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Theory of Electromagnetic Turbulence Driven Intrinsic Current

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We report on new results in the theory of electromagnetic turbulence driven intrinsic current. The intrinsic current driven by electromagnetic (EM) micro-turbulence could be important for ITER because its modification to the local current profile may significantly affect the MHD instability. This paper focuses on the intrinsic current driven by both EM electron temperature gradient (ETG) turbulence in the core region and EM electron drift wave in the edge pedestal region.

This paper presents the mean parallel current density evolution equation using electromagnetic (EM) gyrokinetic equation. We found two types of intrinsic current driving mechanisms resulted from EM turbulence [1]. The first type is the divergence of residual turbulent flux including a residual stress-like term and a kinetic stress-like term. The second type is named as residual turbulent source, which is driven by the correlation between density and parallel electric field fluctuations. This is analogous to the intrinsic rotation drive by EM turbulence [2, 3]. However, the difference is that the intrinsic current density driven by the residual turbulent source is negligible as compared to that driven by the residual turbulent flux. Therefore, the modification of local current density could be significant.

For EM electron temperature gradient (ETG) turbulence in the core region of ITER standard scenario, the ratio of local intrinsic current density driven by the residual turbulent flux for mesoscale variation of turbulent flux can reach about 80% of the bootstrap current density, but there is no net intrinsic current on a global scale [1]. This significant modification of the local current density may affect the NTM instability which has been reported [4].

For EM electron drift wave in ITER pedestal region, there exists strong cancelation between non-adiabatic ES response and the non-adiabatic EM response, and thus the kinetic stress contributed by the adiabatic ES response of parallel electron pressure dominates the intrinsic current drive. This is different from the ES electron DW case. Therefore, the EM effects on turbulence driven intrinsic current density should be carefully considered in the future reactor with high ratio of electron pressure to the magnetic pressure and steep pressure profile. Moreover, the scalings of the ratios of intrinsic current density driven by residual turbulent flux and by turbulent source to the bootstrap current density with electron density and temperature are predicted to be $(T_e^{3/4} T_i)/n_e$ and $(T_e T_i)/n_e$, respectively [5].

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