CERN experiment takes us one step closer to discovering where all the antimatter went

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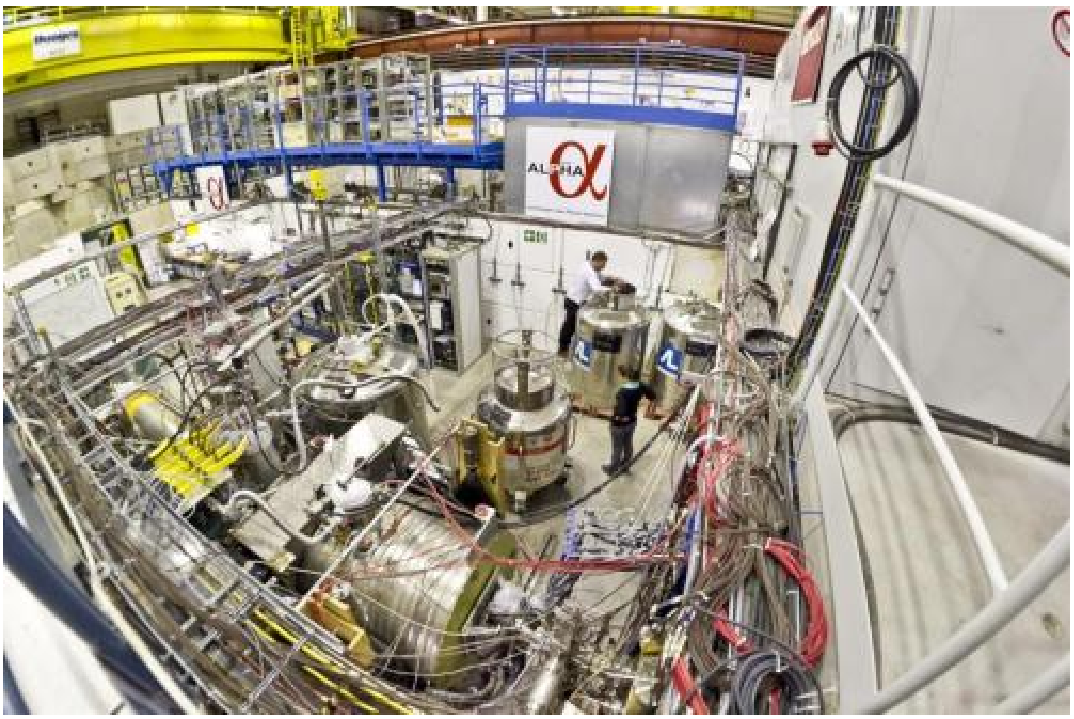

ALPHA experiment facility. Credit: CERN

New research published today by researchers from CERN has brought us a step closer to understanding where all the antimatter has gone. This matter-antimatter asymmetry is one of the greatest challenges in physics and at this moment in time the universe seems to be composed entirely of matter – the only antimatter around is created by us at places like CERN. Yet our theories predict that exactly equal amounts of matter and antimatter would have been created in the Big Bang. So where did all the antimatter go?

This new research, undertaken by the ALPHA experiment at CERN's Antiproton Decelerator (AD) in Geneva, is the first time that the electric charge of an anti-atom has been measured to high precision. Measuring the electric charge of antihydrogen atoms is a way to study any subtle differences between matter and antimatter which could account for the lack of antimatter in the universe.

In a paper published in the journal *Nature Communications* today, the ALPHA experiment reports a measurement of the electric charge of antihydrogen atoms, finding it to be compatible with zero to eight decimal places. This is the first time that the charge of an anti-atom has been measured to high precision and confirms our expectation that the charges of its constituents, the positron and antiproton, are equal and opposite.

"This is the very first study which has made a precise determination of a property of antihydrogen," said Professor Mike Charlton, who leads the UK effort in ALPHA from Swansea University. "This advance was only possible using ALPHA's trapping technique, and we are optimistic that further developments of our programme will yield many such insights in the future. We look forward to the restart of the Antiproton Decelerator program in August, so that we can continue to study antihydrogen with ever increasing accuracy."

Professor John Womersley, particle physicist and Chief Executive of the UK's Science and Technology Facilities Council (STFC) said that, "Though the result is not surprising it is a fundamental test that matter and antimatter have equal and opposite electric charges. It is reassuring that nature behaves as expected, but as scientists we should never take anything for granted and measurements like this are therefore very important indeed."

Antiparticles should be identical to matter particles except for the sign of their electric charge. So while the hydrogen atom is made up of a proton with charge +1 and an electron with charge -1, the antihydrogen atom consists of a charge -1 antiproton and a charge +1 positron. We know, however, that matter and antimatter are not exact opposites - nature seems to have a one-part in 10 billion preference for matter over antimatter. However, we don't know why, so it is important to measure the properties of antimatter to great precision: the principal goal of CERN's AD experiments.

ALPHA achieves this by using a complex system of particle traps that allow antihydrogen atoms to be produced and stored for long enough periods to make detailed studies. Understanding the matter-antimatter asymmetry is one of the greatest challenges in physics today. Any detectable difference between matter and antimatter could help solve the mystery and open a window to new physics.

To measure the charge of antihydrogen, the ALPHA experiment studied the trajectories of antihydrogen atoms released from the trap in the presence of an electric field. If the antihydrogen atoms had an electric charge, the field would deflect them, whereas neutral atoms would be undeflected. The result, based on 386 recorded events, gives a value of the antihydrogen electric charge as $(-1.3 \pm 1.1 \pm 0.4) \times 10^{-8}$, the plus or minus numbers representing statistical and systematic uncertainties on the measurement.

With the restart of CERN's accelerator chain getting underway, the laboratory's antimatter research programme is set to resume soon. Experiments including ALPHA-2, an upgraded version of the ALPHA experiment, will be taking data along with the ATRAP and ASACUSA experiments and newcomer AEGIS, which will be studying the influence of gravity on antihydrogen.

More information: Paper: An experimental limit on the charge of antihydrogen, www.nature.com/ncomms/2014/140 … full/ncomms4955.html

Provided by CERN