Dynamics of immersed interface problems in Stokes flow

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ABSTRACT

"Immersed interface problems in Stokes flow arise in fluid–structure interaction, where an internal interface is coupled to a viscous incompressible fluid. One of the simplest of such problems is the 2D Peskin problem, in which a 1D closed elastic structure is immersed in a 2D Stokes fluid. This has been extensively studied computationally and analytically. We extend the 2D Peskin problem into two in two directions:

(1) 2D inextensible interface problem.

(2) 3D Peskin problem.

For the 2D inextensible interface problem, we impose an inextensibility constraint on the interface. Through the boundary integral method, we reformulate the problem as two coupled contour equations, an evolution equation and a tension determination equation. We first study the well-posedness and the regularity of the generalized tension determination problem in Hölder spaces. Next, we use an appropriate time-weighted Hölder space to study the well-posedness and regularity of the full dynamical problem.

We also study the Peskin problem in the 3D case. With the boundary integral method, the 3D Peskin is reformulated as an evolution equation on a unit sphere S^2 for the elastic interface. We use multiple local charts to prove that the problem is well-posed in low-regularity Hölder spaces. Moreover, we prove that the elastic interface becomes smooth instantly in time.

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