Toward Realization of Electron-Positron Plasma in the Lab: Initial Results on the Injection of an Intense Positron Beam into a Dipole Magnetic Field

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As a first step toward creation of the world’s first laboratory electron-positron plasma, we report on initial efforts to inject positrons from an intense nuclear reactor-based positron source into a dipole magnetic field. The motivation for this work is the first experimental test of the predicted unique properties of plasma consisting of equal mass species – so-called “pair plasma”. Two toroidal configurations show promise for confining either non-neutral positron plasma or quasi-neutral electron-positron plasma: the magnetic dipole and the stellarator. Initial experiments have been conducted to test schemes for injecting positrons into the dipole field produced by a supported permanent magnet; these experiments include investigation of using the ExB drift to inject positrons into the confinement region and initial tests of in situ remoderation on a W crystal to produce low energy positrons close to the confinement region. The ExB drift is effective in steering the positron beam into the dipole field despite strong mirror forces. These experiments were conducted at the NEPOMUC (Neutron-Induced Positron Source Munich) facility located at the FRM II research reactor at the Technical University of Munich (Garching campus). This positron source has an intensity on the order of $10^9$ positrons per second and represents a unique facility for ultimately producing electron-positron plasma with Debye lengths that are small compared to the system size. Two future experiments are planned, one using a levitated superconducting dipole coil and another using closed magnetic surfaces in a stellarator.