Weak solutions for fluid-structure interaction problems with three-dimensional structural displacements

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Abstract

This talk addresses a nonlinear fluid-structure interaction (FSI) problem involving the Navier-Stokes equations, which govern the flow of an incompressible, viscous fluid in a three-dimensional domain, coupled with the motion of a thin viscoelastic lateral wall. The wall's dynamics are modeled by a two-dimensional plate equation with fractional damping, allowing for displacements in all three spatial directions. The system is nonlinearly coupled through kinematic and dynamic conditions imposed on the moving fluid-structure interface, whose position evolves and is not known a priori.

We establish three key results for this class of FSI problems, focusing on cases with vector displacements of thin structures. First, we prove a hidden spatial regularity in the structural displacement, ensuring the absence of self-contact within a finite time interval. Second, we show temporal regularity for the fluid velocity and structural displacement, leading to a novel compactness result for three-dimensional structural dynamics. Finally, leveraging these findings, we construct a proof of local-in-time existence for weak solutions to the FSI problem using a Lie operator splitting method and time discretization.

These results contribute to the mathematical understanding of fluid-structure interaction problems with three-dimensional structural displacements, particularly in terms of solution regularity and well-posedness.

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Keywords: fluid-structure interaction, weak solution, Navier-Stokes equations.