

Reconstruction of MHD modes for energetic particle dynamics studies in toroidal equilibria with arbitrary q profiles

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The interaction of energetic particles with MHD modes of different types is a major concern for the next generation of experiments involving burning plasmas. This issue arises in different contexts such as particle redistribution due to current driven instabilities (involving or not magnetic reconnection), activation of Alfvén eigenmodes (AE) due to wave-particle interaction or loss of confinement caused by neoclassical tearing modes (NTM). The physics involved in these processes is varied and complex. However, the construction of adequate models to study particle redistribution is usually simplified by assuming that the modes affect the particle dynamics through the perturbation of the equilibrium fields. Thus, the knowledge of the total field, equilibrium plus perturbation, produced in each case enables the calculation of the particle redistribution. In previous works, a model employing a fixed equilibrium and internal modes reconstructed from experimental data was developed and successfully applied to study alpha particle redistribution in the presence of kink modes and sawteeth with partial reconnection. To be able to tackle a larger number of problems, in this work, we extend the method to allow for the use of MHD equilibria with arbitrary safety factor (q) profiles. Again, external data either from experiments or simulations may be incorporated to estimate the structure of the modes. The resulting model is flexible and can be employed to study the effect of MHD modes on test particles in a variety of situations. As a first example, the redistribution of energetic particles caused by the sawtooth crash is considered. Several scenarios are investigated including full and partial reconnection in usual tokamak equilibria as well as configurations with an extended region of low magnetic shear at the plasma core.

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