EXTRAORDINARY MODE ABSORPTION AT THE
ELECTRON CYCLOTRON HARMONIC FREQUENCIES
AS A TOKAMAK PLASMA DIAGNOSTIC

by

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ABSTRACT

Measurements of Extraordinary mode absorption at the electron cyclotron harmonic frequencies are of unique value in high temperature, high density Tokamak plasma diagnostic applications. An experimental study of Extraordinary mode absorption at the semi-opaque second and third harmonics has been performed on the ALCATOR C Tokamak. A narrow beam of submillimeter laser radiation was used to illuminate the plasma in a horizontal plane, providing a continuous measurement of the one-pass, quasi-perpendicular transmission.

Experimental electron cyclotron absorption (ECA) data has been found to agree with lowest significant order finite density and finite Larmor radius theoretical results, and to follow \( n_e T_e^2/B^2 \) scaling from 1 to \( 12 \times 10^{21} \ \text{[cm}^{-3} \ \text{eV}^2/(\text{Tesla/cm})] \) at the third harmonic. ECA data has been used along with Tokamak electron density and magnetic field data to determine local electron temperatures in the range \( 75 \leq T_e(\text{eV}) \leq 3300 \). Plasmas with line averaged electron densities \( 0.3 \leq n_e(10^{14}\text{cm}^{-3}) \leq 3.3 \), plasma currents \( I_p \leq 500 \text{kA} \), and magnetic fields \( 7.5 \leq B_T(\text{Tesla}) \leq 10.5 \) have been studied. ECA measurements produce CW temperature data with a large \( T_e \) dynamic range and a spatial resolution \( \leq 1 \text{ cm} \). Conditions studied include Ohmic and Lower Hybrid frequency RF (LHRF) Heating and Current Drive, with powers \( P_{RF} \leq 1 \text{ MW} \). Transmission during LHRF injection remains unaffected by suprathermal electrons due to their low density and the relativistic downshift of the absorption line. This allowed the ECA technique to be used to measure the bulk plasma temperature during LHRF Heating.

Sawtooth and \( m=1 \) MHD activity were observed on the raw ECA signal. These behaved in the expected manner, and were well correlated with other diagnostics of MHD activity. A density dependent non-resonant attenuation (NRA) was observed which, when present, was taken into account in the data analysis. The NRA is thought to possibly originate in scattering of the submillimeter wave radiation by turbulence in the plasma edge region.

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