Injection and trapping of electrons in a dipole magnetic field: towards the formation of an electron-positron plasma

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A project is under way to generate an electron-positron pair plasma in a laboratory [1]. Studies on the pair plasmas are important for the understanding of basic properties of plasmas and elementary processes in astrophysics. We plan to generate the electron-positron plasma by combining a Positron Accumulation Experiment (PAX) and A Positron-Electron eXperiment (APEX) [1], which are to be operated at the NEPOMUC facility, the strongest DC moderated positron source in the world [2]. The positron beam from NEPOMUC will be accumulated in a multi-cell trap of PAX, and on the order of 10^{11} positrons will be transported in the toroidal configuration of APEX, where they will be trapped together with electrons to form a plasma. Closed field lines are needed for APEX, and they will be realized by using a stellarator or a dipole field trap generated by a levitated superconducting magnet. While excellent confinement properties are expected in these toroidal configurations, development of particle injection methods is an essential issue. In this study, we use electron beams to test the feasibility of a method for drift injection of charged particles [1] into the confinement region. According to the numerical analysis of charged particle orbits in the dipole magnetic field and external electric fields, more than 80% of the injected particles are transported into the confinement region and take long orbits. Based on the calculations, we constructed a prototype dipole field device with a permanent neodymium magnet. Although the field lines are intercepted by material objects in this prototype non-levitated device, we can nevertheless investigate and optimize the injection scheme of charged particles into the relevant dipole geometry. We also plan to study the confinement properties of electron plasmas in the dipole field by using the effects of a mirror trap and a negatively biased magnet for suppression of end losses. The numerical and experimental results will be reported.

[1] T S Pedersen *et al.*, 2012 New J. Phys. **14**, 035010

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