Charles Puelz

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(updated: November 29, 2021)

Research Interests

mathematical physiology and medicine, numerical methods for partial differential equations

Experience

Assistant Professor, Dept. of Pediatrics-Cardiology, Baylor College of Medicine	8/2020-present
Adjunct Assistant Professor, Dept. of Mathematics, North Carolina State University	3/2021-present
Lecturer, Dept. of Computational and Applied Math, Rice University	7/2020-present
Visiting Researcher, Dept. of Mathematics, University of North Carolina at Chapel Hill	8/2018-present
Assistant Professor/Courant Instructor, Courant Institute of Mathematical Sciences, NYU advisor: Charles Peskin	9/2018-7/2020
Postdoctoral Researcher, Dept. of Mathematics, University of North Carolina at Chapel Hill advisor: Boyce Griffith	7/2017-8/2018
Graduate Researcher, Dept. of Computational and Applied Math, Rice University advisors: Beatrice Riviere, Craig Rusin, Mark Embree	8/2011-5/2017
Undergraduate Researcher, Dept. of Mathematics, Massachusetts Institute of Technology advisor: Laurent Demanet	Summer 2010
Undergraduate Researcher, Max Planck Institute for Dynamics and Self-Organization advisor: Tsampikos Kottos	Summer 2009

Education

- Ph.D. in Computational and Applied Mathematics, Rice University, Houston, TX — May 2017
  title: *Numerical methods and applications for reduced models of blood flow*
  advisors: Beatrice Riviere, Craig G. Rusin
  committee: Matthias Heinkenschloss, Jane Grande-Allen, Sunčica Čanić
- M.A. in Computational and Applied Mathematics, Rice University, Houston, TX — May 2013
  title: *Improved spectral calculations for discrete Schrödinger operators*
  advisor: Mark Embree
  committee: Danny Sorensen, David Damanik
- B.A. in Mathematics and B.A. in Physics, Wesleyan University, Middletown, CT — May 2011
  Phi Beta Kappa and honors in mathematics

Journal Papers

1. "Computer simulation of surgical interventions for the treatment of refractory pulmonary hypertension."
   S.W. Han, C. Puelz, C.G. Rusin, D.J. Penny, R. Coleman, C.S. Peskin.
   submitted, 2021.
2. "A reduced model for solute transport in compliant blood vessels with arbitrary axial velocity profile."
   R. Masri, C. Puelz, B. Riviere.
   International Journal of Heat and Mass Transfer, *accepted*, 2021. arXiv:1912.09587.

3. "A discontinuous Galerkin method for blood flow and solute transport in one dimensional vessel networks."
R. Masri, C. Puelz, B. Riviere.
Communications on Applied Mathematics and Computation, *accepted*, 2021.

4. "Models for plasma kinetics during simultaneous
therapeutic plasma exchange and extracorporeal membrane oxygenation."
C. Puelz, Z. Danial, J. Marinaro, J.S. Raval, B.E. Griffith, C.S. Peskin.
Mathematical Medicine and Biology, *accepted*, 2021. arXiv:2006:06100.

5. "A physiological model of the inflammatory-thermal-pain-cardiovascular interactions
during a endotoxin challenge."
A. Dobreva, R. Brady, K. Larripa, C. Puelz, J. Mehlsen, and M. Olufsen.
Journal of Physiology, 599(5), pp. 1459-1485, 2021.

6. "Mathematical modeling of the impact of recirculation on exchange kinetics in tandem extracorporeal membrane oxygenation and therapeutic plasma exchange."
C. Puelz, J. Marinaro, Y.A. Park, B.E. Griffith, C.S. Peskin, J.S. Raval.
Journal of Clinical Apheresis, 36(1), pp. 6-11, 2021.

7. "A sharp interface method for an immersed viscoelastic solid."
C. Puelz and B.E. Griffith.
Journal of Computational Physics, 409, 2020. arXiv:1902.02424.

8. "A priori error estimates of Adams-Bashforth discontinuous Galerkin methods
for scalar nonlinear conservation laws."
C. Puelz, B. Rivière.
Journal of Numerical Mathematics, 26(3), pp. 151-172, 2018.

9. "A computational study of the Fontan circulation with fenestration or hepatic vein exclusion."
C. Puelz, S. Acosta, B. Rivière, D. Penny, K. Brady, C.G. Rusin.
Computers in Biology and Medicine, 89, pp. 405-418, 2017.

10. "Cardiovascular mechanics in the early stages of pulmonary hypertension: a computational study."
S. Acosta, C. Puelz, B. Rivière, D. Penny, K. Brady, C.G. Rusin.
Biomechanics and Modeling in Mechanobiology, 16(6), pp. 2093-2112, 2017.

11. "Convergence of IPDG for coupled time-dependent Navier-Stokes and Darcy equations."
N. Chabaane, V. Girault, C. Puelz, B. Rivière.
Journal of Computational and Applied Mathematics, 324, pp. 25-48, 2017.

12. "Comparison of reduced blood flow models using Runge-Kutta discontinuous Galerkin methods."
C. Puelz, S. Čanić, B. Rivière, C.G. Rusin.
Applied Numerical Mathematics, 115, pp. 114-141, 2017.

13. "Numerical method of characteristics for one-dimensional blood flow."
S. Acosta, C. Puelz, B. Rivière, C.G. Rusin, D. Penny.
Journal of Computational Physics, 294, pp. 96-109, 2015.

14. "Spectral approximation for quasiperiodic Jacobi operators."
C. Puelz, M. Embree, J. Fillman.
Integral Equations and Operator Theory, 82(4), pp. 533-554, 2015.

Conference Reports and Abstracts

1. "A hyperelastic immersed boundary finite element model of the human heart." C. Puelz, D. Wells, M. A. Smith, S. Rossi, P. Segars, G. Sturgeon and B. E. Griffith. *6th International Conference on Computational and Mathematical Biomedical Engineering*, Sendai, Japan, 2019.

2. "Mathematical investigation of impact of recirculation in patients receiving tandem extracorporeal membrane oxygenation and therapeutic plasma exchange." C. Puelz, Y.A. Park, J. Marinaro, C.S. Peskin, B.E. Griffith, J.S. Raval. *Journal of Clinical Apheresis*: Special Issue Abstracts from the American Society for Apheresis 40th Annual Meeting 34(2), 88-89, 2019.

3. "Immersed boundary finite element hyperelastic heart model." C. Puelz, M.A. Smith, S. Rossi, G. Sturgeon, P. Segars, and B. Griffith. *ECCM-ECFD 2018*, Glasgow, Scotland.

Theses and Technical Reports

1. *Numerical methods and applications for reduced models of blood flow*, PhD Thesis, Rice University, 2017.
2. *Improved spectral calculations for discrete Schrödinger operators*, Masters Thesis, Rice University, 2013.
3. "Visualizing the Pareto Surface." B. Hosseini, G. Liu, C. Puelz, S. Tracht, M. Smilovic. *IMA Preprint Series* 2401, 2012.

Funding

- AMS MRC Microconference on Parameter Estimation, August 9, 2018. $5,350.
  co-organized with Renee Brady, Ben Randall, and Mette Olufsen.
- National Library of Medicine training fellowship through the Gulf Coast Consortia for the Quantitative Biomedical Sciences, awarded 2014, renewed 2015 and 2016.

Honors and Awards

- Alan Weiser Memorial Travel Award, Rice CAAM department, April 2016.
- Honorable Mention in the National Science Foundation GRFP competition, April 2013.
- SIAM Student Chapter Certificate of Recognition, April 2013.
- Rae Shortt Prize, Wesleyan math department, April 2010.
- Robertson Math Award, Wesleyan math department, April 2009.

Teaching

Differential Equations in Science and Engineering (undergraduate)	S 2022	Rice	Instructor
Matrix Analysis (undergraduate)	F 2021	Rice	Instructor
Differential Equations in Science and Engineering (undergraduate)	S 2021	Rice	Instructor
Computational Science I (graduate)	F 2020	Rice	Instructor
Linear Algebra (undergraduate)	Sp 2020	NYU	Instructor
Numerical Analysis (undergraduate)	F 2019	NYU	Instructor
Modeling and Experiments in Fluid Dynamics (graduate)	Sp 2019	NYU	Teaching Assistant
Numerical Analysis (undergraduate)	Sp 2019	NYU	Instructor
Modeling and Simulation in Sci., Eng, and Econ. (undergraduate)	F 2018	NYU	Co Instructor w/ C. Peskin
Differential Equations in Science and Eng. (undergraduate)	Sp 2015	Rice	Teaching Assistant
Matrix Analysis (undergraduate)	F 2014	Rice	Teaching Assistant
Matrix Analysis (undergraduate)	F 2013	Rice	Teaching Assistant
Matrix Analysis (undergraduate)	Sp 2013	Rice	Lab Instructor
Intro to Engineering Computation (undergraduate)	F 2012	Rice	Rice Learning Assistant

Thesis committees

- Alyssa Taylor, PhD thesis, North Carolina State University Mathematics department.
- Rami Masri, PhD thesis, Rice University CAAM department.
- Zach Danial, Gallatin School Colloquium committee, NYU, December 2019.
- Rami Masri, MA thesis, Rice University CAAM department. May 2019.
  Topic: Oxygen transport in vessel network models.

Mentoring

- Colin Edwards, summer intern at BCM/TCH, co-advised with Craig Rusin and Dan Lior. June 2021-July 2021.
  Topic: Image segmentation and model construction for anomalous aortic origin of coronary arteries.
- Raniyah Nathani, IBB summer research student at Rice, co-advised with Beatrice Riviere. June 2021-July 2021.
  Topic: Compartmental circulation models and species transport.
- Alyssa Taylor, NCSU PhD student, co-advised with Mette Olufsen. Fall 2020-present.
  Topic: Fluid/structure interaction models for reconstructed Fontan aortas.
  Alyssa was awarded a 2021 NSF GRFP fellowship for her project.
- Zan Ahmad, NYU undergraduate (SURE program). Spring-Summer 2020.
  Topic: Models for optimal Fontan circulations.
  Zan was named a Wilfred L. and Ruth S.F. Peltz Research Scholar and received a Dean's Undergraduate Research Fund scholarship for this project.
- Zach Danial, NYU undergraduate (AM-SURE program), with Charlie Peskin. Summer 2019.
  Topic: Species advection in fluid with simple and three dimensional models.
- Lynn Jin, NYU undergraduate (SURE program, summer 2019), with Charlie Peskin. Fall 2018-Summer 2019.
  Topic: Zero dimensional pulsatile models for the fenestrated Fontan and fetal physiologies.
- Margaret Anne Smith, post-bachelors at UNC-CH, with Boyce Griffith. Fall 2017-Fall 2018.
  Topic: Three-dimensional geometrical modeling of the adult human heart.

Service

- Editorial board: *Computational Physiology and Medicine* (Review Editor, 2020-present).
- Journal reviewer: *Numerical Methods for Partial Differential Equations*, *Journal of Theoretical Biology*, *Journal of Engineering in Medicine*, *Journal of Biological Systems*, *Biomechanics and Modeling in Mechanobiology*, *PLOS ONE*, *Computers in Biology and Medicine*, *SIAM Journal on Applied Mathematics*, *Annals of Biomedical Engineering*, *Journal of Fluid Mechanics*
- Conferences/workshops:
  - Co-organizer for minisymposium titled "Mathematics and Computation in Biomedicine," SIAM TX/LA meeting, November 2021.
  - Co-organizer for minisymposium titled "Progress in forward and inverse problems in cardiovascular dynamics," SIAM CSE, March 2021.
  - Organizer for minisymposium titled "Numerical methods and applications for cardiovascular mechanics," 3rd Annual Meeting of the SIAM Texas-Louisiana Section, October 2020.
  - Session chair for contributed presentation session titled "Applications in CSE," SIAM CSE, 2019.
  - Co-organizer of AMS microconference on parameter estimation in physiological models. August 9, 2018.
  - Co-organizer of minisymposium at the 42nd SIAM Southeastern Atlantic Section Conference titled "Cardiovascular Modeling and Simulation." March 9-11, 2018.
  - Co-organizer of an AMS minisymposium at the Joint Mathematics Meeting. Minisymposium titled "Mathematics in Physiology and Medicine." January 5, 2017.
- At New York University:
  - Proud-to-be-first advocate at NYU. This is part of a program to support first generation college students.
  - Co-coordinator of the applied math summer undergraduate research experience (AM-SURE) at Courant, NYU, summer 2019.
  - Co-organizer of Applied Math/Applied Math Lab seminar in the Courant Institute, 2018-2019.
- At University of North Carolina, Chapel Hill:

- Co-organizer of the Applied Mathematics Colloquium in the UNC-CH Mathematics Department, 2017-2018.

- At Rice University:
  - Poster judge for 2021 IBB Summer Research Symposium, August 2021.
  - Speaker at "Rice Summer Math Days," a summer program for high school students interested in studying mathematics, June 2015.
  - SIAM student chapter president, Rice University, 2012-2013.

- Other:
  - Science fair judge. Immaculate Conception School, New York City. January 29, 2020.

Presentations

1. "Immersed boundary methods for pediatric and adult cardiovascular models."
   4th Annual Meeting of the SIAM Texas-Louisiana Section, November 5, 2021.

2. "A fluid/structure interaction model of the human heart."
   Society for Mathematical Biology Annual Meeting. June 17, 2021.

3. "Simulation of a toroidal heart using a sharp interface immersed boundary method."
   SIAM CSE 2021, (virtual), March 3, 2021.

4. "Fluid-structure interaction models for describing the physiology of human hearts."
   New Jersey Institute of Technology Fluids and Waves Seminar (online), November 9, 2020.

5. "A fluid-structure interaction model of the human heart."
   3rd Annual Meeting of the SIAM Texas-Louisiana Section (online), October 18, 2020.

6. "Fluid-structure interaction model of the human heart."
   Modelling the Cardiac Function: Theory, Numerical Methods, Clinical Application (online), September 2, 2020.

7. "A sharp interface version of the immersed boundary finite element method."
   Modeling and Simulation Group Seminar (online), Courant Institute, April 23, 2020.

8. "Computer models and numerical methods for mathematical cardiology."
   Mathematics Department Special Seminar, North Carolina State University, January 21, 2020.

9. "Computer models and numerical methods for mathematical physiology."
   Mathematics Department Colloquium, Baylor University, Waco, TX, December 10, 2019.

10. "Computer models and numerical methods for mathematical physiology."
    Modeling and Simulation Group Seminar, Courant Institute, December 5, 2019.

11. "Computer model of the human heart."
    15th U.S. National Congress on Computational Mechanics, Austin, TX, July 29, 2019.

12. "Models for fetal heart mechanics."
    joint with Lynn Jin (NYU undergrad)
    unSURE Summer Research Seminar, Courant Institute, July 2019.

13. "A hyperelastic immersed boundary finite element model of the human heart."
    6th International Conference on Computational and Mathematical Biomedical Engineering,
    Sendai City, Japan, June 10, 2019.

14. "Modeling recirculation in tandem ECMO and therapeutic plasma exchange."
    American Society for Apheresis annual meeting, Portland, OR, May 17, 2019.

15. "A review of Taylor's 1953 paper on dispersion of a solute in fluid and related applications."
    joint with Ondrej Maxian (Courant).
    Modeling and Simulation Group Seminar, Courant Institute, March 2019.

16. "Hyperelastic immersed boundary finite element model of the human heart."
SIAM CSE, Spokane, WA, 2019.

17. "A sharp interface method for an immersed viscoelastic solid."
WONAPDE 2019, Universidad de Concepción, Concepción, Chile, January 23, 2019.

18. "Hyperelastic immersed boundary finite element model of a human heart."
WONAPDE 2019, Universidad de Concepción, Concepción, Chile, January 23, 2019.

19. "Computer model of the human heart."
CAAM Graduate Seminar, Rice University, Houston, TX, January 16, 2019.

20. "Computer modeling of the human heart."
Courant Instructor Day, Courant Institute, New York, NY, October 12, 2018.

21. "A one-dimensional vessel network model for the Fontan circulation."
Biomath/Comp. Biology Colloquium, Courant Institute, New York, NY, October 2, 2018.

22. "Construction of a hyperelastic immersed boundary model of the human heart."
Biomath/Comp. Biology Colloquium, Courant Institute, New York, NY, September 18, 2018.

23. "A hyperelastic immersed boundary model of the human heart."
SIAM Life Sciences, Minneapolis, MN, 2018.

24. "Reduced model for the Fontan circulation."
SIAM Life Sciences, Minneapolis, MN, 2018.

25. "Immersed boundary finite element hyperelastic heart model."
ECCM-ECFD, Glasgow, UK, June 2018.

26. "Computational modeling of Fontan hemodynamics"
North Carolina State University Biomathematics Seminar, Raleigh, NC, April 2018.

27. "Discretizations of 1D blood flow models and an application to the Fontan physiology"
Virginia Tech Numerical Analysis Seminar, Blacksburg, VA, November 1, 2017.

28. "One dimensional vessel network models for studying abnormal physiologies"
UNC Department of Mathematics Applied Mathematics Colloquium, Chapel Hill, NC, September 2017.

29. "Numerical methods for blood flow"
Rice CAAM department graduate colloquium, Houston, TX, March 2017.

30. "Reduced models for blood flow"
Finite Element Rodeo, University of Houston, Houston, TX, March 2017.

31. "One-dimensional blood flow models: analysis and applications"
SIAM Life Sciences, Boston, MA, July 2016.

32. "Discontinuous Galerkin discretizations of one-dimensional blood flow models"
Finite Element Rodeo, Texas A&M University, College Station, TX, March 2016.

33. "Numerical methods for reduced blood flow models"
National Institute of Standards and Technology, Gaithersburg, MD, June 2015.

34. "Discontinuous Galerkin methods for reduced blood flow models"
Finite Element Rodeo, Southern Methodist University, Dallas, TX, May 2015.

35. "An $O(N^2)$ eigenvalue algorithm for period-N Jacobi operators"
Joint Mathematics Meeting, San Antonio, TX, January 2015.

36. "Spectra of Schrödinger operators via transfer matrices"
Rice CAAM department graduate colloquium, Houston, TX, January 2014.

37. "Electrical networks and Polya's theorem"
Rice CAAM department graduate colloquium, Houston, TX, January 2012.

38. "Random walks and electrical networks"
Wesleyan math department senior honors presentation, Wesleyan University, Middletown, CT, April 2011.

39. "Oil drilling and mathematics"
Wesleyan math department undergraduate colloquium, Middletown, CT, February 2011.

Posters

1. "High fidelity computer models for cardiac fluid and solid mechanics."
with Margaret Anne Smith, Simone Rossi, Marshall Davey, David Wells, and Boyce Griffith.
BCM Cardiovascular Research Institute 8th Annual Symposium, April 2021.

2. "A modeling study of palliations used for refractory pulmonary hypertension."
with Seong Woo Han, Craig Rusin, Dan Penny, Ryan Coleman, and Charles Peskin.
14th International Symposium on Neonatal and Childhood Pulmonary Vascular Disease Conference, virtual, March 2021.

3. "Heart Modeling with the Immersed Boundary Finite Element Method."
with Margaret Anne Smith, Simone Rossi, and Boyce Griffith.
SIAM Annual Meeting, Portland, OR, July 2018.

4. "Hyperelastic immersed boundary finite element heart model."
with Margaret Anne Smith, Simone Rossi, and Boyce Griffith.
42nd SIAM Southeastern Atlantic Section Conference, University of North Carolina, Chapel Hill, NC, March 2018.

5. "One-dimensional model of blood flow discretized with Runge-Kutta discontinuous Galerkin methods"
SIAM Life Sciences, Boston, MA, July 2016.

6. "Computational modeling of hypoplastic left heart syndrome for improved decision support"
NLM Informatics Training Conference, Ohio State University, Columbus, OH, June 2016.

7. "Mathematical modeling of congenital heart defects and abnormal hemodynamic physiologies"
Sigma Xi (Rice and TMC chapter) holiday event, Houston, TX, December 2015.

8. "Blood flow model for improved decision support"
AMIA Annual Symposium, San Francisco, CA, November 2015

9. "A closed-loop reduced hemodynamic model for the simulation of blood flow in patients with hypoplastic left heart syndrome"
25th Keck Annual Research Conference, Bioscience Research Collaborative, Houston, TX, October 2015.

10. "Discontinuous Galerkin methods for reduced blood flow models"
Advanced Numerical Methods in the Mathematical Sciences conference, Texas A&M University, College Station, TX, May 2015.

11. "Numerical methods for one-dimensional blood flow"
poster at the Keck Annual Research Conference, Bioscience Research Collaborative, Houston, TX, November 2014.

Conferences and Workshops

- 14th International Symposium on Neonatal and Childhood Pulmonary Vascular Disease Conference, March 3-5, 2021
- SIAM Computational Science and Engineering, March 1-5, 2021.
- 3rd Annual Meeting of the SIAM Texas-Louisiana Section, October 16-18, 2020.
- Modelling the Cardiac Function: Theory, Numerical Methods, Clinical Applications, August 31 - September 2, 2020.
- 15th U.S. National Congress on Computational Mechanics, Austin, TX, July 28-August 1, 2019.

- 6th International Conference on Computational and Mathematical Biomedical Engineering, Sendai City, Japan, June 10-12, 2019.
- American Society for Apheresis annual meeting, Portland, OR, May 14-18, 2019.
- SIAM CSE, Spokane, WA, February 25-March 1, 2019.
- Sixth Chilean Workshop on Numerical Analysis of Partial Differential Equations (WONAPDE), Concepción, Chile, January 21-25, 2019.
- SIAM Life Sciences, Minneapolis, MN, August 6-9, 2018.
- SIAM Annual Meeting, Portland, OR, July 9-13, 2018.
- European Conference on Computational Mechanics/European Conference on Fluid Dynamics (ECCM-ECFD), Glasgow, UK, June 11-15, 2018.
- 42nd SIAM Southeastern Atlantic Section Conference, University of North Carolina, Chapel Hilll, NC, March 9-11, 2018.
- Finite Element Rodeo, University of Houston, Houston, TX, March 3-4, 2017.
- Joint Mathematics Meeting, Atlanta, GA, January 4-7, 2017.
- SIAM Life Sciences, Boston, MA, July 11-14, 2016.
- National Library of Medicine Informatics Training Conference, Ohio State University, Columbus, OH, June 27-28, 2016.
- AMS MRC: Mathematics in Physiology and Medicine, Snowbird Resort, Snowbird, UT, June 19-25, 2016.
- Finite Element Rodeo, Texas A&M University, College Station, TX, March 4-5, 2016.
- AMIA Annual Symposium, San Francisco, CA, November 14-18, 2015.
- 25th Keck Annual Research Conference, Bioscience Research Collaborative, Houston, TX, October 15-16, 2015.
- National Library of Medicine Informatics Training Conference, National Institutes of Health, Bethesda, MD, June 23-24, 2015.
- Advanced Numerical Methods in the Mathematical Sciences, Texas A&M University, College Station, TX, May 4-7, 2015.
- Finite Element Rodeo, Southern Methodist University, Dallas, TX, February 27-28, 2015.
- Joint Mathematics Meeting, San Antonio, TX, January 10-13, 2015.
- National Library of Medicine Informatics Training Conference, University of Pittsburgh, Pittsburgh, PA, June 17-18, 2014.
- 24th Keck Annual Research Conference, Bioscience Research Collaborative, Houston, TX, November 7, 2014.
- Gene Golub SIAM Summer School on Numerical Linear Algebra, Fudan University, Shanghai, China, July 22-August 9, 2013.
- Recent Advances in Harmonic Analysis and Spectral Theory, Texas A&M University, College Station, TX, August 6-10, 2012.
- Mathematical Modeling in Industry XVI, University of Calgary, Calgary, Alberta, July 18-27, 2012.