Quantitative study of kinetic ballooning mode theory in magnetically confined toroidal plasmas

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Kinetic ballooning modes (KBMs) are investigated by means of analytical theory and linear electromagnetic gyrokinetic (GK) numerical simulations in a magnetically confined toroidal plasma. A physics-based ordering for beta (the ratio of kinetic to magnetic plasma pressure) with small asymptotic parameters is found. This allows us to derive several simplified limits of previously known theory [1] and to identify regimes where quantitative agreement between theory and numerical simulations can be achieved.

For the axisymmetric case, in simple s-alpha geometry, it is found that, for large pressure gradients, the growth rate and frequencies computed by the gyrokinetic codes GS2 and GENE show excellent agreement with those evaluated by using, in the quadratic forms, a diamagnetic modification of ideal MHD. This is true only if geometric drifts are kept consistent with the equilibrium pressure gradient.

In the stellarator Wendelstein 7-X (W7-X), we find a finite-beta stabilization of the ion-temperature-gradient (ITG) and trapped particle (TEM) modes, as well as KBM destabilization. The results are compared to a generic tokamak case. For large pressure gradients in W7-X geometry the KBM frequencies agree with the analytical prediction of the diamagnetic modification of ideal magnetohydrodynamic (MHD) limit already verified for the tokamak [2]. The KBM destabilization thresholds are predicted for different W7-X configurations. We discuss the relation of these thresholds with the ideal MHD stability properties of the corresponding equilibria.

References

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