Seminar

Institute for Plasma Research

Title : Achievement of Long-time Confinement of Electron Plasmas through Investigation and Control of Instabilities in SMARTEX-C

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Venue : Seminar Hall, IPR

Abstract :

Cylindrical electron plasma trapped in Penning-Malmberg (P-M) traps are routinely confined for very long-times (several hours to few days) owing to the perfect confinement guaranteed by conservation of canonical angular momentum of these plasmas.The confined electron plasma evolves towards thermal equilibrium via electron-electron collisions. The perfect confinement of the electron plasmas at quiescence around equilibrium in P-M trap has allowed the investigation of many basic plasma physics phenomena with great details such as equilibrium, stability, transport, instabilities, vortex dynamics of ideal 2-D incompressible fluid, etc. Investigation of cross-field particle and energy transport in these devices have led to the development of new transport theories of long-range interactions via E x B drift collisions.In contrast,attempts to confine electron plasmas in toroidal geometry with purely toroidal B-field, even though chronologically preceded linear trap, had been plagued with poor results. Experiments with electron plasmas in small-aspect ratio torus were initiated at Institute for Plasma Research in the late eighties and proved the existence of the equilibrium in toroidal devices with several effects of strong toroidicity. Confinement times, however, were limited to few 100μs. Later, implementation of the concept of cylindrical P-M trap in toroidal geometry (by breaking the toroidal symmetry) led to experiments in a new and upgraded device named SMARTEX-C (SMall Aspect Ratio toroidal Electron plasma eXperiment in 'C' shaped geometry). Injection of charges along the magnetic field became possible, allowing,for the first time,successful trapping and confinement of the electrons for ~few ms, limited by the pulse length of the toroidal B-field along with presence of instabilities.

In the present thesis work, up-gradation of the trap by increasing the B-field pulse length and improving vacuum conditions led to mitigation of instabilities and excellent confinement of electron plasma in steady state (beyond 10s). Work includes characterizing and identifying the instabilities of electron plasmas observed in SMARTEX-C which has led to determine the parameter regime where instabilities can be controlled and quiescent toroidal electron plasma can be confined in steady-state. Excellent confinement led to the controlled electron plasma experiments in SMARTEX-C. Numerical simulations of a trapped charged particle were also carried out, and when correlated with experiments, gave us some interesting insight into the evolution of the charge cloud dynamics in stable and unstable regimes. Confinement time interestingly exceeds the theoretical limits of confinement hitherto predicted. The steady state confinement in fact gave us the opportunity to examine and test some of these existing theoretical predictions and transport theories.