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A Discontinuous Galerkin Method for the Mono-Energetic Fokker-Planck Equation based on a Spherical Interior Penalty Formulation

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Abstract

We present a new discretization of the mono-energetic Fokker-Planck equation. We build on previous work (Kophazi and Lathouwers, A space-angle DGFEM approach for the Boltzmann radiation transport equation with local angular refinement, j. of computational phys., 297:637-668, 2015) where we devised an angular discretization for the Boltzmann equation, allowing for both heterogeneous and anisotropic angular refinement. The angular discretization is based on a discontinuous finite element method on the unit sphere. Here we extend the methodology to include the effect of the Fokker-Planck scatter operator describing small angle particle scatter. We describe the construction of an interior penalty method on the sphere surface. Results are provided for a variety of test cases, ranging from purely angular to fully three-dimensional. The results show that the scheme can resolve highly forward-peaked flux distributions with forward-peaked scatter.

Keywords: discontinuous Galerkin, Fokker-Planck, particle transport, radiation transport, upwinding, interior penalty

1 Introduction

Charged particle radiation occurs in fields such as radiotherapy, plasma physics, and material sciences. To consider the effects of such radiation one needs an accurate description of how the particles interact with materials of interest such as human tissue.

The interactions of charged particles with the nuclei and the electrons of the material cause a variety of processes that are fundamentally different from those encountered with neutral particles such as photons and neutrons. Charged particle interactions are much more frequent and therefore lead to very large cross sections. Many of these interactions lead to either small deflections in the