Numerical Analysis and Scientific Computing Seminar

Steklov-Poincar analysis of the basic three-domain stent problem

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Abstract: The Steklov-Poincar problem was previously considered in the artery lumen and wall setting with a single interface. Here the analysis is expanded to incorporate solute behavior in the presence of a fixed-volume, solid, simple stent. In this geometry, a third domain is added to the two-domain structure of artery wall and lumen. Through this intersecting domain volume setting there are three interfaces: lumen-wall, stent-lumen, and wall-stent. Steady-state incompressible Navier-Stokes equations are used to explain the behavior of blood through the lumen, while advection-diffusion dynamics are considered for the solute mechanics across the lumen, wall, and stent. Having a fixed blood velocity value, Steklov-Poincar decomposition of the advection-diffusion equations is applied locally to each of the interfaces. To unify these instances on a global scale, their overall intersection is explored in a smaller manifold, reducing the problem to one previously solved by Quarteroni, Veneziani, and Zunino. Through finite element analysis (FEM), the solution is discretized and found to be convergent. Finally, computational simulations with one, three, and five stent rings, placed between the volumes of inner and outer cylindrical meshes, were performed using NGSolve, confirming the convergence of the solution and its relation to the coarseness of the mesh.

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