Comment on "Wave-Particle Decorrelation and Transport of Anisotropic Turbulence in Collisionless Plasmas" (22 January 2008)

Guided by results from a global particle-in-cell gyrokinetic simulation of electron-temperature-gradient (ETG) turbulence, Lin *et al.* [1] present a heuristic explanation for the accompanying electron energy transport in terms of stochastic wave-particle decorrelation. In this comment, we identify questionable features of the numerical results which cast some doubt on the accompanying heuristic arguments.

In Ref. [1], curves of electron energy diffusivity as a function of time are shown for GTC [2] simulations of ETG turbulence. The simulations employ the adiabatic ion approximation, and by varying the number of particles per cell, the authors show that the result, $\chi_e \simeq 5\,\rho_e^2 v_e/L_T$, is adequately converged with respect to velocity-space resolution. The perpendicular grid spacing is said to be ρ_e, but the details of the numerical filter function are not discussed, so the actual $k_\theta\rho_e$ resolution is unspecified. Fig. 1 below shows that the reported value for χ_e is characteristic of **early-time**, **low-resolution** GYRO [3] results for the same case (i.e, the same physical parameters). Specifically, the red and purple curves in Fig. 1 show that as long as wavenumber resolution is limited to $k_\theta\rho_e < 0.6$ in the GYRO simulation, an average electron transport level of $\chi_e \simeq 5\,\rho_e^2 v_e/L_T$ (see dotted horizontal line) is observed on the interval $250 \leq (v_e/L_T)t \leq 1000$. The square box in the lower-left section of Fig. 1 shows electron density fluctuations in the radial-binormal plane at $(v_e/L_T)t \simeq 900$; this indicates that transport is streamer-dominated as noted in Ref. [1]. Thus, under these conditions, the two codes (GTC and GYRO) are apparently simulating the same phenomena with the same accuracy. Yet, at later time, $(v_e/L_T)t > 1000$, the transport level drops significantly in the GYRO simulation ($\chi_e < 1\,\rho_e^2 v_e/L_T$) and is no longer streamer-dominated, as illustrated in the fluctuation plot in the lower-right section of Fig. 1. This effect, which is missing from Ref. [1], is not new; in fact, it has been reported by Parker [4] for exactly the same operating parameters.

Unfortunately, we have a more serious concern with the results presented in Ref. [1]. In GYRO simulations (orange and black curves, Fig. 1) which resolve higher wavenumbers, the ETG transport fails to saturate physically. This "runaway" effect has been corroborated in detail through exhaustive community benchmarking exercises [5, 6] by numerous codes (for both local and global simulations), and is known to be a consequence of the adiabatic ion approximation – which in this case is physically untenable. In order to accurately determine the electron heat transport for the parameters of Ref. [1], it appears that a realistic treatment of long-wavelength ion physics is required. For example, it is known that ion-temperature-gradient turbulence can have a significant mitigating effect on ETG transport [6].

In conclusion, the simulations presented in [1] lack the critical ion physics required to achieve a well-resolved, physically meaningful saturated state. Instead, the simulations exhibit a transport level characteristic of insufficient wavenumber resolution and insufficient simulation duration.

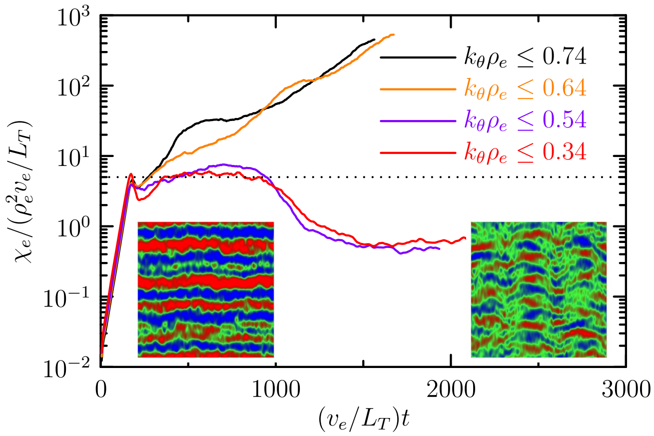

FIG. 1: Time-traces of electron energy transport calculated by GYRO [3] assuming adiabatic ion dynamics. Red and purple curves show that low-perpendicular-resolution cases saturate at a low level, whereas higher-resolution cases in orange and black fail to saturate. Square boxes at left and right show electron density fluctuations in the radial-binormal plane at approximately $(v_e/L_T)t = 900$ and 1500 respectively.

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