Dissipative trapped-electron modes in Wendelstein 7-X and other configurations

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In neoclassically optimised stellarators like Wendelstein 7-X (W7-X) or the Helically Symmetric Experiment (HSX), turbulent transport is expected to be the dominant transport channel at outer radii of the plasma. Research in stellarator turbulent transport and the underlying instabilities has thus gained momentum in the recent years. So far, most research was focussed on electrostatic collisionless instabilities such as ion-temperature-gradient modes (ITG) [1, 2] and trapped-electron modes (TEM). It was found analytically that quasi-isodynamic configurations with the maximum-J property are stable to density-gradient-driven TEM in large regions of parameter space [3]. In these configurations, all trapped particles precess in the direction opposite to the propagation of drift waves. Thanks to the lack of resonance, electrons have a stabilising influence, which leads to the absence of TEM. In linear numerical simulations using the GENE code [4] it was shown that also Wendelstein 7-X, which is only approximately quasi-isodynamic, benefits from enhanced TEM stability [5]. Very recently it was shown that this enhanced stability also persists nonlinearly [6]. With the completion of Wendelstein 7-X we are now in the position to test the theory also experimentally and to compare the numerical simulations against turbulence measurements. However, before meaningful comparisons can be made, we need to include collisions in the simulations since the experimentally accessible plasma conditions call for a collisional treatment. From a theoretical viewpoint, we expect collisions to significantly affect TEMs in a stellarator, due to scattering of particles across the trapping boundary. Here we present how collisions affect the microinstabilities—TEMs in particular—and how the effect differs in various 3D magnetic geometries.

References

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