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Researchers at CERN take most precise measure of magnetic moment of antiproton

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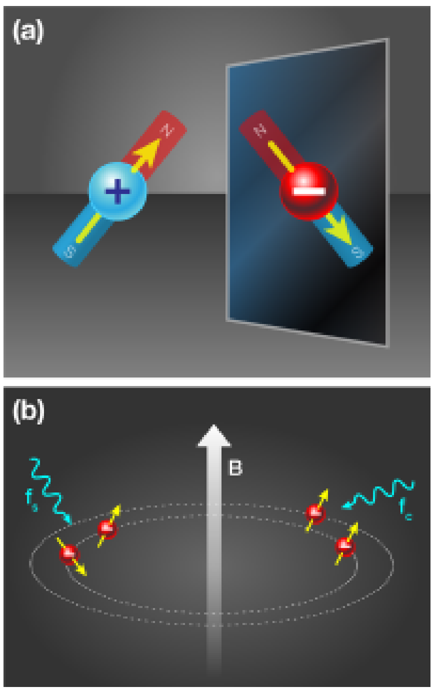

(a) The CPT symmetry can be likened to a mirror that reflects spatial coordinates, flips charge and other additive quantum numbers, and reverses time. To test for cracks in this CPT mirror, physicists check whether the magnetic moment of the proton (left) has the same magnitude as that of the antiproton (right). (Technically, the moments have opposite signs due to the way magnetic moment is defined relative to the spin.) (b) To measure the antiproton's magnetic moment, the ATRAP Collaboration measures the cyclotron and spin-flip frequencies, fc and fs, respectively. The ratio of these frequencies gives the antiproton's magnetic moment in terms of the nuclear magneton μN. Credit: APS/Alan Stonebraker

(Phys.org) —A research team made up of physicists from the US, Canada and Germany has succeeded in making the first individual-particle measurement of the magnetic moment of an antiproton. In their paper published in *Physical Review Letters*, they describe how they managed to capture a single antiproton and measured its magnetic moment in a way that is more precise (by a factor of 680) than any previous measurement efforts to date.

The magnetic moment of an antiproton relates in a broad sense to its angular momentum—theory suggests it should be equal to the magnetic moment of its counterpart, the proton. Testing such theories requires conducting experiments to discern if such symmetry does truly exist. As part of a wide range of experiments meant to compare matter with its antimatter counterparts, researchers look to what is known as "Charge Parity Time" symmetry—the more scientists learn about it, the more they expect to learn about the nature of the universe and to help answer questions such as why there appears to be far more matter than antimatter.

One aspect of such symmetry testing is measuring the magnetic moment of particles such as protons and antiprotons and then comparing them to one another to see if they match. To do that in this latest effort, the research team took equipment that had been developed to measure the magnetic moment of a proton to CERN—it's one of the few places antiprotons can be had. But that was only the beginning, the team had to first slow the antiproton down as it was delivered at near light speed. To do that they shuttled it into a Penning trap—a device that uses magnets to cause particles to orbit around a central hub until they slow down enough to study. They also had to filter out all the other particles that came with the delivery. Overall, the researchers describe the process as very difficult. But in the end, they found success—they took the most precise measurement of the magnetic moment to date of an antiproton and in so doing found that it was close enough to measurements taken of the magnetic moment of protons to proclaim the two to be "exactly opposite"—they have equal strength but opposite spins.

The results obtained by this study add credence to the Standard Model and leads scientists ever closer to gaining a true understanding of how the universe really works at the subatomic level.

More information: One-Particle Measurement of the Antiproton Magnetic Moment, *Phys. Rev. Lett.* 110, 130801 (2013)
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Abstract
For the first time a single trapped antiproton ($\bar{p}$) is used to measure the $\bar{p}$ magnetic moment $\mu_{\bar{p}}$. The moment $\mu_{\bar{p}} = \mu_{\bar{p}} S/(\hbar/2)$ is given in terms of its spin S and the nuclear magneton (μ_N) by $\mu_{\bar{p}}/\mu_N = -2.792\,845 \pm 0.000\,012$. The 4.4 parts per million (ppm) uncertainty is 680 times smaller than previously realized. Comparing to the proton moment measured using the same method and trap electrodes gives $\mu_{\bar{p}}/\mu_p = -1.000\,000 \pm 0.000\,005$ to 5 ppm, for a proton moment $\mu_p = \mu_p S/(\hbar/2)$, consistent with the prediction of the CPT theorem.

Physics Viewpoint