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

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

P. Mulholland[1], K. Aleynikova[2], B.J. Faber[3], I.J. McKinney[3], M.J. Pueschel[1,4] and J.H.E. Proll[1]

[1]*Eindhoven University of Technology, 5600 MB Eindhoven, The Netherlands*

[2]*Max-Planck-Institut für Plasmaphysik, D-17491 Greifswald, Germany*

[3]*Department of Engineering Physics, University of Wisconsin-Madison, Madison, WI 53706, USA*

[4]*Dutch Institute for Fundamental Energy Research, 5612 AJ Eindhoven, The Netherlands*

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.

Acknowledgements

This work has been carried out within the framework of the EUROfusion Consortium, funded by the European Union via the Euratom Research and Training Programme (Grant Agreement No 101052200 — EUROfusion). Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Commission. Neither the European Union nor the European Commission can be held responsible for them.

References

[1] M.J. Pueschel *et al.*, Phys. Plasmas **15**, 102310 (2008)

[2] M.J. Pueschel *et al.*, Phys. Plasmas **17**, 062307 (2010)

[3] A. Ishizawa *et al.*, Phys. Plasmas **21**, 055905 (2014)

[4] A. Ishizawa *et al.*, Phys. Plasmas **26**, 082301 (2019)

[5] K. Aleynikova *et al.*, J. Plasma Phys. **84**, 745840602 (2018)

[6] I. McKinney *et al.*, J. Plasma Phys. **87**, 905870311 (2021)

[7] F. Jenko *et al.*, Phys. Plasmas **7**, 1904 (2000)