STUDIES OF $\langle \tilde{j} \times \tilde{b} \rangle$ CURRENT DRIVE IN A CONVENTIONAL PLASMA TORUS

A Thesis Presented for the Degree of
Doctor of Philosophy

by

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CONTENTS

SUMMARY

This thesis describes experimental and theoretical studies of conventional toroidal plasma equilibria which have been generated and maintained by the application of an external travelling electromagnetic wave.

The experimental work was performed in several devices using an argon plasma. The plasma was embedded in a steady toroidal magnetic field for stability. A steady vertical magnetic field was applied for equilibrium. The travelling radio-frequency (RF) magnetic field was produced by feeding RF currents, dephased by 90^0, through coil structures wound around the outside of the toroidal Pyrex glass vacuum vessel. The majority of the experiments were performed with $m = 1$ helical coil structures.

Discharges produced with the same conditions of filling pressure and applied toroidal and vertical magnetic fields were very reproducible. The discharges were maintained for the entire duration of the RF pulse. Extensive miniature magnetic probe measurements were undertaken to examine in detail the magnetic structure of discharges produced under various experimental conditions. Two-dimensional polynomial smoothing techniques were used on the magnetic probe data to derive contours of constant poloidal magnetic flux and toroidal current density.

A theoretical description of continuous current drive using external $m = 1$ helical coil structures has been developed for an infinitely long plasma cylinder. The theory is based on earlier treatments of transverse rotating magnetic field current drive in a plasma cylinder. In these analyses, the $\langle \tilde{j} \times \tilde{b} \rangle$ non-linear Hall term in Ohm's law is identified as the source of the electromotive force which drives the steady plasma currents.

The theory developed in this thesis has been applied to the appropriate experimentally observed plasma/field configurations to yield quantitative estimates of the (volume averaged) electron density, n_e, electron temperature, T_e and the electron-ion momentum transfer collision frequency, ν_{ei}, in the plasma.

AUTHOR'S PUBLICATIONS

Some of the work presented in this thesis has already been published in the following papers :

1. "Steady toroidal current drive with $m = 1$ radio frequency travelling wave structures." M.J.Dutch and A.L.McCarthy (1986).
   Plasma Physics and Controlled Fusion , **28** , 695.

2. "Double helix current drive for tokamaks."
   M.J.Dutch , A.L.McCarthy and R.G.Storer (1986).
   Physical Review Letters , **56** , 1563.

3. "Double helix $\langle \tilde{j} \times \tilde{b} \rangle$ current drive in the r.f. tokamak device Rythmac."
   M.J.Dutch and A.L.McCarthy (1986). 11th IAEA Plasma Physics Conf., Kyoto , Japan , 13-20 November , 1986.

4. "$\langle \tilde{j} \times \tilde{b} \rangle$ current drive in the r.f. tokamak Rythmac."
   M.J.Dutch and A.L.McCarthy (1987). 16th AINSE Plasma Physics Conf., Sydney , Australia , 9-11 February , 1987. (unpublished)

5. "Helical mesh r.f. current drive for tokamaks."
   M.J.Dutch and A.L.McCarthy (1987).
   Physics Letters A , **122** , 165.

STATEMENT

I certify that this thesis does not incorporate without acknowledgement any material previously submitted for a degree in any university ; and that to the best of my knowledge and belief it does not contain any material previously published or written by another person except where due reference is made in the text.

Signed.....

Date.....

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