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Application of a quasioptical code PARADE: modeling of ECRH, ECCD, and ECE diagnostic in toroidal fusion devices

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The newly developed quasioptical ray tracing code named PARADE (PAraxial RAy DEscription) can simulate the quasioptical propagation and absorption of wave beams in inhomogeneous anisotropic media within a reasonable computational resource. The code is based on the Schrödinger-type partial differential equation, that accounts for refraction, diffraction, non-uniform dissipation across the beam, and uniquely, mode-conversion. This Schrödinger-type equation is solved along the reference ray trajectory given by the ray equation. One of the advantage of PARADE is a capability of treating mode-conversion, and another one is a capability to simulate an arbitrary beam profiles with non-uniform dissipation across the beam cross section, whereas most quasioptical codes assume the Gaussian beam profile and uniform dissipation. These advantages were experimentally validated and the results showed good agreements.

Recently, as one of the most anticipated applications of the PARADE code, numerical modeling of the Electron Cyclotron Resonance Heating (ECRH), Current Drive (ECCD), and Emission (ECE) diagnostic in toroidal fusion devices are performed. Quasioptical dissipation of wave power flux by PARADE is directly used for ECRH prediction. An adjoint technique with parallel momentum conservation is applied for ECCD calculation. A radiative transfer model under local thermodynamic equilibrium conditions is applied for ECE evaluation. Weakly relativistic dispersion tensor for arbitrary wave vector and fully relativistic tensor numerically integrated along the resonance curve in momentum space are applied for Hermitian and anti-Hermitian part, respectively, to account for the relativity within a reasonable computational resource. This new application of PARADE is used for EC predictions on the JT-60SA tokamak, and is compared with a multi-ray tracing code conventionally used on there. The broader deposited power and driven current profiles are obtained by introducing diffraction as expected. Furthermore, it is found that non-uniform dissipation makes more broader deposition profile.

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