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Landau-Fluid Closures for Edge Plasma Simulation: Models and Implementation[1]

ANDRIS DIMITS[2], Lawrence Livermore National Laboratory

Two issues key to the development of practical gyro-Landau-fluid (GLF) simulation capability for magnetic fusion edge plasmas, and of interest for any situation with both strong spatial nonuniformity and a combination of collisionless and collisional regimes, are addressed. A highly efficient non-Fourier method for the computation of Landau-fluid (LF) closure operators [1] is introduced, based on an approximation by a sum of Helmholtz-equation solves (SHS) in configuration space. This method has fast-Fourier-like scaling of the computational cost, and results in large savings compared with direct application of "delocalization" kernels [2]. It also gives a very compact data representation of these operators in a nonuniform plasma. Systematic procedures have been developed to optimize the resulting operators for accuracy and computational cost. A GLF model [1] has been implemented in the BOUT++ code using the SHS method for both the parallel and toroidal-drift resonance closures, and first-order Pade' approximations for the closures associated with gyroaveraging. Excellent agreement has been obtained with gyrokinetic results [3] for linear toroidal ion-temperature-gradient (ITG) mode growth rates. Results from nonlinear simulations including closures for zonal flow and nonlinear phase mixing will be presented. LF closures are extended using the dynamic heat-flux equation to include strong spatial inhomogeneity, flows, collisions, and collisionless phase-mixing. Comparisons of the resulting model with detailed Fokker-Planck calculations will be presented.

[1] M. A. Beer and G. W. Hammett, Phys. Plasmas **3**, 4046 (1996), and references therein.
[2] G. P. Schurtz, Ph. D. Nicolaï, and M. Busquet, Phys. Plasmas **7**, 4238 (2000).
[3] A. M. Dimits, et. al., Phys. Plasmas **7**, 969 (2000).

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[2]In collaboration with I. Joseph, S. S. Kim, M. V. Umansky, P. W. Xi and X. Q. Xu.