Abstract of Workshop on Physics with Ultra Slow Antiproton Beams,
RIKEN, March 14-16, 2005.

Confinement of toroidal non-neutral plasma in Proto-RT

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In contrast to linear configurations for non-neutral plasmas, toroidal devices allow us to trap charged particles without the use of a plugging electric field. Thus it has a potential ability to confine high-energy particles or to simultaneously trap multiple particles with different charges. In spite of the relatively long history of the study in pure toroidal magnetic field devices, toroidal non-neutral plasmas are attracting renewed interest with the use of magnetic surface configurations [1, 2]. Possible applications of toroidal trap for non-neutral plasmas are formation of matter-antimatter plasmas [2], investigation on the fundamental properties of exotic plasmas including pair (equal mass) plasmas, and experimental test on the equilibrium and stability of flowing plasmas [3].

As an initial test on non-neutral plasmas in the toroidal magnetic-surface geometry, formation and confinement properties of pure electron plasma have been investigated at Prototype-Ring Trap (Proto-RT) device with a dipole magnetic field [1, 4, 5]. Electrons can be injected by using chaotic orbits near a magnetic null line generated by the combination of dipole and vertical magnetic fields [4]. The confinement time of electrons is limited due to the effects of collisions with remaining neutral gas, and electrons of $\sim 10^{12}$ are trapped for ~0.5s in the typical magnetic field strength of 100G and back pressure of 4×10^{-7}Torr in Proto-RT. Although the present experiment was carried out on the single-component plasma, the result shows that a stable confinement geometry has been realized for toroidal non-neutral plasmas by using the magnetic surface configuration.

Together with the recent experiments on the toroidal pure electron plasma in Proto-RT, preliminary prospects for the injection and trap of anti-protons and positrons in the toroidal magnetic surface configuration, and creation of multi-component plasmas will be described.

References:

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