An Immersed Interface Method for Simulating the Dynamics of Inextensible Interfaces in Viscous Fluids

Zhijun Tan[1,],D.V. Le[2], K.M. Lim[1,3],B.C. Khoo[1,4]

[1]Singapore-MIT Alliance, 4 Engineering Drive 3, National University of Singapore, Singapore 117576, Singapore. E-mail: smatz@nus.edu.sg

[2]Institute of High Performance Computing, 1 Fusionopolis Way, #16-16 Connexis, Singapore 138632, Singapore. E-mail: ledv@ihpc.a-star.edu.sg

[3]Department of Mechanical Engineering, National University of Singapore, Kent Ridge Crescent, Singapore 119260, Singapore. E-mail: limkm@nus.edu.sg

[4]Department of Mechanical Engineering, National University of Singapore, Kent Ridge Crescent, Singapore 119260, Singapore. E-mail: mpekbc@nus.edu.sg

Abstract

In this talk, an immersed interface method is presented to simulate the dynamics of inextensible interfaces in an incompressible flow, which is described by the Stokes equations. The tension is introduced as an augmented variable to satisfy the constraint of interface inextensibility, and the resulting augmented system is solved by the GMRES method. In this work, the arclength of the interface enclosing a region is locally and globally conserved as the enclosed region undergoes deformation. The forces at the interface are calculated from the configuration of the interface and the computed augmented variable, and then applied to the fluid through the related jump conditions. The governing equations are discretized on a MAC grid via a second-order finite difference scheme which incorporates jump contributions and is solved by the conjugate gradient Uzawa-type method. The proposed method is applied to several examples including the deformation of a liquid capsule with inextensible interfaces in a shear flow. Numerical results reveal that both the area enclosed by interface and arclength of interface are conserved well simultaneously. These provide further evidence on the capability of the present method to simulate incompressible flows involving inextensible interfaces.