stick together and render the system inoperable. The phenomenon is called stiction, and it's thought that the Casimir–Lifshitz force is responsible. Reducing or eliminating the attractive Casimir–Lifshitz force among MEMS components could alleviate the problem of stiction as MEMS are further miniaturized. And actually reversing the force into a repulsion allows the intriguing possibility of levitating one object above another. If a levitation gap can be achieved that's larger than any surface roughness features (typically around 15 nm), it could allow the creation of very low-friction force sensors, bearings, or other devices.

Capasso also hopes that Casimir levitation will help him observe a quantum electrodynamical torque between optically anisotropic materials. By levitating one disk of birefringent material above another, he says, it should be possible to rotate the top disk with circularly polarized light and see that the disks' principal optical axes tend to align when the light is removed.[4]

Johanna Miller

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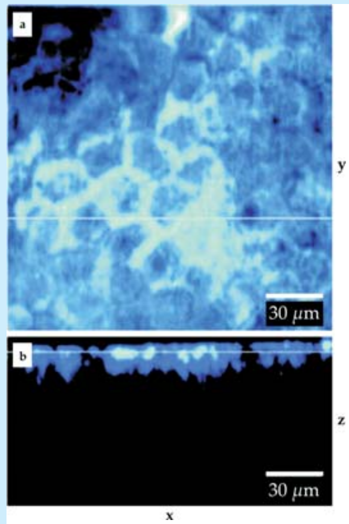
physics update

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

Ice acoustics for detecting neutrinos. Several experiments are operating or being built to detect astrophysical neutrinos. Ranging up to about a cubic kilometer in size, those experiments are embedded in ice or in a liquid such as water, where they watch for telltale flashes of Cherenkov radiation. (See the article by Francis Halzen and Spencer Klein in Physics Today, May 2008, page 29.) But the highest-energy neutrinos, with energies of an exaelectron volt (1EeV = 10^{18} eV) or higher, are so scarce that installations spanning 100 km^3, along with massive numbers of expensive photomultiplier tubes, would be needed to collect adequate event statistics in a reasonable time. So other detection schemes are being explored, one of which involves acoustics: When a very–high-energy neutrino interacts with water or ice, a sudden localized thermal expansion occurs and the resulting wave propagates farther than the light flashes. To explore that method, the Aachen Acoustic Laboratory was set up in late 2007 and its first experiment made a precise measurement of the speed of sound in ice that is entirely devoid of bubbles and cracks. The Aachen physicists carefully positioned an array of sensors—six detectors and one emitter—in a 3-m^3 water tank (shown here) equipped with a freeze-control unit and a degassing system. The difference in arrival times of an acoustic pulse at adjacent receivers determined the speed of sound. Between 0 °C and −17 °C, where they took measurements, the speed ranged from about 3840 m/s to 3890 m/s, agreeing well with earlier laboratory experiments. The team is also part of SPATS (the South Pole Acoustic Test Setup), which is currently obtaining complementary in situ measurements. (C. Vogt, K. Laihem, C. Wiebusch, *J. Acoust. Soc. Am.* **124**, 3613, 2008.)

—SGB

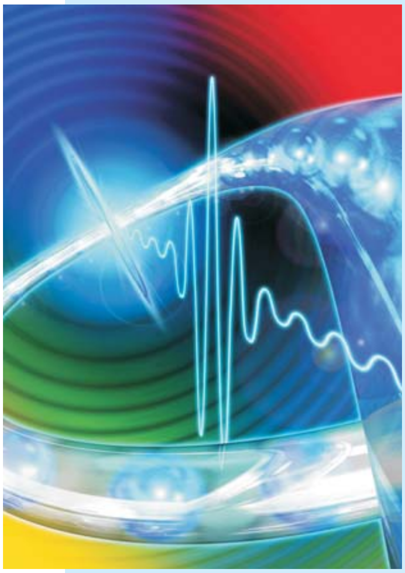
Tuning vibrations for label-free biological imaging. To map molecules in cells and tissue, researchers prefer biomedical imaging techniques that rely solely on the intrinsic responses of chemical bonds to optical stimulation. Although fluorescence microscopy and other chemical tagging methods yield high-resolution images, they also introduce foreign species or synthetic derivatives that can alter the dynamics of intracellular processes. Spontaneous Raman scattering, which uses a single laser beam to excite the vibrational and rotational modes in chemical bonds, requires no chemical labels but generates a weak signal that gets muddled by Rayleigh scattering. A more sensitive technique known as coherent anti-Stokes Raman scattering uses multiple laser beams to generate coherent optical signals that enhance resonant frequencies in the sample; that method, however, also produces nonresonant background noise. Recently a team led by Harvard University chemist Sunney Xie demonstrated a new technique based on stimulated Raman scattering that tunes the difference between the frequencies of two laser beams to match a desired molecule's resonant frequency, thus amplifying the Raman signal. The measurable intensities of the transmitted beams change only when a match occurs; nonresonant signals are not picked up. The images show the top view (a) and the depth profile (b) of an acne medication (blue) that penetrated a mouse's skin, thus demonstrating the potential of the new technique to monitor drug delivery. (C. W. Freudiger et al., *Science* **322**, 1857, 2008.)



—JNAM

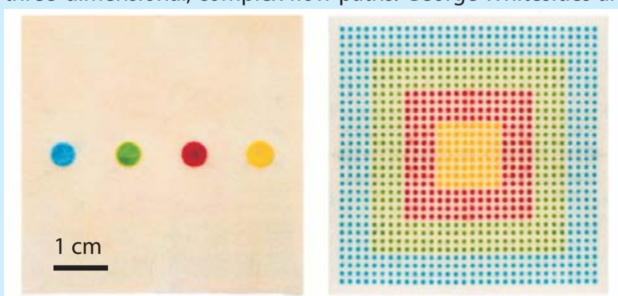
Heating the Sun's corona. It's one of the great natural mysteries: How do the Sun's corona and wind become thousands of times hotter than the Sun's surface? Somehow, energy makes its way up into the corona against a temperature gradient and is converted to heat. A new analysis of data collected by NASA's *Wind* spacecraft doesn't solve the mystery, but it is consistent with a popular explanation. The analysis was done by Justin Kasper of the Harvard-Smithsonian Center for Astrophysics, Alan Lazarus of MIT, and Peter Gary of Los Alamos National Laboratory. They looked at 14 years of in situ observations of particles and fields made as *Wind* flew in and out of the solar wind. The team focused on the two most abundant ion species in the solar wind, H^+ and He^{2+}. Because He^{2+} is four times heavier than H^+ and carries twice the charge, the two species' kinematics can discriminate among various models for transport and heating. Kasper, Lazarus, and Gary found strong evidence for one picture of coronal heating: Ions are carried upward by magnetohydrodynamic disturbances known as Alfvén waves; heating occurs when ions entrained in the waves fall into resonance at their respective cyclotron frequencies. Confirming or refuting the resonance model will require a spacecraft to enter and explore the corona. That's the aim of two missions planned for the next decade: NASA's *Solar Probe* and ESA's *Solar Orbiter*. (J. C. Kasper, A. J. Lazarus, S. P. Gary, *Phys. Rev. Lett.* **101**, 261103, 2008.) —CD

Taming rogue waves to create switchable supercontinua. Supercontinuum emission extends from the IR through the visible to the UV. As Robert Alfano and Stanley Shapiro discovered 40 years ago, one can generate supercontinuum pulses by sending bright, narrowband pulses through an optical fiber or other highly nonlinear material. Sometimes, depending on the noise, the process of generating a supercontinuum pulse also begets rare, intense pulses known as rogue waves. The artist's impression depicts the process. Ordinarily, rogue waves are sporadic and unpredictable, but if they could be produced to order, researchers would have access to bright, amplified pulses of supercontinuum light. UCLA's Daniel Solli, Claus Ropers, and Bahram Jalali have done just that, at least over a broad range in the IR. Their technique relies on sending in a second seed pulse right after the main pump pulse. The seed pulse is 10 000 times weaker than the pump pulse and, with a central wavelength of 1630 nm, redshifted from the pump pulse by about 100 nm. Adjusting the relative timing of the two pulses has a dramatic effect. When timed optimally, the two pulses always generate a supercontinuum pulse of rogue-sized magnitude. What's more, the supercontinuum pulses are uniform in both intensity and spectrum. How does the technique work? Supercontinua begin from a nonlinear process called modulation instability, which produces lobes at either side of the pump pulse spectrum. In the presence of noise, the supercontinuum pulses can vary erratically from pulse to pulse, occasionally yielding a rogue wave. According to the UCLA team's numerical analysis, seed pulses tame the modulation instability and prompt the controllable formation of rogue waves. Data switching and routing in optical networks are among the applications the UCLA team envisions. (D. R. Solli, C. Ropers, B. Jalali, *Phys. Rev. Lett.* **101**, 233902, 2008.) —CD



Solid-state photon storage. Quantum communication networks and other quantum information processing will require coherent and efficient transfer of information between light and matter, and the realm of light–matter interfaces is an active area of research. Much of the activity has focused on the mapping of quantum information onto atomic systems (see, for instance, PHYSICS TODAY, March 2001, page 17). Nicolas Gisin and colleagues at the University of Geneva in Switzerland have now demonstrated the coherent storage and retrieval of information using a solid-state system. The team's quantum memory was an ensemble of roughly 10^7 neodymium ions trapped in a crystal of yttrium vanadium oxide (YVO_4). In such an environment, the resonant frequencies of the rare-earth atoms are inhomogeneously shifted, which broadens the absorption spectrum. That's normally undesirable, but the researchers turned it to their advantage. By optically pumping some of the Nd atoms out of the ground state, they sculpted the spectrum into a series of regularly spaced absorption peaks—an "atomic frequency comb." An incident weak light pulse, with on the order of one photon or less on average, will be uniformly absorbed by the comb and generate a coherent superposition of collective optical excitations, each at a slightly different frequency. The superposition will initially dephase but will get reestablished after a time determined by the comb spacing; once rephased, the atoms will collectively reemit a light pulse that conserves the coherence and phase of the original pulse. Gisin and company achieved storage times of up to a microsecond. Furthermore, they showed that the ensemble can simultaneously store multiple light fields, and they have proposed a means of on-demand retrieval. With such capability, the authors view solid-state systems as a promising contender for quantum storage. (H. de Riedmatten et al., *Nature* **456**, 773, 2008; M. Afzelius et al., http://arxiv.org/abs/0805.4164.) —RJF

Inexpensive 3D microfluidics. With their ability to manipulate microliter to nanoliter volumes of liquids, microfluidic devices have found increasing application in a variety of fields, from ink-jet technology to proteomics and DNA analysis. Most current microfluidic devices are made from glass or polymers, and advances in design and fabrication have opened the realm of three-dimensional, complex flow paths. George Whitesides and



colleagues at Harvard University have recently demonstrated 3D devices made from stacked layers of ordinary paper and tape. Thanks to paper's wicking ability, the devices don't require external pumps to drive the liquids through. Indeed, the wicking property of paper is routinely exploited in medical tests such as those for blood glucose, pregnancy, and HIV. To define the microfluidic pathways in the paper-based microfluidic device, the team impregnated each paper layer with a common photoresist, a hydrophobic polymer that could be patterned with UV light. With their channels thus established, the layers of paper were alternated with layers of double-sided tape; holes cut in the tape connected channels in adjacent paper layers. The figure illustrates the complex routing that can be achieved: Four differently colored liquids deposited on the top of a 5 cm × 5 cm, nine-layer stack (left) are, within 5 minutes, wicked through horizontally and vertically to the array of 1024 detection zones on the bottom (right). With reagents or antibodies placed in detection zones prior to assembly, such devices would provide highly parallel, independent assays. The Harvard team sees particular potential for their paper-based devices in medical diagnostics in developing countries. (A. W. Martinez, S. T. Phillips, G. M. Whitesides, *Proc. Natl. Acad. Sci. USA* **105**, 19606, 2008.) —RJF ■