STUDIES ON HIGH CURRENT ELECTRON RINGS IN A TOROIDAL DEVICE

by

D. CHENNA REDDY

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PHYSICAL RESEARCH LABORATORY
AHMEDABAD 380 009
INDIA

TO

MY PARENTS

CERTIFICATE

I hereby declare that the work presented in this thesis is original and has not formed the basis for the research of any degree or diploma by any University or Institution.

D. Chenna Reddy

D. Chenna Reddy

Certified by :

P.I.John

Professor-in-charge

Place : Ahmedabad

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ABSTRACT

In this thesis, we report, studies on high current electron rings formed by injecting a Relativistic Electron Beam (REB) into a toroidal device filled with plasma. These studies are motivated to understand the dynamics of beam injection and trapping. Another important objective is to study the plasma heating by REB in a toroidal device, where only limited experimental data is available.

An REB generator based on Tesla transformer high voltage source was fabricated for these studies. Plasma was injected into the torus with the help of a gas injected, washer stack plasma gun. Beam was injected into a pre-formed plasma. Beam injection was studied in two different plasma densities, characterized by operating the plasma gun with two different pulse forming net works.

When beam was injected into low density ($\approx 5 \times 10^{12}$ cm^{-3}) plasma, it was found that the beam was lost by hitting the injector from the back after one toroidal transit. No net toroidal current was observed in this case. However in the case of injection into a high density ($\approx 10^{13}$ cm^{-3}) plasma, the beam drifted inward and cleared the injector and was trapped. A net toroidal current ($\approx$ 5 kA) was generated in this case.

Temporally and spatially resolved measurements with miniature Faraday cups and small Rogowski coils showed that

beam trapping was due to a fast return current decay. The return current decay times calculated from ion-acoustic turbulence were found to be consistent with the observed net current rise time. At low plasma densities, where no trapping was observed, the condition for exciting the ion-acoustic turbulence was not satisfied.

Localized measurements of the poloidal field were done which indicated a net current channel moving radially inward with no observable vertical motion. This was found to be consistent with the drift injection-energy loss mechanism proposed for beam trapping. Wall fields were found to significantly influence the current profile calculations from the poloidal field profiles.

To understand the plasma heating process, localized measurements of δB_t (change in toroidal field) were done. It was found that in a toroidal experiment, use of a diamagnetic loop to measure plasma temperature would be inadequate. Localized measurements not only eliminated the uncertainties involved in using a diamagnetic loop but also gave the time evolution of the beam-plasma system. From these measurements it was found that about 50% of the beam energy appears as plasma perpendicular energy and the heating was mainly due to return current dissipation.

The q profiles obtained from the magnetic field measurements indicated that the system goes into a low q state as time progresses.

The beam goes into an equilibrium position from the launch position without applying any vertical field. The equilibrium therefore is maintained by wall fields, indicating a force free equilibrium of the current ring. The beam energies calculated from the observed net currents and shift of the current channel were found to be consistent with the beam energy transfer observed from diamagnetic measurements.

LIST OF FIGURES

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