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A new explicit FSI schemes for immersed thin-walled structures.

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We consider FSI of thin-walled bodies immersed in an incompressible viscous fluid. Cardiac valves are the main motivation of the present study. To our knowledge, the schemes used in this context are usually implicit or semi-implicit. This yields unconditional stability but at the price of solving a coupled system at every time step. The design of explicit coupling schemes is of major interest, especially for 3D studies. However, the drawback of the existing approaches (e.g., [2]) is that either stability or accuracy demands severe time-step restrictions or correction iterations. We propose a new solution that overcomes these difficulties.

The fluid is modelled with the Navier–Stokes equations, and the valves are described by a Reissner-Mindlin shell type model. The coupling is enforced through Lagrange multipliers [3]. Contrary to what is usually done in Fictitious Domains (e.g., [1]), the Lagrange multipliers are approximated with Dirac masses. Our coupling scheme is an extension of the Robin-Neumann splitting proposed in [4] to the unfitted mesh framework. It treats implicitly the coupling of the fluid with the solid inertia and explicitly the coupling with the solid elastic effects. In addition, the choice of Dirac masses for the Lagrange multipliers, combined with a lumped mass in the solid, yield an efficient implementation in the fluid which makes the coupling scheme explicit. The resulting scheme is provably stable in the energy norm.

Comparisons in terms of accuracy and computational efficiency will be discussed. The new method is very promising and outperforms the coupling schemes we are aware of. Nevertheless, an efficient management of the contact still has to be devised in order to address cardiac valves in realistic physiological conditions.

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