An Iterative Phase-Space Explicit Discontinuous Galerkin Method for Stellar Radiative Transfer in Extended Atmospheres

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Abstract

A phase-space discontinuous Galerkin (PSDG) method is presented for the solution of stellar radiative transfer problems. It allows for greater adaptivity than competing methods without sacrificing generality. The method is extensively tested on a spherically symmetric, static, inverse-power-law scattering atmosphere. Results for different sizes of atmospheres and intensities of scattering agreed with asymptotic values. The exponentially decaying behavior of the radiative field in the diffusive-transparent transition region, and the forward peaking behavior at the surface of extended atmospheres were accurately captured. The integrodifferential equation of radiation transfer is solved iteratively by alternating between the radiative pressure equation and the original equation with the integral term treated as an energy density source term. In each iteration, the equations are solved via an explicit, flux-conserving, discontinuous Galerkin method. Finite elements are ordered in wave fronts perpendicular to the characteristic curves so that elemental linear algebraic systems are solved quickly by sweeping the phase space element by element. Two implementations of a diffusive boundary condition at the origin are demonstrated wherein the finite discontinuity in the radiation intensity is accurately captured by the proposed method. This allows for a consistent mechanism to preserve photon luminosity. The method was proved to be robust and fast, and a case is made for the adequacy of parallel processing. In addition to classical two-dimensional plots, results of normalized radiation intensity were mapped onto a log-polar surface exhibiting all distinguishing features of the problem studied.

References

1. V. F. de Almeida. An Iterative Phase-Space Explicit Discontinuous Galerkin Method for Stellar Radiative Transfer in Extended Atmospheres. J. Quant. Spectrosc. Radiat. Transfer 196 (2017) 254-269; https://doi.org/10.1016/j.jqsrt.2017.04.007.