Discontinuous Galerkin High-Order Nonlocal Transport and Energy Equations Scheme for Radiation-Hydrodynamics

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Abstract

The classical description of transport based on Chapman-Enskog approach has been always widely used in fluid models thanks to its simplicity. Nevertheless, it has been shown that the classical local approach is not accurate when the fluid parameters exhibit steep gradiants, which is the typical case of laser heated plasmas. An intensive effort has been made to model the nonlocal radiative energy transport in radiation-hydrodynamics simulations in the last decades [1, 2]. From the existing models [3] we solve directly the photon transport equation allowing one to take into account the effect of long-range photon transport. Our approach delivers a calculation efficiency and an inherent coupling of radiation to the fluid plasma parameters in an implicit way [4]. The use of high-order discontinuous Galerkin method gives us an accurate solution to the transport, that obeys both limiting cases, i.e. the local diffusion asymptotic usually present in radiation hydrodynamics models and the collisionless transport asymptotic of free-streaming photons. In other words, we can analyze the radiation transport closure for the radiation-hydrodynamics and how it behaves when leaving the conditions of validity of Chapman-Enskog method. This is demonstrated numerically in the tests of the exact steady transport of any regime and the approximate time-dependent multi-group diffusion of energy. As an application we present simulation results of intense laser-target interaction, where the radiative energy transport, controlled by the mean free path of photons, shows the importance of the nonlocal model.

References

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