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14. Abstract/Notes

This work reports experimental studies on the current flow to an electrode immersed in a quiescent magnetized plasma. The observed intense current driven instabilities during the current flow were found to be related with an anomalous current transport.

15. Remarks

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OBSERVATIONS OF CURRENT FLOW TO A POSITIVELY POLARIZED ELECTRODE IN A QUIESCENT MAGNETOPLASMA

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The study of current flow to an electrode immersed in collisionless magnetized plasmas is important for the operation of plasma probes, plasma confinement research and space-based experiments. Previous works show that an electrode polarized with a voltage pulse above the plasma potential, within a risetime faster than the ion transit time, can collect currents far in excess than the current predicted by the Langmuir probe theory [1]. In this work we extend these studies to the case where the current flow causes ionization. We were able to show experimentally that a large amount of current collected by the electrode is related to an anomalous transport process driven by strong turbulences [2].

The experiment was performed in a large plasma machine (L = 3.0m, D = 1.5m) located at the University of California in Los Angeles (Figure 1) [3]. A quiescent plasma is produced by a thermionic discharge between a highly transparent grounded grid and an oxide coated nickel plate cathode, indirectly heated. Plasma densities between $10^{11}cm^{-3}$ to $10^{12}cm^{-3}$ and electron temperatures between 1.5eV to 5.0eV are easily obtained in this device depending on the external magnetic field and on the neutral gas pressure, typically 30Gauss and 4.0×10^{-4}torr with Argon, respectively.

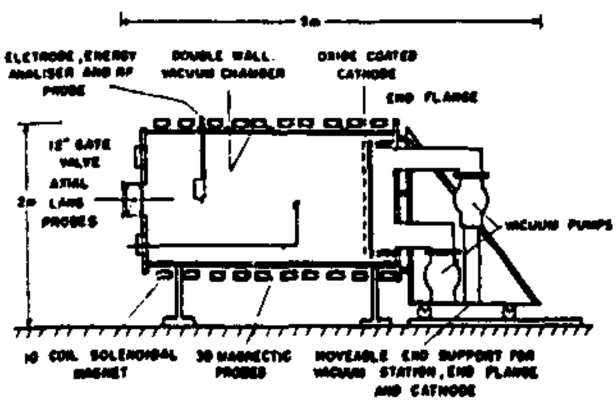

Fig. 1. Quiescent plasma device.

The investigation of plasma instabilities and electron heating during the current flow was carried out by using a specially designed multiple probe. It is made of a Tantalum disc electrode with a centered 2mm diameter hole, a grid energy analyser placed behind the probe and an RF probe placed in front of the electrode. It can also have different orientations with respect to the magnetic field and the current collected by the electrode is measured by a Rogowsky coil. All measurements are made during the afterglow of the discharge with 10 to 20 shots to take average of the signals. The collected current behavior as the voltage pulse increases is shown in the Figure 2. For voltages near the plasma potential (∿5 volts), the current is the same as predicted by the theory. As the voltage pulse increases the electron drift velocity also increases, and a low frequency instability develops. The current overshoots have a period of 2μs, comparable to the ion transit time of ∿1.5μs. This is the time required for an ion bunch to be expelled out of the current channel due to positive space charges.

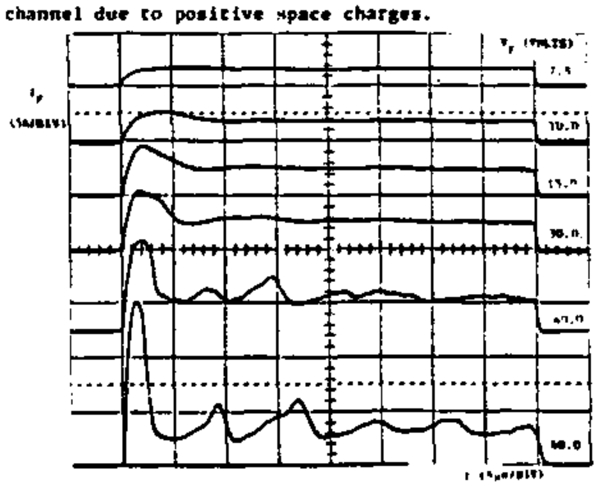

Fig. 2. Electrode currents for different voltages.

We also observe the current flow for higher pressures ∿1.5×10^{-3}torr and higher voltages ∿100 volts. In this case the first current overshoot remains the same, but the low frequency instability is replaced by another long current overshoot due to a localized ionization process in front of the electrode (Figure 3). The signals detected by the RF probe and processed by a spectrum analyser at f = 10 MHz show the presence of high frequency unstable waves during the current flow for both regimes. Further observations show highly nonlinear turbulent waves developing below and above the ion plasma frequency (~30MHz), indicating a possible Buneman instability and confirming the relation between the anomalous large currents and a current driven instability. The formation of a double layer like structure due to ionization was also investigated (Figure 4). The electron temperature ($k_B T_e$) and plasma potential (ϕ_{pl}) profiles show the existence of an anomalous resistivity due to electron scattering by the turbulent waves. The occurrence of the plasma contactor effect is also possible as indicated by the electron density profiles at the electrode vicinity [4].

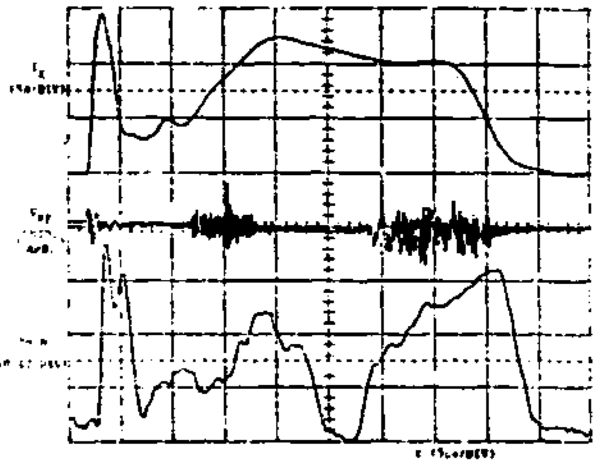

Fig. 3. Electrode current and RF signals.

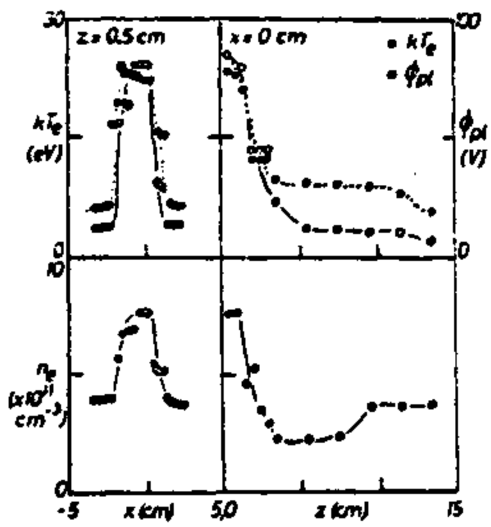

Fig. 4. Plasma potential, electron temperature and density profiles.

In conclusion, the current flow to an electrode was investigated, specially when large and fast voltage pulses were applied to draw currents in magnetized plasmas. The current driven instabilities generated by electrons with drift velocity above the electron thermal velocity give rise to an anomalous condutivity responsible for the observed large current overshoots.

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