Full-Wave Maxwell Simulations for ECRH

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The standard method studying electron cyclotron resonance heating (ECRH) in magnetically confined plasmas is ray-tracing method based on the geometrical optics. This method describe wave absorption due to wave-particle resonances, however, cannot take into account wave diffraction, wave tunneling across the wave-evanescent region between cutoff and resonance, and mode conversion.

We here study full-wave Maxwell simulations for fundamental ECRH of magnetically confined plasmas. We solve numerically Maxwell equations for electromagnetic wave fields (***E***, ***B***) and the equation of motion for induced plasma current ***J*** with the use of a finite difference and time domain (FDTD) method. These basic equations can describe O and X (or, R and L) modes being correct under the approximation of infinite ion mass. We emphasize that our numerical scheme can take into account wave diffraction, wave tunneling across the wave-evanescent region between cutoff and resonance, and also mode conversion, since it solves full Maxwell equations directly. The wave absorption mechanism in the present scheme can be taken into account as follows: The collisional damping of electromagnetic waves can be introduced by adding term to the equation of motion for induced plasma current ***J***, on the other hand, the wave dissipations due to wave-particle resonances such as cyclotron resonance can be introduced by adding term to the Ampere's equation. This artificial conductivity tensor is determined so that our basic equations can reproduce the local dispersion relation with wave-particle resonance terms in the limit of , where is the wavenumber perpendicular to a magnetic field, where the parallel wavenumber appeared in is approximately determined from the local dispersion relation in the numerical calculations. Unfortunately, the present numerical scheme cannot treat harmonic resonances such as second harmonic ECRH, as this basically depends on the fluid theory.

We perform the full-wave Maxwell simulations for fundamental ECRH in a simple magnetic beach configuration, and show the numerical results on the wave absorption by ECRH and wave tunneling across the wave-evanescent region between cutoff and resonance.