Measuring the ground state hyperfine splitting of antihydrogen in the ALPHA experiment

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The matter-antimatter asymmetry problem remains one of the biggest unresolved questions in physics. Antihydrogen, as the simplest purely antimatter atomic system, provides a natural platform for testing CPT symmetry and potentially shedding light on this mystery. Precise measurements of antihydrogen's transition frequencies, compared to their well-established counterparts in hydrogen, offer a stringent test of CPT symmetry in the atomic sector. In particular, microwave spectroscopy of the ground-state hyperfine splitting presents a promising avenue. In hydrogen, this transition has been measured to a precision of 1×10^{-12} [1] and an absolute precision of 2 mHz (compared to 10 Hz for the 1S – 2S transition).

The ALPHA collaboration at CERN has been leading the way in testing fundamental symmetries using magnetically trapped antihydrogen. Recent breakthroughs include precision spectroscopy of the 1S–2S transition [2], fine structure measurements [3], laser cooling of antihydrogen [4], and the first-ever gravitational free-fall study of antihydrogen [5]. Advances in magnetic field control and enhanced antihydrogen trapping rates, enabled by Be+ ion assisted antihydrogen production, have also opened new possibilities for microwave spectroscopy. In this talk, I will present ALPHA's latest hyperfine spectroscopy experiments and discuss prospects for even higher precision measurements in the near future.

References

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