Multiscale Gyrokinetic Analysis in the Tokamak Pedestal

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The spectral transition of multiscale turbulence, which couples ion and electron scales, in the tokamak pedestal is studied with gyrokinetic simulations. While ion-scale turbulence in the tokamak core has been modeled extensively, multiscale simulations are far more challenging, requiring leadership computing resources. To our knowledge, no multiscale simulations of pedestal-like transport with full ion-electron cross coupling have been done previously. In this work, multiscale simulations are performed using parameters based on a DIII-D H-mode plasma in the pedestal. The studies are enabled with the CGYRO code [1, 2], which uses a spatial discretization and array distribution scheme that is spectral/pseudospectral in four of the five phase space dimensions and targets scalability on next-generation, exascale HPC systems that use multicore and GPU-accelerated hardware. The ensemble of 5 multiscale resolution simulations required 250k node-hours on the OLCF Summit supercomputer. In a scan over ion temperature gradient, the experiment lies in a bifurcation region between ion-scale and multiscale-dominated turbulence regimes. The transition in the wavenumber spectrum and mechanism by which electron-scale transport is reduced by nonlinear mixing with ion-scale fluctuations and ion-scale driven zonal flows are analyzed. The analysis highlights the importance of multiscale simulations for pedestal-like regimes.

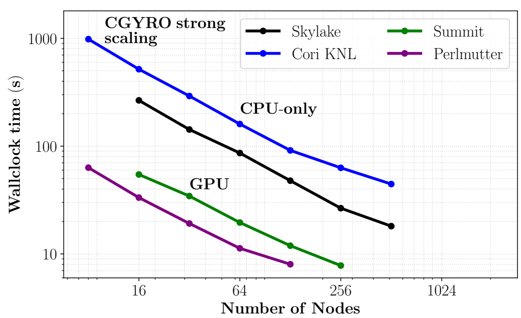

Fig.1. CGYRO strong scaling performance.

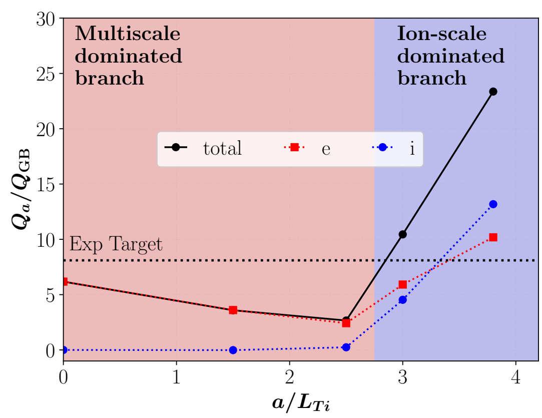

Fig.2. CGYRO pedestal energy flux.

References

[1] J. Candy, E.A. Belli, and R.V. Bravenec, J. Comput. Phys. **324**, 73 (2016)

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