

Martina Bukač

Associate Professor
Applied and Computational Mathematics and Statistics
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Education

- Ph.D. in Mathematics, University of Houston (2012).
Dissertation: A fluid-structure interaction model capturing longitudinal displacement in arteries: modeling, computational method, and comparison with experimental data
Advisors: Sunčica Čanić & Roland Glowinski
- B.S. and M.S. in Applied Mathematics, University of Zagreb, Croatia (2008).
Undergraduate Thesis: Numerical approximation of Newtonian fluid flow through elastic tube
Advisor: Josip Tambača

Research Interests

Numerical analysis; Fluid-structure interaction; Poroelasticity; Numerical methods for partial differential equations; Computational fluid dynamics; Coupled problems

Professional Experience

- Concurrent Associate Professor (Oct. 2020 - present)
University of Notre Dame, Department of Aerospace and Mechanical Engineering
- Associate Professor (Sep. 2020 - present)
University of Notre Dame, Department of Applied and Computational Mathematics and Statistics
- Concurrent Assistant Professor (May. 2018 - Sep. 2020)
University of Notre Dame, Department of Aerospace and Mechanical Engineering
- Assistant Professor (Sep. 2014 - Aug. 2020)
University of Notre Dame, Department of Applied and Computational Mathematics and Statistics
- Postdoctoral associate (Sep. 2012 - Aug. 2014)
University of Pittsburgh, Department of Mathematics

Awards and Honors

- Rev. Edmund P. Joyce, C.S.C. Award for Excellence in Undergraduate Teaching (2021)

Publications

Book chapters

1. Tukovic, Z., Bukac, M., Cardiff, P., Jasak, H., and Ivankovic, A. Added mass partitioned fluid-structure interaction solver based on a Robin boundary condition for pressure, in *OpenFOAM Selected papers of the 11th Workshop.* Eds J. Nobrega, H. Jasak. Springer International Publishing Switzerland (2019) ISBN 978-3-319-60846-4.
2. Bukac, M., Čanic, S. Muha, B., and Glowinski, R. An Operator Splitting Approach to the Solution of Fluid-Structure Interaction Problems in Hemodynamics, in *Splitting Methods in Communication, Imaging, Science, and Engineering.* Eds R. Glowinski, S. Osher, W. Yin. Springer International Publishing Switzerland (2016) ISBN 978-3-319-41589-5.
3. Čanic, S., Muha, B., and Bukac, M.
Fluid-structure interaction with multiple structural layers: theory and numerics, in *Fluid-structure interaction in biomedical applications*, Invited Contribution to Book Series: "Advances in Mathematical Fluid Mechanics" Eds. T. Bodnar, G.P. Galdi, S. Necasova. Birkhauser Basel, Springer (2014) ISBN 978-3-0348-0821-7.

Peer-reviewed journal publications

1. Throop, A., Bukač, M. and Zakerzadeh, R. Prediction of wall stress and oxygen flow in patient-specific abdominal aortic aneurysms: the role of intraluminal thrombus. To appear in *Biomechanics and Modeling in Mechanobiology*.
2. Bukač, M., Fu, G., Seboldt, A. and Trenchea, C. Time-adaptive partitioned method for fluid-structure interaction problems with thick structures. *Journal of Computational Physics*, 473: 111708, 2023.
3. Throop, A., Badr, D., Durka, M., Bukač, M. and Zakerzadeh, R. Analyzing the Effects of Multi-layered Porous Intraluminal Thrombus on Oxygen Flow in Abdominal Aortic Aneurysms. *Oxygen*, 2(4): 518-536, 2022.
4. Wang, Y., Čanić, S., Bukač, M., Blaha, C. and Roy, S. Mathematical and Computational Modeling of Poroelastic Cell Scaffolds in the Design of an Implantable Bioartificial Pancreas. *Fluids*, 7(7): 222, 2022.
5. Bukač, M. and Trenchea, C. Adaptive, second-order, unconditionally stable partitioned method for fluid-structure interaction. *Computer Methods in Applied Mechanics and Engineering*, 393: 114847, 2022.
6. Bukač, M. and Shadden, S.C. Quantifying the effects of intraluminal thrombi and their poroelastic properties on abdominal aortic aneurysms. *Archive of Applied Mechanics*, 92: 435-446, 2022.
7. Seboldt, A., Oyekole, O., Tambača, J. and Bukac, M. Numerical modeling of the fluid-porohyperelastic structure interaction. *SIAM Journal on Scientific Computing*, 43(4): A2923-A2948, 2021.
8. Canic, S., Wang, Y. and Bukač, M. A Next-Generation Mathematical Model for Drug Eluting Stents. *SIAM Journal on Applied Mathematics*, 81(4): 1503-1529, 2021.
9. Bukac, M. An extension of explicit coupling for fluid-structure interaction problems. *Mathematics*, 9(15): 1747, 2021.
10. Seboldt, A. and Bukac, M. A non-iterative domain decomposition method for the interaction between a fluid and a thick structure. *Numerical Methods for Partial Differential Equations* 37 (4): 2803-2832, 2021.

11. Bukac, M. Seboldt, A. and Trenchea, C. Refactorization of Cauchy's method: a second-order partitioned method for fluid-thick structure interaction problems. *Journal of Mathematical Fluid Mechanics*, 23:64, 2021.
12. Bukac, M. and Canic, S. A partitioned numerical scheme for fluid-structure interaction with slip. *Mathematical Modelling of Natural Phenomena*, 16:(8-1)–(8-35), 2021.
13. Bukac, M. and Trenchea, C. Boundary update via resolvent for fluid-structure interaction. *Journal of Numerical Mathematics*, 29(1):1–22, 2021.
14. Oyekole, O. and Bukac, M. Second-order, loosely coupled methods for fluid-poroelastic material interaction. *Numerical Methods for Partial Differential Equations*, 36(4):800–822, 2020.
15. Smodlaka, H., Khamas, W., Jungers, H., Pan, R. Al-Tikriti, M., Borovac, J., Palmer, L. and Bukac, M. A novel understanding of Phocidae hearing adaptations through a study of northern elephant seal (*Mirounga angustirostris*) ear anatomy and histology. *The Anatomical Record*, 302(9):1605–1614, 2019
16. Bukac, M., Canic, S., Tambaca, J. and Wang, Y. Fluid-structure interaction between pulsatile blood flow and a curved stented coronary artery on a beating heart: a four stent computational study. *Computer Methods in Applied Mechanics and Engineering*, 350:679–700, 2019.
17. Oyekole, O., Trenchea, C. and Bukač, M. A second-order in time approximation of fluid-structure interaction problem. *SIAM Journal on Numerical Analysis*, 56(1):590–613, 2018.
18. Forti, D., Bukac, M., Quaini, A., Canic, S. and Deparis, S. A monolithic approach to fluid-composite structure interaction. *Journal of Scientific Computing*. 72(1):396–421, 2017.
19. Bukac, M., Yotov, I. and Zunino, P. Dimensional model reduction for flow through fractures in poroelastic media. *ESAIM: Mathematical Modelling and Numerical Analysis*. 51(4):1429–1471, 2017.
20. Bukac, M. and Alber, M. Multi-component model of intramural hematoma. *Journal of Biomechanics*. 50:42–49, 2017.
21. Bukac, M. and Muha, B. Stability and convergence analysis of the extensions of the kinematically coupled scheme for the fluid-structure interaction. *SIAM Journal on Numerical Analysis*. 54(5):3032–3061, 2016.
22. Bukac, M., Canic, S. and Muha, B. A nonlinear fluid-structure interaction problem in compliant arteries treated with vascular stents. *Applied Mathematics & Optimization*. 73(3):433–473, 2016.
23. Bukac, M. A loosely-coupled scheme for the interaction between a fluid, elastic structure and poroelastic material. *Journal of Computational Physics*. 313:377–399, 2016.
24. Zakerzadeh, R., Bukac, M. and Zunino, P. Computational Analysis of Energy Distribution of Coupled Blood Flow and Arterial Deformation. *International Journal of Advances in Engineering Sciences and Applied Mathematics*. 8(1):70–85, 2016..
25. Cao, K., Bukac, M. and Sucusky, P. Three-Dimensional Macro-Scale Assessment of Regional and Temporal Wall Shear Stress Characteristics on Aortic Valve Leaflets. *Computer Methods in Biomechanics and Biomedical Engineering*. 19(6):603–613, 2016.
26. Bukac, M., Layton, W., Moraiti, M., Tran, H. and Trenchea, C. Analysis of partitioned methods for the Biot system. *Numerical Methods for Partial Differential Equations*. 31(6):1769–1813, 2015.
27. Bukac, M., Yotov, I., Zakerzadeh, R. and Zunino, P. Partitioning strategies for the interaction of a fluid with a poroelastic material based on a Nitsche's coupling approach. *Computer Methods in Applied Mechanics and Engineering* 292(1):38–170, 2015.
28. Bukac, M., Canic, S., and Muha, B. A partitioned scheme for fluid-composite structure interaction problems. *Journal of Computational Physics* 281:493–517, 2015.

29. Bukac, M., Yotov, I. and Zunino, R.. An operator splitting approach for the interaction between a fluid and a multilayered poroelastic structure. *Numerical Methods for Partial Differential Equations* 31(4):1054–1100, 2015.
30. Canic, S., Muha, B., and Bukac, M. Stability of the kinematically coupled beta-scheme for fluid-structure interaction problems in hemodynamics. *International Journal of Numerical Analysis and Modeling* 12(1):54-80, 2015.
31. Mabuza, S., Canic, S., Kuzmin, D., and Bukac, M. A conservative, positivity preserving scheme for reactive solute transport problems in moving domains. *Journal of Computational Physics* 276:563 - 595, 2014.
32. Bukac, M., Canic, S., Glowinski, R., Muha, B., and Quaini, A. Operator Splitting Scheme for Fluid-Structure Interaction Problems with Thick Structures. *International Journal for Numerical Methods in Fluids* 74(8):577-604, 2014.
33. Bukac, M. and Canic, S. Longitudinal displacement in viscoelastic arteries: a novel fluid-structure interaction computational model, and experimental validation. *Mathematical Biosciences and Engineering* 10(2):295-318, 2013.
34. Bukac, M., Canic, S., Glowinski, R., Tambaca, J. and Quaini, A. Fluid–structure interaction in blood flow capturing non-zero longitudinal structure displacement. *Journal of Computational Physics* 235:515-541, 2013.

Peer-reviewed conference proceedings

1. Bukac, M., Yotov, I., Zakerzadeh, R., and Zunino, P. Effects of poroelasticity on fluid-structure interaction in arteries: a computational sensitivity study. Modeling the heart and the circulatory system, in Springer Series in Modeling, Simulation and Applications (MS&A) Vol. 14 (2015), A. Quarteroni (Ed.).

Submitted manuscripts

1. Bukač, M., Muha, B. and Salgado, A. J. Analysis of a diffuse interface method for the Stokes-Darcy coupled problem. *Submitted*, 2022.

Press

- A paper by Canic, S., Wang, Y. and Bukač, M. entitled “A Next-Generation Mathematical Model for Drug Eluting Stents” was featured in Medical News: “Research investigates how drug-eluting stent affects arterial tissue permeability and blood flow” by Emily Henderson, *Medical News*, September 02, 2021. [Link](#)
- A paper by Canic, S., Wang, Y. and Bukač, M. entitled “A Next-Generation Mathematical Model for Drug Eluting Stents” was featured as a research nugget in SIAM News: “Mathematical Model Reveals Possible Role of Drug-Eluting Stents in Artery Re-closure” by Jillian Kunze, *SIAM News*, July 28, 2021. [Link](#)

Grants

- 2022 - 2025 NSF DMS-2208219 (PIs: M. Bukač, C. Trenchea): Collaborative Research: Time Accurate Fluid-Structure Interactions, \$224,923.

- 2022 - 2025 NSF DMS-2205695 (PI: M. Bukač): The Diffuse Interface Method and Applications to Coupled Systems in Fluid Dynamics, \$229,965.
- 2020 - 2023 NSF DCSD-1934300 (PI: J-X. Wang, co-PI: M. Bukač): Physics- Constrained Deep Learning for Surrogate Modeling of Dynamics of Fluids and Fluid-Structure Interaction, \$300,288.
- 2019 - 2022 NSF DMS-1912908 (PI: M. Bukač): Numerical methods for fluid-structure interaction problems with large displacements, \$174,942.00.
- 2016 - 2019 NSF DMS-1619993 (PI: M. Bukač): Development and analysis of high-order partitioned schemes for fluid-structure interaction problems, \$187,946.
- 2013 - 2016 NSF DMS-1318763 (PI: S. Čanić; co-PI: M. Bukač): Fluid-structure interaction with multi-layered structures: a new class of partitioned schemes, \$280,858.
- 2013 - 2014 University of Pittsburgh Mathematical Research Center support to organize a workshop, \$10,000.

Students Supervised

- Graduate Students
 - Anyastassia Seboldt (former PhD student)
 - Oyekola Oyekole (former PhD student, currently at Xceptor)
- Undergraduate Students
 - Carolina Santiago (research project, 2021-2022)
 - Zachary Pavlisin (research project, 2021)
 - Michael Calcagni (research project, 2020)
 - Davina Russel (research project, 2020)
 - Nicholas Rossiter (honors thesis, 2017-2019. Current position: PhD student at the University of Michigan)

Teaching experience

- University of Notre Dame
 - Numerical methods for fluid-structure interaction (Fall 2019).
 - Numerical Analysis (Fall 2014, Spring 2016, Fall 2016, Fall 2017, Fall 2018, Spring 2020, Fall 2020, Spring 2021, Fall 2021, Fall 2022).
 - Numerical Analysis 1 (Fall 2021).
 - Numerical Analysis 2 (Spring 2016).
 - Mathematical and Computational Hemodynamics (Spring 2015).
 - Introduction to Applied Mathematics Methods I (Fall 2015, Spring 2020).
- University of Pittsburgh
 - Calculus 1 (Fall 2012, Fall 2013).
 - Calculus 2 (Spring 2013).
 - Numerical Linear Algebra (Spring 2014).
- University of Houston (Graduate teaching assistant)
 - Calculus 2 (Spring 2010).

Calculus 3 (Fall 2010, Spring 2011).

Organizational activities

- Co-organizer of “Deterministic and stochastic models for complex cardiovascular phenomena” minisymposium at the Society for Mathematical Biology Annual Meeting, 2021 (online).
- Co-organizer of “Domain-decomposition methods for coupled problems in fluid dynamics” minisymposium at the 26th International Conference on Domain Decomposition Methods, 2020 (online).
- Co-organizer of “Numerical methods for coupled problems involving fluids and solids” minisymposium at the ECCM-ECFD Conference, 2018, Glasgow, UK.
- Co-organizer of “Recent Advances in Modeling, Computational PDEs and their Applications” minisymposium at the 5th International Conference on Computational and Mathematical Biomedical Engineering, April 10-12, 2017, Pittsburgh, PA.
- Co-organizer of “Fluid-Solid Interaction for Blood Flows” minisymposium at the 19th International Conference on Finite Elements in Flow Problems, April 5-7, 2017, Rome, Italy.
- Co-organizer of “Numerical Methods for Coupled Problems in Biomedical Applications ” minisymposium at ECCOMAS Congress 2016, June 5-10, 2016, Crete Island, Greece.
- Co-organized the Applied Math Seminar at the University of Notre Dame.
- Co-organizer of the Workshop on Computational Geomechanics, May 22-23, 2014, Pittsburgh, Pennsylvania.
- Co-organizer of “The Fluid-Structure Interaction: Analysis, Numerics and Applications ” minisymposium at SIAM Analysis of PDEs, December 7-10, 2013, Orlando, Florida.
- Member of the organizing committee of 66th Annual Division of Fluid Dynamics Meeting, November 24-26, 2013, Pittsburgh, Pennsylvania.

Synergistic Activities

- Participated as a mentor in the American Association of University Women- Notre Dame Women Leaders - STEM Program, 2018.
- Participated in Expanding your horizons workshop for middle school girls, Notre Dame, 2015-2018.
- Gave a guest lecture at the Washington High School, South Bend, 2016.
- Participated in a panel discussion at the Women in STEM luncheon series, Notre Dame, 2015.

Service

- Member of the curriculum committee for the Minor in Scientific Computing (2022-current)
- Member of the Center for Research Computing Faculty Advisory Board, Notre Dame (2022-current)
- Associate editor of IAMS Advances in Computational Science and Engineering (ACSE) (2022 - current).
- Reviewer for the Croatian National Science Award, 2022.
- Member of the University Council for Academic Technologies, Notre Dame (2021 - current)
- Member of the ACMS Committee on Teaching Assignments, Notre Dame (2021 - 2022)
- Member of the ACMS Awards Committee, Notre Dame (2021 - current)
- Member of the College of Science Diversity Council, Notre Dame (Spring 2021).

- Advised the Calligraphy Club at Notre Dame, Notre Dame (Fall 2018-Fall 2020).
- Member of the ACMS Undergraduate Committee, Notre Dame (Spring 2015, Fall 2015, Spring 2016, Fall 2017, Spring 2018, Fall 2019).
- PhD thesis committee member: Amy Buchmann (2015), Wenzhao Sun (2015), Liang Wu (2016), Kai Cao (2016), Timur Kupaev (2016), Dong Lu (2017), Francesco Pancaldi (2017), Kelsey DiPietro (2019), Margaret Regan (2020), Samantha Sherman (2021), Xiaozhi Zhu (2021), Xue Li (2021), Wenlong Pei (2022).
- Oral candidacy committee member: Kai Cao (2015), Kelsey DiPietro (2016), Daniel Howard (2017), Samantha Sherman (2018), Xue Li (2018), Xiaozhi Zhu (2018), Zachary Miksis (2019), Cedric Williams (2019), Wenzheng Kuang (2022), Rentian Hu (2022).
- Graduate student appeal committee member, Notre Dame (2016).

Computer skills

- Programming: Fortran, C, Java, Matlab, FreeFem++, Mathematica
- Software: L^AT_EX, MS Office, Paraview

Languages

- Croatian: mother language
- English: fluent (TOEFL certified)
- German: basic

Invited Talks

- Applied PDE Seminar talk at the University of California, Berkeley, online, 2022.
- Computational and Applied Math seminar talk at the University of Tennessee, Knoxville, 2022.
- Minisymposium talk at the XXIV International Conference on Computational Methods in Water Resources, Poland, online, 2022.
- Popular science lecture at the University of Zagreb, Department of Computer Science, Croatia, 2022.
- Gastkolloquium at the Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany, online, 2022.
- Applied Math seminar talk at the Texas Tech University, online, 2022.
- Workshop talk at the Mathematisches Forschungsinstitut Oberwolfach, Oberwolfach, Germany, 2022.
- Colloquium talk at the Center for Mathematics and Artificial Intelligence at George Mason University, 2021.
- Minisymposium talk at the 16th U.S. National Congress on Computational Mechanics, online, 2021.
- Minisymposium talk at the SIAM Conference on Mathematical & Computational Issues in the Geosciences, online, 2021.
- Minisymposium talk at the Annual Canadian Applied and Industrial Mathematics Society Meeting, online, 2021.
- Minisymposium talk at the 9th International Conference on Computational Methods for Coupled Problems in Science and Engineering, online, 2021.
- Colloquium talk at the University of Zagreb, Department of Mathematics, Croatia, 2021.

- Applied and Computational Mathematics seminar talk at the Auburn University, Department of Mathematics and Statistics, 2021.
- Applied Math seminar talk at the University of California - Berkeley, Department of Mathematics, 2020.
- Minisymposium talk at the Tenth Conference on Applied Mathematics and Scientific Computing, Brijuni, Croatia, 2020.
- Minisymposium talk at the SIAM Conference on Analysis of Partial Differential Equations, La Quinta, CA, 2019.
- Minisymposium talk at the Conference on Computational Mathematics and Applications, University of Nevada, Las Vegas, NE, 2019.
- Minisymposium talk at the 5th Annual Meeting of SIAM Central States Section, Ames, IA, 2019.
- Minisymposium talk at the SIAM Conference on Applications of Dynamical Systems, Snowbird, UT, 2019.
- Minisymposium talk at the 71th Annual Meeting of the APS Division of Fluid Dynamics, Atlanta, GA, 2018.
- Computational Math seminar talk at the University of Pittsburgh, Department of Mathematics, 2018.
- Keynote minisymposium talk at WCCM 2018, New York, NY, 2018.
- Minisymposium talk at WCCM 2018 (presenting author: O. Oyekole), New York, NY, 2018.
- Minisymposium talk at SIAM Annual Meeting, Portland, OR, 2018.
- Colloquium talk at the Colorado State University, Department of Mathematics, 2017.
- Minisymposium talk at 5th International Conference on Computational and Mathematical Biomedical Engineering, Pittsburgh, PA, 2017.
- Colloquium talk at the Indiana University–Purdue University Indianapolis, Department of Mathematics, 2016.
- Special session (In celebration of the 60th birthday of Prof. William Layton) talk at AMS Sectional Meeting, Denver, CO, 2016.
- Numerical Analysis and Predictability of Fluid Flow Conference, Pittsburgh, PA, 2016.
- Scientific computing seminar talk at the University of Houston, Department of Mathematics, 2016.
- Minisymposium talk at ASC 30th Technical Conference, Michigan State University, East Lansing, MI, 2015.
- Minisymposium talk at USNCCM 13, San Diego, CA, 2015.
- Colloquium talk at the University of Maryland Baltimore County, Department of Mathematics and Statistics, 2014.
- Colloquium talk at the University of Notre Dame, Department of Applied and Computational Mathematics and Statistics, 2014.
- Minisymposium talk at the SIAM Conference on Mathematical and Computational Issues in the Geosciences, Padua, Italy, 2013

Conference and Workshop Presentations and Posters

- ECCOMAS Congress 2016, Crete Island, Greece, 2016.
- MultiMat 2015, Würzburg, Germany, 2015
- Coupled problems 2015, San Servolo, Venice, Italy, 2015
- Workshop on Computational Geomechanics, Pittsburgh, PA, 2014

- From the Clinic to Partial Differential Equations and Back: Emerging challenges for Cardiovascular Mathematics, ICERM, RI, 2014
- SIAM conference on Analysis of PDEs, Orlando, FL, 2013
- 66th Annual Meeting of the APS Division of Fluid Dynamics, Pittsburgh, PA, 2013
- CTW: Mathematics Guiding Bioartificial Heart Valve Design, MBI Ohio, OH, 2013
- Equadiff13, Prague, Czech Republic, 2013
- SIAM Conference on Computational Science & Engineering, Boston, MA, 2012
- Finite Element Circus, University of Pittsburgh, PA, 2012
- V European Congress on Computational Mechanics (ECCOMAS V), Vienna, Austria, 2012
- Frontiers in Mathematical Biology: Young Investigators Conference, University of Maryland, MA, 2012
- 2011 Workshop for Young Researchers in Mathematical Biology, MBI Ohio, OH, 2011
- 34th Annual Texas Differential Equations Conference, Edinburg, TX, 2011
- Women in Mathematics Symposium, Los Angeles, CA, 2011
- Joint SIMAI/SEMA Conference on Applied and Industrial Mathematics, Cagliari, Italy, 2010
- IV European Congress on Computational Mechanics (ECCOMAS IV), Paris, France, 2010
- Workshop on Interdisciplinary Mathematics, Penn State University, State College, PA, 2010
- Harmonic Analysis and PDEs, University of Nebraska-Lincoln, NE, 2010
- Texas Applied Mathematics Meeting for Students, Houston, TX, 2010

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