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Simulation of ECE from MAST

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Abstract

The characteristic low magnetic field and high plasma density of a spherical tokamak do not permit the typical radiation of O and X modes from the first five electron cyclotron harmonics. Thus only electron Bernstein modes, (modes not subject to a density limit) which mode convert into electromagnetic waves in the upper hybrid resonance region, can be responsible for any observed ECE radiation.

To interpret the experimental results we develop a realistic 3D model of the MAST plasma. The instantaneous magnetic field and its spatial derivatives are reconstructed from a 2D splining of two potentials determined by an EFIT equilibrium reconstruction code, assuming toroidal symmetry. The plasma density and temperature profiles in the whole RZ cross-section of the plasma are obtained from mapping the high spatial resolution Thomson scattering measurements on magnetic surfaces and then interpolating between the low and high field side values.

About 50 rays represent an antenna, receiving an oblique - with respect to the magnetic field at the plasma surface - Gaussian beam. For each ray, we determine the corresponding spot on the separatrix as well as the EBW-X-O conversion efficiency in the transport barrier. The intensity of the inciden electron Bernstein wave from the plasma interior is determined from studying the absorption of the reciprocal EBW ray (incident from the UHR as it propagates into the plasma interior) in the vicinity of electron cyclotron harmonics. Non-local absorption characteristics ($N_{\|}$ profoundly oscillates for rays launched near the equatorial plane) calls for the introduction of an effective temperature determined by the integration of the equation for radiative transfer [1] above the ray. The resulting intensity of EBW is than determined from the Rayleigh-Jeans black body radiation law using the effective radiative temperature, which takes into account reabsorption. In this way we can simulate relative amplitudes and field polarization detected by the ECE antenna.

The results of our simulations will be compared with recent ECE measurement in MAST. Moreover, this representation of the antenna can be used to determine optimal launching directions for the proposed 1 MW, 60 GHz source in MAST

[1] Bornatici et al., Nucl. Fusion 23 (1983), 1153