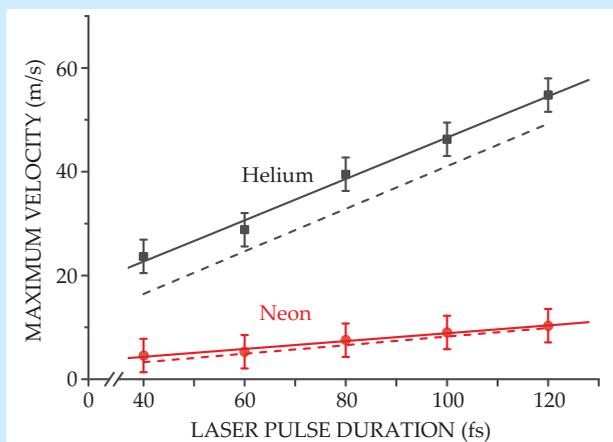


Accelerating neutral atoms. The intensity gradients of inhomogeneous laser-light fields impose ponderomotive forces on charged particles. Such forces—proportional to the square of the particle's charge and inversely proportional to its mass—push the particle toward lower light intensity and have been used to trap and manipulate ions, diffract electrons, and generate charge waves in plasmas. But they were thought to act only very weakly on neutral atoms—having to rely on the polarizability of an atom's charge distribution. Now, however, a group at the Max Born Institute in Berlin has reported the use of intense ultrashort laser pulses to accelerate neutral helium atoms for about 100 femtoseconds at 10^{15} m/s². That's eight orders of magnitude greater than the acceleration (or deceleration) one can get with the continuous-wave techniques used in laser cooling of neutral atoms. The Berlin group argues that the strong laser pulse excites an electron to the outer reaches of the helium atom where it "quivers" in the oscillating light field and experiences the



tion by as much as 2.5%. Nature, though, has already solved the puzzle in animals that have evolved biophotonic structures for signaling, vision, and coloration (see PHYSICS TODAY, January 2004, page 18). An international team of researchers from the UK, Australia, and the US has discovered a near-ideal achromatic retarder in the eyes of the colorful peacock mantis shrimp, *Odontodactylus scyllarus*, shown in the image. The mantis shrimp's biophotonic retarder is the R8 photoreceptor cell—a UV-photopigment-filled lipid bundle with critical radii of 26 nm and 40 nm, which are sub-wavelength for visible light. When subjected to linearly polarized light, the R8 cell acts as a quarter-wave retarder, converting the incident light to circularly polarized light, as confirmed by close experimental agreement with theoretically determined Stokes parameter values. Moreover, the retardation varied by only 0.8% from ideal values across the visible spectrum. (N. W. Roberts et al., *Nat. Photonics* **3**, 641, 2009. Image courtesy of Roy Caldwell, University of California, Berkeley.) —JNAM



ponderomotive force almost as a free electron would. But still bound to the atom's ionic core, it tugs the much heavier core with it away from the laser beam's focus. The figure shows how the maximum velocity thus acquired by neutral atoms in the Berlin experiment increases with pulse duration. The dashed curves show the theoretical expectation for the group's model of electron excitation and the consequent ponderomotive force. Such "ultrastrong" acceleration of neutral atoms, they suggest, could be exploited for atomic-beam optics, atom deposition, and controlled chemical reactions. (U. Eichmann et al., *Nature* **461**, 1261, 2009.) —BMS

A mantis shrimp's extraordinary eyes. Photonic devices that can detect and control the polarization of light across a range of wavelengths are rare. More common are materials such as quartz that can be made into monochromatic optical retarders. Through their intrinsic birefringence, those devices retard the phases of a specific wavelength of incident light, converting the light from linearly to circularly polarized or vice versa. Some multilayered thin films exhibit achromatic retardation through fabricated periodic nanoscale structures that effectively combine the dispersive properties of each layer to achieve wavelength-independent birefringence. But engineering on the nanoscale is tricky, and even the best synthetic achromatic retarders perform poorly across the full visible range, straying from the expected retarda-

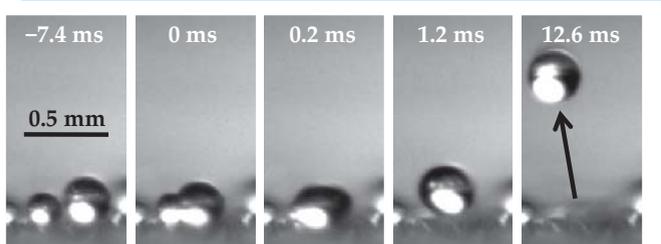
Yoctosecond light pulses from quark-gluon plasmas. In recent years, photon pulses in the attosecond (10^{-18} s) regime have been precisely engineered and are being increasingly put to work—for example, in experimental quantum control and chemical dynamics (see PHYSICS TODAY, March 2005, page 39). But can much shorter pulses be generated and put to use? Three physicists at the Max Planck Institute for Nuclear Physics in Heidelberg, Germany, have proposed some answers. They modeled the photon emission in the early expansion of a quark-gluon plasma, a hot dense stew of fundamental particles created when heavy nuclei smash into each other at relativistic speeds. Prompt gamma rays in the GeV range, produced primarily by quark-gluon Compton scattering and quark-antiquark annihilation, would exit the expanding QGP in at most a few yoctoseconds (10^{-24} s). With certain collision parameters and with detectors nearly aligned with the collision axis, the model predicts a double-peaked pulse before the QGP disappears. One peak is blueshifted, arising from the approaching side of the QGP, the other is redshifted from the receding side; the peaks are separated roughly by the light-travel time across the hot soup. The dip between the peaks occurs during an intermediate time at which the stew acquires an anisotropy and emits nothing along that axis. If the model proves correct, such a double pulse could enable pump-probe experiments at the nuclear scale, though new detection schemes would first need to be invented. (A. Ipp, C. H. Keitel, J. Evers, *Phys. Rev. Lett.* **103**, 152301, 2009.) —SGB

Trading farms and forests for biofuel. With political sentiment growing in favor of greenhouse gas (GHG) restrictions, biofuels from plant cellulose are being considered among the alternatives to fossil fuels: Plants are renewable and biodegradable, and



they sequester carbon. Yet a new report validates concerns that a global biofuels program could put intense pressure on land supply and distribution. To predict the impact of a biofuels-based economy on climate change, an international team of researchers from the US, Brazil, and China linked an economic model of land use with a terrestrial biogeochemical model of global GHG levels. The team considered two cases for cellulose biofuel crop growth: The primary focus of case 1 is on converting unfarmed areas such as forests, as shown in the image; of case 2, on exploiting existing farmland to the extent possible. In both cases, biofuel feedstock becomes a dominant global crop by year 2100, but in the process, total forest area is cut—by 56% in case 1 and by 24% in case 2. The loss of carbon-sequestering trees in case 1 results in a net release of carbon. In case 2, the gains from biofuel production ultimately lead to increased carbon sequestration in the farmed soil from the addition of nitrogen fertilizer, which paradoxically releases N_2O , another potent GHG. The research suggests that stabilizing GHG levels will require a limited and more efficient use of forests and fertilizers for biofuel crop production. (J. M. Melillo et al., *Science*, in press, doi:10.1126/science.1180251. Image courtesy of Chris Neill, Marine Biological Laboratory, Woods Hole, MA.) —JNAM

Rough surface gives drops the heave-ho. A common step in industrial cooling processes is the liquefaction of a vapor on a condenser. However, if a liquid film forms on the condenser, the cooling may be compromised. The problem can be addressed



by coating the condenser with a hydrophobic material conducive to drop formation and then letting the drops slide off due to gravity. Chuan-Hua Chen of Duke University and his student Jonathan Boreyko now report a different approach. By depositing carbon nanotubes on silicon micropillars and coating both with hexadecanethiol ($C_{16}H_{34}S$), they engineered a rough “superhydrophobic” surface. The water drops that condensed on it were about a hundred times smaller than those on a conventional hydrophobic surface that the Duke team considered as a standard; the surface roughening offers the promise for more efficient cooling. Furthermore, as the figure and online video show, when two sufficiently large drops coalesce into a single drop, that drop literally springs off the condenser—no external prompting needed. The post-combination drop has less surface energy than do the two drops from which it forms. Most of the released surface energy is dissipated, but Chen and Boreyko observed that the vertical component of the drop’s velocity can be as much as one-sixth of the theoretical maximum. Nature has her own version of the jumping trick: Coalescence of a wet portion of a spore with a dew drop provides the energy for spore ejection in certain mushrooms. (J. B. Boreyko, C.-H. Chen, *Phys. Rev. Lett.* **103**, 184501, 2009.) —SKB

Understanding ferromagnetism in graphite. Ferromagnetism usually arises from transition metals rich in $3d$ and $4f$ electrons. The occurrence of ferromagnetism in pure carbon, which contains only s and p electrons, is thus surprising—even controversial, given the weakness of the magnetic signal and a Curie temperature well above room temperature. Using magnetic force microscopy and a superconducting quantum interference device to probe the surface and bulk magnetization of graphite, Dutch researchers Jiri Červenka and Kees Flipse (Eindhoven University of Technology) and Mikhail Katsnelson (Radboud University) offer evidence that the ferromagnetism arises from a two-dimensional network of point defects at grain boundaries. The breaking of the lattice’s translational symmetry by the defects leads to localized electron states at the Fermi level. Because of electron–electron interactions, those states become polarized, which, in turn, leads to the formation of local magnetic moments. Grain-boundary defects are more complicated than single vacancies: The figure here shows 2D planes of periodic defects, each an extended zigzag discontinuity that propagates through individual graphene sheets of the bulk crystal. A magnetic moment can be associated with each defect; and the step edge at the surface is a manifestation of the grain boundary buried underneath it. The Curie temperature deduced from experiment is, reassuringly, comparable to the theoretical value based on weak interlayer coupling. (J. Červenka, M. I. Katsnelson, C. F. J. Flipse, *Nat. Phys.* **5**, 840, 2009.) —RMW

