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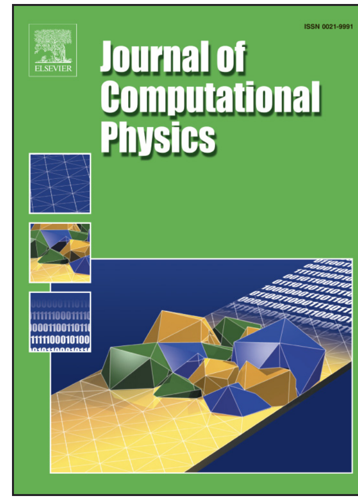

A unified mathematical framework and an adaptive numerical method for fluid-structure interaction with rigid, deforming, and elastic bodies

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A unified mathematical framework and an adaptive numerical method for fluid-structure interaction with rigid, deforming, and elastic bodies

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Abstract

Many problems of interest in biological fluid mechanics involve interactions between fluids and solids that require the coupled solution of momentum equations for both the fluid and the solid. In this work, we develop a mathematical framework and an adaptive numerical method for such fluid-structure interaction (FSI) problems in which the structure may be rigid, deforming, or elastic. We employ an immersed boundary (IB) formulation of the problem that permits us to avoid body conforming discretizations and to use fast Cartesian grid solvers. Rigidity and deformational kinematic constraints are imposed using a formulation based on distributed Lagrange multipliers, and a conventional IB method is used to describe the elasticity of the immersed body. We use Cartesian grid adaptive mesh refinement (AMR) to discretize the equations of motion and thereby obtain a solution methodology that efficiently captures thin boundary layers at fluid-solid interfaces as well as flow structures shed from such interfaces. This adaptive methodology is