A Lattice Boltzmann Method for particle margination in shear flows

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ABSTRACT

Particle motion in shear flows plays an important role in biomedical applications, characterised by low-Reynolds (Re) number regimes. A Lattice Boltzmann Method (LBM) [1] is employed, due to its great accuracy and efficiency in the limit of Re approaching to zero. A big improvement in LBM modeling is the derivation of the lattice equation on a more rigorous mathematical basis by a Gauss-Hermite projection of the corresponding continuum equation. The solid-wall conditions are imposed through the Zuo-He framework to guarantee mass conservation [2]. The dynamic of particles immersed in the flow has been simulated through a rigid-body-dynamics equations solver [3] coupled itreratively with the flow solver.

The fluid-structure interaction will be firstly presented for the case of a cylinder moving with prescribed motion. Then the dynamics of two differently shaped particles immersed in a low-Re Couette and planar Poiseuille flow will be studied to verify their lateral migration and orientation behavior. Regardless of their initial position, the neutrally buoyant particles are observed to migrate toward an equilibrium position, depending on the type of the flow.

Finally, numerical solutions will be presented to understand the influence of Re upon the lateral migration and orientation behavior of different elliptic particles immersed in a Couette flow. Then the motion of a deformable vesicle in a shear flow will be considered. In particular, the study will focus on the evolution of a red-blood cell, modeled by means of a simple spring-network approach [4].

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