Testing the High Turbulence Level Breakdown of Low-Frequency Gyrokinetics Against High-Frequency Cyclokinetic Simulations [*]

Zhao Deng, Peking University

Gyrokinetic simulations of L-mode near edge tokamak plasmas with the GYRO code underpredict both the transport and the turbulence levels by 5 to 10 fold [1], which suggest either some important mechanism is missing from current gyrokinetic codes like GYRO or the gyrokinetic approximation itself is breaking down. It is known that GYRO drift-kinetic simulations with gyro-averaging suppressed recover most of the missing transport [2]. With these motivations, we developed a flux tube nonlinear cyclokinetic [3] code rCYCLO with the parallel motion and variation suppressed. rCYCLO dynamically follows the high frequency ion gyro-phase motion (with no averaging) which is nonlinearly coupled into the low frequency drift-waves thereby interrupting and possibly suppressing the gyro-averaging. By comparison with the corresponding gyrokinetic simulations, we can test the conditions for the breakdown of gyrokinetics. rCYCLO nonlinearly couples grad-B driven ion temperature gradient (ITG) modes and collisional fluid electron drift modes to ion cyclotron (IC) modes. As required, rCYCLO cyclokinetic transport recovers gyrokinetics at high relative ion cyclotron frequency (Ω^*) and low turbulence levels. However, because the IC modes are stable and act as a turbulence sink, we have found that at high turbulence levels and low-Ω^* cyclokinetic transport is lower (not higher) than gyrokinetic transport. Work is in progress with unstable IC modes to explore the possibility of driving cyclokinetic transport higher than gyrokinetic transport.

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[2] R.E. Waltz, Bull. Am. Phys. Soc. **57**, 105 (2012).
[3] R.E. Waltz and Zhao Deng, Phys. Plasmas **20**, 012507 (2013).