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Precision improvements for laser spectroscopy of anti-hydrogen in the ALPHA experiment

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A high priority in the worldwide search for 'New Physics' involves testing violations of fundamental symmetries. In particular, one the largest remaining cosmological questions is why the observable universe is populated by only matter, rather than equal amounts of matter and antimatter. By comparing the results of precise laser spectroscopy of both matter and antimatter, CPT symmetry can be directly tested. Since the 1S-2S transition in hydrogen has been measured with unmatched precision [1], the ALPHA experiment has performed ultrahigh precision spectroscopy on the equivalent transition in antihydrogen [2]. By a combination of improvements in ion-trapping [3], laser cooling [4] and metrology instrumentation such as the use of a Caesium fountain clock, we aim to achieve the highest ever precision spectroscopy of the 1S-2S transition in antihydrogen. I will discuss the latest progress in the laser setup and the metrology techniques required to achieve such precision.

[1] C. G. Parthey et al. Improved Measurement of the Hydrogen 1S - 2S Transition Frequency. Phys. Rev. Lett. 107, 203001 (2011)

[2] M. Ahmadi et al. (ALPHA collaboration). Characterization of the 1S-2S Transition in Antihydrogen. Nature 557, 71-75 (2018).

[3] G. B. Andresen et al. (ALPHA collaboration). Trapped Antihydrogen. Nature 468, 673-676 (2010)

[4] C. J. Baker et al. (ALPHA collaboration). Laser cooling of antihydrogen atoms. Nature 592, 35-42 (2021).

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