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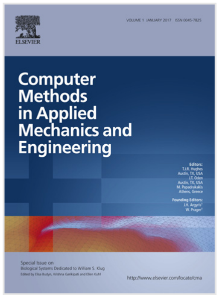

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A central moments-based lattice Boltzmann scheme for shallow water equations

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Abstract

In this paper we explore the possibility to derive an original lattice Boltzmann scheme for solving shallow water equations. Specifically, it is proposed to decompose the collision operator by means of a non-orthogonal basis of central moments which relax independently to a discrete equilibrium. Our method is strictly consistent with the BGK operator, as the latter is recovered exactly if all the moments relax with a common frequency. The methodology is validated against five well-consolidated established benchmark problems, showing very good agreement. Moreover, it possesses very high properties in terms of stability.

Keywords: Lattice Boltzmann scheme, shallow water equations, dam-break flow

1. Introduction

The lattice Boltzmann method is a popular and effective technique for computational fluid dynamics [1, 2, 3, 4, 5]. Instead of solving the Navier-Stokes equations, it is based on the Boltzmann equation and kinetic theory, idealizing a fluid as a set (or populations) of fictitious particles which stream and collide along the links of a Cartesian lattice. Interestingly, kinetic-based methods possess some advantages with respect to a macroscopic-based formulation. Among these, a computational convenience appears because the Boltzmann equation is a first-order linear partial differential one, as opposed to the second order Navier-Stokes equations that contain terms that are simultaneously non-local and non-linear. Interestingly, these two aspects are completely separated in the LBM ("Nonlinearity is local, non-locality is linear", say Succi [6]). In fact, while the streaming step entails the non-locality of the

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