Center for Momentum Transport and Flow Organization in Plasmas and Magnetofluids (CMTFO)
DE-SC0002090, Final report, 9/15/2009-3/14/2012

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The CMTFO funding partially supports a junior researcher and a graduate student at UCI. During this project, we have further developed the global gyrokinetic particle code GTC to study the momentum transport in tokamak driven by electrostatic ion temperature gradient (ITG) turbulence [1] with kinetic electrons and by collisionless trapped electron mode (CTEM) turbulence [2]. We have also upgraded GTC for fully electromagnetic simulation and for linear plasma configuration with verification and validation of the electron temperature gradient (ETG) turbulence in Columbia Linear Machine. The followings are the highlights on the physics results reported in the key publications of this project.

- [1] [*Effects of electron dynamics in toroidal momentum transport driven by ion temperature gradient turbulence*](#), I. Holod and Z. Lin, *Plasma Phys. Contr. Fusion* **52**, 035002 (2010).

Several issues in the toroidal angular momentum transport by the ion temperature gradient (ITG) turbulence are addressed in this work: the system size effect in the momentum transport, the symmetry breaking mechanism for the generation of the spontaneous rotation and the effect of the trapped electron dynamics. We find that the magnitude of the momentum flux scales with the system size according to the gyroBohm scaling, with no significant size effect on the radial structure of the perturbed toroidal angular momentum. The symmetry breaking due to the shear of the radial electric field is found to be a mechanism for generating the residual momentum flux. However, it is small compared with the momentum pinch term in the case of a finite background rotation. The trapped electrons in the ITG turbulence increase the intensity and modify the spectral properties of the electrostatic fluctuations, leading to the increase in the toroidal momentum pinch.

- [2] [*Turbulent Transport of Toroidal Angular Momentum in Fusion Plasmas*](#), I. Holod, Z. Lin, and Y. Xiao, *Phys. Plasmas* **19**, 012314 (2012).

Global nonlinear gyrokinetic simulations of ion temperature gradient (ITG) and collisionless trapped electron mode (CTEM) turbulence find significant spinning up of a plasma in the directions opposite for CTEM and ITG turbulence. The outward momentum convection by the particle flux could be strong enough to overcome the inward momentum pinch and reverse the radial direction of the convective momentum flux. Momentum pinch velocity shows no explicit dependence on background temperature, while it is significantly affected by steepening the background density. Convective momentum fluxes are generally smaller in the CTEM turbulence than the ITG turbulence, while the intrinsic Prandtl number is similar or slightly larger in the CTEM turbulence.

Key publications:

1. [*Effects of electron dynamics in toroidal momentum transport driven by ion temperature gradient turbulence*](#), I. Holod and Z. Lin, *Plasma Phys. Contr. Fusion* **52**, 035002 (2010).
2. [*Turbulent Transport of Toroidal Angular Momentum in Fusion Plasmas*](#), I. Holod, Z. Lin, and Y. Xiao, *Phys. Plasmas* **19**, 012314 (2012).