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Gyrokinetic simulations of plasma turbulence, transport and zonal flows in a closed field line geometry[1]

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We present nonlinear gyrokinetic simulations of small-scale plasma turbulence and transport in closed field-line geometries relevant to the Levitated Dipole Experiment (LDX) and planetary magnetospheres: the Z-pinch and the ring-dipole. As in toroidal geometries, the instabilities present in the system depend on the steepness of the plasma pressure gradient: for sufficiently steep gradients, the system is unstable to ideal interchange modes, while for weaker gradients, short wavelength non-MHD modes at the ion gyro-radius scale (entropy modes) typically dominate. Considering the latter, ideally-stable case at low plasma beta, we find an enormous variation in the nonlinear dynamics and particle transport as a function of the density and temperature gradients and the plasma collisionality. This variation is explained in part by the damping and stability properties of spontaneously formed zonal flows in the system. As in toroidal systems, the zonal flows can lead to a strong nonlinear suppression of transport below a critical gradient that is determined by the stability of the zonal flows.

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