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Multi-Phase Simulation of Alfvén Eigenmodes and Fast Ion Distribution Flattening in DIII-D Experiment

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This paper presents the first simulation that predicts both nonlinear saturation amplitude of Alfvén eigenmodes (AE modes) and fast ion transport that are close to measured values in experiment. This simulation enables us to predict the alpha particle distribution and the AE modes activity, which is one of the major concerns for burning plasmas such as ITER. A multi-phase simulation [1], which is a combination of classical simulation and hybrid simulation for energetic particles interacting with a magnetohydrodynamic (MHD) fluid, is employed in this work. The classical simulation follows energetic particle orbits in the equilibrium magnetic field without MHD perturbations. The hybrid simulation code MEGA is extended with realistic beam deposition profile, collisions (slowing down, pitch angle scattering, and energy diffusion), and losses, and is used for both the classical and hybrid phases. The simulation is applied to DIII-D discharge #142111 where the fast ion spatial profile is significantly flattened due to multiple AE modes [2]. Temperature fluctuations due to two of the dominant toroidal Alfvén eigenmodes (TAE modes) in the simulation results are compared in detail with the electron cyclotron emission (ECE) measurement in the experiment. It is demonstrated that the temperature fluctuation profile and the phase profile are in very good agreement with the measurement, and the amplitude is also in agreement within a range of 40%. The fast ion pressure profile flattening observed in the experiment is also successfully reproduced.

[1] Todo Y. et al submitted to Nucl. Fusion

[2] Van Zeeland M. A. et al 2012 Nucl. Fusion 52 094023

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