Theory of the tokamak plasma dielectric response in constant-$k_{//}$ coordinates

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The toroidal coordinate system presented in [1], obtained by adequate stretching of the poloidal and toroidal angles (resp. to new $\bar{\theta}$ and $\bar{\varphi}$), has the defining property to yield poloidal-toroidal Fourier modes $\propto exp(im\bar{\theta} + in\bar{\varphi})$ with a constant parallel wavenumber on magnetic surfaces: $k_{//} = [m + n\,q(\Psi)] / H(\Psi)$. In other words the differential distance along field lines is $ds = H(\Psi)\,d\bar{\theta} = H\,d\bar{\varphi}/q$ and $ds/d\bar{\theta}$, $ds/d\bar{\varphi}$ are constant on each magnetic surface.

This coordinate system exhibits attractive properties for the theoretical and numerical analysis of linear wave perturbations in tokamak plasmas. For the sake of comparison with other straight magnetic field line coordinates, its Jacobian is

$$J_{ckp} = [(\nabla\Psi \times \nabla\bar{\theta}).\nabla\bar{\varphi}]^{-1} = H(\Psi)/2\pi B_0,$$

whereas for the Boozer coordinates [2],

$J_{Boozer} = H_B(\Psi)/2\pi B_0^2$ and $k_{//\,Boozer} = [m + n\,q(\Psi)]\,B_0 / H_B(\Psi)$.

The poster focuses on the theoretical representation of the plasma dielectric response in constant-$k_{//}$ coordinates. For Maxwellian equilibrium distribution functions, this leads to semi-analytical evaluation of the poloidal Fourier transform of the plasma dispersion function. For non-Maxwellians, the cyclotron resonance condition $\omega = \omega_c + k_{//}(\Psi)\,v_{//}$ exactly reduces to a quadratic equation in $v_{//}/v$ when guiding centre (gc) radial drifts are neglected, which allows *(i)* a simple classification of relative gc orbit - resonance configurations; *(ii)* derivation of semi-analytical expressions for the active and reactive components of the dielectric response density in constants-of-motion space.

The implementation of the resulting expressions in the CYRANO full-wave code have been presented in [3, 4] for the Maxwellian case; the companion poster [5] addresses numerical implementation of the non-Maxwellian case and application to simulations of ICRF minority heating.

References

[1] P. U. Lamalle, ECA **25A** (2001), p.1145, 28th EPS Conference on Plasma Physics, Madeira.
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[3] E. A. Lerche and P.U. Lamalle, in *Theory of Fusion Plasmas*, Joint Varenna-Lausanne International Workshop 2004, p.359.
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[5] E. A. Lerche and P.U. Lamalle, this Conference.