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Visentin, Denis (2007). Control of ion motion in rotating magnetic field current drive. University Of Tasmania. Thesis. <https://doi.org/10.25959/23210378.v1>

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CONTROL OF ION MOTION IN ROTATING MAGNETIC FIELD CURRENT DRIVE

by

Denis C. Visentin B.Sc. (Hons)

Submitted in fulfilment of the requirements for the Degree of Doctor of
Philosophy

University of Tasmania

March 2007

DECLARATION

I hereby declare that this thesis contains no material which has been accepted for the award of any other degree or diploma in any tertiary institution, and that, to the best of knowledge and belief, it contains no material published or written by any other person except where due acknowledgement is made in the text of the thesis.

Denis Visentin, 9th March 2007

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ABSTRACT

This thesis presents theoretical results, a numerical model and simulation results for the control of the ion motion for a pre-formed field-reversed-configuration (FRC) using two counter-rotating magnetic fields (RMFs). One RMF (denoted the (-) RMF) is applied first to entrain the electron fluid and maintain the plasma current. In the absence of a mechanism for controlling the ion motion, if the confinement time is sufficiently large, the rotation of the ion fluid due to collisions with the electron fluid would diminish the plasma current and thus destroy the FRC equilibrium. A second RMF (denoted the (+) RMF) is applied after the (-) RMF has penetrated the plasma, to entrain the ion fluid and maintain the equilibrium.

It is shown that there exists a true steady state (the Clemente steady state), where the electron fluid rotates almost synchronously with the (-) RMF and the ion fluid rotates almost synchronously with the (+) RMF. This allows the equilibrium to be maintained indefinitely. Both RMFs penetrate much farther than a classical skin depth. The accessibility of the Clemente steady states are examined theoretically and by simulation.

A 1-D numerical model is developed to simulate the application of the RMF for two cases:

1. A constant density model where the radial motion is constrained.
2. A preformed FRC model with radial motion.

For both cases it is demonstrated that the Clemente steady states are accessible from a small class of initial conditions. The class of initial conditions may be broadened by allowing the frequency of the (+) RMF to vary. The penetration and entrainment of the (+) RMF is shown to be highly non-linear (as is well known for the (-) RMF) and hence the magnitude of the (+) RMF required for accessibility of the steady state

is much greater than that required to maintain the steady state. It is also demonstrated that it is possible to increase the closed flux of the FRC by increasing the frequency of either RMF.

ACKNOWLEDGEMENTS

I wish to express my thanks to the many people who have assisted in making this thesis possible. Firstly to my supervisor Dr. Waheed Hugarass, whose introduction to the field and guidance through the research has been superb. One of the great pleasures arising from this period has been to work with a person who embodied the oft-used expression, “a scholar and a gentleman”. Although I have gone to great lengths to irritate him over the years as a postgraduate student and a colleague, my efforts have borne no fruit.

Many thanks to the staff and postgraduate students at the School of Computing in Launceston. With the transfer of Dr. Hugarass and myself to the school, they have been very accepting and accommodating of the physicists in their midst. Thanks especially to the technical and administrative staff who have facilitated almost every whim. My appreciation also to staff in other departments who have helped me juggle teaching commitments and research during the course of my candidature, in the School of Human Life Sciences, especially Marie-Louise Bird, and at the Australian Maritime College. My thanks also go to the staff from the now defunct School of Applied Science, particularly Roger Taylor.

Finally I would like to thank family and friends who have supported me, especially my mother Carlene and my wonderful children Gianni and Antonina. Watching my children grow, learning to draw and write on thesis drafts has been a pure pleasure and a most welcome distraction. To Susannah for her care and aid in proofing the thesis, Paul Semmens and the other members of ‘Hoof Hearted’, and everyone who has at least had a drink and been polite enough to not ask me how my research was going.

A Tasmanian Postgraduate Scholarship was held during the course of this research.

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