physics update

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

Radiocarbon identification of illegal ivory. Carbon-14 dating is routinely used to determine the age of organic matter going back some 60 000 years. The radioisotope, whose half-life is 5730 years, is continually produced as neutrons from cosmic rays interact with nitrogen in the atmosphere. Through photosynthesis, feeding, and respiration, ^{14}C spreads up the food chain and equilibrates through the biosphere, but when an organism dies—or when hair, teeth, or other "permanent" tissue is formed—the isotopic fraction of ^{14}C is locked and begins to decay. Starting in the early 1950s, the vast number of neutrons released in thermonuclear bomb tests caused the amount of ^{14}C in the atmosphere to shoot up. At its peak a decade later, the concentration had nearly doubled; it has been falling steadily since then as atmospheric carbon gets exchanged with that in the biosphere and oceans. Through measurements on samples with known ages (including a donated tusk from Misha, seen here before she died), Kevin Uno (now at Lamont–Doherty Earth Observatory), Thure Cerling (University of Utah), and colleagues have now demonstrated that the so-called bomb curve of ^{14}C concentration can be used with accelerator mass spectrometry to accurately determine (within 1.3 years) the age of teeth, tusks, horn, hair, and other tissue that was synthesized in the last 60 years. A 1989 international treaty and other regulations ban the ivory trade, but some exceptions are made for older ivory: In the US, for example, interstate trade is legal for ivory imported before 1989. Despite the ban, elephant poaching is now at its highest level since record keeping began in 2002, according to a 2012 report. Carbon dating thus can serve as a forensic tool to combat the illegal trade of animal parts. (K. T. Uno et al., *Proc. Natl. Acad. Sci. USA* **110**, 10501, 2013. Photo courtesy of Hogle Zoo.) —RJF

Lithium isotope abundances test Big Bang nucleosynthesis. Six stable isotopes of hydrogen, helium, and lithium are thought to be the only nuclear species left over from the Big Bang. Their relative primordial abundances are tightly constrained by the theory of Big Bang nucleosynthesis (BBNS) and the well-determined present cosmological density of ordinary (non-dark) matter. Of the six, only the two lithium isotopes, ^7Li and the even scarcer ^6Li, seem to challenge the BBNS predictions. Spectroscopic observations of very old stars have appeared to show a moderate shortfall of ^7Li and an immoderate excess of ^6Li. Theory predicts a primordial ^6Li admixture so tiny that it should be absolutely undetectable in such spectra. The apparent detection of ^6Li had been the more puzzling of the two lithium problems. But the two problems exacerbate each other. Plausible astrophysical mechanisms, such as Li destruction in stellar interiors, that might well explain the ^7Li shortfall would worsen the ^6Li excess. Now Karin Lind (Max Planck Institute for Astrophysics) and colleagues have availed themselves of a high-resolution spectrometer on the 10-meter Keck-I telescope (shown here) to take a fresh look at several old stars that had yielded the strongest ^6Li signals. Because the Li absorption lines are much wider than the isotope shifts, deducing the tiny ^6Li fraction depends on details of the absorption-line shapes which, in turn, depend on details of the turbulent stellar atmospheres. Analyzing the high-resolution line shapes with a sophisticated new three-dimensional stellar model that drops questionable thermodynamic assumptions, Lind and company report that the new spectra no longer yield any significant detection of ^6Li. (K. Lind et al., *Astron. Astrophys.* **544**, A96, 2013.) —BMS

Ocean acidification inhibits oyster shell formation. The oyster industry in the Pacific Northwest has been suffering from high mortality rates in oyster seeds—young oysters ready for transplanting to an oyster bed—and those losses have been linked to increased ocean acidity from higher carbon dioxide levels. The frequently cited explanation is that the acidic water corrodes and dissolves the shells. Now George Waldbusser and colleagues at Oregon State University have uncovered an additional cause, one rooted in kinetics and energetics: At elevated CO_2 concentrations, mineral precipitation requires significant energy input at a stage of an oyster's life—newly fertilized larva—when energy is limited. To understand the relative contributions that food and dissolved carbon in seawater make to the growth and composition of oyster seeds, the team measured the carbon-isotope composition and the proportions of shell, lipids, and organic matter in Pacific oysters over the course of the first few weeks following fertilization. By the second day, the larvae had formed calcified shells that accounted for more than 90% of the total oyster mass. Precipitating so much calcium carbonate so quickly requires energy, and, argue the authors, the expenditure is higher at higher CO_2 levels. Yet as the isotope studies confirmed, larvae draw solely from the reserves originally within the egg when making that initial shell—they don't start to feed on their surroundings until after it is formed. Faced with a limited energy budget, the larvae can find the kinetic hurdle of shell formation increasingly difficult to overcome in acidic water, even if the conditions aren't yet corrosive. (G. G. Waldbusser et al., *Geophys. Res. Lett.* **40**, 2171, 2013.) —RJF