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Gyrokinetic-MHD coupled simulation of RMP plasma interaction reproduces density pump-out seen in the tokamak edge

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The gyrokinetic neoclassical particle-in-cell code XGCa coupled to the MHD code M3D-C1 is applied to study the particle and heat flux caused by external 3D magnetic perturbations in a DIII-D H-mode plasma. Despite the existence of KAM surfaces in the pedestal, our simulations, which so far are limited to the 0.5 to 1 ms directly after the RMP field is switched on, show the beginning of density pump-out at the pedestal top as well as a steepening and narrowing electron temperature pedestal around the separatrix similar to observations in the DIII-D tokamak [L. Cui et al., Nucl. Fusion 17, 116030 (2017)].
The RMP field is known to enhance particle transport leading to density pump-out and to be able to suppress edge localized modes (ELMs) in tokamak plasma. Pump-out occurs with or without ELM suppression [R. Nazikian et al., Phys. Rev. Lett., 105002 (2015)], and understanding its physics basis is important for developing predictive understanding.
Due to the short time scales studied so far with XGCa, core heat and torque sources, and turbulent transport can be neglected. Only an electron heat sink on the separatrix and in the scrape-off layer is added to model radiative cooling. The increased, RMP induced particle and energy fluxes observed in our study - despite the presence of KAM surfaces in the M3D-C1 computed screened RMP field - are mostly of convective nature as can be seen from the weak change in the electron temperature compared to the particle density at the pedestal top.
While these XGCa simulations already reproduce essential experimental findings such as the beginning density pump-out and the convective nature of the RMP induced energy flux, several enhancements are being investigated. Those enhancements include initializing the simulation with experimental toroidal rotation profiles, adding NBI torque source, replacing the simple SOL heat sink by an actual model for impurity radiation, and adding a turbulent transport model, and core heat and torque sources. Self-consistent, kinetic calculation of the screened RMP field with an XGCa-internal solver for Ampére's law and comparison to the M3D-C1 screened RMP field is investigated as well.

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