Development of a hyperbolic solver for gyrokinetic equation using discontinuous Galerkin method

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A hyperbolic solver for the gyrokinetic equation is developed in tokamak geometry. The new solver is based on the discontinuous Galerkin method on a mesh constructed by Cartesian products of irregular triangles and regular rectangles, which discretize spatial domain and velocity space, respectively. A strong-stability-preserving Runge-Kutta method is used for the time integration. In an axisymmetric configuration of toroidal plasma, we look into the influence of the basis function on the conservation properties of physical quantities such as mass, kinetic energy, and toroidal canonical angular momentum. The results of numerical experiments show that the new solver with the proper basis functions has good conservation properties of the key physical quantities in the simplified circular magnetic geometry and realistic tokamak geometry. We also confirm that the time invariance of the canonical Maxwellian distribution function is well satisfied with the new solver. We consider the Maxwellian weighted polynomials to investigate the effect of weighing functions. The conservation properties of the Maxwellian weighted polynomial basis functions are similar to those of the polynomial basis; however, good invariance can be obtained even with the lower-order polynomials with canonical Maxwellian function weights. In order to verify the MPI parallelization performance, we carried out numerical tests, which indicate that the new solver shows good parallelization efficiency up to a few thousand CPU cores.

References

[1] G. Jo, J.-M. Kwon, J. Seo, E. Yoon, Comput. Phys. Commun. 273 (2022) 108265