RF Wave Propagation and Scattering in Turbulent Plasmas

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Models for the propagation, heating and current-drive distributions from the injected Lower Hybrid RF [LHRF] waves of 3 to 5 GHz and the Electron Cyclotron 170 GHz electron cyclotron *(ECH)* waves in single lower null divertor geometries are developed and evaluated[1,2]. Plasma density fluctuations from spectra of ETG turbulence produce diffraction and refraction RF waves. The LHCD antennas launch slow quasi-electrostatic waves that scatter in to fast whistler-like RF waves[3]. The dominant power in slow waves is scattered into the subdominant fast wave spectrum by the ETG turbulence[4]. For ECH, the gyrotron beam is forward scattered, increasing cross-section of the RF beam and thus the deposition profiles in the plasma.[5] For the ECH spectrum 2D PIC simulations are used to model the change scattering between the X and O mode polarizations during the propagation. This allows a more detailed picture of the heating and current drive than that from following rays. The parallel and crossfield derivatives in the RF wave equations are calculated from the Poisson brackets with the poloidal field flux function that contains the separatrix for the single-null divertor geometry. The RF waves are shown to change character inside the magnetic separatrix. The plasma density and magnetic fluctuations are taken from previous ETG turbulence simulations. The scattering and reflections change RF waves' polarizations between X and O modes which is key element for ECH heating and current drive in high B-field toroidal plasmas. For the ECH spectrum the 2D PIC simulations are used to model the complex OXB scenario that yields harmonic Bernstien waves reaching resonant electron cyclotron harmonics in the plasmas as observed in EAST and W7-X. A theoretical model for WEST and EAST with two symmetric RF antennas on inside and outside chamber walls gives optimal RF wave penetration and reduces spectral computations. The hypothesis is advanced that symmetric inside-outside RF antennas pairs may yield more efficient current drive and heating. Simulations for the driven plasma current $j(\mathbf{x},t)$ and the temperature $T_e(\mathbf{x},t)$ with anisotropies are presented.

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