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An efficient numerical solver for relativistic hydrodynamics with an implicit Runge-Kutta method

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We develop an implicit numerical method for solving relativistic hydrodynamics that can be more efficient than conventional explicit methods. While implicit Runge-Kutta methods have nice properties such as their stability, they are not used usually since they are generally considered to be computationally expensive. In the present study, we solve this problem by introducing a fixed-point solver for the implicit Runge-Kutta methods with several optimizations. The Kurganov-Tadmor scheme is employed for the space discretization. The accuracy and computational cost of our new method are compared with those of explicit ones with the same space scheme in the case of ideal hydrodynamics for the initial conditions of the Riemann problem and the Gubser flow, as well as the event-by-event initial conditions for heavy-ion collisions generated by TRENTo. We demonstrate that the solver converges with only one iteration in most cases, and as a result, contrary to the general expectation, the implicit method requires smaller computational cost than the explicit one at the same accuracy in these cases.

Category

Theory

Collaboration (if applicable)

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