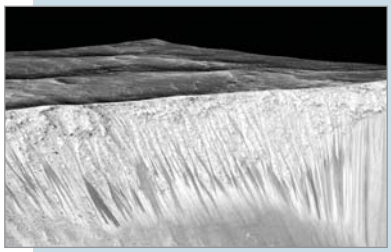
physics update

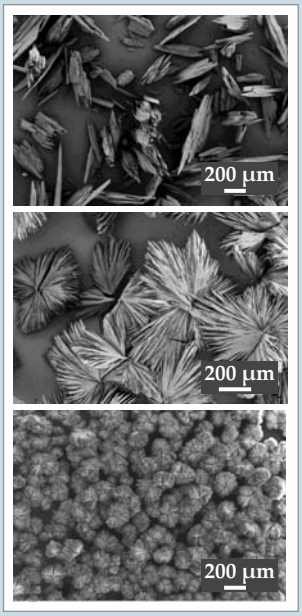
These items, with supplementary material, first appeared at http://www.physicstoday.org.

A new probe for a changing constant. Water in distant galaxies is difficult to detect from Earth because the molecule lacks favorably placed spectral transitions. Astronomers seeking a proxy turn instead to water's protonated form, hydronium (H_3O^+), whose lowest vibrational transitions lie in the millimeter band. Now Vladimir Špirko of Charles University in Prague and his collaborators have identified another use for hydronium: as a probe to determine whether the proton-to-electron mass ratio, μ, varies. Given that gluons, not quarks, make up most of the proton's mass, variations in μ could arise if the strong nuclear force changes through cosmic time, as some theorists have speculated. The energy of a vibrational state depends on the molecular mass and therefore on the proton mass and μ. When those vibrational states lie close to inversion and rotational states, the μ dependence strengthens. To determine how sensitive those combined states are to variations in μ, Špirko and his collaborators calculated hydronium's potential energy and dipole moment as functions of the positions of its constituent atoms. They then fed those functions into a nuclear motion code to calculate the transition energies. It turned out that some of the transitions could indeed serve as probes. The difference between two of them—from the ground state to the third excited state—was about four times more sensitive to μ than the methanol transitions used earlier this year to constrain the value of $\Delta\mu/\mu$ during the past 7 billion years to be no more than 10^{-7}. (A. Owens et al., *Mon. Not. R. Astron. Soc.* **454**, 2292, 2015; see also the article by David DeMille on page 34.) —CD

Liquid water inferred on present-day Mars. Morphological evidence abounds for the flow of liquid water on ancient Mars; see, for example, the article by Bruce Jakosky and Michael Mellon, PHYSICS TODAY, April 2004, page 71. However, little definitive evidence for it exists on today's surface. What surface water Mars holds has long been thought to reside as ice at its poles. In 2010 the *Mars Reconnaissance Orbiter* (*MRO*) spotted features known as recurring slope lineae that are consistent with transient flow: The dark, narrow streaks—the ones in the figure are hundreds of meters long—elongate on warm slopes in the spring and summer when their temperatures exceed about 250 K, fade and vanish in colder seasons, and reappear annually. Georgia Institute of Technology doctoral student Lujendra Ojha and his colleagues have now analyzed absorption spectra taken by *MRO* of four separate regions containing the streaks. They found signatures of a family of hydrated salts known as metal perchlorates at all of the sites during the warm seasons when the streaks are most extensive. Perchlorates can depress the freezing point of water by up to 70 K, and even in Mars's scant relative humidity, they may be able to adsorb moisture from the atmosphere (or from seeps underground) and dissolve; the hydrated salts whose *MRO* spectra the researchers analyzed are thought to be the dried precipitates. Ojha and colleagues conclude that the spectra support the hypothesis that the seasonal streaks form as a result of the activity of liquid, albeit very briny, water on contemporary Mars. Even so, the proof is indirect; the spectral lines are too narrow to come from liquid water itself. (L. Ojha et al., *Nat. Geosci.* **8**, 829, 2015; image courtesy of NASA/JPL/University of Arizona.) —RMW



Custom shapes for organic crystals. As the feature sizes of electronic devices become smaller, the mass production of nanometer- and micron-scale hierarchical structures is a major challenge. (See the article by Matthias Imboden and David Bishop, PHYSICS TODAY, December 2014, page 45.) One possible approach is to coax crystals to grow into a desired structure by exploiting chemical interactions between crystal faces and dissolved molecules. Though much used for inorganic systems, that technique has been less explored for organic materials—even though organic molecules offer a far richer range of chemical properties. Now Helmut Cölfen (University of Konstanz, Germany) and colleagues have used a diblock copolymer (see the article by Frank Bates and Glenn Fredrickson, PHYSICS TODAY, February 1999, page 32) to control the morphology of a material called PTCAPS, one of an important class of organic semiconductors. The polymer consists of a block of polyethylene glycol, which is highly soluble in water, bound to a block of polyethyleneimine, which has a strong electrostatic affinity to the (001) face of the nascent PTCAPS crystals. For PTCAPS in a water–polymer solution, therefore, crystal growth on the (001) face is stifled, so the crystals grow in micron-thick plates. The polymer concentration determines whether the plates cluster into irregular aggregates (top panel in the figure), star-shaped structures (middle panel), or round flower-like particles of uniform size (bottom panel). Adjusting the solution's pH—which affects the polyethyleneimine's electric charge and thus the strength of the polymer–PTCAPS interaction—also influences the crystals' final morphology. (M. Huang, M. Antonietti, H. Cölfen, *APL Mater.* **4**, 015705, 2015.) —JLM



History matters for glass hardness. Two objects of the same material—wooden blocks, say, or windowpanes—are commonly thought to be identical. Microscopically, of course, things are not always so straightforward. Researchers from Denmark, Poland, and the US now show that the route a glass takes to reach its final state can profoundly affect its macroscopic properties. Morten Smedskjaer of Aalborg University in Denmark and his colleagues used both experiments and simulations in a comparative study of aluminosilicate glasses that had identical composition but were brought to the same density via two routes: thermal annealing and high-pressure quenching in a nitrogen-gas chamber. The effects of annealing are well known, but the role of pressure history is less studied. When the researchers compared glasses of the same density and chemical makeup, those that had been annealed were significantly harder—as measured by indentation tests—than the pressure-quenched ones. The simulations reveal that both methods result in the same interatomic