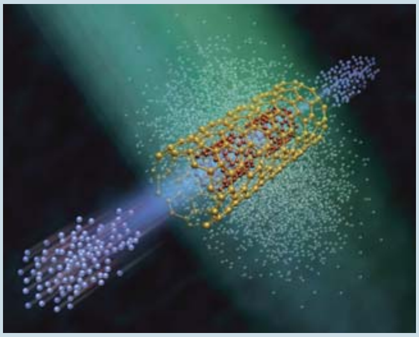
physics update

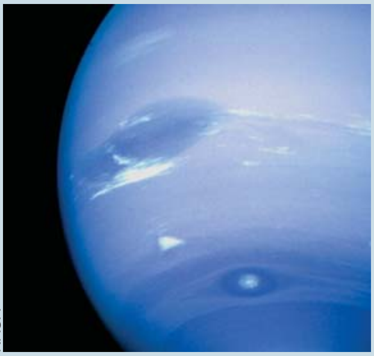
These items, with supplementary material, first appeared at http://www.physicstoday.org.

What kept the Moon's dynamo alive? The Moon's magnetic field used to have both the strength and the dipolar structure of a vigorous, dynamo-generated field like Earth's. Now, however, the lunar field is weak and patchy. Accounting for the field's enfeeblement might seem straightforward. As it aged, the Moon's molten core cooled and shrank to the point at which it could no longer sustain a dynamo. The trouble is, whereas an analysis of Moon rocks published last year put that transformation at 3.7 billion years ago, models of thermal convection in the Moon's core put it at 4.1 billion years ago. What kept the dynamo alive for the intervening 400 million years? To find out, MIT's Clément Suavet and his collaborators recently subjected two Moon rocks, both 3.56 billion years old, to magnetic, thermal, and other tests. (The photo shows a 5-g sample of one of the rocks next to a 1-cm^3 cube.) The researchers deduced that the rocks had been magnetized by a surface field of at least 13 µT, which is consistent with a strong dynamo. Although the age difference is just 4% between the rocks in the 2012 study and the younger rocks in the new study, one explanation for the prolonged life of the dipolar field beyond its expected span can be ruled out: an off-center hit by an asteroid that set the Moon rocking back and forth in its tidally locked orbit. No impacts big enough occurred that late. Another proposed mechanism remains in play: The chemically stratified layers that formed when the mantle crystallized could have become dynamically unstable and triggered a second round of convection. (C. Suavet et al., *Proc. Natl. Acad. Sci. USA*, in press, doi:10.1073/pnas.1300341110.) —CD

Proton beams from a nanotube accelerator. Carbon nanotubes (CNTs) are hardy and versatile, with remarkable material and electronic properties. And they could be useful in some extreme conditions as well. Two physicists in Japan, Masakatsu Murakami of Osaka University and Motohiko Tanaka of Chubu University, propose using a CNT as a shotgun barrel to shoot a beam of protons. Their scheme nests two small hydrogen-rich fragments—which could be water ice, paraffin, or some other low-*Z* material but were modeled as hydrogen nanotubes—within a larger CNT that has gold atoms chemically adsorbed in its wall. The assembled structure is then zapped from the side with an ultraintense femtosecond laser pulse (green in the schematic). As shown in three-dimensional simulations, the laser partially ionizes the gold and fully ionizes the hydrogen and carbon in the assemblage; after a few swings of the laser's electric field, significant numbers of electrons (white) are blown off and form a cloud around the CNT. The now highly ionized coaxial structure generates a Coulomb potential in which the protons (blue) from the low-*Z* shotgun shells are squeezed toward the axis and accelerated out both ends of the CNT. The simulations indicate that even a non-optimized setup can produce highly collimated beams of nearly monoenergetic protons—1.5 MeV for the parameters used. Such beams are of great interest in fields as diverse as medicine, fusion energy, and materials engineering. (M. Murakami, M. Tanaka, *Appl. Phys. Lett.* **102**, 163101, 2013.) —SGB



Demystifying the ice giants' puzzling poles. Like our own planet, Jupiter and Saturn have magnetic and geographic poles that are closely, but not perfectly, aligned; each planet's magnetic dipole is angled just a few degrees off its rotational axis. But the magnetic fields of Uranus and Neptune, the so-called ice giants, are dramatically tilted—by 59° and 46°, respectively. New experiments by Eric King (University of California, Berkeley) and Jonathan Aurnou (UCLA) may help to explain why. Planetary magnetic fields are thought to be generated by dynamos—turbulent, convective flows of electrically conducting fluid in the planet's interior (see the article by Daniel Lathrop and Cary Forest in PHYSICS TODAY, July 2011, page 40). Coriolis forces due to planetary rotation can influence those convective flows and thereby orient the dynamo's field. To probe that effect in the lab, King and Aurnou did what's known as a rotating Rayleigh–Bénard experiment: They heated a 20-cm-wide spinning drum of liquid gallium from below while simultaneously cooling it from above. Using conditions that, through appropriate scaling, mimic those of planetary interiors, the researchers found that the rotation–convection coupling is especially pronounced in fluids with high thermal conductivity. Therein may lie the secret of the ice giants' skewed poles: Based on trends seen in the experimental data, the researchers estimate that Earth, Jupiter, and Saturn, whose dynamos comprise high-conductivity molten metal, fall within the strongly coupled regime, whereas Uranus and Neptune, whose dynamos comprise moderate-conductivity aqueous solution, do not. (E. M. King, J. M. Aurnou, *Proc. Natl. Acad. Sci. USA* **110**, 6688, 2013.) —AGS


NASA

Hot fire, cool soil. Wildfires around the planet burn an average of 3.7 million km^2 of vegetation annually and can leave landscapes scorched, barren, and vulnerable to erosion and flooding. According to the literature, the more vegetative fuel, the more intense the fire, the hotter the soil, and the more severe the damage to fragile roots, seeds, and microbes.