Linear kinetic-MHD stability of internal modes in toroidally rotating plasmas

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Analytical theory and numerical simulation have shown that the linear stability of internal modes such as the 1/1 internal kink mode can be strongly influenced by kinetic effects due suprathermal [1,2] and thermal ions [3-5] and by centrifugal effects associated with toroidal rotation [6-9]. For an accurate description of the kinetic effects, radial drifts and the resulting finite orbit width of particles need to be taken into account accurately [1,5]. Based on analytical theory, it has been suggested [7,8] that the stabilization of internal kink modes due to toroidal rotation is due to coupling of this mode with zonal modes. The strong dependence on parallel, in addition to the perpendicular, dynamics in rotating plasmas motivates a kinetic-MHD approach [8], including a parallel electric field.

In the present work, some aspects of the problem of the kinetic-MHD stability in toroidally rotating plasmas are addressed. First, a kinetic equation, suitable for inclusion in a kinetic-MHD code and allowing for sonic plasma rotation as well as finite Larmor-radius effects is derived. To this end, a link between the linear gyrokinetic description [10] and the description adopted in [1], and used in many hybrid kinetic-MHD codes, is established. We show that in the long-wavelength limit and in the limit of vanishing plasma rotation, the results of [1] are recovered. We also show that our results are consistent with [3]. In particular, the quasi-neutrality equation in the form given in [3] is obtained.

To study the combined influence of toroidal rotation and kinetic effects on internal modes, a numerical code for the self-consistent computation of the linear kinetic-MHD stability of toroidally rotating plasmas is currently under development. The VENUS-LEVIS code [11] is extended and used to solve the kinetic equation in the long-wavelength limit. The integration of the kinetic equation along unperturbed guiding-centre orbits, utilizing a decomposition into bounce-harmonics employed in the analytical work [1], allows full finite orbit width effects to be retained. We report on progress in the numerical implementation and first results using this new code.

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