Theory of the Drift-Wave Instability at Arbitrary Collisionality

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Drift-waves (DW) are low-frequency modes that arise in a magnetized plasma when a finite pressure gradient is present. In order to become unstable, DW require some form of dissipation, such as finite resistivity, electron inertia or wave-particle resonances. Despite significant development over the last decades, a numerically efficient model able to describe the DW instability at arbitrary collisionality regimes is still missing. This is particularly worrisome since the linear growth rate, together with the gradient removal hypothesis, is used to predict the scrape-off layer width, a parameter crucial to the overall performance of present and future tokamak devices such as ITER. Furthermore, since quasi-linear transport models estimate the turbulence drive by evaluating the linear instability growth rate, quantitative differences in the growth rate have a large impact on the prediction of the level of transport, in particular by affecting the threshold for $\mathbf{E}\times\mathbf{B}$ shear flow stabilization. In this work, a numerically efficient framework that takes into account the effect of the Coulomb collision operator at arbitrary collisionalities is introduced [1]. Such model is based on the expansion of the distribution function on a Hermite-Laguerre polynomial basis able to study magnetized plasma instabilities at arbitrary mean-free path [2]. We show that our framework allows retrieving established collisional and collisionless limits. At the intermediate collisionalities relevant for present and future magnetic nuclear fusion devices, deviations with respect to collision operators used in state-of-the-art turbulence simulation codes show the need for retaining the full Coulomb operator in order to obtain both the correct instability growth rate and eigenmode spectrum.

References

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