Linearization for Fluid Structure Interaction

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Abstract

We consider an elastic body immersed into an incompressible viscous fluid, contained in a bounded lipschitz domain of dimension bigger or equal to two. The solid is partly attached to the boundary of the fluid domain. The fluid is modeled by the incompressible Navier-Stokes equations in Eulerian coordinates, while the solid is described by its deformation in Lagrangian coordinates. The existence of weak solutions for this problem was established in [1]. Now we assume smallness of external forces, meaning the force is given by $f_\delta = \delta f$ for some positive scaling parameter $\delta > 0$. We linearize the deformation describing the solid around the identity and the fluid velocity around zero. We prove that, assuming a suitable scaling of the initial conditions, the resulting first order perturbations converge weakly towards the unique weak solution of a corresponding linearized fluid-solid interaction problem with external force f as $\delta \to 0$. Our result rigorously shows that, assuming smallness of external forces and initial conditions, fluid-structure interaction systems involving nonlinear elasticity can be approximated by corresponding much simpler, linearized systems.

References

[1] B. Benešová, M. Kampschulte and S. Schwarzacher, *A variational approach to hyperbolic evolutions and fluid-structure interactions*, Journal of the European Mathematical Society (JEMS), 2024.