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Towards the controlled formation of antiprotonic atoms at AEGIS

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The Antimatter Experiment: Gravity, Interferometry, Spectroscopy (AEgIS) at CERN's Antimatter Decelerator (AD) is used for the production and study of antimatter bound systems, such as antihydrogen for the gravitational influence on a horizontal beam of cold antihydrogen atoms [1]. AEGIS has achieved remarkable performance in trapping antiprotons and successfully demonstrated the pulsed production of Rydberg excited antihydrogen [2,3]. The production process of antihydrogen is achieved through a charge-exchange reaction using laser-excited Rydberg positronium interacting with cold antiprotons stored within a Penning-Malmberg trap.

This technique is currently being adapted for the controlled formation of antiprotonic atoms containing medium-heavy nuclei [4]. So far, antiprotonic atoms were formed in beam-on-target experiments, primarily focusing on light systems such as antiprotonic helium [5,6]. Using the charge-exchange procedure developed for antihydrogen production, antiprotonic atoms can be selectively formed in highly excited Rydberg states inside a trapping environment, enabling precision spectroscopy of these systems. The relaxation of the bound antiproton leads to Auger electron and x-ray photon emission, eventually forming a fully or nearly fully stripped nucleus with the bound antiproton. The subsequent annihilation on the nucleus will result in the formation of highly charged nuclear fragments which can be captured within a nested trap. The rapid capture of the highly charged nuclear fragments opens the avenues for new applications and nuclear structure studies [7].

Recent, experiments at AEgIS have successfully demonstrated the trapping of fully stripped nuclear fragments resulting from antiprotons annihilating with residual nitrogen gas in the cryogenic trap. These highly charged fragments were manipulated and identified through a time-of-flight spectroscopy. Furthermore, the ongoing installation of a negative ion source will allow the first co-trapping of negative ions with cold antiprotons for the controlled laser-triggered formation of antiprotonic atoms. These new developments pave the way for precision studies using antiprotonic atoms and exotic highly charged nuclei at AEgIS.

[1] M. Doser et al. 2012 Class. Quantum Grav. 29 184009
[2] D. Krasnicky et al. 2016 Phys. Rev. A 94 022714
[3] C. Amsler et al. 2021 Commun. Phys. 4 19
[4] Doser, M. Progress in Particle and Nuclear Physics (2022): 103964.
[5] Hori, Masaki, et al. PRL 87.9 (2001): 093401.
[6] Sótér, Anna, et al. Nature 603.7901 (2022): 411-415.
[7] Kornakov, G., et al. Phys. Rev. C 107.3 (2023): 034314.

Author: PARNEFJORD GUSTAFSSON, Fredrik Olof Andre (CERN)

Co-authors: LINEK, Adam Ryszard (Nicolaus Copernicus University (PL)); GISZCZAK, Anna (Warsaw University of Technology (PL)); CAMPER, Antoine (University of Oslo (NO)); BERGMANN, B. (Institute of Experimental and Applied Physics, Czech Technical University in Prague, Husova 240/5, 110 00, Prague 1, Czech Republic); RIENACKER, Benjamin (University of Liverpool (GB)); Mr RAWAT, Bharat Singh (University of Liverpool / Cockcroft Institute); WELSCH, Carsten Peter (Cockcroft Institute / University of Liverpool); TEFELSKI, Dariusz (Warsaw University of Technology (PL)); NOWICKA, Dorota (Warsaw University of Technology (PL)); CASTELLI, Fabrizio (Università degli Studi e INFN Milano (IT)); GUATIERI, Francesco (Universita degli Studi di Trento and INFN (IT)); PRELZ, Francesco (Università degli Studi e INFN Milano (IT)); KORNAKOV, Georgy (Warsaw University of Technology (PL)); CERCHIARI, Giovanni; CONSOLATI, Giovanni (Politecnico di Milano (IT)); KASPROWICZ, Grzegorz (Warsaw University of Technology (PL)); KHATRI, Gunn (CERN); SANDAKER, Heidi (University of Oslo (NO)); ZIELINSKI, Jakub (Warsaw University of Technology (PL)); ELIASZUK, Kamil (Warsaw University of Technology (PL)); LAPPO, Lidia Kalina (Warsaw University of Technology (PL)); GLOGGLER, Lisa Theresa (CERN); PENASA, Luca (Universita degli Studi di Trento and INFN (IT)); POVOLO, Luca (Universita degli Studi di Trento and INFN (IT)); GRACZYKOWSKI, Lukasz (Warsaw University of Technology (PL)); Dr KLOSOWSKI, Lukasz (Nicolaus Copernicus University (PL)); AUZINS, M. (University of Latvia, Department of Physics Raina boulevard 19, LV-1586, Riga, Latvia); JANIK, Malgorzata Anna (Warsaw University of Technology (PL)); GROSBART, Malgorzata (CERN); Mr VOLPONI, Marco (Universita degli Studi di Trento and INFN (IT)); PIWINSKI, Mariusz (Nicolaus Copernicus University (PL)); GERMANN, Matthias; DOSER, Michael (CERN); ZAWADA, Michal (Nicolaus Copernicus University); GUSAKOVA, Natali (Norwegian University of Science and and Technology (NTNU) (NO)); ZURLO, Nicola (Universita di Brescia (IT)); ROHNE, Ole (University of Oslo (NO)); BURIAN, P. (Institute of Experimental and Applied Physics, Czech Technical University in Prague, Husova 240/5, 110 00, Prague 1, Czech Republic); MOSKAL, Pawel (Jagiellonian University); Dr SMOLYANSKIY, Petr (Czech Technical University in Prague (CZ)); BRUSA, R. S (Department of Physics, University of Trento, via Sommarive 14, 38123 Povo, Trento, Italy fTIFPA/INFN Trento, via Sommarive 14, 38123 Povo, Trento, Italy); CIURYLO, Roman Jerzy (Nicolaus Copernicus University (PL)); CARAVITA, Ruggero (Universita degli Studi di Trento and INFN (IT)); RANGWALA, Sadiq; HUCK, Saiva (Hamburg University (DE)); MARIAZZI, Sebastiano (Universita degli Studi di Trento and INFN (IT)); POSPISIL, Stanislav (Czech Technical University in Prague (CZ)); HAIDER, Stefan (CERN); SHARMA, Sushil (Jagiellonian University (PL)); RAUSCHENDORFER, Tassilo (Universitaet Leipzig (DE)); SOWINSKI, Tomasz (Polish Academy of Sciences (PL)); JANUSZEK, Tymoteusz Henryk (Warsaw University of Technology (PL)); KRUMINS, Valts (University of Latvia (LV)); PETRACEK, Vojtech (Czech Technical University (CZ)); RODIN, Volodymyr (CERN)

Presenter: PARNEFJORD GUSTAFSSON, Fredrik Olof Andre (CERN)

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