Also shown is the NMR protein structure, with the locations of the unexchangeable amides shaded in red.

Pintacuda and colleagues didn't need to deuterate their sample, but they did use ^{13}C and ^{15}N labeling to get information about the positions of C and N atoms. So their method is still limited to proteins that can be grown in laboratory cell cultures—they can't, for example, harvest a protein sample directly from a human patient. Pintacuda speculates that it could one day be possible to find a solid-state NMR structure of a protein using no isotopic labeling at all, merely the naturally present magnetic nuclei. "But resolving the proton resonances would be much harder," he says, "because we wouldn't have the information from nearby carbons and nitrogens."

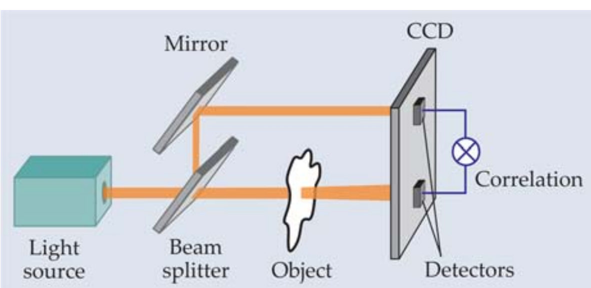
Although GB1 and AP205CP are both

PHYSICS UPDATE

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

X-RAY GHOST IMAGING

In its basic form, ghost imaging is a technique that indirectly produces a likeness of an object by combining the information from two light detectors—one that views the object and one that doesn't. By splitting a speckled laser beam so that two beams strike spatially separated locations on a CCD camera screen and by placing an object in one of the beams, as shown here, researchers can calculate the intensity correlations between the two signals as the beams are scanned in synchrony and construct the object's ghost image. Demonstrated in 2002 using visible light, the technique holds promise for remote atmospheric sensing because of its insensitivity to turbulence. Two research groups have now extended ghost imaging to the hard x-ray regime. Daniele Pelliccia (RMIT University in Australia) and his colleagues passed an x-ray beam produced by the European Synchrotron source through a diffracting silicon crystal grating oriented to transmit part of the undiffracted beam at a slight angle from the diffracted beam. An ultrafast camera placed 20 cm downstream of the beamsplitter detected both signals—one of which was partially blocked by the imaging target, a copper wire. Because the system worked with individual synchrotron pulses, retrieving the wire's ghost image took more than just calculating intensity correlations; the group also had to filter out low-frequency artifacts associated with mechanical vibrations induced by the synchrotron pulse rate. By contrast, Hong Yu (Chinese Academy of Sciences) and colleagues periodically moved their test object—a gold film with five slits—into and out of a synchrotron's x-ray beam to create their intensity-correlated signals—no beamsplitter or frequency filtering required. Turbulence is not a problem for x-ray imaging, but radiation exposure is. Pelliccia and colleagues speculate that one could pass a weak beam through fragile tissue but use its intensity correlations with a stronger beam that never touches the tissue to produce a low-noise microscopy image. (D. Pelliccia et al., *Phys. Rev. Lett.*, in press; H. Yu et al., *Phys. Rev. Lett.*, in press.)



—RMW

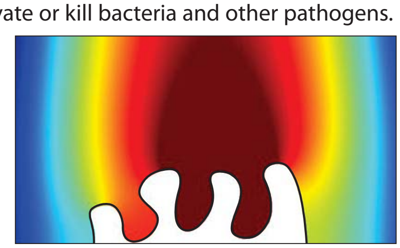
HIGH-VELOCITY CLOUD BLOWS MILKY WAY BUBBLE

Spread through the disk of the Milky Way are about 20 vast bubbles of million-degree plasma wrapped in warm shells of neutral atomic hydrogen. Blowing up a so-called supershell to its typical size of 1000 light-years requires an energy, 10^{45} J, equivalent to at least 30 supernovas. Given that massive short-lived stars cluster in groups of a few dozen, it's indeed possible that supershells are inflated by supernovas. But evidence for an alternative formation scenario has been uncovered recently by Geumsook Park of Seoul National University in Korea and her collaborators. The team used a seven-band receiver at the Arecibo radio telescope in Puerto Rico to resolve the spatial and velocity structure of a supershell known as GS040. At the very center of GS040 they found a high-velocity cloud (HVC). Such clouds contain a million or so solar masses of warm gas and fly through space at speeds 50 km/s higher than is typical for stars and other galactic components. According to previous calculations, when an HVC slams into the galactic disk, it launches a supersonic expansion of hot plasma that is energetic enough to form a supershell. That appears to be what led to the formation of GS040, which, given the shell's current size, took place 5 million years ago. Where did the HVC come from, and how did it acquire its high speed? Park and her colleagues speculate that the HVC is either a fragment of a nearby galaxy that was tidally disrupted by ours or a leftover part of the intergalactic medium from which our galaxy and its neighbors formed. (G. Park et al., *Astrophys. J. Lett.* **827**, L27, 2016.)

—CD

PLASMA DISCHARGE FOR FOOD STERILIZATION

Nonequilibrium plasmas, generated at atmospheric pressure through electric discharge, are in wide commercial use, especially for cleaning surfaces and improving surface adhesion. By producing a range of reactive chemical species, both charged and neutral, they can also inactivate or kill bacteria and other pathogens. When bacteria colonize the surface of fresh fruits and leafy vegetables, they encase themselves in a protective layer known as a biofilm. Plasmas' ability to breach biofilms has caught the attention of the food industry. Yet for plasmas to be deployed as food decontamination tools, their ability to do the job must be understood, controllable, and reproducible. In one step toward that goal, Dawei (David) Liu, Xinpei Lu, and colleagues at China's Huazhong University of Science and Technology and at Shanghai Jiao Tong University have now used a two-dimensional discharge model to analyze the interactions between the plasma and a biofilm on the surface of an apple. In the simulations, which spanned a region 3 mm wide by 5 mm high, the apple served as a floating electrode, and a series of



small proteins, high-frequency MAS NMR can potentially be used on much larger molecules. The main challenge is measurement sensitivity: The larger the protein, the fewer copies of it there are in a 0.5 mg sample, and the weaker the resulting signals. Doubling the size of the molecule under study would require an experiment four times as long. But each of Pintacuda and colleagues' structures was found with less than two weeks of data collection. There is plenty of room to expand.

Johanna Miller

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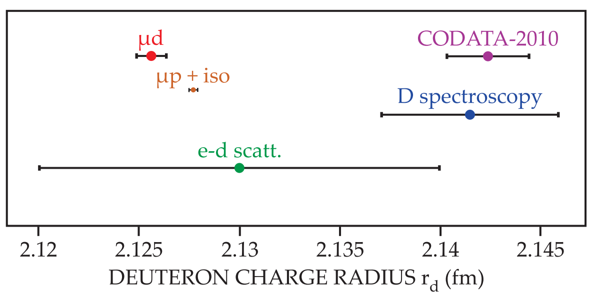
nanosecond pulses of −25 kV applied to a full-width electrode 4 mm above it triggered narrow plasma filaments known as streamers. To calculate the details of the streamers' propagation and interactions with the 400-μm-wide, 100-μm-thick biofilm, shown here in white, the researchers self-consistently accounted for 115 reactions involving 18 different chemical species, photoionization, and biofilm structure and conductivity. They found that localized ionization occurs above the biofilm, and the plasma spreads into the biofilm recesses. Although the biofilm's irregular shape may shield some nooks from reactive chemical species, diffusion between the plasma pulses evens out the distribution to a level that could satisfy decontamination thresholds. (H. Cheng et al., *Phys. Plasmas* **23**, 073517, 2016.) —RJF

DEUTERON JOINS PROTON AS SMALLER THAN EXPECTED

According to the international Committee on Data for Science and Technology (CODATA), the charge radius of the proton is 0.8768(69) fm. Few researchers would give that number much thought if not for measurements in 2010 and 2013 that yielded a radius 4% smaller than and 7.2 standard deviations distant from the CODATA value. Randolf Pohl of the Max Planck Institute of Quantum Optics in Garching, Germany, and colleagues obtained the curiously low radius after analyzing the energy-level shifts of muons orbiting hydrogen nuclei. With a mass 207 times that of the electron, a muon has a tighter orbital that more closely overlaps the nuclear charge distribution, which makes the negatively charged particle a useful tool for probing nuclear dimensions. The discrepancy between the results of muon-based and other experimental investigations has come to be known as the proton radius puzzle.



Now Pohl and his colleagues have used the same technique to measure the radius of the deuteron, a nucleus of one proton and one neutron. The researchers shot a beam of muons at a target of D_2 gas. Lasers excited some of the atoms whose electrons were replaced by muons and probed the muons' energy-level transitions. By combining the measurements with theory, the researchers came up with a deuteron charge radius of 2.12562(78) fm. That's 7.5 σ smaller than the CODATA value (see graph; the new result is in red). In addition, both the proton and deuteron sizes are in tension with the values obtained by applying the same technique to atoms with electrons rather than muons.

The new study reinforces the notion that something is amiss in our understanding of particle or atomic physics. The most tantalizing possibility is that the standard model is wrong—perhaps muons interact with other particles differently than electrons do, for example. Pohl considers that explanation unlikely. His group and others are conducting experiments to precisely measure the Rydberg constant, which, if favorably reevaluated, could resolve the discrepancy. (R. Pohl et al., *Science* **353**, 669, 2016.) —AG

UNRAVELING THE JET-LAG ASYMMETRY

Jet lag, the sluggishness we feel after landing in a new time zone, has a directional bias: Studies suggest it takes longer to recover from eastward travel than from westward travel. A new model developed by Michelle Girvan, Edward Ott, Thomas Antonsen, and colleagues at the University of Maryland, College Park, may explain why. The team used tools of nonlinear dynamics to model a region of the brain known as the suprachiasmatic nucleus (SCN), a network of roughly 20 000 time-keeping neurons devoted to maintaining the body's circadian rhythm. Jet lag happens when those neurons fall out of sync with the local cycle of night and day. Modeling the dynamics of the SCN, however, is a tall order. Although the neurons all take cues from the same source—the retina—they don't all respond in the same way. Nor do they share the same natural oscillation periods; absent visual cues, the periods of the average person's SCN neurons would be distributed around an average value slightly longer than a day—about 24.5 hours. In 2008 Ott and Antonsen devised a way to represent such heterogeneous networks of oscillators in terms of just a few key variables. Now they've applied that approach to the SCN. Their model predicts that the slight deviation of the neurons' natural periods from 24 hours can lead to large recovery-time asymmetries. The worst-case scenario turns out to be an eastward trip across nine time zones: An Angeleno arriving in Paris would require six more days to recover than would a Parisian landing in Los Angeles. (Z. Lu et al., *Chaos* **26**, 094811, 2016.) —AGS PT