Testing fundamental physics with trapped antihydrogen

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Antimatter and gravity are subjects of two of the biggest mysteries in physics. The universe exhibits an excess of matter over antimatter, and unifying gravity and quantum mechanics remains an open challenge. Antihydrogen, the simplest purely antimatter atomic system, is a promising candidate for investigating these fundamental questions [1]. CPT symmetry predicts that the spectra of hydrogen and antihydrogen should be identical, making antihydrogen a tool for precision tests of this symmetry due to the well-understood hydrogen spectrum. Additionally, antihydrogen's electric neutrality makes it an ideal probe of the gravitational interaction between matter and antimatter.

The ALPHA experiment at CERN has made significant progress on both fronts. Major results have recently been published on spectroscopy [2, 3] and cooling [4] of antihydrogen. Additionally, the recently constructed and commissioned ALPHA-g apparatus has enabled a test of Einstein's weak equivalence principle with an antihydrogen gravitational free-fall experiment. This talk will discuss the most recent results from the ALPHA collaboration on spectroscopy and gravity measurements with antihydrogen as well as future prospects for precision measurements.

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[1] M. Charlton, S. Eriksson, and G. M. Shore. "Antihydrogen and Fundamental Physics" (Springer Cham, 2020).
[2] M. Ahmadi et al. (ALPHA collaboration). Nature 557, 71 (2018).
[3] M. Ahmadi et al. (ALPHA collaboration). Nature 578, 375 (2020).
[4] C.J. Baker et al. (ALPHA collaboration). Nature 592, 35 (2021).