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A NEW SCHEME FOR SOLVING HIGH-ORDER DG DISCRETIZATIONS OF THERMAL RADIATIVE TRANSFER USING THE VARIABLE EDDINGTON FACTOR METHOD

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ABSTRACT

We present a new approach for solving high-order thermal radiative transfer (TRT) using the Variable Eddington Factor (VEF) method (also known as quasidiffusion). Our approach leverages the VEF equations, which consist of the first and second moments of the S_N transport equation, to more efficiently compute the TRT solution for each time step. The scheme consists of two loops – an outer loop to converge the Eddington tensor and an inner loop to converge the iteration between the temperature equation and the VEF system. By converging the outer iteration, one obtains the fully implicit TRT solution for the given time step with a relatively low number of transport sweeps. However, one could choose to perform exactly one outer iteration (and therefore exactly one sweep) per time step, resulting in a semi-implicit scheme that is both highly efficient and robust. Our results indicate that the error between the one-sweep and fully implicit variants of our scheme may be small enough for consideration in many problems of interest.

KEYWORDS: thermal radiative transfer, Variable Eddington Factor, high-order, nonlinear iteration

1. INTRODUCTION

We are interested in solving S_N thermal radiative transfer (TRT) on high-order, curved meshes with arbitrary-order discontinuous Galerkin (DG) spatial discretizations. Our motivation stems from the increasing popularity of high-order spatial discretizations and meshes in hydrodynamics simulations. For Lagrangian and arbitrary Lagrangian-Eulerian hydrodynamics, high-order methods have been shown to provide greater robustness (especially if mesh distortions are present), improved symmetry preservation, and stronger scaling compared to low-order, straight-mesh methods [1,2,3]. In many applications of interest (inertial confinement fusion, astrophysical phenomena), hydrodynamics and TRT are tightly coupled, and solving both physics on the same spatial