# Gyrokinetic exact linearized Landau collision operator: conservative formulation and initial implementation

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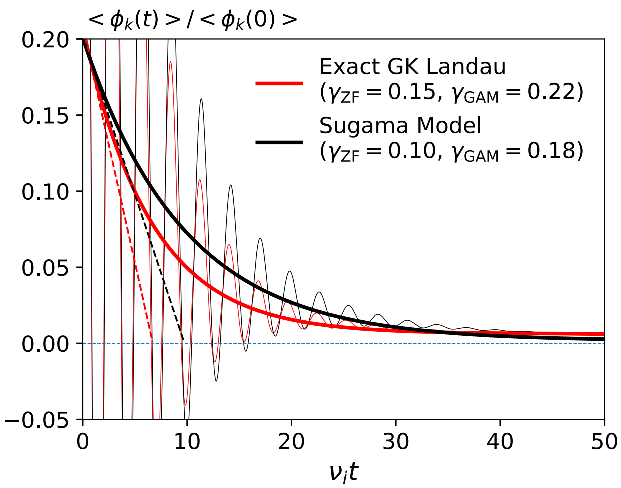


We have formulated the exact gyrokinetic linearized Landau collision operator in symmetric and conservative Landau form [1] and have implemented the new operator in the GENE gyrokinetic code. The new exact operator displays stronger collisional damping of GAMs and zonal flows than the Sugama model. As shown in the figure, the new exact operator yields a zonal flow damping rate 50% greater, and a GAM damping rate 22% greater, than the Sugama model operator (here $\nu_{ii}R/c_s \sim 1$, $k_r\rho_s \sim 0.1$). The operator has now been used in gyrokinetic calculations of TEM and ITG growth rate spectra with finite $k_y\rho_i$ collisional corrections. Initial results show the Sugama model operator accurately captures the finite gyroradius collisional corrections which reduce TEM growth rates as $k_y\rho_i$ increases. The Sugama operator has previously been implemented in GENE using the same finite-volume method [3], allowing direct comparison. Numerical tests have demonstrated the equivalence between the new Landau form and Fokker–Planck form [2] and verified the conservation properties and H-theorem. Dependence of the zonal flow damping on inverse aspect ratio and collisionality will be discussed.

The new operator is comprised of test-particle and field-particle contributions, and finite Larmor radius (FLR) effects are evaluated in either Bessel function series or gyrophase integrals. The gyrokinetic conservative Landau form explicitly preserves the symmetry between test-particle and field-particle contributions. This symmetry underlies the conservation laws and the H-theorem, and enables discretization with finite-volume or spectral methods to preserve the conservation properties numerically, independent of resolution. The form of the exact linearized field-particle terms differs from those of widely used model operators. The FLR corrections to the field-particle terms in the exact linearized operator involve Bessel functions of all orders, while present model field-particle terms involve only the first two Bessel functions. Work supported by U. S. DOE Contract DE-FC02-08ER54966.

References:

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[2] B. Li and D. R. Ernst, Phys. Rev. Lett. **106**, 195002 (2011).
[3] P. Crandall, D. Jarema, H. Doerk, Q. Pan, G. Merlo, T. Görler, A. Bañón-Navarro, D. Told, M. Maurer, and F. Jenko, submitted to Computer Physics Communication (2018).