Oberwolfach-Seminar
Mathematical theory of evolutionary fluid-flow structure interactions
Organizers

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PROGRAM

This Seminar will be focused on the analysis and control of three distinct yet broadly related topics: fluid-structure interaction, flow-structure interaction and sound-structure interaction. In each case the overall model is described by systems of strongly coupled PDEs. The emphasis is put on demonstrating how the coupling on an interface changes drastically the overall dynamics with respect to the dynamics determined by each component.

1. In fluid-structure interaction, the structure (a hyperbolic system of dynamic elasticity) is immersed in a fluid (a parabolic Navier-Stokes equation) with matching velocities and stresses at the interface between the two respective domains. The case of a "static" structure (small rapid oscillations) will be considered first to appreciate the mathematical problems involved and discover the resulting (at times surprising) properties of the model. This will lead to the analysis of the physically significant and mathematically more challenging case of a structure moving within the fluid. Local and global well-posedness and long time behavior will be discussed

2. In flow structure interaction (a plate interacting with an air-flow), wellposedness of finite energy solutions will be followed by a construction of attractors which capture long time behavior of the nonlinear dynamics. The originally rough and oscillatory dynamics can be stabilized to a smooth and finite dimensional set. Moreover, in the subsonic case, solutions stabilize to equilibria points.

3. In nonlinear structure-sound interaction, after a description of nonlinear (ultra) sound propagation, the focus will be the interaction such as it arises in lithotripsy. Here well-posedness will be discussed of a linearly elastic (or acoustic) focusing lens being immersed in a nonlinearly acoustic fluid, each component -fluid and lens - having its distinguished physical parameters. Finally, the optimization problem of designing the lens shape will be presented: this will involve the shape derivative which is needed for numerical optimization.

Introductory reading

1. V.Barbu, I.Lasiecka and R.Triggiani, Tangential Boundary Stabilization of Navier-Stokes Equations, *Memoirs AMS,* Vol. 181, N. 852, 2006

2. I. Kukavica and A. Tuffaha, Regularity of solutions of a free boundary problem of fluid-structure interaction, Indiana Univ. Math. J. 61 (2012),

3. [I. Chueshov and I. Lasiecka, Irena *Von Karman evolution equations. Well-posedness and long-time dynamics.* Springer Monographs in Mathematics, (2010). Chapter 6 and section 12.4 in Chapter 12.

4. B. Kaltenbacher, Mathematics of Nonlinear Acoustics, Evolution Equations and Control Theory, 4 (2015), 447-491. This is a review paper.