Electron Cyclotron Heating in the Constance 2 Mirror Experiment

by

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Abstract

Electron cyclotron heating of a highly-ionized plasma in mirror geometry is investigated. Of primary interest is the experimental diagnosis of the electron energy distribution and the comparison of the results of this diagnosis with a two-dimensional, time-dependent Fokker-Planck simulation. These two goals are accomplished in four steps. (1) First, the power balance of the heated and unheated Constance 2 plasma is analyzed experimentally. It is concluded that the heated electrons escape the mirror at a rate dominated by a combination of the influx of "cool" electrons from outside the mirror and the increased loss rate of the ions. This analysis is used later to help construct the simulation. (2) The microwave parameters at the resonance zones are then calculated by cold-plasma ray tracing. High N$_e$ waves are launched, and, for these waves, strong first-pass absorption is predicted. The absorption strength is qualitatively checked in the experiment by surrounding the plasma with non-reflecting liners. (3) A simplified quasilinear theory including the effect of N$_e$ is developed to model the electrons. An analytic expression is derived for the RF-induced "pump-out" of the magnetically-confined "warm" electrons (T$_e$ $\geq$ 100eeV). Results of the Fokker-Planck simulations show the development of the electron energy distribution for several plasma conditions and verify the scaling of the analytic expression for RF-induced diffusion into the loss cone. (4) Sample x-ray and endloss data are presented, and the overall comparison between the simulation and experiment is discussed. The x-ray signals indicate that, for greater RF power, the hot electron density increases more rapidly than its temperature. The time history of the endloss data, illustrating RF-enhancement, suggests the predicted scaling for warm-electron "pump-out". Finally, a comparison between the measured and predicted energy distribution shows that, over the range of parameters investigated (2 $\times$ $10^{11}$ cm$^{-3}$ $< n_e < 1 \times 10^{12}$ cm$^{-3}$ and $(n_eT_e) \leq 200$eeV $\cdot$ cm$^{-3}$) and within the accuracy with which the plasma parameters can be determined, the "bulk", "warm", and "hot" components of the heated Constance 2 electrons are indeed reproduced by the simulation.

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