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Direct identification of Predator-Prey dynamics in Gyrokinetic Simulations

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The interaction between spontaneously formed zonal flows and small-scale turbulence in nonlinear gyrokinetic simulations is explored in a shearless closed field line geometry. It is found that when clear limit cycle oscillations prevail, the observed turbulent dynamics can be quantitatively captured by a simple Lotka-Volterra type predator-prey model. Fitting the time traces of full gyrokinetic simulations by such a reduced model allows extraction of the model coefficients. Among other findings, it was observed that the effective growth rates of turbulence (i.e. the prey) remain roughly constant, in spite of the higher and varying level of primary mode linear growth rates. The effective growth rate that was extracted corresponds roughly to the zonal-flow-modified primary mode growth rate. The result also demonstrates that the effective damping of zonal flows (i.e. the predator) in the parameter range, where clear predator-prey dynamics is observed (i.e. near marginal stability), agrees with the collisional damping expected in these simulations. This implies when the tertiary instability plays a role the dynamics becomes more complex than a simple Lotka-Volterra predator prey model.

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