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Phase space effects on fast ion transport modeling in tokamaks[1]

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Simulations of burning plasmas require a consistent treatment of energetic particles (EP), possibly including the effects of instabilities. Reduced EP transport models are emerging as an effective tool to account for those effects in long time-scale simulations. Available models essentially differ for the main transport drive, which is associated to gradients in real or phase space. It is crucial to assess to what extent those different assumptions affect computed quantities such as EP profile, Neutral Beam (NB) driven current and energy/momentum transfer to the thermal populations. These issues are investigated through a kick model, which includes modifications of the EP distribution by instabilities in real and velocity space [M. Podestà et al., Plasma Phys. Control. Fusion 56 055003 (2014)]. TRANSP simulations including the kick model are applied to NB-heated NSTX discharges featuring unstable toroidal Alfvén eigenmodes (TAEs). Results show that TAEs mainly affect fast ions with large parallel velocity, i.e. the most effective for NB current drive. Other portions of the EP distribution are nearly unperturbed. Core NB driven current decreases by 10-30%, with even larger relative changes toward the plasma edge. When TAEs evolve in so-called avalanches, the model reproduces measured drops of $\sim 10\%$ in the neutron rate. Consistently with previous results, the drop is caused by both EP energy loss and EP redistribution. These results are compared to those from a simple diffusive model and a "critical gradient" model [N. Gorelenkov et al., Proc. 25$^{\text{th}}$ IAEA-FEC, St. Petersburgh (Russia), CD-ROM file TH/P1-2, (2014)], which postulates radial EP gradient as the only transport drive. The importance of EP velocity space modifications is discussed in terms of accuracy of the predictions, with emphasis on Neutral Beam driven current.

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