Gyrokinetic Simulations of Ion and Impurity Transport

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Abstract

We present a systematic study of turbulent particle and energy transport in both pure and multi-component plasmas. In this study, gyrokinetic results from the GYRO code are supplemented with those from the GLF23 transport model, as well as from quasilinear theory. A variety of new results are obtained. We demonstrate the production of a particle pinch driven by temperature gradients (a thermal pinch), and show that it is weakened by finite electron collisionality. We also examine helium transport and the effects of helium density gradient in a deuterium plasma. Interestingly, we find that the simple $D - v$ (diffusion versus pinch-velocity) model of impurity flow is consistent with results obtained from nonlinear gyrokinetic simulations. We also study transport in a 50-50 deuterium-tritium plasma, and observe a striking type of symmetry breaking that gives rise to a robust confinement improvement for tritium. The effect indicates the potential for fuel separation in a burning plasma. Quasilinear theory together with linear simulations shows that symmetry breaking which enhances the tritium confinement arises largely from finite-larmor-radius effects. To justify the numerical methods used in the paper, a variety of linear benchmarks and nonlinear grid refinement studies are detailed.

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