-widths of a surface as they do in unbounded fluid; in a channel a few body-widths wide, the increase is nearly 10-fold. The time-lapse reconstructions shown here further illustrate the boundaries' influence. Each curve represents the worm's configuration at a different stage of its stroke; the color gives the phase. Under confinement, the nematodes' undulations decrease in amplitude and frequency, which suggests the nearby surfaces may be triggering a modulation from a swimming to a crawling gait. (R. D. Schulman et al., *Phys. Fluids* **26**, 101902, 2014.) —AGS

High-resolution imaging meets vibrational spectroscopy. In a scanning transmission electron microscope (STEM), a high-energy electron beam is focused to near-atomic dimensions and scanned over a thin specimen. In addition to generating images from the scattered electrons, one can simultaneously use an electron spectrometer to map the energy lost by the beam. Among the details energy-loss spectroscopy can reveal are elemental composition and chemical bonding, but the technique has traditionally suffered from poor energy resolution, typically because of fluctuations in the high voltage supplied to the electron source. Now researchers led by Ondrej Krivanek, an adjunct professor of physics at Arizona State University and president of Nion Co, which manufactures commercial STEMs, have ameliorated the problem. By implementing a newly designed monochromator that is immune to voltage variations, they achieve an energy spread of 9 meV, as shown here. That's a nearly 30-fold improvement in energy resolution compared with the unfiltered beam and a 10-fold improvement over earlier monochromator designs. Thanks to



the narrow energy spread, the researchers could resolve the low-energy excitation peaks caused by lattice vibrations in materials such as silicon dioxide, silicon carbide, and titanium hydride. Although the peaks were wider than those measured with more traditional tools such as Raman spectroscopy, energy-loss spectroscopy in a STEM benefits from extremely high spatial resolution: The researchers mapped variations in the phonon spectra at the nanometer length scale as a 2-nm-wide