Effects of fast ion phase space modifications by instabilities on fast ion modeling

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Reduced models for energetic particle (EP) transport are emerging as an effective tool for long time-scale integrated simulations of tokamak plasmas, possibly including the effects of instabilities on EP dynamics. Available models differ in how EP distribution properties are modified by instabilities, e.g. in terms of gradients in real or phase space. It is therefore crucial to assess to what extent different assumptions in the models affect predicted quantities such as EP profile, energy distribution, Neutral Beam (NB) driven current and energy/momentum transfer to the thermal populations. A newly developed kick model, which includes modifications of the EP distribution by instabilities in both real and velocity space, is used to address these issues. The model condenses information on EP distribution response to instabilities, e.g. modeled through the particle following code ORBIT, in a EP transport probability. The latter can be included in the NUBEAM module of the TRANSP tokamak transport code, which computes EP evolution. Coupled to TRANSP simulations, the kick model is used to study NB-heated NSTX discharges featuring unstable toroidal Alfvén eigenmodes (TAEs). Results show that TAEs selectively affect the EP energy distribution, with a decrement of 10-30% for the core NB driven current. When TAEs evolve in so-called TAE avalanches, the model reproduces the measured drops of ~10% in the neutron rate.

Results from the kick model will be compared to those from a simple diffusive model and a “critical gradient” model, which postulate radial EP gradient as the only transport drive. The importance of EP modifications in real and velocity space is discussed in terms of accuracy of simulations vs. experimental results, with emphasis on Neutral Beam current.

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