Towards self Consistent Tearing Mode Evolution and Micro-Turbulence Interaction in Gyrokinetics

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The non-linear evolution of the tearing mode (TM) in collisionless limit is investigated using the gyrokinetic code ORB5 [1] solving the electromagnetic Maxwell-Vlasov system of equations with a PIC scheme in collisionless limit. An m/n=2/1 TM is destabilized by an unstable current profile in toroidal geometry with large aspect ratio and low mass ratio. We investigate the self-consistent time evolution of the 2/1 TM varying several plasma parameters, in presence or not of turbulence. In order to properly take the mutual interaction of the TM with micro instability and turbulence during the non-linear phase, the number of numerical particles (markers), number of modes and resolution are important. For instance, the electron skin depth, d_e determines the width of the reconnection layer in collisionless limit and is related to the mass ratio and the plasma-β: $d_e \sim [m_e/(m_i\beta)]^{1/2}$. At realistic mass ratio, a large radial resolution is required to resolve the reconnection layer using fully kinetic species. At the same time, a sufficient number of markers is necessary to investigate the mutual interaction of the tearing mode with micro-instability and turbulence. Even though several control variate and noise reduction techniques together with a Fourier filter allow simulations with good signal-to-noise with a reduced numerical burden, the simulation time required to reach steady states is still costly. Our simulations demonstrate that turbulence develops at the island separatrix even flat temperature and density profiles. At low plasma-beta, strong electromagnetic turbulence is produced which can modify the equilibrium safety factor. This results in a strong reduction of the island size at saturation and strong zonal current generation.

References

1 Lanti, E., Ohana, N., Tronko, N., et al. 2020, Computer Physics Communications, 251, 107072.