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Dynamics of a cilium/cilia beating in 3D non-Newtonian flow

CHENGLEI WANG, SIMON GSELL, UMBERTO D'ORTONA, JULIEN FAVIER, Aix-Marseille Univ, CNRS, Centrale Marseille, M2P2, Marseille, France — Cilia are micro-scale hair-like organelles protruding from the surfaces of eukaryotic cells. Through fluid-structure interaction (FSI), they usually serve for fluid transport and locomotion. Such a FSI problem has been widely explored recently. In most existing works, the fluid is modeled as Newtonian. However, this is not always the case in nature, such as for the airway surface liquid (ASL) covering the epithelial surface of the respiratory system of the human body. In other words, the non-Newtonian flow could play a significant role on the cilia dynamics, which yet has been rarely studied. Therefore, this study aims to bridge this gap. Specifically, the non-Newtonian fluid is described using the power-law model, and each cilium is represented by a flexible filament. A single cilium or an array of cilia are placed in the fluid and driven at their base by a configuration-dependent torque. With a well-established numerical solver based on the immersed boundary lattice Boltzmann method (IBLBM) and the nonlinear finite element method (FEM), the cilia dynamics and their hydrodynamic interactions in the 3D non-Newtonian flow are systematically investigated, and the effects of several key parameters including the power-law index and the cilia spacing are also revealed.

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