Quasi-Optical Propagation of a EC Gaussian Beam, Absorption and Current Drive in Tokamaks

Daniela Farina

Istituto di Fisica del Plasma, CNR, Euratom-ENEA-CNR Association, Milano, Italy

Propagation of electron cyclotron (EC) waves in tokamaks and the relevant power absorption and current drive have been widely investigated in the literature since long. Usually, the issue of wave propagation is addressed within the geometric optics approximation, by means of ray-tracing techniques in which the wave beam is modeled by an array of independent rays. In some cases, this approach may be inadequate as, e.g., in the case of focused beams or general astigmatic beams, and a description that takes into account diffraction effects is necessary. These effects can be described by beam tracing techniques, which have been theoretically investigated in plasmas by many authors (see, e.g., [1-3]). Here, we present the new code GRAY that has been written for the quasi-optical (QO) propagation of a Gaussian beam of EC waves and the relevant absorbed power and driven current in a general tokamak equilibrium. The problem of beam propagation is addressed in the framework of the complex eikonal approach [1], in which the beam is modeled by a set of quasi-optical (QO) rays, which obey to the QO ray-tracing equations, coupled together through an additional constraint in the form of a partial differential equation. The adopted approach has the drawback to be in principle numerically cumbersome with respect to the other approaches, the crucial numerical point being the solution of the additional differential constraint on the trajectories. To solve this problem a new, quite fast, and "enough" accurate algorithm has been developed. On each QO ray of the beam, EC wave absorption is computed solving either the fully or the weakly dispersion relation of EC waves with the dielectric tensor expansion at a given order in Larmor radius [4], and the EC driven current is computed using a linear adjoint model, taking into account trapped particle effects and the full wave polarization [5]. The code has been benchmarked against other existing EC codes [6] and used for calculations of EC driven current in different ITER scenarios. Applications to ITER will be presented and discussed.

References

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