Martin R. Pfaller, Ph.D.

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Academic Training

2022 **Postdoctoral Scholar**, *Pediatrics – Cardiology*, Stanford University
Focus: Cardiovascular Fluid Dynamics, Growth and Remodeling
PIs: Alison L. Marsden, Jay D. Humphrey

2019 **Ph.D.**, *Mechanical Engineering*, TU Munich (Technical University of Munich, Germany)
Thesis: Predictive Computational Modeling of Patient-Specific Cardiac Mechanics
PIs: Wolfgang A. Wall, Cristóbal Bertoglio

2013 **M.Sc.**, *Mechanical Engineering*, TU Munich
Thesis: Instabilities During Mucosal Folding Induced by Volumetric Growth
PIs: Ellen Kuhl, Wolfgang A. Wall

2012 **B.Sc.**, *Mechanical Engineering*, TU Munich
Thesis: Skew Maximum-Entropy Prior Functions for Convection-Diffusion Problems
PI: Wolfgang A. Wall

Honors and Awards

2022 – 2027 **NIH Pathway to Independence Award (K99/R00)**, National Heart, Lung, and Blood Institute
Award for mentored and faculty research on cardiac remodeling, $1,071,432 (summary)

2022 – 2024 **Instructor K Award Support**, Stanford Maternal and Child Health Research Institute
Supplement to research expenses of NIH K99 award, $100,000

2022 **Travel Awards**, Additional Ventures & Stanford Cardiovascular Institute

2019 **Dissertation Award**, Association of German Engineers (VDI)

2016 & 2017 **Awards for Outstanding Teaching**, *Student Council Mechanical Engineering*, TU Munich

2013 **Exchange Scholarships**, German Academic Exchange Service (DAAD) & Erich Müller-Stiftung

Research Experience

Since 2022 **Instructor**, *Pediatrics – Cardiology*, Stanford University
PI on NIH K99 award: Computational Stability Analysis to Predict Heart Failure after Myocardial Infarction

2019 – 2022 **Postdoctoral Scholar**, *Pediatrics – Cardiology*, Stanford University
- Co-mentored eleven undergraduate and graduate students
- Lead open-source software development
- Generated reduced-order models for fast yet accurate cardiovascular fluid dynamics
- Improved the reliability of cardiovascular fluid dynamics simulations
- Invented a method for fast initialization of 3D fluid dynamics simulations
- Implemented methods for fluid-solid-growth interaction in blood vessels

2014 – 2018 **Research Assistant**, *Mechanical Engineering*, TU Munich
- Mentored ten undergraduate and graduate thesis projects
- Built the new area of cardiac mechanics within the research group
- Established collaborations with scientists from other groups
- Validated a mechanical boundary condition for the heart with magnetic resonance imaging
- Developed a data-driven method to speed up cardiac mechanics simulations
- Derived a method for fast parameter estimation from medical imaging

2013 **Visiting Student Researcher**, *Mechanical Engineering*, Stanford University
Validated a computational model for airway wall growth with mathematical models

Mentored students, * corresponding

Journal Articles – Submitted

S3. Pegolotti L,* **Pfaller MR**, Rubio NL, Ding K, Brugarolas Brufau R, Darve E, Marsden AL. Learning Reduced-Order Models for Cardiovascular Simulations with Graph Neural Networks, 2022.

S2. Schwarz EL, Pegolotti L, **Pfaller MR**, Marsden AL.* Beyond CFD: Emerging Methodologies for Predictive Simulation in Cardiovascular Health and Disease, 2022.

S1. Gebauer AM,* **Pfaller MR**, Braeu FA, Cyron CJ, Wall WA. A homogenized constrained mixture model of cardiac growth and remodeling: Analyzing mechanobiological stability and reversal, 2022. arXiv

Journal Articles – Accepted

A12. Pham J,* Wyetzner S, **Pfaller MR**, Parker DW, James DL, Marsden AL. svMorph: Interactive geometry-editing tools for virtual patient-specific vascular anatomies, *Journal of Biomechanical Engineering*, 2022. arXiv

A11. **Pfaller MR**,* Pham J, Verma A, Pegolotti L, Wilson NM, Parker DW, Yang W, Marsden AL. Automated generation of 0D and 1D reduced-order models of patient-specific blood flow, *International Journal for Numerical Methods in Biomedical Engineering*, 2022 (selected for October 2022 journal cover). DOI

A10. Anbazhakan S, Rios Coronado PE, Sy-Quia ANL, Seow A, Hands AM, Zhao M, Dong ML, **Pfaller MR**, Raftrey BC, Cook CK, Bernstein D, Nieman K, Paşca AM, Marsden AL,* Red-Horse K.* Blood flow modeling reveals improved collateral artery performance during mammalian heart regeneration, *Nature Cardiovascular Research*, 2022. DOI

A9. **Pfaller MR**,* Pham J, Wilson NM, Parker DW, Marsden AL. On the periodicity of cardiovascular fluid dynamics simulations, *Annals of Biomedical Engineering*, 2021. DOI

A8. Pegolotti L,* **Pfaller MR**, Marsden AL, Deparis S. Model order reduction of flow based on a modular geometrical approximation of blood vessels, *Computer Methods in Applied Mechanics and Engineering*, 2021. DOI

A7. **Pfaller MR**,* Cruz Varona M, Lang J, Bertoglio C, Wall WA. Parametric model order reduction and its application to inverse analysis of large nonlinear coupled cardiac problems, *International Journal for Numerical Methods in Biomedical Engineering*, 2020 (in Top Articles in 2020-2021). DOI

A6. Pivovarov D, Willner K, Steinmann P, Brumme S, Müller M, Srisupattarawanit T, Ostermeyer GP, Henning C, Ricken T, Kastian S, Reese S, Moser D, Grasedyck L, Biehler J, **Pfaller M**, Wall W, Kohlsche T, von Estorff O, Gruhlke R, Eigel M, Ehre M, Papaioannou I, Straub D, Leyendecker S.* Challenges of order reduction techniques for problems involving polymorphic uncertainty, *GAMM Mitteilungen*, 2019. DOI

A5. Hörmann JM, **Pfaller MR**, Avena L, Bertoglio C,* Wall WA. Automatic estimation of atrial fiber orientations for patient-specific modeling of cardiac electromechanics using image-registration, *International Journal for Numerical Methods in Biomedical Engineering*, 2019. DOI

A4. **Pfaller MR**,* Hörmann JM, Weigl M, Nagler A, Chabiniok R, Bertoglio C, Wall WA. The importance of the pericardium for cardiac biomechanics: From physiology to computational modeling, *Biomechanics and Modeling in Mechanobiology*, 2019. DOI

A3. Hörmann JM, Bertoglio C, Kronbichler M,* **Pfaller MR**, Chabiniok R, Wall WA. An adaptive hybridizable discontinuous Galerkin approach for cardiac electrophysiology, *International Journal for Numerical Methods in Biomedical Engineering*, 2018. DOI

A2. Hörmann JM, Bertoglio C,* Nagler A, **Pfaller MR**, Bourier F, Hadamitzky M, Deisenhofer I, Wall WA. Multiphysics modeling of the atrial systole under standard ablation strategies, *Cardiovascular Engineering and Technology*, 2017. DOI

A1. Eskandari M, **Pfaller MR**, Kuhl E.* On the role of mechanics in chronic lung disease, *Materials*, 2013. DOI

Mentored students, * presenting

Book Chapter – Submitted

B1. **Pfaller MR**, Pegolotti L, Pham J, Rubio NL, Marsden AL. Reduced Order Modeling of Cardiovascular Hemodynamics, *Biomechanics of the Aorta: Modelling for Patient Care*, edited by C Gasser, S Avril, J Elefteriades, 2022.

Conference Proceedings and Abstracts

P9. **Pfaller MR**,* Latorre M, Schwarz EL, Szafron JM, Humphrey JD, Marsden AL. A Computational Model for Cardiovascular Fluid-Solid-Growth Interaction, *Additional Ventures Single Ventricle Investigator Meeting*, Baltimore, MD, 2022.

P8. **Pfaller MR**,* Latorre M, Schwarz EL, Szafron JM, Humphrey JD, Marsden AL. A Computational Model for Cardiovascular Fluid-Solid-Growth Interaction, *7th International Conference on Computational and Mathematical Biomedical Engineering – CMBE*, P Nithiarasu and C Vergara (Eds.), Milan, Italy, 2022.

P7. **Pfaller MR**,* Lan IS, Wilson NM, Parker DW, Marsden AL. The Vascular Model Repository and SimVascular, *Society for Cardiovascular Magnetic Resonance (SCMR) Virtual Scientific Sessions*, online, 2021.

P6. **Pfaller MR**,* Hörmann JM, Weigl M, Nagler A, Chabiniok R, Bertoglio C, Wall WA. Physiology, computational modeling, and impact of pericardial boundary conditions, *Modelling the Cardiac Function*, online, 2020.

P5. **Pfaller MR**,* Wilson NM, Yang W, Parker DW, Marsden AL. Automated reduced-order modeling for a repository of large-scale patient-specific blood flow simulations, *Virtual Physiological Human Conference*, online, 2020.

P4. **Pfaller MR**,* Wilson NM, Yang W, Parker DW, Marsden AL. Automatic creation of one-dimensional flow models from three-dimensional anatomical geometries, *Summer Biomechanics, Bioengineering, and Biotransport Conference*, online, 2020.

P3. **Pfaller MR**,* Lang J, Cruz Varona M, Biehler J, Bertoglio C, Wall WA. Parametric model order reduction using POD for coupled nonlinear cardiac mechanics, *6th European Conference on Computational Mechancis – ECCM-ECFD*, Glasgow, United Kingdom, 2018.

P2. **Pfaller MR**,* Nagler A, Hörmann JM, Weigl M, Bertoglio C, Kozerke S, Stoeck CT, Wall WA. Influence of Fiber Architecture and Pericardial Boundary Conditions on Cardiac Mechanics Simulations, *7th European Congress on Computational Methods in Applied Sciences and Engineering – ECCOMAS*, Crete Island, Greece, 2016.

P1. **Pfaller MR**,* Nagler A, Bertoglio C, Hirschvogel M, Wall WA. Pericardial Boundary Conditions for Cardiac Mechanics Simulations, *4th International Conference on Computational and Mathematical Biomedical Engineering – CMBE*, P Nithiarasu and E Budyn (Eds.), Cachan, France, 2015.

Software Projects and Repositories

Development, maintenance, and administration of open-source scientific software projects and repositories

- Vascular Model Repository: Curated subject-specific fluid dynamics models of blood vessels
- SimVacsular: Cardiovascular fluid dynamics simulation suite with a graphical user interface
- svOneDSolver: One-dimensional fluid dynamics solver for a network of tube-like blood vessels
- svZeroDSolver: Zero-dimensional fluid dynamics solver for lumped-parameter networks of blood vessels
- svFSI: Three-dimensional finite element solver for electrophysiology, structure, and fluid dynamics

Professional Service

- **Grant Review**: Dutch Research Council (NWO) – Vidi Program
- **Journal Peer Review**: Bioengineering, Cardiovascular Engineering and Technology, European Radiology, International Journal for Numerical Methods in Biomedical Engineering, Medical Image Analysis

Teaching Experience

At Stanford

2021 **Nonlinear Continuum Mechanics**, *Instructor*
Created and taught a mini-course for lab-members

2021 **SimVascular software workshop**, *Instructor*, SB3C conference
Taught a section on reduced-order modeling in our open-source software

2020 – 2021 **Bioengineering**, *Guest lecturer*
Taught selected lectures in several courses
- BIOE 285 – Computational Modeling in the Cardiovascular System
- BIOE 390 – Introduction to Bioengineering Research
- BIOE 301C – Diagnostic Devices Lab

At TU Munich

2017 – 2018 **Solid Mechanics 3 – Dynamics**, *Teaching assistant*
Organized online course and lecture recordings, transitioned teaching responsibilities

2017 **Solid Mechanics 2 – Elastostatics**, *Head teaching assistant*
Transitioned to teaching with five teaching assistants, introduced computer-based exam reviews

2016 – 2017 **Solid Mechanics 1 – Statics**, *Head teaching assistant*
Taught 703 undergraduate students weekly, supervised 23 section leaders, introduced lecture recordings

2016 **Visualization in Solid Mechanics**, *Instructor*
Mentored teams of highly talented students developing their own teaching software (e.g. Google Play)

2015 – 2016 **Solid Mechanics 3 – Dynamics**, *Head teaching assistant*
Taught 610 undergraduate students weekly, supervised 17 section leaders, introduced live quizzes

2015 **Solid Mechanics 2 – Elastostatics**, *Teaching assistant*
Created video tutorials. See e.g. tutorial on Mohr's Circle on YouTube (55k views)

2014 – 2015 **Solid Mechanics 1 – Statics**, *Teaching assistant*
Created video tutorials. See e.g. tutorial on influence lines on YouTube (10k views)

Work Experience

2019 – 2020 **Research Consultant**, Ablacon
Devised simulation tools to diagnose atrial fibrillation and guide catheter ablation surgery

2012 – 2013 **Student Trainee**, *Research and Development*, BMW
- Preformed stress analysis calculations for electric motors
- Enabled a fast prototyping process by giving design recommendations based on simulations

2011 – 2012 **Student Trainee**, *Corporate Technology*, Siemens
- Implemented software for communication between various finite element solvers
- Reduced costs for software licenses by using open-source software for the simulation process

2009 – 2011 **Undergraduate Teaching Assistant**, *Mechanical Engineering*, TU Munich
- Gained a deep understanding of mechanical engineering core subjects by teaching others
- Taught a class of non-engineering undergraduate students in solid mechanics

Outreach

Performed in "science slams," giving entertaining short talks about my scientific research to a general audience

2020 **Participant**, invited by the German Academic International Network (YouTube)

2017 **Winner**, invited by the Mechanical Engineering Student Council, TU Munich

Student Research Mentoring

Doctoral candidates

Since 2021	**Faiza Tabassum**, Reduced-order modeling of blood flow using the Port Hamiltonian method.	*TU Munich*
Since 2021	**Erica Schwarz**, Simulating growth and remodeling of blood vessels.	*Stanford*
Since 2021	**Priya Nair**, Simulation-based treatment planning for patients with aortic coarctations.	*Stanford*
Since 2020	**Janina Datz**, Mechanical effects of coronary in-stent restenosis.	*TU Munich*
Since 2020	**Amadeus Gebauer**, Computational modeling of cardiac growth and remodeling.	*TU Munich*
Since 2020	**Natalia Rubio**, Machine learning-enhanced reduced-order models of blood flow.	*Stanford*
Since 2020	**Numì Sveinsson**, Automatic segmentation of blood vessels using convolutional neural networks.	*UC Berkeley*
2020	**Luca Pegolotti**, Model order reduction of flow based on a modular geometrical approximation of blood vessels.	*EPFL*
Since 2019	**Jonathan Pham**, Interactive geometry-editing tools for virtual patient-specific vascular anatomies.	*Stanford*

Master's theses (six months)

Since 2022	**Jakob Richter**, Multi-fidelity boundary condition tuning for cardiovascular fluid dynamics simulations under uncertainty.	*Stanford*
2019	**Amadeus Gebauer**, Growth and remodeling for cardiac mechanics simulations.	*TU Munich*
2018	**Magnus Mechler**, Projection-based hyper-reduction for 3D-0D coupled cardiovascular mechanics.	*TU Munich*
2017	**Johannes Lang**, Projection-based parametric model order reduction for 3D-0D coupled cardiac mechanics.	*TU Munich*
2015	**Jonas Schollenberger**, A lumped parameter model of cerebral blood flow regulation: Applications to simulation of carotid endarterectomy.	*University of Michigan*

Semester theses (three months)

2018	**Maximilian Gruber**, Electrophysiological simulation of atrial fibrillation.	*TU Munich*
2017	**Miriam Bastian**, Influence of pericardial boundary conditions on systolic cardiac function in mechanical simulations.	*TU Munich*
2016	**Sebastian Kaltenbach**, Reduced-order mathematical modeling of cardiac growth and remodeling.	*TU Munich*

Bachelor's theses (three months)

2018	**Lukas Küchle**, Implementation and verification of a Gauss-point-based fiber formulation.	*TU Munich*
2016	**Janina Datz**, Estimation of cardiac muscle fiber architecture from diffusion-weighted magnetic resonance imaging.	*TU Munich*
2015	**Christina Insam**, A reduced-order model of left ventricular mechanics using a prolate spheroid geometry.	*TU Munich*

Student projects

2021	**Elena Martinez**, Modeling blood pressure losses over blood vessel junctions, *Summer Undergraduate Research Fellowship (SURF) and McNair Scholar*.	*Stanford*
2017	**Raphael Gebhart**, Live quizzes for Solid Mechanics lectures.	*TU Munich*
2016	**Martina Weigl**, Segmentation of a four-chamber cardiac geometry.	*TU Munich*
2015	**Martina Weigl**, Implementation of a Laplace fiber lifting class in Python.	*TU Munich*