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EXPLICIT ROBIN-NEUMANN SCHEMES FOR INCOMPRESSIBLE FLUID-STRUCTURE INTERACTION

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Over the last decade, the development of efficient numerical methods for incompressible fluid-structure interaction problems has been an extremely active field of research. This is due, in particular, to the fact that the coupling can be very stiff. So called explicit coupling (or *loosely coupled*) schemes, that only involve the solution of the fluid and of the structure once per time-step, are known to be unconditionally unstable for standard Dirichlet-Neumann strategies whenever the amount of added-mass in the system is large (see, e.g., [3, 7]). This explains why explicit coupling schemes have been practically ruled out for the simulation of incompressible fluid-structure interaction problems and, in part, it has motivated the tremendous amount of work devoted to improve efficiency via alternative methods, based on the more computationally onerous implicit or semi-implicit coupling paradigms.

Stability in explicit coupling requires a different treatment of the interface coupling conditions. In [1, 2], added-mass free stability is achieved through a specific Robin-Robin treatment of the coupling, derived from Nitsche's method, together with an interface pressure stabilization in time. The price to pay is the deterioration of the accuracy, which requires correction iterations.

In this talk we present an alternative explicit coupling paradigm based on Robin-Neumann transmission conditions (see [4, 5, 6]). The key ingredient in these methods is the notion of interface Robin consistency. This property is well-known in the case of the coupling with thin-walled structures (see, e.g., [9, 8]). We show that a certain interface Robin consistency can also be recovered with thick-walled structures after discretization in space, using a lumped-mass approximation in the structure. The implicit treatment of the sole interface solid inertia within the fluid guarantees added-mass free stability. As regards accuracy, the thickness matters. In the case of the coupling with thin-walled structures, optimal (first-order) accuracy is obtained without any restriction on the discretization parameters. In the case of the coupling with thick-walled structures, a 3/2-CFL condition is required to achieve overall first-order accuracy (without the need of correction iterations). This constraint is intrinsically related the non-uniformity of the discrete visco-elastic operator. Several numerical experiments illustrate the theoretical discussion.

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