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Study of Nonlinear Fast Particle Transport and Losses in the Presence of Alfvén Waves

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A nonlinear hybrid model is used to study energetic particle transport and losses in realistic TOKAMAK – particularly ASDEX Upgrade –multi-mode scenarios. The model consists of the vacuum-extended version of the drift kinetic HAGIS code. 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.
In the view of ITER, where in certain scenarios, a "sea"of small-amplitude perturbations is likely, realistic multi-mode simulations will be carried out in the near-stability regime. This requires the use of the newly implemented non-local damping via accounting for a parallel electric field. The crucial question is, if the interaction between the "sea"of perturbations with the EPs will drive linearly stable or weakly unstable modes such that particle losses occur in a domino effect. Which of the modes are driven unstable in the simulation and their amplitudes can then be compared with the dominant modes measured in present-day experiments such as ASDEX Upgrade.
Moving further above the stability threshold, it is not only important to account for the correct damping mechanisms. Also, the radial wave structure is very sensitive to the EP distribution function and is expected to evolve, as the distribution function changes. Although the nonlinear wave-particle interaction is calculated self-consistently within the HAGIS-LIGKA model, at the present status, other nonlinearities such as the evolution of wave structure and damping rate are not included yet. Before extending the model in this direction, the expected effect of the radial wave structure evolution is investigated, both with a numerical approach as well as with the help of experimental observation. Concerning the numerical study, HAGIS-LIGKA results are compared to those of a different hybrid code, HMGC, which already contains wave structure evolution. For that comparison, a new phase space diagnostic technique is developed for both codes, the so called Hamiltonian Mapping Technique. From the experimental side, next to Alfvénic modes, fishbones offer a good opportunity to model frequency and amplitude evolution according to experimental observation and compare the occurring transport in phase space.

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