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Gyrokinetic δf particle simulation of trapped electron mode driven turbulence[1]

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Turbulent transport driven by collisionless trapped electron modes (CTEM) is systematically studied using gyrokinetic delta-f particle-in-cell simulation. Scaling with local plasma parameters, including density gradient, electron temperature gradient, magnetic shear, temperature ratio and aspect ratio, is investigated. Simulation results are compared with previous simulations and theoretical predictions. Nonlinearly the transport level increases with increasing magnetic shear. We explain the nonlinear magnetic shear scaling by differences in the radial correlation lengths caused by toroidal coupling. The turbulence is more radially elongated at higher magnetic shear compared with low magnetic shear. We show that the suppression effect of zonal flow on CTEM transport depends on both the electron temperature gradient and the electron to ion temperature ratio. This helps explain the previous contradictory conclusions on the importance of zonal flows in different parameter regimes.[2] Zonal flow suppression is consistent with the rate of EXB shearing from the ambient turbulence as well as the radial broadening of the spectra. Strong geodesic acoustic modes (GAMs) are generated along with zonal flows and the frequency of the GAMs agrees well with kinetic theory.[3] We further explore the nonlinear saturation mechanism when the zonal flows are not important. We find that when only a single toroidal mode (and its conjugate) is kept, reasonable nonlinear saturation is obtained. Investigating a range of n, modes with larger mode number n saturate at a higher level relative to lower n modes, indicating a turbulent inverse cascade process.

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[2]T. Dannert, F. Jenko, Phys. Plasmas 12, 072309 (2005); D. Ernst, et al., Phys. Plasmas 11, 2637 (2004).
[3]T. Watari, et al., Phys. Plasmas 13, 062504 (2006).