Helicon Waves in

High Density Plasmas

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November 10, 1998

A thesis submitted for the degree of

Doctor of Philosophy

of the Australian National University

This thesis is entirely my own work,

except where specifically indicated.

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Acknowledgements

I am indebted to my supervisor Dr. Gerard Borg for his enthusiastic interest in the Basil experiment. I have not only learnt much about plasma physics but also no end of interesting experimental techniques and an approach, a thoroughness, to solving scientific problems which has laid the foundations for my future work. I must also give a special thanks to Dr. Rod Boswell who got me started on Basil and whose continued support and interest has been invaluable.

The people of the Plasma Research Laboratory have given me no end of help. I am very grateful to Dr. Boyd Blackwell for the huge amount of time he has given me, and Prof. Sydney Hamberger, Dr. Andrew Perry, Dr. Harold Persing, Dr. Antoine Durandet, Dr. John Howard, Dr. Les Sharp, Dr. Gaelle Giroult-Matlakowski, Dr. Robert Porteous, Dr. David Vender, Dr. Terry Sheridan, Dr. Christine Charles, and Helen Hawes. I have enjoyed the company and gained much from fellow PhD students, Mark, Bert, Alex, Peter, Beichao, Chunshi, Sarah, Dimitry, George, Roy, and Xuan. My work has been greatly enhanced by the fine numerical model of fellow student Igor Kamenski.

The many technicians that have given me great advice, done fine work on projects for Basil, and from whom I've leant much need special thanks. In the mechanical workshops there has been Peter A., Peter L., Steve, Joel, and the many members of the school workshop and other support services (especially Herb for the beautiful copper box that houses the matching network and George for being a great electrician). In the Electronics Unit there is Tom, Dave, Dennis, Michael, Tony, and Walter. And the School Computer Unit deserves a medal, Julie, Shiu, Oscar, and James. Then there are the Toro techs that have always put a smile on my face, Clint, John, Jerry, Ray, Eddie, and Bob.

A thesis would not be possible without the support of family and friends. I would like to thank Dr. Ray Morris and my Casey friends. Helen deserves my eternal thanks for keeping me going.

I dedicate this thesis to my parents, Laurie and Gwenda.

Abstract

This thesis investigates helicon wave propagation in a 1.5m long, 2.5cm radius, high density ($n_e > 5 \times 10^{18}\text{m}^{-3}$), high static magnetic field ($B_0 > 0.05$T) plasma, where the plasma has been produced by the helicon wave. Helicon waves launched with a double saddle coil antenna were found to consist of the first radial, $m = +1$ azimuthal mode, with no observable $m = -1$ mode under any conditions. The wave was found to propagate with the infinite plane wave dispersion relation $k_{||} \propto \sqrt{n_e/B_0}$ as if the plasma had no boundaries. Comparisons of experimental measurements of wavelength and radiation resistance with predictions of a magnetohydrodynamic numerical model show very good agreement. The numerical model also indicates that, for the conditions used in the experiment, the radiation resistance of the $m = -1$ mode is too low for it to be significantly excited.

Plasma formation by a helical antenna was also investigated.This antenna can excite $m = +1$, and $m = -1$ modes in opposite directions along the field. The helical antenna produced an axially asymmetric plasma, with the plasma density highest along the axial direction of propagation of the $m = +1$ mode. No $m = -1$ mode was again observed and the plasma extended only a short distance in the direction where the $m = -1$ mode would be expected to propagate. The helical antenna was found to produce plasma more efficiently than the double saddle coil antenna, however it had a more limited range of operating conditions due to its high $k_{||}$ selectivity.

Attempts to produce plasma using helicon waves of azimuthal modes other than $m = +1$, by means of a phased double saddle coil antenna were unsuccessful. However, by

launching waves into a pre-formed plasma it was possible to control the azimuthal mode content of the wave launched. When the antenna was phased for excitation of $m = -1$, significant $m = +3$ was observed and no $m = +1$ mode, as expected.

Observations were made of the plasma formation process in the early phase of the discharge. During the initial stages of the discharge, as the plasma diffuses away from the antenna, a high density peak was observed downstream from the antenna, near the end of the uniform field region. A 1-D diffusion model was used to investigate this phenomenon, and predicted increased downstream ionisation due to a directed flux of neutrals created by the expansion of the plasma from the source region. After a period of about 10msec this density peak collapses and the plasma density drops to a uniform lower value that typifies the static phase of the discharge.

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