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Highly charged ions challenge QED

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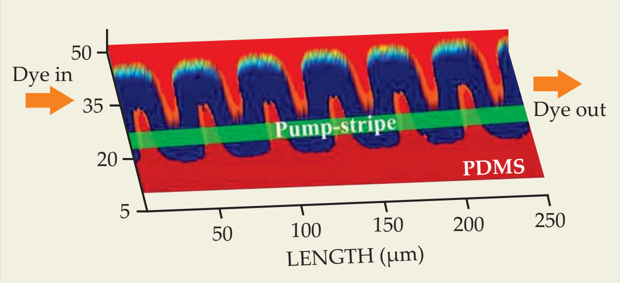
Highly charged ions challenge QED. Quantum electrodynamics (QED), the relativistic field theory describing interactions of light and charge, is justly celebrated for the astonishing accuracy with which it predicts, for example, the anomalous magnetic moment of the lone electron. But the reach of QED extends to substantially more complex systems. One class of objects amenable to experimental study and QED calculation includes helium-like ions with atomic number Z of about 25 and two orbiting electrons. In those three-body entities, the significant nuclear charge enhances the QED interactions. A recent experiment at the NIST Electron Beam Ion Trap facility by an international team led by Christopher Chantler (University of Melbourne, Australia) has made the most precise measurement to date for the energy of a specific atomic transition, called the w transition, in helium-like titanium $^{22}Ti^{20+}$ and has obtained a value that disagrees with QED by three standard deviations. But the bigger surprise came when the group reviewed the published literature for w transitions in helium-like ions with Z between 16 and 36. Taken as a whole, the experimental data differed from theory by five standard deviations, and a least-squares fit through the data indicates that the discrepancies scale as Z^3. Chantler and company note that the mismatches between experiment and theory potentially involve a variety of QED effects with various Z dependencies. Future experiments in the unexplored $Z = 27–31$ range, they say, could further systematize the discrepancies and guide theoretical work. (C. T. Chantler et al., *Phys. Rev. Lett.* **109**, 153001, 2012.) —SKB

Snowfall thickens the East Antarctic ice sheet. As Earth's climate warms, water from glaciers and ice sheets more readily ends up in the ocean, raising sea levels. Although the thermal expansion of seawater also raises sea levels, discharge from glaciers and ice sheets poses the more imminent threat. How much water an ice sheet sheds depends on the temperature of the air, land, and surrounding ocean. It also depends on the rate at which snowfall replenishes the ice. Provided it remains on land, snow lowers sea levels by sequestering evaporated seawater. Carmen Boening of NASA's Jet Propulsion Laboratory in Pasadena, California, and her colleagues have just finished a study of ice accumulation over the entire Antarctic continent. Their study makes use of altimetry data gathered by NASA's *Gravity Recovery and Climate Experiment* spacecraft between 2003 and 2011. Stark regional differences emerged. Whereas West Antarctica lost ice mass throughout that period, East Antarctica was stable until 2008, after which it gained 350 gigatons. That accumulation is equivalent to a *decrease* in global sea level rise of 0.32 mm/yr, or 10% of the current total rate. Precipitation data show two heavier-than-average snowfalls in May 2009 and June 2011 that could account for the mass gain. No snowfalls of similar magnitude occurred in the region since record keeping began in 1979. What's more, whereas the heavy snowfalls in 2009 and 2011 coincided with an El Niño and a La Niña, respectively, previous El Niños and La Niñas had no such correlation. Recent changes in the character of El Niños could therefore be behind the mass gain. (C. Boening et al., *Geophys. Res. Lett.* **39**, L21501, 2012.) —CD

An optofluidic random laser. Optofluidics is a burgeoning area of research seeking to combine microfluidics and optics to produce optical elements that are versatile, controllable, and readily incorporated in fluid-based "lab-on-a-chip" devices. The pressure of a fluid flowing through a microchannel can change the shape of an adjacent soft lens, for example, and a fluid's composition can modify the channel's refractive index. Among the many applications being pursued are optofluidic lasers. Lasers at any scale require some mechanism—such as mirrors or an extended diffraction grating—to produce sufficient stimulated emission. Disordered media provide an alternative way to achieve gain: The disorder causes photons to scatter multiple times, getting amplified each time. Shivakiran Bhaktha (Indian Institute of Technology Kharagpur) and colleagues have now demonstrated random lasing in a microfluidic channel. The disorder in their 3-mm-long, 28-μm-deep channel arises naturally in the photolithographic fabrication process: Finite-sized pixels in



the photomask pattern, imperfect mask adhesion, and diffraction all contribute to micron-scale roughness in the channel's transparent polydimethylsiloxane (PDMS) walls (as seen in this profilometer image). Flowing through the microchannel is an organic dye—one also used in tabletop dye lasers—that emits yellow photons when pumped by green laser light. For sufficient pump power, the multiple scattering of the emitted photons triggers lasing. The researchers note that the lasing threshold is comparable to that of optofluidic lasers employing external cavities, and thus optofluidic random lasers offer an interesting, cheap alternative to technologically demanding cavity lasers. (B. N. S. Bhaktha et al., *Appl. Phys. Lett.* **101**, 151101, 2012.) —RJF

Extreme water. Stars, nuclear explosions, and the early universe are three realms where matter exists in extreme conditions of pressure, temperature, and density. Over the past few decades, extreme matter has become increasingly accessible in the laboratory. (For an overview, see the article by Paul Drake in PHYSICS TODAY, June 2010, page 28.) Water is a favorite material to use because of its near incompressibility and its relevance to the interiors of giant planets, but taking water to the extreme has typically required about 100 kJ of energy per experiment. A team of physicists at the Technion–Israel Institute of Technology in Haifa has now generated extreme water on a smaller scale. By winding copper or aluminum wires around a ball and then dissolving the ball, the team created a spherical cage, as shown in the figure. The cage is connected to a pulse power generator with about 6 kJ of stored energy. When the wires are submersed in water and the stored energy suddenly released, the wires vaporize and produce strong shock waves that overlap to form a larger one that then converges on the sphere's center. There, for less than a microsecond, the water is compressed sevenfold. Combining the experimental results with simulations, the researchers inferred that the water's temperature reached nearly 10^5 K at a pressure of 2×10^7 atm. (O. Antonov et al., *Phys. Plasmas* **19**, 102702, 2012.) —SGB