Confinement and dynamics of electron-rich plasmas in the Columbia Non-neutral Torus

T. Sunn Pedersen, J. W. Berkery, A. H. Boozer, Q. R. Marksteiner, M. S. Hahn, P. W. Brenner, B. Durand de Gevigney, J. P. Kremer, R. G. Lefrancois, H. Himura[a]
Department of Applied Physics and Applied Mathematics, Columbia University, New York, NY 10025, USA
[a] *Kyoto Institute of Technology, Department of Electronics, Matsugasaki, Kyoto, Japan*

tsp22@columbia.edu

The Columbia Non-neutral Torus (CNT) is a compact, two-period stellarator created from four circular coils, dedicated to the study of non-neutral and electron-positron plasmas on magnetic surfaces [1]. First results included the confirmation that pure electron plasmas can be confined stably in a stellarator, that confinement times of up to 20 msec can be achieved, and that confinement is limited by the perturbing presence of internal rods [2], as well as by electron-neutral collisions [3]. In the absence of perturbing rods, and at neutral pressures of 2×10^{-10} Torr, we expect a confinement time exceeding 1 second. Despite these rather long confinement times, the electron-neutral limited confinement time is much smaller than expected from neoclassical predictions, and is on the order of the electron-neutral collision time. The electron orbits in CNT are now being investigated numerically.
At neutral pressures $< 10^{-7}$ Torr and magnetic field strengths $B > 0.02$ T, the plasmas are rather quiescent and well confined. At higher neutral pressures (and consequently, higher ion fraction), and lower B-field strengths, oscillations [4] and confinement jumps are seen. The oscillations that are observed are generally periodic or near-periodic with frequencies in the $10 - 50$ kHz range, and result from an interaction between the ion and electron fluids. These oscillations decrease the confinement somewhat. The confinement jumps are sudden and occur at specific values of the emission current of electrons from the emitting filament that sustains the plasma. The confinement change can be as large as a factor of two, and shows hysteretic behavior. A copper mesh boundary, conforming to the shape of the last closed flux surface, is being installed in CNT, and will be used to impose an electrostatic boundary condition that conforms to the magnetic surface shape, minimizing electrostatic potential variations on the outer magnetic surfaces. An increase in confinement is expected with this new boundary. The electrostatic boundary will also be used to diagnose the plasma from the outside. Combined with the now operational retractable emitter, this will allow studies of electron plasmas unperturbed by internal material objects. The absence of internal objects should also improve confinement and is necessary for future experiments with electron-positron plasmas.

[1] T. Sunn Pedersen et al., Phys. Plasmas **13** (2006) 012502
[2] J. P. Kremer et al., Phys. Rev. Letters **97** (2006) 095003
[3] J. W. Berkery et al., Phys. Plasmas **14** (2007) 062503
[4] Q. R. Marksteiner et al., submitted to Phys. Rev. Letters (2007)