Abstract

In this thesis we have experimentally investigated the role of electron inertia in electronmagnetohydrodynamics (EMHD). The experiments are carried out in a regime where electromagnetic character of the excited perturbations is maintained and at the same time electron inertia effects are significant. To enable these studies, a large volume plasma device (LVPD) has been built along with the supporting subsystems such as large magnet coil system, large area plasma source, power supply system, diagnostics, probe drive and data acquisition and control system. The experiments are carried out in a large, uniform, high density, low temperature, quiescent plasma in LVPD.

In an initial investigation concerning the method of exciting EMHD structures, it is shown that EMHD structures excited by biased electrodes by charge particle collection/repulsion have characteristics determined by the topology of return current system and not by the antenna system. In particular, it is shown that full extent of the biased electrode may not take part in radiating the structures and only that part of the biased electrode which has return current system parallel/antiparallel to the background magnetic field is responsible for excitation of the structures.

EMHD structures with dimensions ~ electron skin depth ($kd_e \sim 1$), such that electron inertia effects become significant, have been excited for the first time in a laboratory plasma. Presence of null-points in the propagation path leads to significant changes in the properties of linear EMHD structures. Rapid attenuation of wave fields occurs in the region around the null-point. It is found that one of the components is transmitted beyond the null-point whereas the other is not. It does not seem to get regenerated from the other. An important result is that electron inertia does not manifest itself in a significant manner in the determination of the propagation characteristics of linear EMHD structures.

On the other hand, electron inertia effects play a significant role in determination of the characteristics of nonlinear ($\tilde{B} \geq B_0$) EMHD structures. Electron inertia allows validity of EMHD conditions even in the region around null-point where $B_0 \approx 0$. Thus, physical processes responsible for the propagation of the EMHD structures in the form of whistler waves, seem to occur even in the region around the null-point. As a result, there is considerable weakening of nonlinearities. Inclusion of finite electron inertia also leads to changing the form of the freezing-in constant, namely from magnetic field to generalized vorticity. This enables the EMHD structures to propagate across the null-point without field lines undergoing any reconnection. Observations also indicate that reconnection rates in EMHD may have sensitive dependence on electron skin depth, in contrast to theoretical predictions.