Dynamical Low-Rank Approximation for Neutrino Kinetic Equations

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Abstract

Dynamical low-rank approximation (DLRA) is an emerging tool for reducing computational costs and provides memory savings when solving high-dimensional problems. In this work, we propose and analyze a semi-implicit dynamical low-rank discontinuous Galerkin (DLR-DG) method for the space homogeneous kinetic equation with a relaxation operator, modeling the emission and absorption of particles by a background medium. Both DLRA and the DG scheme can be formulated as Galerkin equations. To ensure their consistency, a weighted DLRA is introduced so that the resulting DLR-DG solution is a solution to the fully discrete DG scheme in a subspace of the standard DG solution space. Similar to the standard DG method, we show that the proposed DLR-DG method is well-posed. We also identify conditions such that the DLR-DG solution converges to the equilibrium. Numerical results are presented to demonstrate the theoretical findings.