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Full wave simulation based on weakly relativistic Vlasov-Maxwell system for electron cyclotron wave in magnetized plasmas

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The relativistic dielectric tensor is necessary to model wave propagation and absorption in high-temperature magnetized plasmas. In fusion plasmas, electron cyclotron resonance heating (ECH) requires ray-tracing calculations to evaluate a heating location and a heating efficiency in plasmas. In this study, for a non-uniform medium, a full-wave approach is applied to simulating the propagation and absorption of EC waves in combination with the weakly relativistic dielectric tensor [1]. A finite element method is adopted for the full-wave approach.

The background medium is set to the electron density of 2×10^{19} m^{-3} and electron temperature of 5.76 keV in a two-dimensional rectangular area of 65 mm × 50 mm. An EC wave with a Gaussian profile starts from the left boundary of the area and propagates as an O-mode in the increasing magnetic field B_z. We confirmed that an EC wave decays across the EC resonance layer in Figure 1. To characterize the wave absorption on the electron temperature, the absorption efficiency $(|S_0|-|S_{out}|)/|S_0|$ is evaluated from the line integral of the Poynting vector $|S|$ of electromagnetic waves, where the subscripts 0 and out indicate the locations at the input and the opposite boundaries, respectively. The absorption efficiency increases up to 100%, as the electron temperature increases from 0 to more than 20 keV. In another situation, when a density cutoff exists in the area, EC waves reflect at the cutoff layer. This demonstration attains insight into the behaviour of electromagnetic waves in weakly relativistic plasmas.

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