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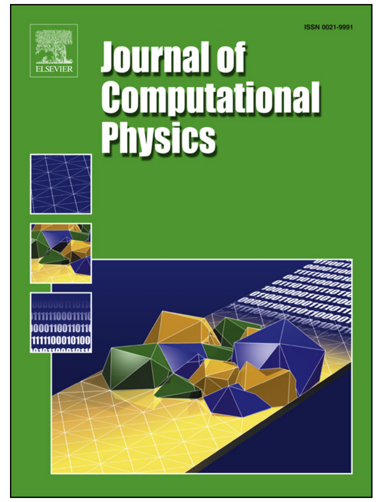

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An all-speed relaxation scheme for gases and compressible materials

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Abstract

We present a novel relaxation scheme for the simulation of compressible material flows at all speeds. An Eulerian model describing gases, fluids and elastic solids with the same system of conservation laws is adopted. The proposed numerical scheme is based on a fully implicit time discretization, easily implemented thanks to the linearity of the transport operator in the relaxation system. The spatial discretization is obtained by a combination of upwind and centered schemes in order to recover the correct numerical viscosity in all different Mach regimes. The scheme is validated by simulating gas and liquid flows with different Mach numbers. The simulation of the deformation of compressible solids is also approached, assessing the ability of the scheme in approximating material waves in hyperelastic media.

Keywords: Low Mach limit, compressible flows, relaxation method, Eulerian elasticity, all-speed scheme

1. Introduction

Different physical phenomena are affected by drastic changes of the sound speed or, in general, of specific waves speeds. The occurrence of these changes may be caused for example by the geometry of the problem, e.g. a gas or a fluid flow in a nozzle. Other examples include the propagation of waves in heterogeneous compressible solids: these waves can travel at different speeds due to the local stiffness of the material.

This work focuses on the study of flows with different Mach numbers pertaining both fluid dynamics and continuum mechanics. Phenomena involving fluid flows and elastic materials deformations are investigated with