Self-propelled motions of solids in viscous fluids, Modeling and mathematical analysis

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Abstract

In this presentation we consider two initial and boundary value problems modeling the self-propelled motion of solids in a bi-dimensional viscous incompressible fluid.

In the *first part* we consider the high Reynolds numbers flows. In this case, the self-propelling mechanism, consisting in appropriate deformations of the solids, is a simplified model for the propulsion mechanism of fish-like swimmers. The governing equations are composed of the Navier-Stokes equations for the fluid, coupled to Newton's laws for the solids. Since we consider the case in which the fluid-solid systems fills a bounded domain we have to tackle a free boundary value problem. The main theoretical result in the asserts the global existence and uniqueness (up to possible contacts) of strong solutions of this problem. The second novelty brought in by this work is that we give a numerical method for the fluid-solid system. This method allows the simulation of the simultaneous displacement of several swimmers and it is tested on several examples.

In the *second part*, we consider the case a very low Reynolds flows by using a control theoretic approach. The control of the system is the relative velocity of the fluid with respect to the solid on the boundary of the rigid body (the thrust). Our main results show that, there exists a large class of finite dimensional input spaces for which the system is exactly controllable, i.e., one can find controls steering the rigid body

in any final position with a prescribed velocity field. The equations we use are motivated by models of swimming of micro-organisms like cilia.