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Laser cooling of antihydrogen using pulsed VUV radiations

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The ALPHA (Antihydrogen Laser PHysics Apparatus) Collaboration at CERN is engaged in precision tests of fundamental symmetries between matter and antimatter. A primary goal is to study the optical spectroscopy of antihydrogen, the bound state of an antiproton and positron. Recent progress in the synthesis and confinement of antihydrogen has resulted in the availability for spectroscopy of a thousand trapped anti-atoms at a time. The two-photon 1S-2S transition frequency has been measured to a relative precision of 2×10^{-12}, only some three orders of magnitude away from the precision of normal hydrogen atom. In order to further improve the measurement accuracy, we are now implementing laser cooling of trapped antihydrogen via the 1S- 2P transition using a nano-second VUV laser pulses. The 1S-2P manifold contains a cycling transition, presenting the possibility of laser cooling of antimatter, but the control of the 1S- 2P excitation is challenging due to the lack of convenient VUV laser source. We have developed an all solid state, narrow linewidth, nano-second pulsed laser system at 121.6 nm and successfully demonstrated that the 1S- 2P transition of antihydrogen can be controlled with a precision of better than several tens of MHz at 121.6 nm. This accuracy is enough to cool antihydrogen from the present 500 mK temperature to a few tens of mK. We will discuss how the cooling of trapped atoms with pulsed laser radiation works, and will also report the status and outlook for laser cooling of antihydrogen.

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