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A conservative immersed boundary method for fluid-structure interaction

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In this work, we present a conservative immersed boundary method for three-dimensional inviscid fluid-structure interaction problems. On the fluid side, we consider an inviscid Euler fluid in conservative form solved using a Finite Volume method. On the solid side, we consider an elastic deformable solid with possible fragmentation. We use a Discrete Element method (particles connected with springs) for the discretization of the solid [1].

Body-fitted methods are not well-suited for large displacements or fragmentation of the structure, since they involve possibly costly remeshing of the fluid domain. We use instead a conservative and well-balanced cut-cell method in the vicinity of the solid [2, 3]. In the event of fragmentation, void can appear due to the velocity of crack opening, which is treated with the Lax-Friedrichs flux near cracks [4].

Since both fluid and solid methods are explicit, the coupling scheme is designed to be explicit too. The computational cost of the fluid and solid methods lies mainly in the evaluation of fluxes on the fluid side and of forces and torques on the solid side. It should be noted that the coupling algorithm evaluates these only once every time step, ensuring the computational efficiency of the coupling. We will present numerical results showing the robustness of the method in the case of a fragmenting solid coupled with a compressible fluid flow.

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