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Integral dielectric kernels for Maxwellian tokamak plasmas

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To accurately model the plasma dielectric properties in presence of rotational transform, most of the theoretical models and full-wave codes addressing radiofrequency wave propagation and absorption in tokamaks are based on toroidal and poloidal Fourier expansions of the RF fields (see for instance [1-4]). A significant drawback of this field representation is its lack of flexibility, in that it does not allow local refinements of numerical discretizations on a given magnetic surface.
As a first remedy to this, theoretical expressions have been obtained which are free from the poloidal mode expansion, but nevertheless preserve the description of wave dispersion along the curved inhomogeneous magnetic field [5]. These integral kernels, which describe the dielectric response of Maxwellian tokamak plasmas, were derived to lowest order in the Larmor radius and still made use of the Fourier expansion with respect to the toroidal angle.
The present communication generalizes these earlier results in two respects: (i) New theoretical expressions of the dielectric response have been obtained which are also free from the toroidal mode expansion. These mildly singular integral kernels depend on transcendental functions of a single variable ("kernel dispersion functions") and incorporate the non-local nature of wave-particle interactions along the equilibrium magnetic field lines. They are independent of the RF field representation inside the plasma volume and therefore amenable to three-dimensional finite element discretizations. (ii) Moreover, our new results include finite Larmor radius effects to all orders in ρLT /λ⊥, i.e. (thermal Larmor radius) / (characteristic RF field lengthscale across the equilibrium magnetic field).
Once implemented in a finite element wave propagation code, this approach will provide full flexibility to implement local mesh refinements in the plasma, as required for instance near cyclotron resonance layers and in regions of rapid RF field variations. Moreover, it will easily interface with advanced antenna modelling codes based on the finite element method (e.g. [6]), and will hence enable the latter to accurately model plasma wave kinetic effects.
The paper will present the theoretical results and discuss their forthcoming application in ICRH modelling.

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