An all-regime, well-balanced, positive and entropy satisfying one-step finite volume scheme for the Euler's equations of gas dynamics with gravity

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In this presentation, we propose a flux splitting finite volume method for the approximation of the Euler equations with source terms derived from a potential. The flux splitting strategy that we adopt here relies on a separate treatment of the terms related to pressure effects from the terms related to transport. We show that this approach can be recast into a relaxation approximation that shares similarities with the Lagrange-Projection method, so that the present flux splitting method can be viewed as an "unsplit Lagrange-Projection" algorithm. We perform a flux modification in order to preserve the accuracy of the method in this regime. We show that the resulting method is well-balanced in the sense that it preserves hydrostatic equilibrium profiles. Under a CFL condition, the numerical scheme is also positivity preserving for the mass and the internal energy and it also verifies a discrete entropy inequality. One-dimensional and two-dimensional numerical experiments show the ability of the method to deal with a wide range of Mach regime, shocks, rarefaction and to preserves hydrostatic equilibrium states. Note that we do not solve the issue of checkerboard modes. However, our method has the computational advantage of not needing an intermediate state to be stored, reducing the memory print of the update with respect to previous algorithms.

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