An Explicit, Positivity-Preserving Flux-Corrected Transport Scheme For The Radiation Transport Equation

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ABSTRACT

High-order numerical solutions of the radiation transport equation

$$\vec{\Omega} \cdot \vec{\nabla} \psi + \sigma \psi = q$$

are known to exhibit negativities, or undershoots, as a well as overshoots. These numerical artefacts can lead to numerical difficulties, notably in simulations where radiation transport is coupled to hydrodynamics equations. Here, we solve the time-dependent transport equation using a P_1 continuous finite element (CFEM) discretization, stabilized using the entropy viscosity method (an artificial viscosity technique). A flux-corrected transport (FCT) technique is applied to this higher-order solution in order to produce a positivity preserving scheme that satisfies a local discrete maximum principle (DMP). Explicit time discretizations are employed, including explicit Euler and strong-stability-preserving Runge-Kutta (SSPRK) schemes such as the 3-stage, 3rd-order-accurate Shu-Osher scheme (SSPRK33). Results are presented for 1-D test problems, demonstrating that the entropy viscosity method stabilizes the pure Galerkin discretization but does not satisfy a DMP (undershoots and overshoots are still present). On the other hand, the “entropy viscosity + FCT” solution is both stable and discrete-maximum-principle satisfying.