The universal instability in optimised stellarators

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Abstract

In tokamaks and neoclassically optimised stellarators, like Wendelstein 7-X (W7-X) and the Helically Symmetric Experiment (HSX), turbulent transport is expected to be the dominant transport mechanism. Among the electrostatic instabilities that drive turbulence, the trapped-electron mode (TEM), which is one of the dominant instabilities in tokamaks, has been shown both analytically [1] and in simulations [2, 3] to be absent over large ranges of parameter space in quasi-isodynamic stellarator configurations with the maximum-*J* property. For some modes of operation of W7-X, the magnetic geometry approximately satisfies the quasi-isodynamic and maximum-*J* properties. It has been proposed that the reduction of the linear TEM growth rate in such configurations may lead to the passing-electron-driven universal instability [4, 5], which is often subdominant to the TEM, becoming the fastest growing instability over some range of parameter space. Here, we show through gyrokinetic simulations using the GENE code [6], that the universal instability is dominant in a variety of stellarator geometries over a range of parameter space typically occupied by the TEM, but most consequentially in maximum-*J* devices like W7-X. We find that the universal instability exists at long perpendicular wavelengths, and as a result dominates the potential fluctuation amplitude and heat-flux spectrum in non-linear simulations. In W7-X, universal modes are found to differ in parallel mode structure from trapped-particle modes which may impact turbulence localisation in experiments.

References

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