Title

Anomalous ion transport in the near wake of a magnetoplasma-obstacle system

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ANOMALOUS ION TRANSPORT IN THE NEAR WAKE OF A MAGNETOPLASMA-OBSTACLE SYSTEM*, D. P. SHEEHAN, R. McWILLIAMS, University of California, Irvine--Laboratory plasma-obstacle systems may be used to model aspects of a number of natural and technological systems including interactions of space plasmas with planets and satellites,[1] interpretation of plasma diagnostics,[2] semiconductor device manufacture, antenna-plasma and limiter-plasma interactions in tokamaks.[3] We report on the ion phase space development, and anomalous configuration space and velocity space transport in the near wake of a plasma-obstacle system. The experiments were performed on the UCI Q-machine ($B = 3$ kG, $n_i = 10^9$ cm^{-3}, $T_i = 0.2$ eV, L = 1m, Dia. = 5 cm) using laser induced fluorescence to measure the spatial evolution of the perpendicular ion velocity distribution.[4] A floating 2 cm diameter metal disc was placed in the supersonic flow (Mach 2) of two types of Plasma, Ba^+/e^- and $Ba^+/SF_6^-/e^-$, to model initially quiescent and turbulent flows respectively. Ion velocity distributions and wave spectra were obtained at various radial and axial locations upstream and downstream of the disc. Ion and electron configuration space transport ($D_\perp \sim 10^4$ cm^2/sec) and ion velocity space transport exceeded predictions based on ballistic particle motion, Fokker-Planck formalism, a turbulence theory due to Dupree,[5] or standard models of self-similar plasma expansion, but results were consistent with turbulent wave-particle interactions, and agree with observations in edge plasma-limiter regions of tokamaks.[3] Near wake ion acceleration resulted in local two-fold increases in ion perpendicular kinetic energy densities over ambient plasma values. Large amplitude, low-frequency noise ($f \leq 20$ kHz), probably drift wave turbulence was observed at the obstacle edge, in the wake, and propagating radially into the ambient plasma downstream. Large density fluctuations ($\delta n/n \sim 0.25$) were inferred at the obstacle edge. Low frequency turbulence and density fluctuations have been observed in the vicinity of the U.S. Space Shuttle.[6] The obstacle pre-wake exhibited density enhancements many Debye lengths upstream of the obstacle ($\ell \sim 50\ \lambda_D$) indicating a collisionless shock front. The obstacle mid-wake displayed an ion flux peak.[7] Numerical simulations were carried out for the plasma-obstacle system in order to differentiate particle ballistic effects from other plasma effects. Results scale to several space plasma-obstacle systems.

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