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Improved precision on the measurements of low energy antimatter in the ALPHA experiment

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Antihydrogen is one of the most simple pure antimatter bound states, which can be synthesised and trapped for extended periods of time by the ALPHA collaboration since 2010 [1]. A consequence of CPT symmetry is that antimatter bound states will present the same energy spectrum as their matter equivalents, and over the last five years ALPHA have measured antihydrogen transitions as a direct test of this fundamental symmetry [2][3][4]. Through upgrading metrology instrumentation at ALPHA it will become possible to measure antihydrogen transition energies with the best precision yet. Specifically, the collaboration intends to improve the frequency reference precision by two orders of magnitude via the inclusion of a Caesium fountain clock and Hydrogen maser to replace the GPS-disciplined quartz oscillator reference. The metrology upgrades alongside the recent implementation of laser cooling antihydrogen [5] will signifiantly improve the precision on the measurement of the 1S-2S antihydrogen transition, in the bid to one day reach parity or surpass the precision of similar measurements made with hydrogen.

[1] G. B. Andresen et al. (ALPHA-Collaboration). Trapped antihydrogen. Nature 468, 673 (2010)
[2] M. Ahmadi et al. (ALPHA-Collaboration). Observation of the 1S–2S transition in trapped antihydrogen. Nature 541, 506–510 (2017)
[3] M. Ahmadi et al. (ALPHA-Collaboration). Observation of the hyperfine spectrum of antihydrogen. Nature 548, 66–69 (2017)
[4] M. Ahmadi et al. (ALPHA-Collaboration). Observation of the 1S–2P Lyman-α transition in antihydrogen. Nature 561, 211–215 (2018)
[5] C. J. Baker et al. (ALPHA collaboration). Laser cooling of antihydrogen atoms. Nature 592, 35-42 (2021).

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