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Particle Pinch in Gyrokinetic Simulations of Closed Field-line Systems

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Gyrokinetic GS2 simulations of plasma turbulence and particle and heat transport in a dipole magnetic field geometry created by a ring current are presented. This study is relevant to the MIT/Columbia University Levitated Dipole Experiment (LDX) [Kesner et al, Plasma Phys. Reports, 1997], a fusion experiment designed to explore hot plasma confinement in a dipolar magnetic field. The work also has potential applications to planetary magnetospheres. In addition to magnetohydrodynamic (MHD) ideal interchange and ballooning modes, a non-MHD mode known as the entropy mode is present in this system. The entropy mode has a scale length smaller than ideal modes ($k_\perp \rho_i \sim 1$) but comparable growth rates. Considering parameter regimes that are ideally stable, we explore the physics of turbulent transport generated by entropy modes, finding enormous variation in the nonlinear dynamics as a function of the density and temperature gradients. In particular, we report here the existence a new particle pinch regime, in which the particles are transported up the density gradient. We show that this discovery is consistent with gyrokinetic and two-fluid quasi-linear theory. The presence of a particle pinch appears to be consistent with recent observations in LDX [Boxer et al, Nature Physics, 2010].