KBM and Finite-β ITG Turbulence in the Wendelstein 7-X stellarator

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The impact of fluctuations of the confining magnetic field – brought about by finite plasma pressure – has been studied in detail in axisymmetric toroidal fusion devices (i.e., in tokamaks) [1, 2]. One consequence of finite pressure is the possible destabilisation of electromagnetic plasma waves such as the kinetic ballooning mode (KBM). Much remains to be better-understood in terms of linear and nonlinear KBM physics in more complex three-dimensional magnetic geometries [3, 4, 5, 6].

Here, we study the behaviour of finite-β ion-temperature gradient (ITG) modes and KBMs - and the ensuing turbulence - in the Wendelstein 7-X (W7-X) stellarator. Using the gyrokinetic Vlasov code GENE [7], we determine the onset of KBMs by varying the plasma pressure β. Of particular interest is how changes in the magnetic equilibrium or the driving gradients influence the KBM onset. From linear simulations, we find that increasing the magnitude of magnetic shear delays the onset of KBMs in W7-X (i.e., increases the $\beta_{\mathrm{crit}}^{\mathrm{KBM}}$ threshold). This effect of magnetic shear on the onset of KBMs is in agreement with previous work [6].

We further report on the nonlinear behaviour of KBMs, as this regime is of particular interest for high-performance operation. Here, we present the first-ever nonlinear KBM turbulence simulations in W7-X geometry, and we discuss the numerical prerequisites for achieving a quasi-stationary state. Scalings of heat flux with β in the ITG-dominated regime as well as above the KBM threshold are reported.

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