Journal of Computational Physics

Volume 229, Issue 9, 1 May 2010, Pages 3189-3213

On the use of flux limiters in the discrete ordinates method for 3D radiation calculations in absorbing and scattering media

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https://doi.org/10.1016/j.jcp.2009.12.037

Abstract

The application of flux limiters to the discrete ordinates method (DOM), S_N, for radiative transfer calculations is discussed and analyzed for 3D enclosures for cases in which the intensities are strongly coupled to each other such as: radiative equilibrium and scattering media. A Newtonâ€“Krylov iterative method (GMRES) solves the final systems of linear equations along with a domain decomposition strategy for parallel computation using message passing libraries in a distributed memory system. Ray effects due to angular discretization and errors due to domain decomposition are minimized until small variations are introduced by these effects in order to focus on the influence of flux limiters on errors due to spatial discretization, known as numerical diffusion, smearing of the beam scattering. Results are presented for the DOM-integrated

quantities such as heat flux, irradiation and emission. A variety of flux limiters are compared to â€œexactâ€ solutions available in the literature, such as the integral solution of the RTE for pure absorbing-emitting media and isotropic scattering cases and a Monte Carlo solution for a forward scattering case. Additionally, a non-homogeneous 3D enclosure is included to extend the use of flux limiters to more practical cases. The overall balance of convergence, accuracy, speed and stability using flux limiters is shown to be superior compared to step schemes for any test case.

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Keywords

Radiative transfer equation (RTE); Discrete ordinates method (DOM); Flux limiters; TVD schemes; Radiation heat transfer; Non-homogeneous 3D media; Newtonâ€“Krylov GMRES

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