## 3rd Jagiellonian Symposium on Fundamental and Applied Subatomic Physics



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## Illuminating Antimatter: the ALPHA antihydrogen experiment at CERN

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At CERN, we have recently become able to study atoms of 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 Standard Model requires that hydrogen and antihydrogen have the same spectrum. I will discuss the latest developments in antihydrogen physics: observation of the first laser-driven transition (1S-2S) [1,2] observation of the antihydrogen hyperfine structure [3], and observation of the Lyman-alpha transition [4]. To study antihydrogen, it must first be produced, trapped [5], and then held for long enough [6] to observe a transition - using very few anti-atoms. I will discuss the techniques necessary to achieve the latest milestones, and then consider the future of optical and microwave spectroscopy, as well as gravitational studies [7], with antihydrogen.

- Observation of the 1s-2s Transition in Trapped Antihydrogen, M Ahmadi et al., (ALPHA Collaboration) Nature 541, 506–510 (2017). 2 Characterization of the 1S-2S transition in antihydrogen, M Ahmadi et al., (ALPHA Collaboration), Nature 557, 71–75 (2018). 3, Observation of the hyperfine spectrum of antihydrogen, M Ahmadi et al., (ALPHA Collaboration) Nature 548, 66–69 (2017).
- 2. Observation of the 1S–2P Lyman- $\alpha$  transition in antihydrogen, M Ahmadi et al., (ALPHA Collaboration), Nature 561, 211–215 (2018).
- 3. Andresen, G.B. et al., Trapped Antihydrogen, Nature, 468, 673 (2010).
- 4. Andresen, G. B. et al. Confinement of antihydrogen for 1,000 seconds. Nature Physics 7, 558 (2011).
- 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).

Primary author: HANGST, Jeffrey (Aarhus University, ALPHA Collaboration at CERN)
Presenter: HANGST, Jeffrey (Aarhus University, ALPHA Collaboration at CERN)
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