Numerical investigation of fast-ion driven modes in Wendelstein 7-X

C. Slaby[1], A. Könies[1], R. Kleiber[1], S. Äkäslompolo[1]

[1] *Max-Planck-Institut für Plasmaphysik, Teilinstitut Greifswald, Wendelsteinstaße 1, 17491 Greifswald, Germany*

Fast ions in fusion plasmas are typically generated by heating methods such as neutral beam injection or ion cyclotron resonance heating. In future fusion reactors, there will additionally be fast alpha particles created from the deuterium-tritium fusion reaction. The fast ions need to remain in the plasma for a time period that is comparable to the slowing-down time in order to thermalize. If they leave the plasma prematurely, energy losses and possibly damage to plasma-facing components are the consequences [1].

Especially in a stellarator, due to the lack of a continuous symmetry, the confinement of fast particles is not guaranteed in general. Hence, one of the optimization goals of Wendelstein 7-X is the good confinement of fast ions [2].

However, in the process of slowing down, even the well-confined the fast particles can excite Alfvénic perturbations in the plasma, which have been shown to enhance fast-ion transport [1].

This paper investigates the resonant interaction of fast particles with Alfvénic perturbations in the Wendelstein 7-X stellarator using the non-linear CKA-EUTERPE code package [3]. The approach is perturbative in the sense that an MHD mode structure is calculated by CKA, which is used by the gyro-kinetic code EUTERPE to compute the power transfer from the fast particles to the mode. The mode structure remains fixed for the entire simulation run.

Our simulations include a triple-slowing-down distribution of the fast ions coupled with realistic fast-ion density profiles computed by the ASCOT code [4, 5]. A fast-ion collision operator is included in the EUTERPE modeling to assess the effects of pitch-angle collisions and slowing-down drag on the non-linear dynamics of the mode and its transport properties.

References

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