RAY-TRACING CALCULATIONS FOR THE W7-X STELLARATOR BY BRT CODE

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The BRT ray tracing code was developed for electron cyclotron (EC) and electron Bernstein wave (EBW) studies in arbitrary 3D magnetic configurations, with emphasis on heating, current drive (CD) and diagnostic of the W7-X stellarator under construction in Greifswald, Germany.

The magnetic configuration provided by the 3D equilibrium code VMEC is converted in Boozer co-ordinates and rapidly interpolated by a specialy developed module. The Hamiltonian suggested by Tokman and Westerhof [1] is adopted for the ray tracing. This accounts for anomalous dispersion in the vicinity of the EC resonance. In turn, the cold, warm non-relativistic or weakly relativistic dielectric tensor can be used in the Hamiltonian, depending on which model applies. Finally, absorption and emissivity are calculated from the anti-Hermitian part of the fully relativistic dielectric tensor. Wave-particle interaction is modelled separately for passing and trapped electrons, the results are also plotted separately and combined in macroscopic quantities such as the deposition profile. This approach provides a better understanding of trapped particle effects on heating, emission, and CD in stellarators, not only in interpreting the experiments but also in preparing suitable plasma targets and magnetic configurations. The electron distribution used for absorption, CD, and emissivity calculations can be Maxwellian, bi-Maxwellian or arbitrary, thus allowing future coupling with a Fokker-Planck solver. At present, the adjoint approach is used to calculate the CD efficiency.

The code was partly benchmarked against the one previously in use at the W7-AS stellarator [2]. It incorporates also the modules from ART [3] to deal with the ordinary-extraordinary-Bernstein (OXB) mode conversion. Care was taken in writing the weakly relativistic dielectric tensor in a form which captures the EBW physics, including not only the short perpendicular wavelength but also the finite parallel wavenumber typical of OXB experiments. Interfacing BRT with a 1D transport code [4] is also under way, with an aim to self-consistently model plasma profile modifications.

The BRT code can be used through a specially designed graphical user interface program, which allows preparation of input parameters and presenting the results of simulations in convenient form. The code is now routinely exploited in modelling heating and CD at various harmonics of the ordinary and extraordinary mode (O1, O2, X2 and X3) in different magnetic configurations. Similarly, EC emission spectra collected from the low or high field side of the machine in different poloidal sections are easily contrasted and might be used to diagnose fast electrons. The code is also supporting the design of some ECRH components for W7-X [5]. Further applications include Cotton-Mouton polarimetry and predictions of the stray radiation level in case of incomplete plasma absorption and multiple reflections from the walls.

References

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