



Laser cooling of molecular anions for sympathetic cooling of antiprotons

Tuesday, 26 September 2023 19:30 (2 hours)

The Antimatter Experiment: Gravity, Interferometry, Spectroscopy (AEGIS) at CERN utilizes cold antiproton beams from the Antimatter Decelerator to study gravitational effects on antihydrogen beams. The pulsed production of Rydberg excited antihydrogen is achieved through a charge exchange reaction between laser-excited Rydberg positronium and cold antiprotons. This same technique is now being adapted for creating cold antiprotonic atoms through charge exchange with Rydberg excited atoms within the trap.

At present, the antiprotons are sympathetically cooled by co-trapped electrons, which can reach temperatures down to tens of K. However, to achieve much lower plasma temperatures, laser cooling is required. Antiprotons can be sympathetically cooled using a laser-cooled species with a negative charge. Among various anions studied, the diatomic molecular anion C_2^- emerges as a promising candidate due to its well-known level scheme, absence of hyperfine structure, and high Franck-Condon factors. Simulations indicate that laser-cooled C_2^- could enable antiprotons to reach millikelvin temperatures within the Penning-Malmberg trap at AEGIS. This would pave the way for the novel formation of Super Rydberg antiprotonic atoms for precision QED studies and cold antihydrogen for measuring the influence of gravity on antimatter.

A proof-of-principle setup at CERN has been successful in generating pulsed beams of C_2^- molecules and trapping them in a Paul trap. Ongoing spectroscopic measurements aim to investigate the ro-vibronic ground state fraction post pulsed production, followed by the first photodetachment cooling of the molecular anion. Subsequent studies will explore non-destructive cooling methods, such as Sisyphus cooling, necessary for sub-K sympathetic cooling of the antiprotons.

Primary authors: PARNEFJORD GUSTAFSSON, Fredrik (CERN); CAMPER, Antoine (University of Oslo); DOSER, Michael (CERN); CARAVITA, Ruggero (University of Trento); HAIDER, Stefan (CERN); KRUMINS, V (CERN); BERGMANN, B (Institute of Experimental and Applied Physics, Czech Technical University in Prague, Husova 240/5, 110 00, Prague 1, Czech Republic); BRUSA, R. S. (TIFPA/INFN Trento, via Sommarive 14, 38123 Povo, Trento, Italy); CASTELLI, F. (INFN Milano, via Celoria 16, 20133 Milano, Italy); CIURYLO, R. (Institute of Physics, Faculty of Physics, Astronomy, and Informatics, Nicolaus Copernicus University in Torun, Grudziadzka 5, 87-100 Torun, Poland); CONSO-LATI, G. (INFN Milano, via Celoria 16, 20133 Milano, Italy); FARRICKER, A. (University of Liverpool, UK and The Cockcroft Institute, Daresbury, UK); GROSBART, Malgorzata (CERN); GLÖGGLER, L. (Physics Department, CERN, 1211 Geneva 23, Switzerland); GRACZYKOWSKI, L. (Warsaw University of Technology, Faculty of Physics ul. Koszykowa 75, 00-662, Warsaw, Poland); GUATIERI, F. (TIFPA/INFN Trento, via Sommarive 14, 38123 Povo, Trento, Italy); GUSAKOVA, N. (Department of Physics, NTNU, Norwegian University of Science and Technology, Trondheim, Norway); HUCK, Saiva (CERN); JANIK, M (Warsaw University of Technology, Faculty of Physics ul. Koszykowa 75, 00-662, Warsaw, Poland); KASPROWICZ, G (Warsaw University of Technology, Faculty of Physics ul. Koszykowa 75, 00-662, Warsaw, Poland); KHATRI, G; KLOSOWSKI, L (Institute of Physics, Faculty of Physics, Astronomy, and Informatics, Nicolaus Copernicus University in Torun, Grudziadzka 5, 87-100 Torun, Poland); KORNAKOV, Georgy (Warsaw University of Technology); LAPPO, L; LINEK, Adam (Nicolaus Copernicus University in Torun); MALAMANT, Jan (University of Oslo); MALBRUNOT, C.; MARIAZZI, S; NOWAK, L; NOWICKA, D. (Warsaw University of Technology, Faculty of Physics ul. Koszykowa 75, 00-662, Warsaw,

Poland); OSWALD, E (Physics Department, CERN, 1211~Geneva~23, Switzerland); PENASA, L. (TIFPA/INFN Trento, via Sommarive 14, 38123~Povo, Trento, Italy); PRELZ, F. (INFN Milano, via Celoria 16, 20133~Milano, Italy); RIENACKER, B (University of Liverpool, UK and The Cockcroft Institute, Daresbury, UK); RODIN, V (University of Liverpool, UK and The Cockcroft Institute, Daresbury, UK); ROHNE, O.M. (Department of Physics, University of Oslo, Sem Sælandsvei 24, 0371~Oslo, Norway); SANDAKER, H (Department of Physics, University of Oslo, Sem Sælandsvei 24, 0371~Oslo, Norway); SMOLYANSKIY, P (Institute of Experimental and Applied Physics, Czech Technical University in Prague, Husova 240/5, 110 00, Prague 1, Czech Republic); SOWINSKI, T. (Institute of Physics, Polish Academy of Sciences, Aleja Lotnikow 32/46, PL-02668 Warsaw, Poland); TEFELSKI, D. (Warsaw University of Technology, Faculty of Physics ul. Koszykowa 75, 00-662, Warsaw, Poland); VOLPONI, Marco (CERN); WELSCH, C.P. (University of Liverpool, UK and The Cockcroft Institute, Daresbury, UK); ZAWADA, M. (Institute of Physics, Faculty of Physics, Astronomy, and Informatics, Nicolaus Copernicus University in Toruń, Grudziadzka 5, 87-100 Toruń, Poland); ZIELINSKI, J. (Warsaw University of Technology, Faculty of Physics ul. Koszykowa 75, 00-662, Warsaw, Poland); ZURLO, N (INFN Pavia, via Bassi 6, 27100~Pavia, Italy)

Presenter: PARNEFJORD GUSTAFSSON, Fredrik (CERN)

Session Classification: Tuesday Poster