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Enhancing Efficiency and Stability in Hydrodynamic Simulations with Adaptive Step Size Methods

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Abstract

The adaptive step size method dynamically adjusts the step size of a time integrator based on the behavior of the solution, and is widely used in various scientific and engineering applications. In this work, we introduce this method into ANTARES, a tool for astrophysical and more general hydrodynamical simulations, aiming to enhance both the efficiency and accuracy of numerical simulations. To determine how the step size should be adjusted, we employ an error estimator based on the total energy of the solution, which is evaluated using two different numerical methods. This estimator helps decide whether to decrease or increase the step size in the subsequent iterations, ensuring that the solution maintains reliable accuracy while optimizing computational performance. Specifically, (embedded) pairs of strong stability preserving Runge-Kutta methods are used for error estimation. For illustration the method is applied to magnetohydrodynamics and Rayleigh Benard convection.

References