Mode Conversion Processes to attain Electron Cyclotron Emission in Spherical Tokamaks

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Abstract

Spherical tokamaks are characterized by low magnetic fields and high plasma density. Under these conditions, cutoffs prevent the radiation of O- and X- modes from the first 5 electron cyclotron harmonics from reaching the plasma boundary. Thus any ECE radiation that is detected outside the plasma must arise from electron Bernstein waves (EBW) generated near the plasma center. While these electrostatic EBW cannot be detected in a vacuum, they undergo mode conversion to electromagnetic waves in the upper hybrid region and these electromagnetic waves can be detected. Detailed 3D modeling of the MAST plasma includes the effects of bootstrap, diamagnetic and Pfirsch-Schluter currents on the magnetic surfaces. This yields better fit to experimental ECE data than earlier attempts which assumed very simple current profile and ignored many details of the physics of the H-mode. The plasma density and temperature profiles are obtained from high spatial resolution Thomson scattering measurements while the measured Z_{eff} is incorporated into the simulation code. The effect of collisions on the absorption of EBW and the weakening of the ECE is examined.

Our ECE simulation codes also use a more sophisticated representation of the ECE antenna (on considering the reciprocal process of the launch electromagnetic waves into the plasma, with these waves mode converting finally to the EBW which is then absorbed near an electron cyclotron harmonic.). This model incorporates the horn, a thin lens, two mirrors and a window. With the Gaussian beam formalism the exact positions of the waists and the corresponding angular beam divergence at each frequency can be determined. Ray tracing is used to determine the intensity of EBW, and for each ray the EBW-X-O mode conversion efficiency is calculated at the UHR within the transport barrier. An adaptive finite element code has been developed to study the full wave problem.