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Trapped antihydrogen: the ALPHA experiment at CERN

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It has been just over 100 years since Niels Bohr proposed his famous model for the hydrogen atom. It is thus very exciting that we are now actually able to experimentally study antihydrogen - the antimatter equivalent of hydrogen. The question to be addressed is fundamental and profound: "Do matter and antimatter obey the same laws of physics?"The so-called Standard Model of fundamental particles and interactions requires that hydrogen and antihydrogen have the same spectrum. At CERN in Geneva, the ALPHA collaboration is working to test this requirement by performing direct spectroscopic measurements on trapped atoms of antihydrogen. Antihydrogen atoms have been produced in quantity at CERN since 2002, when the ATHENA collaboration demonstrated[1] how to mix cryogenic plasmas of antiprotons and positrons to produce low energy anti-atoms. I will discuss the newest development along the road to antihydrogen spectroscopy: magnetically trapped antihydrogen. In November of 2010 we reported[2] the first trapping of antihydrogen atoms in a magnetic multipole trap. The atoms must be produced with an energy - in temperature units - of less than 0.5 K in order to be trapped. Subsequently, we have shown that trapped antihydrogen can be stored[3] for up to 1000 s, and we have performed the first resonant quantum interaction experiments with anti-atoms[4]. We have recently demonstrated a new technique[5] to study the gravitational behaviour of antihydrogen atoms in free-fall, and we have put a limit on the charge of antihydrogen[6]. I will discuss the many developments necessary to realise trapped antihydrogen, and I will consider the future of this rapidly evolving field of study.

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2. Andresen, G.B. et al., Trapped Antihydrogen, Nature, 468, 673 (2010).

3. Andresen, G. B. et al. Confinement of antihydrogen for 1,000 seconds. Nature Physics 7, 558 (2011).

4. Amole, C. et al., Resonant quantum transitions in trapped antihydrogen atoms, Nature 483, 439 (2012).

5. Amole, C. et al., Description and first application of a new technique to measure the gravitational mass of antihydrogen, Nature Communications DOI: 10.1038/ncomms2787 (2013)

6. Amole, C. et al., An experimental limit on the charge of antihydrogen,
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