physics update

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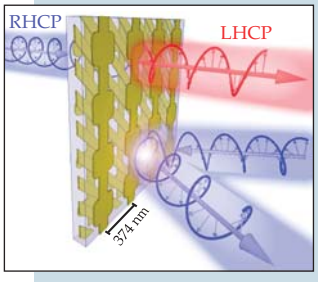
The Casimir force in one dimension. In 1937 Fritz London showed how the van der Waals attraction between two atoms could be explained by quantum mechanical fluctuations in the ground-state positions of the molecules' charged components (see the article by Steve Lamoreaux, PHYSICS TODAY, February 2007, page 40). A decade later Hendrik Casimir, having cast the physics in terms of so-called vacuum fluctuations in the electromagnetic field, famously predicted that two perfectly conducting plates in a vacuum would attract each other. With real, imperfect conductors, the strength—and, in certain cases, the sign—of the interaction depends on the details of the conductors' shape (see, for instance, PHYSICS TODAY, February 2009, page 19). Now Ephraim Shahmoon and Gershon Kurizki (Weizmann Institute of Science) and Igor Mazets (Vienna University of Technology) have looked at the consequences of dimensionality: They examine what happens to vacuum forces between atoms in the vicinity of an electrical transmission line, such as a coaxial cable or coplanar waveguide, in which the quantum fluctuations are effectively confined to one dimension. The researchers find analytically that the fluctuation-mediated attraction between the atoms in such an environment is much stronger and longer range than in free space. When the interatomic separation z is small, the attraction decreases very slowly with z, compared with the $1/z^6$ dependence of the van der Waals attraction; at larger separations, it falls off as only $1/z^3$ instead of $1/z^7$. The trio predicts that even with imperfect conductors, the enhanced interactions should be observable, with potential applications in quantum information processing. (E. Shahmoon, I. Mazets, G. Kurizki, *Proc. Natl. Acad. Sci. USA*, in press.) —RJF

Tailor-made surface swaps light polarization. Manipulating the properties of light—amplitude, phase, and polarization, for instance—typically involves using an array of lenses, polarizers, and other elements on an optical table. Two-dimensional metamaterials called metasurfaces offer a compact alternative based on the engineering of subwavelength structural features to achieve specific electromagnetic properties. For example, Anthony Grbic and his colleagues at the University of Michigan have designed and fabricated a new type of asymmetric circular polarizer. As illustrated here, their 400-nm-thick device consists of three patterned gold surfaces separated by dielectric substrates. When right-handed circularly polarized (RHCP) light is incident on one side of the metasurface, it emerges from the other side as left-handed circularly polarized (LHCP) light. At the operating wavelength of 1.5 μm, the transmittance for RHCP to LHCP is 50% whereas for other combinations — LHCP to RHCP, LHCP to LHCP, and RHCP to RHCP — the transmittances are below 2.5%. What's more, the device is asymmetric: It reflects RHCP light incident on the other side while converting LHCP light to RHCP light. The tiny circular polarizer could be useful in applications like optical polarimetry, where it could be combined with a detector to make a single integrated device. What is maybe more important, the researchers believe the basic geometry of cascading patterned metallic sheets can provide the basis for cleverly designing and fabricating a broad range of optical devices, including symmetric circular polarizers, polarization rotators, and asymmetric linear polarizers. (C. Pfeiffer et al., *Phys. Rev. Lett.* **113**, 023902, 2014.) —SC



The influence of liquid flow on interfacial chemistry. The natural world is full of materials being weathered or dissolved from their contact with water—by its percolating through pores, say, or its flowing over a riverbed. But distinguishing the influence of such dynamic flows from the liquid's mere presence has proven difficult. As a material dissolves, its surface becomes charged as ions from solution bind with it, a process that both aligns the dipole moments of nearby water molecules and attracts oppositely charged ions from solution to the interface. Dan Lis (University of Namur, in Belgium), Mischa Bonn (Max Planck Institute for Polymer Research, in Germany), and their colleagues have now found that the flow of an aqueous solvent over a material can exert a dramatic influence on the charge structure. To reach that conclusion they used a nonlinear optical technique known as sum frequency generation (SFG), whose signal is exquisitely sensitive to the extent of the water molecules' dipole alignment on two different minerals, calcium fluoride and fused silica, each held in a microfluidic channel. From the change in SFG spectra when the channel's flow was turned on and off, the researchers determined the change in surface charge and compared it with the charge they predicted would develop during dissolution. For both minerals, the shear from a rapid laminar flow modified the charge by clearing away products of dissolution near the interface. The effect on the dissolution rate for CaF_2 was roughly equivalent to increasing the acidity of a free-standing solution by two units on the pH scale. (D. Lis et al., *Science* **344**, 1138, 2014.) —RMW

Confirming antihydrogen neutrality with voltage bias. Neutral atoms appear to have literally zero net electric charge. The consistency of quantum field theory requires that the proton and electron have the same charge magnitude e, and observations of several atoms and molecules have confirmed neutrality to 10^{-21} e. Theory demands that antiatoms are likewise strictly neutral. But direct experimental confirmation of the theoretical expectation has been problematic. Now the ALPHA collaboration at CERN has measured the charge of antihydrogen to be -1.3×10^{-8} e, consistent with zero to within about one standard deviation and six orders of magnitude more precise than the previous best antihydrogen measurement. To obtain its result, the collaboration returned to data it had taken a few years ago on antihydrogen in its cryogenic trap, a detail of which is shown in the figure. As part of those experiments, group members released antihydrogen atoms and then detected where 386 of them annihilated on the trap walls. Since their device might have inadvertently trapped