Zonal flow dynamics and size-scaling of anomalous transport

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The dependence of plasma confinement on the device size is obviously a very crucial issue in fusion energy research. Assuming drift waves are responsible for the anomalous transport, this size-scaling issue then can be reduced, in the simplest model, to the dependence of drift-wave fluctuation intensity on ρ_*. Here $\rho_* = \rho_\mathrm{i}/L$ with ρ_i and L being, respectively, the ion Larmor radius and the plasma inhomogeneity scale length. Since in the $L \to \infty$ limit, the coherent 4-wave drift wave-zonal flow modulation interaction model of Chen, Lin and White [1] has captured the essential features observed in global gyrokinetic simulations, we are thus motivated to adopt , as a theoretical paradigm, the coherent 4-wave model including the finite L (i.e., finite ρ_*) plasma inhomogeneities. In this finite-ρ_* coherent 4-wave model, thus, not only the pump radial envelope will be localized leading to reduction in the modulational instability growth rate due to the finite interaction region; but more interestingly the damped pump and sidebands will disperse outward leading to radial spreading of the drift wave turbulence; qualitatively similar to that observed in recent simulations by Lin et al [2].

We have constructed a numerical model which displays these features. Thresholds, growth rates, and nonlinear saturation properties are studied as a function of scale length L. Results are compared to gyrokinetic simulations.

References

[1] Liu Chen, Zhihong Lin and Roscoe White, Phys. Plasmas **7**, 3129, (2000).
[2] Z. Lin, S. Ethier, T.S. Hahm and W.M. Tang, Phys. Rev. Lett. **88**, 195004, (2002).