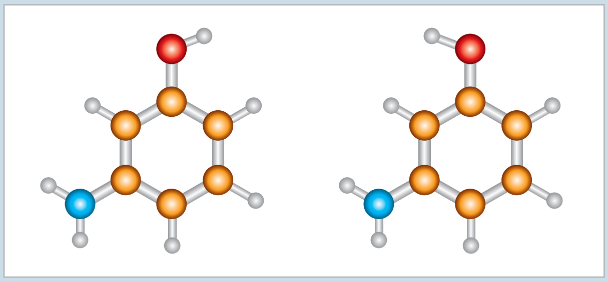
Traffic congestion drives urban evolution. As a city grows, it evolves from a so-called monocentric organization, with activities concentrated in the same geographical area—typically a central business district—to a polycentric organization, in which a number of subcenters coexist. Researchers Rémi Louf and Marc Barthelemy, both at France's Atomic Energy Commission in Saclay, have now developed a stochastic model that accounts for the emergence of that transition as an effect of rising traffic congestion. According to a 30-year-old economic model, the location at which individuals choose to work is one that maximizes income, taken as the difference between their wages and commuting costs. But cities are not static distributions of households and businesses; as populations increase, so do congestion and the time and thus cost of a commute. That trend, incorporated into the researchers' new model, reduces the attractiveness of some areas in which individuals might otherwise opt to work and raises the attractiveness of others, which become new subcenters. The model predicts that there always exists a critical value of the population above which a city abruptly turns polycentric and that the total commuting distance and number of subcenters in a city scale sublinearly with its population. Those predictions are consistent with data—specifically, the number of employees per ZIP code—gathered from some 9000 US cities between 1994 and 2010. (R. Louf, M. Barthelemy, *Phys. Rev. Lett.* **111**,198702, 2013.) —RMW

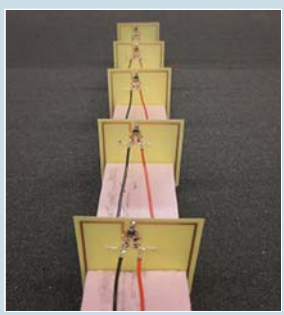
Newly sighted microwave-background polarization mode. The cosmic microwave background (CMB) has been streaming freely since the dawn of transparency, when the universe was only 4×10^5 years old and still incandescent. Now cooled to 2.7 K by 10^{10} years of cosmic expansion, the CMB still carries valuable imprints of the Big Bang, especially in its tiny departures from perfect isotropy. Harder to observe than the temperature anisotropies, which have for decades been a mainstay of cosmology's standard model (see PHYSICS TODAY, June 2013, page 18), are the much weaker spatial fluctuations in the CMB's polarization field—in particular their divergence-free *B* mode. (The designation *B* is meant to recall the divergence-free **B** field of electromagnetism.) The *B* mode is prized as a unique probe of primordial gravity waves thought to have been generated in the Big Bang. Now a collaboration using data from new polarization-sensitive detectors on the South Pole Telescope (shown in the photo) has reported the first detection of the CMB's *B* mode. The surveyed field of view, 10° × 10°, is still too small to reveal the large-angular-scale primordial gravity waves. But the team's analysis of the polarization data, in conjunction with the *Herschel Space Observatory*'s far-IR survey of the same patch of sky, has revealed the expected *B*-mode signature of gravitational lensing, a valuable probe of the mass distribution of the later cosmos. Furthermore, such lensing maps can be subtracted from larger *B*-mode surveys to facilitate the ongoing search for the primordial gravity waves. (D. Hanson et al., *Phys. Rev. Lett.* **111**, 141301, 2013.) —BMS

Conformer-dependent reactivity. Most organic molecules are flexible. Their chemical bonds can turn and twist, shifting the molecule into several distinct shapes called conformers. At room temperature, conformers often rapidly interconvert. But in a molecular beam, internal molecular motions are cooled and the interconversion is suppressed. Five years ago Jochen Küpper and colleagues showed that they could sort a molecular beam of 3-aminophenol into its two conformers, *trans*-3AP (on the left in the figure; carbon atoms are shown in yellow, oxygen in red, nitrogen in blue, and hydrogen in gray)



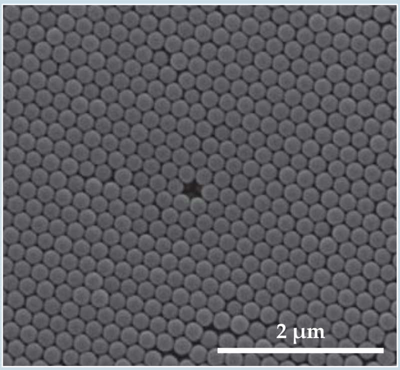
and *cis*-3AP (on the right). (See PHYSICS TODAY, June 2008, page 17.) Because *cis*-3AP has an electric dipole moment three times that of *trans*-3AP, it's more strongly deflected by an electric field gradient. Now Küpper and colleagues have teamed up with Stefan Willitsch to show that the conformers have different chemical reactivities. The researchers confined laser-cooled calcium ions in a cigar-shaped trap. Then they directed a beam of 3AP through an inhomogeneous electric field and toward the trap. Gradually tilting the angle of the beam allowed them to control which of the 3AP conformers interacted with the Ca^+ ions. By monitoring the Ca^+ population in the trap, they were able to derive the reaction rate constants for both conformers; the Ca^+ + *cis*-3AP reaction, they found, was twice as fast as the Ca^+ + *trans*-3AP reaction. The researchers are working to extend their method to other molecules and more complicated reactions. (Y.-P. Chang et al., *Science* **342**, 98, 2013.) —JLM

A metamaterial power harvester. Metamaterials are composite materials whose electromagnetic or acoustic properties are quite different from those of the subwavelength building blocks they comprise. By carefully tailoring small constituent pieces, researchers can create large-scale exotic phenomena such as negative indices of refraction, superlensing, and invisibility cloaking (see the articles by John Pendry and David Smith, PHYSICS TODAY, June 2004, page 37, and by Martin Wegener and Stefan Linden, PHYSICS TODAY, October 2010, page 32). Metamaterials have also shown promise for more familiar applications, including harmonic generation and nonlinear wave mixing. Allen Hawkes, Alex Katko, and Steve Cummer at Duke University have now demonstrated that metamaterials can function well as power harvesters, rectifying incident RF energy to deliver DC power to integrated components. The building block of the Duke metamaterial is a split-ring resonator: a nearly closed square metallic loop,



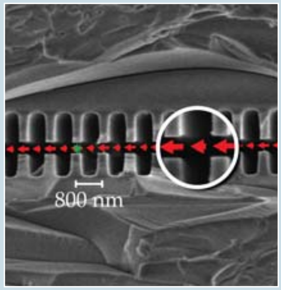
40 mm on a side, designed to resonantly couple to the magnetic field from incident microwaves at 900 MHz. The researchers integrated into the resonator additional circuit elements—capacitors and diodes—to harness and rectify the AC current induced in the loop. A metamaterial (shown in the figure) consisting of an array of five such resonators wired together achieved a power-conversion efficiency of 37%, in close agreement with the team's simulations. Since the collective response of the resonators can be finely engineered, the team expects that metamaterial power harvesters could find wider application than general antenna-based implementations. (A. M. Hawkes, A. R. Katko, S. A. Cummer, *Appl. Phys. Lett.* **103**, 163901, 2013.) —RJF

A gem of a breathalyzer. Among the dizzying assortment of chemical sensors are those based on photonic crystals—regular arrays of materials with different refractive indexes—with their well-defined physical properties and good sensitivity. Gem-quality opals are naturally occurring photonic crystals made of closely packed, tiny spheres of hydrated silica.



An opal's shimmering range of colors arises from the interference and diffraction of light passing through its microarrays. Synthetic opals made with nanospheres of silica or polystyrene and infiltrated with a chemically active hydrogel make for good, inexpensive chemical sensors; as the hydrogel reacts, it swells or shrinks, which changes the spacing of the crystal and thereby shifts the crystal's Bragg diffraction peak. A team of researchers at the University of Palermo in Italy has now engineered a hydrogel that swells to a baseline volume when infused with water vapor, and swells significantly more when ethanol vapor is present. What's more, when the hydrogel infiltrates a synthetic opal film (shown here), the additional swelling shifts the Bragg peak linearly with respect to the concentration of ethanol, producing a calibrated color change. As a bonus, the device can be reused many times just by letting the ethanol evaporate. The downside of the prototype device is that the full response took about 47 minutes. However, the researchers expect that removing the polystyrene will speed things up significantly, because then the spheres won't impede ethanol's diffusion. (R. Pernice et al., *Opt. Mater. Exp.* **3**, 1820, 2013.) —SGB

Particle acceleration on a chip. Researchers are working on various fronts to develop compact, inexpensive particle accelerators for medical imaging, security scanning, and more. One promising approach is dielectric laser acceleration (DLA), in which a laser field drives acceleration across a channel etched in a dielectric material. Now, in an experiment conducted by a team including Joel England (SLAC), Robert Byer (Stanford University), and Byer's graduate students Edgar Peralta and Ken Soong, DLA has successfully accelerated relativistic (60 MeV) electrons. The figure illustrates the group's



fused silica structure that, at full-size, can fit on a fingertip. Here's how it works. An 800-nm polarized laser field propagates through the device from top to bottom in the plane of the figure. The arrows in the figure represent the electric field at a particular instant of time; the important point is that in the vertically extended channel regions, the field amplitude is relatively small. The device's repetitions match the 800-nm laser wavelength. Thus, if a relativistic electron traversing the channel encounters an accelerating field at the starred location, it will encounter another accelerating field one period length and one laser oscillation later. On the way, it passes through a relatively weak decelerating region; on balance, the electron gains energy. In the actual experiment by England and company, some initially relativistic electrons were further accelerated while others were decelerated. But a sizable fraction received an energy boost of 60 keV or more. A team led by Peter Hommelhoff has recently reported that DLA can also accelerate nonrelativistic electrons. (E. A. Peralta et al., *Nature* **503**, 91, 2013; J. Breuer, P. Hommelhoff, *Phys. Rev. Lett.* **111**, 134803, 2013.) —SKB

El Niño intensifies and shifts seasonal storms. The frequency and intensity of winter and spring storms in North America are increasing. Climate change is the likely culprit, but the interannual climate disturbance known as El Niño might also be contributing to the upward trend. To see if that's the case, Xiangdong Zhang of the University of Alaska Fairbanks and his colleagues conducted a series of simulations using the National Center for Atmospheric Research's

community atmosphere model. Because Earth's weather is so sensitive to initial conditions, Zhang and his team ran 120 simulations in all, each beginning a little differently. Half included the elevated sea-surface temperatures off Ecuador that characterize El Niño. The other half didn't. After seven months of number crunching, the results are in. El Niño intensifies winter–spring storms and boosts their frequency in the northwestern, southeastern, and southwestern quadrants of North America. But in the northeastern quadrant, El Niño's main effect was to weaken winter storms. From the various parameters generated by the model, Zhang and his team identified the cause of that regional pattern. The largest nursery of storms was a concentration of atmospheric angular momentum that lay above the Aleutian Islands in the non–El Niño runs but moved south in the El Niño ones. El Niños are not caused by climate change. But if, as observations and simulations suggest, climate change is making El Niños stronger and more frequent, most of Canada and the US could be in for worse winter weather. (S. Basu et al., *Geophys. Res. Lett.* **40**, 5228, 2013.) —CD ■