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Analysis of energetic particle driven toroidal Alfven eigenmodes in CFETR baseline scenario

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For burning plasmas in fusion reactors, Energetic Particles (EP) generated from plasma heating and D-T reaction can destabilize Alfven Eigenmodes (AE). Alfven eigenmodes can conversely induce transport and loss of energetic particles. It is one of the crucial issues to study the interaction between EPs and AEs for CFETR (China Fusion Engineering Test Reactor). Eigenanalysis of AEs in CFETR baseline scenario is taken by using AWEAC (Alfven Wave Eigen-Analysis Code), a developing code similar to NOVA/NOVA-k but dealing with asymmetric configuration of tokamaks. Linear simulations of TAEs driven by EPs are performed using the hybrid-kinetic MHD module in the NIMROD code. This HK-MHD module includes the kinetic effects of EPs through the coupling between a δf particle-in-cell (PIC) model for EPs and the 3D MHD model for the bulk plasma. The CFETR equilibrium used is obtained from the EFIT code based on self-consistent core-pedestal coupled OMFIT workflow. The "slowing down"distribution is used to model the equilibrium distribution of energetic ions from α particles produced by fusion. The frequency of TAEs generated by EPs in NIMROD simulation are consistent with the eigen-analysis results from AWEAC, which are within the range 40-100 kHz. For TAEs/EPMs driven by α particle from D-T fusion, the growth rate increases with both the toroidal mode number and EP beta fraction. Global 2D twist structures of TAEs/EPMs in CFETR baseline scenario, especially RSAE (Reverse Shear Alfven eigenmode) structure for some cases, are obtained for the first time using NIMROD. These results may be helpful for the future design of CFETR operations.

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