PHYSICS UPDATE

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

NEUTRON STARLIGHT GETS QED-FUELED POLARIZATION BOOST

In 1936 Werner Heisenberg and Hans Euler predicted that as a consequence of quantum electrodynamics (QED), strong magnetic fields should affect the propagation of light through a vacuum. The effect, known as vacuum birefringence, is caused by virtual electron–positron pairs that get yanked along in the direction of the field. Light that is polarized in the same direction as the magnetic field should interact more strongly with the raging river of virtual particles, and thus propagate more slowly, than light polarized in other directions.

Because vacuum birefringence scales with the square of magnetic field strength, Nir Shaviv and Jeremy Heyl proposed analyzing the light emitted by neutron stars, which sport fields in excess of 10^{12} gauss. The signature would be a common direction of polarization, since the QED effect ensures that polarization follows the changing direction of the ultrastrong magnetic field.

Now a team led by Roberto Mignani from the National Institute for Astrophysics in Milan, Italy, and the University of Zielona Góra in Poland claims to have detected the signature of vacuum birefringence in optical photons from a neutron star. Using the Very Large Telescope in Chile (pictured above), the astronomers targeted the bright, isolated stellar corpse RX J1856.5–3754, whose surface is not obscured by a dense plasma-filled magnetosphere. The researchers measured a polarization degree of 11–22%, a figure they say is too high to be explained by interstellar magnetic fields and other known factors.

Mignani and colleagues can ensure that they have confirmed Heisenberg and Euler's 80-year-old proposal by probing the neutron star's x rays, which should be nearly 100% polarized. But that study will have to wait: A space telescope that can measure x-ray polarization with sufficient sensitivity probably won't launch for another decade or so. (R. P. Mignani et al., *Mon. Not. R. Astron. Soc.* **465**, 492, 2016.)

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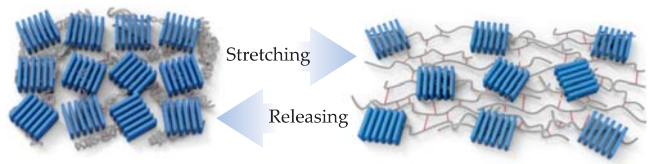
WEARABLE TRANSISTOR CAN HEAL ITS OWN WOUNDS

The ideal wearable electronic device would, in many ways, resemble human skin. It would be stretchable, durable, and able to heal itself when damaged. But semiconductors, key ingredients in electronic devices, are typically hard and brittle. Now a team led by Stanford University's Zhenan Bao has tinkered with the organic polymer diketopyrrolopyrrole (DPP) to create a semiconductor that's flexible and self-healing. On its own, DPP is semiconducting but stiff—it tends to fold into tight, rigid crystals. To make the polymer stretchy, Bao and her coworkers inserted molecules of pyridine dicarboxamide along its molecular backbone. The pyridine dicarboxamide disrupts the crystalline ordering and causes



segments of the polymer to remain floppy and amorphous. (In the illustration, floppy segments are shown in gray, crystalline portions in blue.) The floppy segments are linked by hydrogen bonds (red), which both strengthen the material and give it the ability to self-heal: They'll snap if the polymer is stretched too tight but then spontaneously reform when it's treated with solvent and heat. As a proof of concept, Bao and her colleagues used their semiconducting polymer to build thin-film field-effect transistors, which they mounted on rubber patches and stuck to the hands, arms, and elbows of human test subjects. Hundreds of hand twists, arm folds, and elbow flexes later, the transistors still functioned. Granted, turning the proof-of-concept transistors into commercial devices will take work. For instance, the researchers will need to figure out how to reduce the operating voltage—currently on the order of 10 V—to levels more practical for use in autonomous wearable devices. (J. Y. Oh et al., *Nature* **539**, 411, 2016.)

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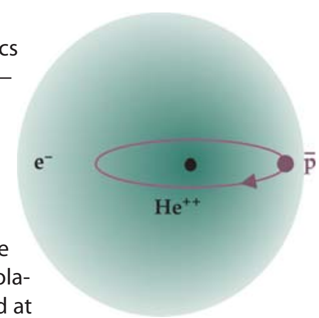
ANTIPROTONIC HELIUM



Underlying nearly all of particle physics is the presumption of *CPT* symmetry—that a system will look the same if, simultaneously, every particle is replaced by its antiparticle, space undergoes mirror reflection, and time runs backward. An immediate corollary is that a particle and its antiparticle will have the same mass. So far, no violations of the corollary have been found at accelerators or in the laboratory, but the hunt continues. (See the article by Maxim Pospelov and Michael Romalis, PHYSICS TODAY, July 2004, page 40.) To obtain the requisite precision, it helps to have samples that are sufficiently cold and sufficiently long-lived. Masaki Hori of the Max Planck Institute for Quantum Optics and colleagues now report that buffer-gas cooling can chill antiprotonic helium to 1.5–1.7 K and that laser spectroscopy on the cooled atoms can offer more-precise measurements of the antiproton-to-electron mass ratio.

In antiprotonic helium ($\bar{p}$He), one of the atom's two electrons has been knocked out and replaced by an antiproton. The antiproton is in an excited, so-called Rydberg state that keeps the antiparticle safely away from protons in the helium nucleus. Meanwhile, the lone electron, whose wavefunction extends well past that of the antiproton, partially shields the antiproton during collisions with other atoms. Nestled in that protective environment, the antiproton survives for microseconds. That margin gave the researchers sufficient time to cool $\bar{p}$He atoms via collisions with cold He gas and then measure the cooled atoms' sharpened spectral lines. The results, collected from two billion $\bar{p}$He atoms over a three-year period, had parts-per-billion precision and achieved comparable agreement with theoretical quantum electrodynamics calculations. Reassuringly, the team found agreement between the proton and antiproton masses to better than 0.5 ppb. (M. Hori et al., *Science* **354**, 610, 2016.)

—RJF