physics update

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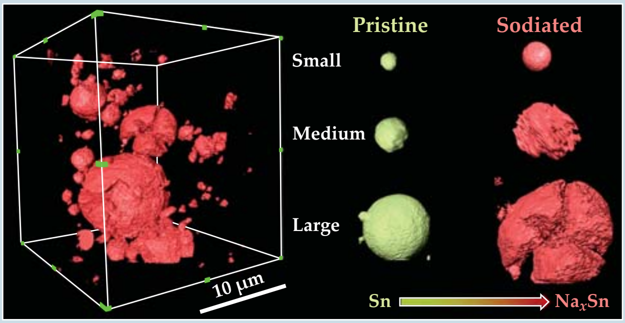
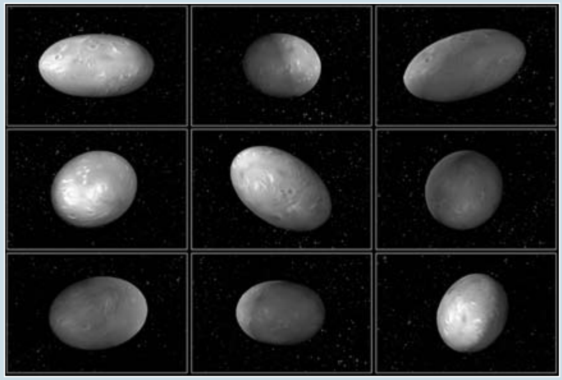
Surprising stability for sodium-ion batteries. Material degradation is a limiting factor for lithium-ion rechargeable batteries. Among other causes, each cycle of charging and discharging places mechanical strain on the battery's anode as the electrode (typically graphite or a metal alloy) swells or shrinks with the addition and removal of Li ions. One would expect sodium-ion batteries, in many ways similar to their Li cousins, to experience more severe electrode fractures—and degrade faster—because of the Na ion's bigger size. Yet Jun Wang and colleagues at Brookhaven National Laboratory have found that tin anodes in Na-ion batteries are unexpectedly resilient over many charging cycles. The team developed a full-field x-ray transmission microscope that could deliver *in situ*, three-dimensional tomographic images with 50-nm resolution during the anode's repeated sodiation and desodiation. In the first sodiation, as Na ions became alloyed with the Sn electrode, the anode volume tripled and the surface area quintupled (the figure illustrates size-dependent changes). But after that initial damage, subsequent desodiation and nine further charging–discharging cycles produced no further fractures: The expansion and shrinkage were reversible and produced a minimal decrease in charge capacity. Armed with those results, the researchers plan to examine other electrode materials to better understand their stability and device potential. (J. Wang et al., *Nat. Commun.* **6**, 7496, 2015.) —RJF



Pluto's intriguing moons. Roaming around the complicated gravitational field of Pluto and its large moon, Charon, are four smaller satellites—Styx, Nix, Kerberos, and Hydra—all of which were discovered only within the past decade. Now, based on an analysis of *Hubble Space Telescope* images, Mark Showalter (SETI Institute) and Douglas Hamilton (University of Maryland) have deduced several novel properties of the Plutonian system. The two researchers found, for example, that the orbital periods of Styx, Nix, and Hydra—but not Kerberos—are in simple, whole-number ratios. An analysis of the four moons' light curves (reflected light versus time) yielded other surprises. The data for Nix and Hydra are incompatible with rotation about a fixed axis. Instead, Showalter and Hamilton posit, the oddly shaped moons—and possibly Kerberos and Styx too—tumble chaotically, as illustrated in the accompanying simulated images of Nix, courtesy of Showalter and Greg Bacon (Space Telescope Science Institute). The light curves also indicate that Kerberos is much darker than its three companions—so much so that it appears to be made of different material. A unique composition would be a mystery because current theory holds that Pluto's moons were formed when a large object crashed into the dwarf planet: Why should one ejected fragment have a special composition?



In mid July, NASA's *New Horizons* spacecraft cruised past Pluto. Its observations will test some of the assumptions Showalter and Hamilton used in their orbital and illumination modeling and should definitively establish whether Kerberos is the darkest of Pluto's moons. (M. R. Showalter, D. P. Hamilton, *Nature* **522**, 45, 2015.) —SKB

A new look for magnetic-mirror plasma confinement. Controlling thermonuclear fusion requires confining hot plasmas at high densities and high temperatures for sufficiently long periods of time. Tokamaks, such as the one under construction at ITER, provide that confinement through a strong magnetic field that loops around in a closed, toroidal geometry; the plasma's charged ions and electrons follow the field lines in tight spirals. (See the articles by Don Batchelor, PHYSICS TODAY, February 2005, page 35, and by Richard Hazeltine and Stewart Prager, PHYSICS TODAY, July 2002, page 30.) A different strategy for magnetic confinement uses a cylindrical solenoid capped at each end by a magnetic mirror, a region of higher field that forces the charged particles to slow and reverse direction. The electron temperature is the main factor limiting the plasma confinement time and thus the power efficiency of a fusion reactor. Concerns over the attainable electron temperature were a factor in magnetic mirrors largely falling out of favor in the 1980s. Peter Bagryansky and colleagues now report more than tripling the electron temperature—up to 900 eV from their previous 250 eV and well above early estimated limits—of the deuterium plasma in their 7-m-long magnetic-mirror reactor at the Budker Institute of Nuclear Physics in Novosibirsk, Russia. Key to the group's achievement were a novel system that resonantly heated the electrons by high-power microwaves and a new technique to mitigate the plasma's so-called flute instability. The results, say the researchers, show promise for such uses as developing and testing fusion materials and reprocessing nuclear waste. (P. A. Bagryansky et al., *Phys. Rev. Lett.* **114**, 205001, 2015.) —RJF