Active Elastic Structures in a Viscous Fluid

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ABSTRACT

In biology, many micro-organisms are interacting with the surrounding fluid by mean of thin active structures, such as flagella or cilia, which play critical roles in numerous systems. Examples of these are respiratory and nervous systems, where cilia are important for moving the mucus and the cerebrospinal fluid. When dealing with direct simulation, the study of the related fluid-structure interaction problems is essential to characterize the critical parameters in active complex fluids.

The work in progress focuses on the interaction problem between active cilia, considered as elastic thin structures, and the bronchial mucus, a viscous fluid in lungs, modelled by Stokes equations. Many numerical works have been interested in the numerical simulation of this problem, either by approximation methods, estimating the hydrodynamical interaction [1], or by direct simulations. Regarding these ones, recent works have treated the interaction problem by imposing the movement of the structure, using for instance, a penalisation method [2] or a lineic Dirac force distribution [3].

Nevertheless, these approaches do not enable to model the reaction of such a system to an increase of the viscosity, for example, because the displacements of the structures are imposed. Thus, we consider a model of active cilia represented either as 3D solids or as 1D manifolds, plunged in a 3D fluid. Their movements should not be imposed, but rather be determined by the action of internal motors, to take into account the retroaction of the fluid on the structures [4].

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