# Immersogeometric fluid—structure interaction analysis of bioprosthetic heart valves: stability and mass conservation

**David Kamensky[1,*], Ming-Chen Hsu[2], John A. Evans[3], Michael S. Sacks[1], and Thomas J.R. Hughes[1]**

[1] Institute for Computational Engineering and Sciences, The University of Texas at Austin, Austin TX 78712, USA

[2] Department of Mechanical Engineering, Iowa State University, 2025 Black Engineering, Ames, IA 50011, USA

[3] Department of Aerospace Engineering Sciences, University of Colorado at Boulder, 492 UCB, Boulder, CO 80309, USA

[*] Correspondence to: kamensky@ices.utexas.edu

## ABSTRACT

We present a methodology for immersing spline-based representations of thin flexible structures into stabilized discretizations of unsteady viscous incompressible flows [1]. The fluid and structure sub-problems are coupled through a Lagrange multiplier field, augmented with penalization of the interface velocity difference. The fully discrete system is advanced in time using a semi-implicit algorithm. The stability of this algorithm may be analyzed by relating it to fully implicit integration of a surrogate problem, which penalizes the time integral of interface velocity difference.

We apply this methodology to the analysis of bioprosthetic heart valves, where mass conservation in the fluid sub-problem is essential to obtaining useful solutions. The Lagrange multiplier and penalty forces acting on the fluid sub-problem are concentrated on a surface of co-dimension one to the fluid domain, which can produce unacceptable violations of mass conservation in stabilized fluid discretizations. We find that a simple modification of stabilization parameters within an order-*h* neighborhood of the structure can greatly reduce this error, even when the fluid is discretized using continuous equal-order pressure and velocity spaces, defined over a quasi-uniform mesh.

## REFERENCES

[1] D. Kamensky, M.-C. Hsu, D. Schillinger, J.A. Evans, A. Aggarwal, Y. Bazilevs, M.S. Sacks, and T.J.R. Hughes, "An immersogeometric variational framework for fluid—structure interaction: application to bioprosthetic heart valves," *Computer Methods in Applied Mechanics and Engineering*, accepted (2014).