Overview of the status of the PAX/APEX pair plasma project

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By combining recent progress in the fields of toroidal non-neutral plasmas and antimatter physics, we aim to create magnetically-confined electron-positron pair plasmas [1] in a dipole magnetic configuration [2]. Experimental verification of the pair plasma properties, such as remarkable stability [3] and wave propagation characteristics, is the final goal of the project. Ultimately, intense slow positrons from NEPOMUC (NEutron induced POsitron source MUniCh) [4] will be accumulated in PAX (Positron Accumulator eXperiment) by using the so-called buffer gas technique [5], and then transported to and confined in the levitated dipole trap APEX (A Positron Electron eXperiment) together with an equal number of electrons. Our key challenges include the accumulation of a large number of positrons in PAX, highly efficient transport of positrons from the NEPOMUC beamline into the closed dipole field lines of APEX, and stable and simultaneous trapping of positrons and electrons as plasmas therein. Based on beam characterization [6] and numerical orbit analysis, we have realized essentially lossless injection of positrons into a prototype dipole field trap created by a permanent magnet. After injection, we observed more than 1 s of long trapping of positrons in the dipole magnetic field. This was realized by carefully eliminating the asymmetry of the electric fields in the system and reducing the loss channel of positrons toward the magnet poles. Based on these initial results in the prototype dipole trap [7], we are conducting design and construction studies for a buffer gas type positron accumulator and a superconducting levitated dipole configuration for pair plasma confinement. This work is supported by the European Research Council (T. Sunn Pedersen, ERC-2016-ADG No.741322).

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