Scattering of electromagnetic wave beams from density fluctuations in tokamak plasmas

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The propagation of high-frequency waves in fusion plasmas in the presence of density fluctuations is investigated through a numerical solution of the wave kinetic equation in tokamak geometry. The propagation of the beam is computed for general injection conditions and in a realistic equilibrium retaining diffraction effects and the standard linear description of the absorption process. In the absence of fluctuation, the absorption profiles recover those of well benchmarked beam tracing codes like TORBEAM [1]. The fluctuations are treated following the approach of McDonald [2], which assumes that the effect of wave scattering on the propagation can be treated perturbatively (Born approximation). On the other hand, the scattering operator is written in a general integral form; the conditions for the validity of the diffusive limit are discussed. The power scattered in a different mode of propagation is monitored, but not retained in the numerical implementation. In the examples presented here, mode-to-mode scattering is shown to be negligible.

In this paper, we discuss the basic features of the mathematical treatment (based on Weyl calculus) employed in our work, its implementation in the new code WKBeam [3], the present status of the validation of the code against both analytic [4] and numerical benchmark solutions, along with first results obtained for medium and large-size tokamaks. Significant broadening of the power deposition profile is predicted for ITER, while scattering effects are found to be negligible in ASDEX Upgrade. Implications of beam broadening for applications of electron cyclotron waves like stabilization of neoclassical tearing modes are discussed [5].