Non-linear Energetic Particle Transport in the Presence of Multiple Alfvénic Waves in ITER

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The interplay of fast ions with Alfvénic instabilities is an important topic in fusion research, since future fusion devices will exhibit large fractions of highly energetic particles (EP). Strong EP transport might reduce the heating and current drive efficiencies, while losses could even damage the first wall. The aim of the here presented work is to enhance the understanding of interaction mechanisms between EP and multiple Alfvén waves in a realistic ITER case.
The focus lies on the 15 MA baseline scenario, where a "sea" of small-amplitude perturbations is expected to be marginally unstable [1]. Based on quasi-linear estimates [2], the EP transport would be rather low. The question of interest here is, whether the EP population can drive linearly stable or weakly unstable modes non-linearly unstable – and if so, under which EP conditions. As a consequence, domino-like transport can occur. Such behavior has been found already in realistic ASDEX Upgrade double-mode simulations [3], which could explain experimentally found EP losses [4]. Basis of the simulations is a non-linear hybrid model, the driftkinetic HAGIS code [5]. As crucial new elements of a realistic scenario, the perturbation structures, frequencies and damping rates are taken as obtained from the gyrokinetic eigenvalue solver LIGKA [6].
Although the non-linear wave-particle interaction is calculated self-consistently within the HAGIS-LIGKA model, at the present status, other non-linearities such as the evolution of wave structure are not included yet. Before extending the model in this direction, the expected effect of the radial wave structure evolution is investigated: HAGIS-LIGKA results are compared to those of a different hybrid code, HMGC [7], which already contains wave structure evolution. For that comparison, a newly implemented phase space diagnostic, the so called Hamiltonian Mapping Technique [8] is used. It allows for a detailed study of wave-particle interaction processes, especially in the view of non-linear saturation mechanisms, including the newly implemented effect of a parallel electric field.

References

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