Towards Semi-Implicit Methods for the GX Gyrokinetics Code

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Abstract

Gyrokinetics is one of the main models used for understanding turbulent transport in tokamak and stellarator plasmas. Unfortunately, transport simulations are often limited by the large computational cost of gyrokinetic codes. Recently, the GX gyrokinetics code [1], [2] has demonstrated dramatic improvements in speed due to its pseudo-spectral representation in velocity space and GPU implementation. However, GX uses a purely explicit time-integration scheme, and so suffers from a greatly reduced time-step when kinetically evolving electrons as they have a thermal speed 60 times greater than that of deuterium ions. In this work, we begin implementing semi-implicit methods to address the stiff electron terms in the gyrokinetic equation using third-order additive Runge-Kutta methods from [3]. In particular, we focus on the terms associated with parallel streaming of the electrons in slab geometry. Our implicit method takes advantage of the sparsity of the GX equations due to its pseudo-spectral representation, which allows us to efficiently invert the resulting linear system at each implicit step. Overall it allows us to increase the maximum stable time-step by a factor of 60 with minimal increase in computational cost per time-step. We demonstrate our new integration scheme for both linear (electrostatic and electromagnetic) and nonlinear (electrostatic) simulations.

References

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