§11. Study of Interaction between Plasma and EM Wave in Prospect of Application of Millimeter & Sub-millimeter Waves – Linear Analysis of Global Structure of Drift Wave –

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It is now well recognized that spatial transport and energy transfer in plasmas are strongly connected to global structures of plasma parameters. This is essentially true for fusion, non-neutral and gyrotron plasmas magnetized and confined in conductor walls. With wide and integrated scope of various plasmas, we take a first step of linear analysis of global structure of drift waves. Many works have been reported for decades on drift waves, and formations of global structures in nonlinear stages have been examined numerically. However, only a few works have been reported in connection to linear analyses of global structures. [1,2,3] Actually most of extensive linear analyses have been limited to slab models or fluid dynamics in cylindrical configurations.

In this paper we construct a Vlasov–based equation with the guiding-centre approximation including arbitrary radial distributions of density and anisotropic temperature for multi-species. Various distributions can be described by the superposition of multiple Maxwellians. The potential perturbation $\phi_\ell(r) \equiv \phi(r,\ell,k_z,\omega)$ with zimuthal and axial modes (ℓ, k_z) satisfies

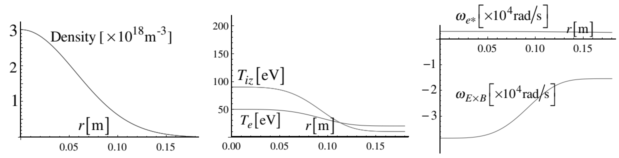
$$\frac{d^2\phi_\ell(r)}{dr^2} + \left[\frac{1}{r} - \sum_s \frac{k_{Ds}^2 v_{sz}}{k_z\omega_{cs}}\frac{\omega}{\omega_{cs}} h_{s\ell}(r)\right]\frac{d\phi_\ell(r)}{dr} +$$

$$\left[-\frac{\ell^2}{r^2} + \frac{\ell}{r}\sum_s \frac{k_{Ds}^2 v_{sz}}{k_z\omega_{cs}} h_{s\ell}(r) - k_z^2 + \frac{1}{2}\sum_s k_{Ds}^2 Z'(\zeta_{s\ell})\right]\phi_\ell(r) = 0$$

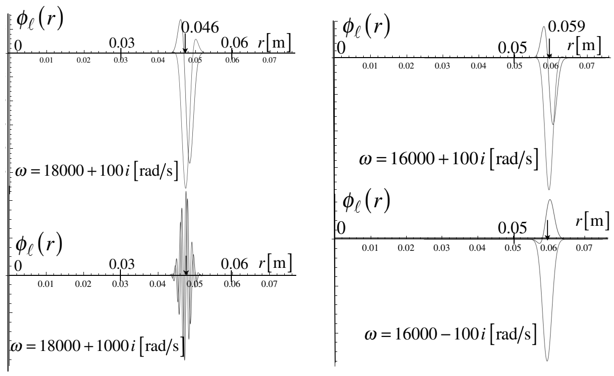
where $\zeta_{s\ell} = (\omega - \ell\omega_E)/\sqrt{2}k_z v_{sz}$, $v_{sz} = \sqrt{T_{sz}/m_s}$, and

$$h_{s\ell}(r) \equiv \frac{1}{\sqrt{2}}\left\{\frac{d\ln n_{s0}(r)}{dr} Z(\zeta_{s\ell}) - \frac{1}{2}\frac{d\ln T_{sz}(r)}{dr}\left[\zeta_{s\ell} Z'(\zeta_{s\ell}) + Z(\zeta_{s\ell})\right]\right\}$$

Though transverse-temperature-driven drift is taken into account, only $\omega_E(r) = -E_{r0}(r)/rB$ remains in $\zeta_{s\ell}$ after velocity integration. In the limit of slab geometry, this equation agrees with already established dispersion relations including density and axial-temperature gradients. Eigen modes of the D.E. satisfying the boundary condition $\phi_\ell(0) = \phi_\ell(w) = 0$ are examined by employing shooting method under various radial profiles of plasma parameters typically observed in the central cell of GAMMA10 such as:



High transverse temperature does not contribute in this guiding-center approximation. Numerical analyses have revealed that unstable eigen function $\phi_\ell(r)$ that satisfies the above D.E. is non-zero only in a radially limited region, and that the growth rate increases with radial wave number reflecting destabilizing contribution of 90 deg. shifted polarization drift. Examples for the mode of $(\ell, k_z) = (-1, 0.25\mathrm{m}^{-1})$ are plotted below.



So far global-scale monochromatic eigen functions have not been obtained as derived in collision-dominated fluid models or as observed in GAMMA10. Contribution of finite Larmor-radius will be taken into account in the next step. This may also be useful for generalized analysis of gyrotron power generation placed in our scope.

[1] R.F.Ellis et al. Plasma Physics **22**, 113 (1980).
[2] C. Schroder et al. Phys. Plasmas **11**, 4249 (2004).
[3] V. Naulin et al. Phys. Plasmas **15**, 012307 (2008).