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Second-Order Semi-Implicit Partitioned Method for Fluid-Structure Interaction Problems

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This paper is concerned with numerical solution of fluid-structure interaction (FSI) problems involving an incompressible viscous flow and an elastic structure. A semi-implicit partitioned method (first introduced by Fernandez et al. [1]) is developed that separates the pressure term of the fluid equations and implicitly couples it to the structure, while the rest of the fluid terms are only explicitly coupled. Strong coupling of the fluid pressure term retains the stability of the method while loose coupling of the remaining terms greatly decreases the computational cost.

Semi-implicit FSI methods rely on a fractional-step (projection) method to segregate the fluid pressure term. Thus, the projection method does not only serve to solve the fluid equations but also as a framework for the FSI coupling. Semi-implicit FSI methods in the literature have used a first-order projection method, so the temporal accuracy of the solution is one. However, increasing the order of accuracy of these methods is not straightforward. Although it is relatively easy to achieve a second-order accuracy for velocity, the pressure remains first-order accurate for most of the projection methods. Considering that fluid pressure is the acting load on the structure, second-order accuracy for pressure is essential for having a second-order FSI solution.

In this study a second-order time accurate semi-implicit partitioned method for FSI problems with strong added-mass effect is proposed. A projection method is used and special attention is paid to the fluid pressure accuracy. An Arbitrary Lagrangian-Eulerian formulation together with a conforming mesh technique is used to solve the fluid flow. Structural equations are discretized using second-order temporal schemes on a Lagrangian domain. The proposed semi-implicit coupling method retains the second-order accuracy for the coupled problem. Numerical tests are carried out on a benchmark FSI problem and the second-order accuracy for all the variables (fluid velocity and pressure, and structural deformation) is demonstrated.

REFERENCES

[1] M. A. Fernández, et al., A projection semi-implicit scheme for the coupling of an elastic structure with an incompressible fluid. *Int. J. Num. Meth. Eng.* (2007) **69**:794–821.