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Hybrid Simulation of Global Alfvén Eigenmode and Energetic Particle Mode in Heliotron J, a Low Shear Helical Axis Heliotron

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Magnetohydrodynamic (MHD) and energetic particle hybrid simulation code, MEGA, is applied to Heliotron J, an advanced stellarator/heliotron device with low magnetic shear, helical axis, and finite vacuum magnetic well. Due to the low magnetic shear, the global Alfvén eigenmode (n/m=2/4) has been dominantly observed, along with the energetic particle mode (n/m=1/2) in the experiment. In a recent experiment, a low frequency mode has also been observed when the plasma current is ramped up to a certain threshold. A bump at the high energy tail of the energetic particle distribution is observed in Heliotron J experiment for particles with low pitch angle, due to the significant charge-exchange loss at the

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peripheral region. It is gradually changed to the slowing-down distribution for particles with high pitch angles. The objective of this paper is to clarify the interaction between energetic particles and magnetohydrodynamic waves in the experiment and present the dependency of the energetic particle-driven mode on the equilibrium energetic particle distribution function. In this calculation, MHD equilibrium is based on the low bumpiness (low toroidal magnetic mirror) configuration. The slowing-down and the bump-on-tail distributions are utilized to study the dependency of energetic particle mode and global Alfvén eigenmode on the energy distribution. The n/m=1/2 energetic particle mode and the n/m=2/4 global Alfvén eigenmode have been successfully reproduced in the simulation. Both the n/m =1/2 and 2/4 modes are dominantly destabilized by two velocity ranges of the passing energetic particles, which are 7 to 14 keV, and 20 to 24 keV, where the injection energy is 28 keV. This results in no significant difference in the linear growth rate of the mode, despite changing the location of the distribution peak in energetic particle energy distribution. The discrepancies between the simulation and the experiment will be discussed for further improvement.

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