

ing interference should produce a wave that describes an elliptical helix in space and rotates circularly about the propagation axis with time. At each minimum in the electric field, the intensity diminishes but the optical chirality doesn't, since the field's orientation shifts dramatically in the regions nearby. The net effect, then, should be increased dissymmetry near those minima. The more eccentric the ellipse—that is, the more reflective the mirror—the greater the dissymmetry factor.

To test their idea, the researchers needed only to detect absorption rates for chiral material near one of the electric-field minima. That target region, however, is both very narrow—just a few nanometers wide—and very dim; the placement of the sample had to be precise and the absorption detection had to be sensitive.

The team's solution was to coat a glass coverslip with reflecting material on one side and a sample of fluorescent chiral molecules on the other, as illustrated in figure 2. The glass coverslip held the sample a fixed distance from the mirror, and its slight slant ensured that some parts of the sample lay near a minimum in the electric field. The tiny absorption rates could then be detected, by proxy of fluorescence, with a CCD camera.

Applied to a chiral, naphthalene-based compound, the scheme yielded a dissymmetry roughly 10 times that for plain CPL—a result that matched the team's prediction to within 15%. The gain, however, comes at the cost of measurement precision. Says Cohen,

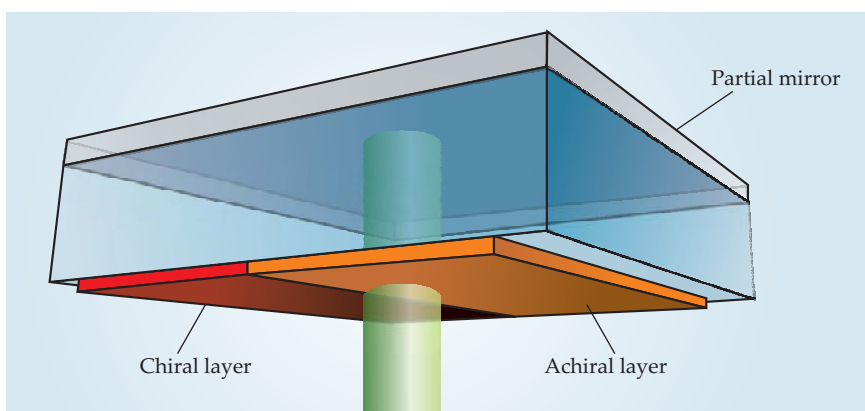


Figure 2. Experimental setup. Green circularly polarized light directed at normal incidence into a glass coverslip and partially reflected by a mirror produces a field that's well-suited to detect a molecule's chirality. That field causes chiral and achiral samples coated on the coverslip's surface to fluoresce, with only the chiral molecules displaying partiality to the handedness of the incident beam. For those chiral molecules that lay near a minimum of the field, switching between left- and right-handed incident beams induced a roughly 1% shift in fluorescence—10 times the difference measured using circularly polarized light alone. (Adapted from ref. 2.)

"The energy density in the dim regions is so small that shot noise begins to drown out the signal. The more we enhance the dissymmetry, the noisier the signal."

In fact, although the dissymmetry factor increased considerably, the measurement error grew in equal proportion. In part for that reason, Cohen says he'd "be surprised if this particular arrangement leads to better CD measurements. But we wanted to demonstrate the physical quantity, and these fields were simple enough to calculate with pencil and paper."

Cohen hopes the work can help to put

more complicated experiments on a sounder theoretical footing and aid in the design of more effective CD spectroscopy methods. Kadodwala, for one, is optimistic: "I'm convinced that these concepts will be a real boon for chiroptical spectroscopy."

Ashley G. Smart

References

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physics update

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

CERN collider achieves record collision rate. The Large Hadron Collider at CERN has reached a milestone in its quest to find—or lay to rest—the Higgs boson predicted by particle theory's standard model. The LHC produces 7-TeV head-on collisions between protons in countercirculating beams stored in its 27-km-circumference ring, part of which is shown here. On



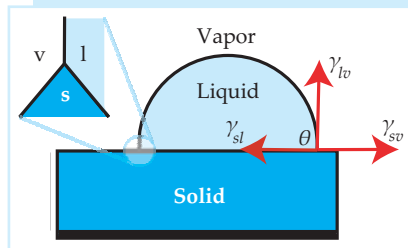
22 April, the colliding beams achieved a record luminosity of $4.7 \times 10^{32}/(\text{cm}^2 \text{ s})$, surpassing for the first time the previous record held by the 2-TeV Tevatron collider at Fermilab. The new record luminosity (defined as the collision rate per unit scattering cross section)

translates into 50 million proton–proton collisions per second at each of the LHC detectors. If the standard-model Higgs exists, it will be produced in only a tiny fraction of those collisions. But given the new record luminosity, the LHC detectors should accumulate enough data by the end of 2012 to provide a statistically robust sighting of the Higgs somewhere in the mass range (115–155 GeV) from which it has not already been excluded—or to demonstrate that Nature here parts company with the standard model. To allow that decisive accumulation of data, the start of the 18-month shutdown required to bring the LHC up to its full 14-TeV design energy has now been postponed from the end of this year to the end of 2012. (W. J. Murray et al., in *Proceedings of the Chamomix 2011 Workshop on LHC Performance*, https://espace.cern.ch/acc-tec-sector/Chamomix/Chamx2011/papers/BM_4_01.pdf.)

—BMS

Resolving the tension between droplets and solids. In 1805 Thomas Young derived the relationship between the static forces of a liquid droplet at rest on a solid substrate. As shown in the schematic, the droplet's contact angle, θ , can be determined by balancing the horizontal solid–liquid and solid–vapor forces and the horizontal component of the liquid–vapor force, determined by the surface tension, γ/v (see *PHYSICS TODAY*, February

2007, page 84). However, for more than two centuries, theories yielded unrealistic singularities for stress and strain at the three-phase contact line. That's because Young's equation does not account for the vertical, out-of-plane force pulling on the solid substrate, which naturally should be balanced by the substrate's elastic response. Now,



researchers at Yale University and at consumer products manufacturer Unilever have experimentally and theoretically resolved the out-of-plane contributions. Using a confocal fluorescence microscope, the

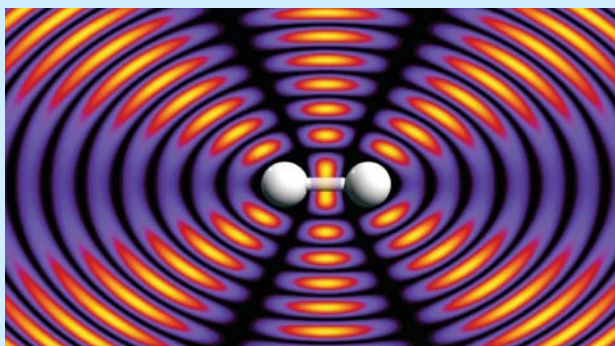
researchers, led by Yale's Eric Dufresne, laced a 20-micron-thick film of silicone gel with fluorescent beads and measured the deformation due to a water droplet. At equilibrium, a one-micron-high ridge, illustrated in the inset, formed in the gel at the contact line. When the researchers factored the gel's surface tension and thickness into a linear elastic model, they arrived at a nonsingular theoretical solution for stress that closely fit their experimental data. Their model, however, underestimates the deformations in the solid-liquid contact plane, which they believe are caused by pinning or viscous drag. (E. R. Jerison et al., *Phys. Rev. Lett.* **106**, 186103, 2011.) —JNAM

Mending polymers with light. We know all too well from daily life that materials made from polymers can be damaged: Tires get punctured, garbage bags rip, plastic eyeglass lenses get scratched. But over the past decade, several ways have been developed to heal polymers. Some methods are autonomous, drawing only on resources within the material. More commonly, though, the repair process is externally activated, typically by heat: When heated above their glass transition or melting temperature, the polymer chains can rearrange, diffuse, and reentangle. Stuart Rowan (Case Western Reserve University), Christoph Weder (University of Fribourg), and colleagues have now demonstrated a healing mechanism activated by light. The team's method exploits so-called supramolecular polymers, in which noncovalent bonds connect large repeating units. In the new work, the repeating units were elastic, hydrophobic hydrocarbon segments terminated by hydrophilic ligands. Those building blocks, termed macromonomers, were joined together into chainlike structures by metal ions, either Zn^{2+} or La^{3+} . The chains' hydrophobic and hydrophilic regions phase separated into a tough, cross-linked lamellar pattern. When UV light excited the metal-ligand bonds, most of the absorbed energy went into heating, which locally dissociated and liquefied the macromonomers. Thus freed, the macromonomers could quickly diffuse and mend defects. The researchers found that for some experimental samples, two 30-second bursts of light could completely heal cuts halfway through a thin film and restore the material to its original toughness. (M. Burnworth et al., *Nature* **472**, 334, 2011.) —RUF

New limit on putative dark-matter particle. Several lines of evidence suggest that dark matter, the mysterious substance that makes up 83% of the mass of the universe, consists of subatomic particles known generically as WIMPs (weakly interacting massive particles). On cosmic scales, the presumed influence of WIMPs is easy to spot; the particles' collective gravity controls the distribution and motion of stars in galaxies. Detecting single WIMPs is far harder. After running continuously for 100 days, the

XENON100 experiment has now yielded the most stringent limits on WIMP properties. Situated in a cavern in Italy's Apennine mountains, XENON100 consists of a bank of photomultiplier tubes that monitor 100 kg of liquid xenon. If a WIMP—or any other energetic particle—were to collide with one of the xenon atoms, the resulting scintillation would be detected. The overlying rock prevents cosmic muons from reaching the xenon, but the rock also contains radioactive elements, whose gamma-ray emission can beget scintillations. Although XENON100 incorporates ways to discriminate between the two sources of scintillations, some residual, unremovable background remains. In a paper submitted for publication, the XENON100 team report detecting three events that survived all the discrimination criteria. Given that the expected background was 1.8 events, the three events don't constitute a firm detection, but they do lower the limits on the WIMP mass and the WIMP-nucleon cross section. Supersymmetry, an extension to the standard model of particle physics, predicts the existence of WIMPs of order 100 GeV/c^2 , which is both consistent with the XENON100 results and within reach of the Large Hadron Collider. (E. Aprile et al., <http://arxiv.org/abs/1104.2549>.) —CD

Simple molecules mimic double slits. The double slit experiment, in which a coherent beam of particles diffracts through closely spaced slits to produce interference fringes, is perhaps the simplest and most famous demonstration of wave-particle duality. It has been shown to work with photons, electrons, and even the comparatively massive buckminsterfullerenes. According to a theory outlined by Howard Cohen and Ugo Fano nearly 50 years ago, interference fringes should also result from the photoionization of a diatomic molecule, provided electrons on each atom are ejected simultaneously and bestowed with enough kinetic energy that their wavelengths are similar to the



interatomic distance, as illustrated here. Unfortunately, the direct approach—fixing molecules' orientation in space, photoionizing them, and detecting fluctuations in the angular distribution of electron density—is, for the most part, impractical. Instead, an international team of scientists led by Fernando Martín (Autonomous University of Madrid) used an elaborate first-principles theory to predict the effect that interference should have on the relationship between a molecule's photoionization cross section and its vibrational energy. Working at Lawrence Berkeley National Laboratory's Advanced Light Source, they then used extreme UV light pulses to ionize hydrogen, nitrogen, and carbon monoxide gas. For H_2 , the simplest molecule of the bunch, the theory almost perfectly described the vibrationally resolved ionization spectra. For N_2 and CO , the theory was less accurate, but still in qualitative agreement with the data. The results could help to resolve ambiguities surrounding previous attempts to demonstrate the phenomenon. (S. E. Canton et al., *Proc. Natl. Acad. Sci. USA* **108**, 7302, 2011.) —AGS ■