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(I) Measuring the gravitational free-fall of antihydrogen

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Antimatter and gravity are subjects of two of the biggest mysteries in physics: How can we explain the observed excess of matter over antimatter in the universe? And, how can the theories of gravity and quantum mechanics be unified? Antihydrogen, as the simplest purely antimatter atomic system, is a natural candidate for experimentally testing some fundamental theories related to these questions. For example, CPT (Charge-Parity-Time) symmetry predicts that the spectra of hydrogen and antihydrogen should be identical. Because the hydrogen spectrum is one of the best understood in physics, similar measurements of antihydrogen can provide a precise test of this symmetry. In addition, because antihydrogen is electrically neutral it can be used as a probe of the gravitational interaction between matter and antimatter. If the weak equivalence principle in general relativity holds, then the gravitational mass of antimatter should be identical to that of matter but so far there have been no direct free-fall style experiments to test this.

The ALPHA antihydrogen experiment at CERN's Antiproton Decelerator has made major strides in the trapping and spectroscopy of antihydrogen. In recent years, the ALPHA collaboration has turned its attention toward the weak equivalence principle with the construction of a new apparatus, known as ALPHA-g, that aims to measure the gravitational acceleration of antihydrogen. In this experiment, antihydrogen atoms are magnetically confined and then allowed to escape up or down. The up-down balance of atoms that escape will allow a measurement of the gravitational acceleration of antihydrogen. ALPHA-g has been successfully commissioned and the first measurement campaign was completed in 2022. This talk will discuss the details of the ALPHA-g apparatus, the experimental methodology, and the latest results of the experiment.

Keyword-1

Fundamental symmetries

Keyword-2

Antimatter

Keyword-3

Gravity

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