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Preserving all non-moving stationary solutions of the Euler equations with gravity

I. Gmez-Bueno[1], **M.J. Castro**[2], **C. Pars**[2]

SUMMARY

In previous research, we introduced a general methodology for designing high-order well-balanced finite-volume methods for one-dimensional systems of balance laws. This methodology is based on the use of local well-balanced reconstructions. In this work, we examine a family of hyperbolic PDE systems where the fluid velocity is an eigenvalue of the Jacobian of the flux function. For these systems, hydrostatic stationary solutions, where the velocity is zero, are resonant at every point. Two significant examples from this family are the compressible Euler equations with a gravitational source term and the Ripa model.

Some approaches which are able to preserve discrete approximations of hydrostatic stationary solutions can be found in the literature. Our focus is to design methods that not only approximately preserve all hydrostatic equilibria of these systems, but also are able to exactly preserve a distinguished family of hydrostatic equilibria which is relevant. To verify the efficiency and well-balancedness of our methods, we conducted several numerical tests for both systems. The results of these tests demonstrate the effectiveness and generality of our approach.

Keywords: well-balanced, Euler equations, Ripa model, hydrostatic stationary solutions

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[1]Departamento de Matemtica Aplicada
Universidad de Mlaga
email: igomezbueno@uma.es

[2]Departamento de Anlisis Matemtico, Estadstica e I.O. y Matemtica Aplicada
Universidad de Mlaga