A Fast Numerical Scheme for Causal Relativistic Hydrodynamics with Dissipation

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In this paper, we develop a stable and fast numerical scheme for relativistic dissipative hydrodynamics based on Israel-Stewart theory. Israel-Stewart theory is a stable and causal description of dissipation in relativistic hydrodynamics although it includes relaxation process with the timescale for collision of constituent particles, which introduces stiff equations and makes practical numerical calculation difficult. In our new scheme, we use Strang's splitting method, and use the piecewise exact solutions for solving the extremely short timescale problem. In addition, since we split the calculations into inviscid step and dissipative step, Riemann solver can be used for obtaining numerical flux for the inviscid step. The use of Riemann solver enables us to capture shocks very accurately. Simple numerical examples are shown. The present scheme can be applied to various high energy phenomena of astrophysics and nuclear physics.

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