# Fluid-structure interaction with multiple structural layers

Suncica Canic
Department of Mathematics, University of Houston, USA
canic@math.uh.edu
Boris Muha
Department of Mathematics, University of Zagreb, Croatia
borism@math.hr
Martina Bukac
Department of Mathematics, University of Pittsburgh, USA
martina@pitt.edu

Fluid-structure interaction (FSI) problems arise in many applications. The widely known examples are aeroelasticity and biofluids. In biofluidic applications, such as, e.g., the study of interaction between blood flow and cardiovascular tissue, the coupling between the fluid and the relatively light structure is highly nonlinear because the density of the structure and the density of the fluid are roughly the same. In such problems, the geometric nonlinearities of the fluid-structure interface and the significant exchange in the energy between a moving fluid and a structure require sophisticated ideas for the study of their solutions. In the blood flow application, the problems are further exacerbated by the fact that the walls of major arteries are composed of several layers, each with different mechanical characteristics. No results exist so far that analyze solutions to fluid-structure interaction problems in which the structure is composed of several different layers.

In this talk we make a first step in this direction by presenting a program to study the **existence of solutions and their numerical simulation** for a class of problems describing the interaction between a multi-layered structure and the flow of an incompressible, viscous fluid, giving rise to a fully coupled, **nonlinear moving boundary, fluid-multi-structure interaction problem.** As a start we study the structures composed of two layers: a thin layer modeled by the 1D membrane or shell equations, and a thick layer modeled by the equations of 2D elasticity. The thin structure is in contact with the fluid, serving as a fluid-structure interface with mass. The fluid flow is modeled by the Navier-Stokes equations for an incompressible viscous fluid in 2D. The problem is driven by the time-dependent inlet/outlet dynamic pressure data. The coupling between different structural layers and the coupling with the fluid is achieved through the kinematic and dynamic coupling conditions evaluated at the deformed fluid-structure interface. We present a proof of the existence of a weak solution to this fluid-multi-layered structure interaction problem. The main steps of the proof are based on a partitioned scheme, known as the kinematically-coupled scheme. Therefore, we effectively prove that the kinematically-coupled numerical scheme converges to a weak solution of the fluid-multi-layered structure interaction problem.

The work discussed in this talk reveals a new regularizing mechanism in FSI problems that is due to the presence of a fluid-structure interface with mass. The inertia of the fluid-structure interface regularizes the evolution of the FSI solution.

All theoretical results will be illustrated with numerical examples.