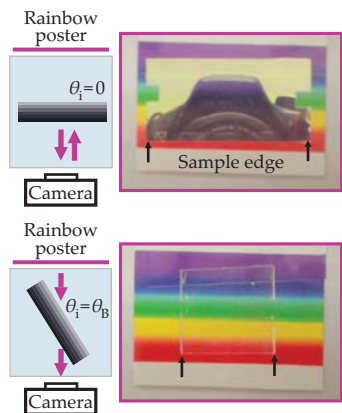


physics update

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

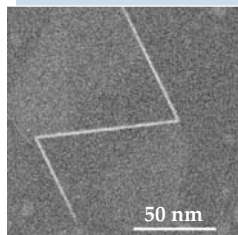
Filtering light by angle. Light comes to us with an infinite of frequencies and polarizations, and from every direction. Photonic crystals isolate desired frequencies and familiar filters block specific polarizations. Now the first material that selects a specific incidence angle of light for a wide range of optical frequencies has been fabricated by a group



of physicists led by MIT's Marin Soljačić. The key element in the new device is a stack of alternating layers of two oxide films with different dielectric constants ϵ_1 and ϵ_2 . Each of the 14 layers in the stack has the same thickness, and the stack as a whole blocks certain frequencies and incidence angles of light from getting through. But light incident at the Brewster angle, defined by $\tan \theta_B = (\epsilon_2/\epsilon_1)^{1/2}$, and polarized in the plane of incidence (a restriction that in principle

can be relaxed) passes through the stack, regardless of frequency. In the MIT device, six stacks are deposited on top of each other. Each stack has a different layer thickness—70 nm for the thinnest stack, 150 nm for the thickest. The six-stack gauntlet is no problem for light incident at the Brewster angle, but for incidence angles more than about 4° off from θ_B , one of the stacks reflects the light back. The figure shows the researchers' experimental test. In the top panel, a camera faces the six-stack material, measuring 2 cm $\times$ 4 cm, and photographs its own reflection. In the bottom panel, light incident on the stacks at θ_B from the rainbow poster passes through the now-transparent material and is captured by the camera. (Y. Shen et al., *Science* **343**, 1499, 2014.) —SKB

A new angle on electron microscopy. An elusive goal in optics is the perfectly achromatic lens—a lens that focuses every color of light to the same point. When it comes to electron microscopy, however, an imperfect lens isn't necessarily a bad thing. So report Joanne Etheridge (Monash University, Australia) and her colleagues, who have exploited chromatic aberration—the tendency of a lens to bend rays of different wavelengths by different amounts—to devise a chemical-mapping technique for scanning confocal electron microscopes. Standard SCEMs use two lenses: one to focus an electron beam onto a small volume in a target sample and another to focus transmitted electrons onto the detector. The energies of the transmitted electrons carry clues about the chemical identity of the target. Normally, electron spectrometers are used to collect that energy information, but Etheridge and her coworkers adopt a simpler approach: They align their electron beam at an angle through the microscope lenses. Due to chromatic aberration, the lenses spatially separate electrons by energy, much like a



prism separates colors of white light. An SCEM image can then be constructed exclusively with electrons of a selected energy. As a proof of principle, the team produced the image here, which shows the distribution of silver atoms in an aluminum–silver alloy. The bright, zigzagged line is a silver-rich region that precipitated out of the surrounding mixture. The million-pixel image took about 25 seconds to capture; with conventional techniques, it would have taken nearly half an hour. (C. Zheng et al., *Phys. Rev. Lett.*, in press.) —AGS

Looking for microscopic black holes. Gravity is by far the weakest of the fundamental forces. In elementary-particle interactions, it's thought to become comparable to the other forces only at collision energies of 10^{16} TeV—the so-called Planck energy. The perplexing disparity between the Planck energy and the TeV energy scale of electroweak unification is called the hierarchy problem. Several appealing attempts to address that problem posit extra spatial dimensions that make gravity only seem to be intrinsically weak (see *PHYSICS TODAY*, February 2002, page 35); gravity's true energy scale would be in the TeV regime. Such theories predict that the threshold for producing microscopic black holes is somewhere in the TeV collision-energy range of CERN's Large Hadron Collider (LHC, shown in the photo) rather than at the inaccessible Planck energy. Now the collaborations that run the LHC's CMS and ATLAS detectors have both reported the results of their searches for evidence of the production and prompt decay of perhaps a few hundred microscopic black holes in some 10^{15} proton–proton collisions at 8 TeV. Having looked at final states into which black holes with masses just above threshold are expected to decay, neither team finds evidence of black hole production. For a variety of models and final states, the CMS analysis constrained the black hole threshold mass to be above 6.2 TeV. And for one important class of final states not previously examined, the ATLAS analysis sets a lower mass limit of 5.3 TeV. With the LHC scheduled to run next year with a collision energy of 13 TeV, the search will resume. (S. Chatrchyan et al., CMS collaboration, *J. High Energy Phys.* **178**(7), 1, 2013; G. Aad et al., ATLAS collaboration, *Phys. Rev. Lett.* **112**, 091804, 2014.) —BMS

Macrophages in a liquid biopsy. A physician typically turns to an invasive biopsy—the removal of tissue—to determine if a tumor is benign or malignant and, if the latter, to identify the stage of the disease. In many cancer patients, cells leave the tumor, enter the bloodstream, and sometimes engender a new tumor elsewhere. Those circulating tumor cells (CTCs) are showing potential for a so-called liquid biopsy in a routine blood draw, as detailed by Chwee Teck Lim and Dave Hoon in *PHYSICS TODAY*, February 2014, page 26. Now Daniel Adams of Creatv MicroTech in Rockville, Maryland, and colleagues at several medical centers report using a gentle, low-pressure filtration system that caught not only CTCs but, to their surprise, some previously unknown fellow travelers they dubbed circulating cancer-associated macrophage-like cells (CAMLs). A macrophage is a shape-shifting cell found in the immune system—and in tumors—that can either repair or destroy other cells depending on the biological context.



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