Application of the ‘constant $k_{//}$’ coordinates to full-wave ICRF heating simulations of non-Maxwellian tokamak plasmas

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The fast computation of the plasma dielectric response is one of the key issues in ion-cyclotron radio-frequency (ICRF) full-wave simulations. In the past, most of the available ICRF full-wave codes considered only Maxwellian plasma distributions in order to simplify the numerical evaluation of the dielectric response, despite the evident non-Maxwellian character of the heated species in high power ICRF experiments. With the evolution of computer processing capabilities, several full-wave codes have recently been modified to take into account non-Maxwellian plasma distributions in order to describe the heating scenarios more accurately [1-3], most of them relying on intensive parallel computing techniques.

The introduction of a new coordinate system [4,5], where the parallel wave-vector of each Fourier mode, $k_{//}(m,n)$, is constant on magnetic surfaces, allows drastic simplifications in the representation of the plasma dielectric response for both Maxwellian and non-Maxwellian particle distributions. Following the successful implementation of these coordinates for Maxwellian plasmas in the CYRANO full-wave code [6], where the new method has shown to perform significantly faster than the standard (ρ, θ, φ) calculations, we are now extending the numerical procedure to the non-Maxwellian case. In this much more general situation, the new formalism allows to express the guiding center trajectory integrals embedded in the plasma response in terms of semi-analytical series and standard elliptic integrals, and thus seems very attractive from the numerical point of view.

After a brief introduction of the expressions obtained for the plasma dielectric response in the ‘constant-$k_{//}$’ coordinate frame for non-Maxwellian particle distributions, the first numerical applications will be shown. The final goal of this rather long-term project is to obtain a speed-optimised full-wave code for general particle distributions and to couple it with a quasi-linear Fokker-Planck diffusion code [7], in order to provide an advanced tool for self-consistent simulations of ICRF heating in tokamaks.

References

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