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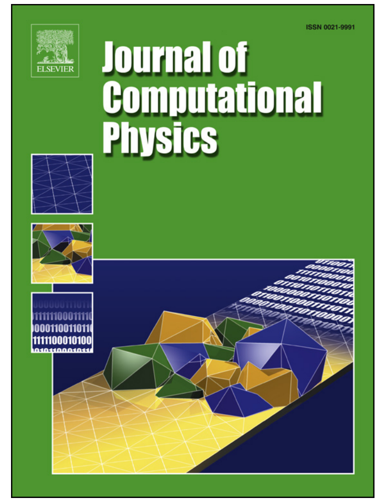

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A coupled Immersed Boundary - Lattice Boltzmann method for incompressible flows through moving porous media

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Abstract

In this work, we propose a numerical framework to simulate fluid flows in interaction with moving porous media of complex geometry. It is based on the Lattice Boltzmann method including porous effects via a Brinkman-Forchheimer-Darcy force model coupled to the Immersed Boundary method to handle complex geometries and moving structures. The coupling algorithm is described in detail and it is validated on well-established literature test cases for both stationary and moving porous configurations. The proposed method is easy to implement and efficient in terms of CPU cost and memory management compared to alternative methods which can be used to deal with moving immersed porous media, e.g. re-meshing at each time step or use of a moving/chimera mesh. An overall good agreement was obtained with reference results, opening the way to the numerical simulation of moving porous media for flow control applications.

Keywords: Lattice Boltzmann method, Immersed Boundary method, moving porous medium, poroelastic coating

1. Introduction

Fluid flows in porous media is a research topic of growing interest due to its numerous applications in chemical or oil engineering [1, 2, 3], but also in other areas such as biological flows or even aeronautics, where coatings made of porous materials are more and more considered for flow control applications [4]. Indeed controlling the flow using a porous coating, or a porous actuator, has been tested in previous literature studies and showed to yield a positive effect on the aerodynamic performances of immersed bluff bodies [5]. The present work is motivated by a potential use in aeronautical applications of a porous coating, which would have a moving feature, i.e. would be capable of adapting its shape to the flow topology to promote drag-reducing and lift-enhancement properties. This breakthrough and novel technology for flow control actuators has recently showed a promising potential [6], but there actually exist several issues in terms of numerical modelling. The main challenge is to model numerically a moving

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