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PARALLEL NUMERICAL LIBRARY FOR FLUID-STRUCTURE INTERACTION IN BIOMECHANICS

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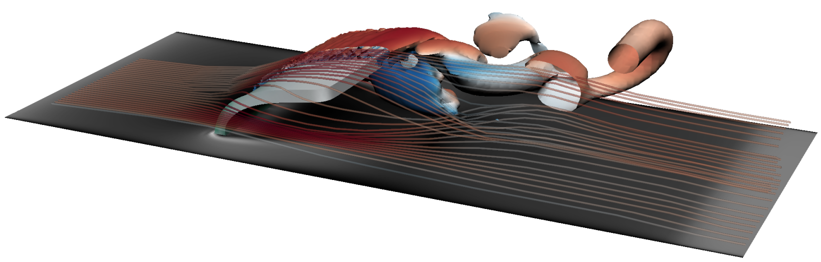
A new numerical framework for fluid-structure interaction (FSI) using high-performance computing (HPC) libraries is presented. This modular FSI framework based on the Immersed Boundary Method [1] incorporates a high-order finite-difference Navier–Stokes solver for incompressible flow [2], a time-implicit finite-element solver for the elastodynamic equations of solid motion using various constitutive laws [3] and a novel approach to data transfer between grids of arbitrary type [4]. All modules are optimized for a massively-parallel supercomputing platform with GPGPUs (Cray XC50 at CSCS, Switzerland). The framework was developed to study the effects of FSI in aortic heart valves. Fluid and solid are coupled in a weak fashion by transferring velocities from fluid to structure and reaction forces back. A fixed-point iteration at each time step ensures stability of temporal evolution, solving the coupled spatial problems to a desired accuracy. The framework was validated with benchmarks from literature and problems with analytic solutions. Three-dimensional simulations were performed at various Reynolds numbers.



Vortical structures and streamlines around an elastic Holzapfel–Ogden wall at Re $= 2250$.

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