

Brendan Keith

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Disciplinary field(s)

High-order finite element methods, scientific computing, scientific machine learning, optimal design

Appointments

Division of Applied Mathematics
Brown University

Providence, Rhode Island

ASSISTANT PROFESSOR

July 2022 – present

Center for Applied Scientific Computing
Lawrence Livermore National Laboratory

Livermore, California

POSTDOCTORAL RESEARCHER

Feb. 2021 – June 2022

Institute for Computational and Experimental Research in Mathematics (ICERM)
Brown University

Providence, Rhode Island

POSTDOCTORAL FELLOW

Sept. 2020 – Dec. 2020

Chair of Numerical Mathematics
Technische Universität München

Garching, Germany

POSTDOCTORAL RESEARCHER

Sept. 2018 – Aug. 2020

Supervisor: Barbara Wohlmuth

Education

Oden Institute for Computational Engineering and Sciences
University of Texas at Austin

Austin, Texas

PH.D. COMPUTATIONAL SCIENCE, ENGINEERING, & MATHEMATICS

2018

Supervisor: Leszek Demkowicz

Dissertation: A saddle-point paradigm for finite element analysis and its role in the DPG methodology

Department of Mathematics and Statistics
McGill University

Montréal, Quebec

M.SC. APPLIED MATHEMATICS

2013

Supervisor: George Haller

Thesis: Lagrangian coherent structures in three-dimensional steady flows

Departments of Applied Mathematics, Pure Mathematics, and Physics
University of Waterloo

Waterloo, Ontario

B.MATH HONOURS APPLIED MATHEMATICS WITH PHYSICS OPTION

2011

B.MATH HONOURS PURE MATHEMATICS

2011

Teaching

Brown University

2023 – present

- APMA 1160, An Introduction to Numerical Optimization
- APMA 2560, Numerical Solution of Partial Differential Equations II

Research Funding as Lead PI

2024–'28	DOE SC ECRP , REASON-3D: Randomized, Entropic, Adaptive, and Scalable Optimization for Non-Intrusive Data-Driven Design	\$875k
2023	OVPR Seed Award (Brown Internal) , Data-Driven High-Order Accurate Fail-Safe Neural Topology Optimization for Plastic Deformation and Fracture	\$100k
2022–'24	LLNL LDRD , Adaptive Sampling for Risk-Averse Design and Optimization	\$1.4m

Preprints

1. Izmailov, A., Meeker, M., Deskos, G., and Keith, B. (2024). *DRDMannTurb: A python package for scalable, data-driven synthetic turbulence simulation*. Version 0.1.0. Submitted to the Journal of Open Source Software. URL: <https://github.com/METHODS-Group/DRDMannTurb>.
2. Duswald, T., Keith, B., Lazarov, B., Petrides, S., and Wohlmuth, B. (2024). *Finite elements for Matérn-type random fields: Uncertainty in computational mechanics and design optimization*. arXiv: 2403.03658 [cs.CE].
3. Andrej, J., Atallah, N., Bäcker, J.-P., Camier, J., Copeland, D., Dobrev, V., Dudouit, Y., Duswald, T., Keith, B., Kim, D., Kolev, T., Lazarov, B., Mittal, K., Pazner, W., Petrides, S., Shiraiwa, S., Stowell, M., and Tomov, V. (2024). *High-performance finite elements with MFEM*. arXiv: 2402.15940 [cs.MS].
4. Keith, B. and Surowiec, T. M. (2023). *Proximal Galerkin: A structure-preserving finite element method for point-wise bound constraints*. arXiv: 2307.12444 [math.NA].

Scientific Journal Articles

5. Dzanic, T., Mittal, K., Kim, D., Yang, J., Petrides, S., Keith, B., and Anderson, R. (2024). *DynAMO: Multi-agent reinforcement learning for dynamic anticipatory mesh optimization with applications to hyperbolic conservation laws*. J. Comput. Phys., 112924. DOI: <https://doi.org/10.1016/j.jcp.2024.112924>.
6. Gillette, A., Keith, B., and Petrides, S. (2024). *Learning robust marking policies for adaptive mesh refinement*. SIAM J. Sci. Comput., **46** (1), A264–A289. DOI: 10.1137/22M1510613.
7. Bollapragada, R., Karamanli, C., Keith, B., Lazarov, B., Petrides, S., and Wang, J. (2023). *An Adaptive Sampling Augmented Lagrangian Method for Stochastic Optimization with Deterministic Constraints*. Comput. Math. Appl., **149**, 239–258. DOI: 10.1016/j.camwa.2023.09.014.
8. Beiser, F., Keith, B., Urbainczyk, S., and Wohlmuth, B. (2023). *Adaptive sampling strategies for risk-averse stochastic optimization with constraints*. IMA J. Numer. Anal. drac083. DOI: 10.1093/imanum/drac083.
9. Kodakkal, A., Keith, B., Khristenko, U., Apostolatos, A., Bletzinger, K.-U., Wohlmuth, B., and Wuechner, R. (2022). *Risk-averse design of tall buildings for uncertain wind conditions*. Comput. Methods Appl. Mech. Engrg., **402**, 115371. DOI: 10.1016/j.cma.2022.115371.
10. Keith, B., Khadse, A., and Field, S. E. (2021). *Learning orbital dynamics of binary black hole systems from gravitational wave measurements*. Phys. Rev. Res., **3** (4), 043101. DOI: 10.1103/PhysRevResearch.3.043101.
11. Keith, B. (2021). *A priori error analysis of high-order LL* (FOSLL*) finite element methods*. Comput. Math. Appl., **103**, 12–18. DOI: 10.1016/j.camwa.2021.10.015.
12. Keith, B., Khristenko, U., and Wohlmuth, B. (2021). *Learning the structure of wind: A data-driven nonlocal turbulence model for the atmospheric boundary layer*. Phys. Fluids., **33**(9), 095110. DOI: 10.1063/5.0064394.
13. Keith, B., Khristenko, U., and Wohlmuth, B. (2021). *A fractional PDE model for turbulent velocity fields near solid walls*. J. Fluid Mech., **916**, A21. DOI: 10.1017/jfm.2021.182.
14. Drzisga, D., Keith, B., and Wohlmuth, B. (2020). *The surrogate matrix methodology: Accelerating isogeometric analysis of waves*. Comput. Methods Appl. Mech. Engrg., **372**, 113322. DOI: 10.1016/j.cma.2020.113322.
15. Drzisga, D., Keith, B., and Wohlmuth, B. (2020). *The surrogate matrix methodology: A reference implementation for low-cost assembly in isogeometric analysis*. MethodsX, **7**, 100813. DOI: 10.1016/j.mex.2020.100813.
16. Demkowicz, L., Gopalakrishnan, J., and Keith, B. (2020). *The DPG-star method*. Comput. Math. Appl., **79**(11), 3092–3116. DOI: 10.1016/j.camwa.2020.01.012.
17. Drzisga, D., Keith, B., and Wohlmuth, B. (2020). *The surrogate matrix methodology: Low-cost assembly for isogeometric analysis*. Comput. Methods Appl. Mech. Engrg., **361**, 112776. DOI: 10.1016/j.cma.2019.112776.
18. Drzisga, D., Keith, B., and Wohlmuth, B. (2019). *The surrogate matrix methodology: a priori error estimation*. SIAM J. Sci. Comput., **41**(6), A3806–A3838. DOI: 10.1137/18M1226580.
19. Keith, B., Vaziri Astaneh, A., and Demkowicz, L. (2019). *Goal-oriented adaptive mesh refinement for discontinuous Petrov–Galerkin methods*. SIAM J. Numer. Anal., **57**(4), 1649–1676. DOI: 10.1137/18M1181754.
20. Vaziri Astaneh, A., Keith, B., and Demkowicz, L. (2019). *On perfectly matched layers for discontinuous Petrov–Galerkin methods*. Comput. Mech., **63**(6), 1131–1145. DOI: 10.1007/s00466-018-1640-3.
21. Keith, B., Petrides, S., Fuentes, F., and Demkowicz, L. (2017). *Discrete least-squares finite element methods*. Comput. Methods Appl. Mech. Engrg., **327**, 226–255. DOI: 10.1016/j.cma.2017.08.043.
22. Keith, B., Knechtges, P., Roberts, N., Elgeti, S., Behr, M., and Demkowicz, L. (2017). *An ultraweak DPG method for viscoelastic fluids*. J. Non-Newton. Fluid Mech., **247**, 107–122. DOI: 10.1016/j.jnnfm.2017.06.006.
23. Fuentes, F., Keith, B., Demkowicz, L., and Le Tallec, P. (2017). *Coupled variational formulations of linear elasticity and the DPG methodology*. J. Comput. Phys., **348**, 715–731. DOI: 10.1016/j.jcp.2017.07.051.

24. Keith, B., Fuentes, F., and Demkowicz, L. (2016). *The DPG methodology applied to different variational formulations of linear elasticity*. Comput. Methods Appl. Mech. Engrg., **309**, 579–609. DOI: 10.1016/j.cma.2016.05.034.
25. Fuentes, F., Keith, B., Demkowicz, L., and Nagaraj, S. (2015). *Orientation embedded high order shape functions for the exact sequence elements of all shapes*. Comput. Math. Appl., **70**(4), 353–458. DOI: 10.1016/j.camwa.2015.04.027.

Conference Proceedings

26. Yang, J., Mittal, K., Dzanic, T., Petrides, S., Keith, B., Petersen, B., Faissol, D., and Anderson, R. (2023). *Multi-Agent Reinforcement Learning for Adaptive Mesh Refinement. Proceedings of the 22nd International Conference on Autonomous Agents and Multiagent Systems (AAMAS-2023)*, 14–22. URL: <https://www.southampton.ac.uk/~eg/AAMAS2023/pdfs/p14.pdf>.
27. Tosi, R., Nuñez, M., Keith, B., Pons-Prats, J., Wohlmuth, B., and Rossi, R. (2021). *Scalable dynamic asynchronous Monte Carlo framework applied to wind engineering problems. Advances in Uncertainty Quantification and Optimization Under Uncertainty with Aerospace Applications. Proceedings of the 2020 UQOP International Conference*. Ed. by Vasile, M. and Quagliarella, D. Vol. 8. Space Technology Proceedings. Springer, 55–68. DOI: 10.1007/978-3-030-80542-5_4.

Technical Reports

28. Keith, B., Demkowicz, L., and Gopalakrishnan, J. (2017). *DPG* method*. ICES Report 17-25. The University of Texas at Austin.

Theses

29. Keith, B. (2018). *New ideas in adjoint methods for PDEs: A saddle-point paradigm for finite element analysis and its role in the DPG methodology*. PhD thesis. Austin, Texas: University of Texas at Austin.
30. Keith, B. (2014). *Lagrangian Coherent Structures in Three-dimensional Steady Flows*. Master's Thesis. Montreal, Quebec: McGill University.

Other Writings

31. Keith, B. (2023). *The technique that can find a system's state through data alone*. Nature, **622** (7982), 246–247. DOI: 10.1038/d41586-023-03070-x.
32. Robison¹, B. K. (2011). *The Wave Equation and Multi-Dimensional Time*. The Waterloo Mathematics Review, **1**(1), 32–42.

Selected Conference Presentations and Invited Talks

2024	CMAI , Center for Mathematics and Artificial Intelligence Colloquium	Fairfax, VA
2024	Stony Brook , Optimization Workshop	Stony Brook, NY
2024	Cornell , Center for Applied Mathematics Colloquium	Ithaca, NY
2024	U of Utah , Applied Math Seminar	Salt Lake City, UT
2024	Sandia , Center for Computing Research Seminar	Albuquerque, NM
2024	WONAPDE , Workshop on Numerical Analysis of Partial Differential Equations	Concepcion, Chile
2024	UPC , Instituto de Ingeniería Matemática y Computacional Seminar	Santiago, Chile
2023	Oxford , Numerical Analysis Group Internal Seminar	Oxford, UK
2023	ACM , Advances in Computational Mechanics Workshop in Honor of the 80th birthday of Thomas J.R. Hughes	Austin, TX
2023	USNCCM17 , US National Congress on Computational Mechanics	Albuquerque, NM
2023	HOFEIM , International Workshop on High-Order Finite Element and Isogeometric Methods	Larnaca, CY
2023	WIAS , Weierstrass Institute Mathematical Optimization Seminar	Berlin, DE
2023	UT Austin , Workshop in Honor of Leszek F. Demkowicz's 70th Birthday	Austin, TX
2023	UT Austin , Oden Institute Seminar	Austin, TX
2023	JMM , Joint Mathematics Meeting	Boston, MA
2022	Simula RL , Optimization in Oslo	Oslo, NO
2022	EPFL , Mathematics in Computational Science and Engineering Seminar	Lausanne, CH
2022	USACM , Large-Scale TTA Early-Career Colloquium	Virtual
2022	NC State , Numerical Analysis Seminar	Virtual
2022	ICCOPT , International Conference on Continuous Optimization	Bethlehem, PA

¹Personal name legally changed by the Government of Ontario to Brendan Keith on February 22, 2012.

2022	SIAM UQ22 , SIAM Conference on Uncertainty Quantification	Atlanta, GA
2021	USNCCM16 , US National Congress on Computational Mechanics	Virtual
2021	SIAM OP21 , SIAM Conference on Optimization	Virtual
2021	SIAM DS21 , SIAM Conference on Applications of Dynamical Systems	Virtual
2021	ECOM , East Coast Optimization Meeting	Virtual
2021	SIAM CSE21 , SIAM Conference on Computational Science and Engineering	Virtual
2019	SSDSS , AICES School for Simulation and Data Science Seminar	Aachen, DE
2019	IGA2019 , International Conference on Isogeometric Analysis	München, DE
2019	FrontUQ19 , Workshop on Frontiers of Uncertainty Quantification in Fluid Dynamics	Pisa, ITL
2019	USNCCM15 , US National Congress on Computational Mechanics	Austin, TX
2018	Oberwolfach , Workshop on Computational Engineering	Oberwolfach, DE
2018	WCCM13 , World Congress on Computational Mechanics	New York, NY
2018	SIAM AN18 , SIAM Annual Meeting	Portland, OR
2018	ETAMM2 , Emerging Trends in Applied Mathematics and Mechanics	Kraków, PL
2017	MRLSFEM2 , Minimum Residual & Least-Squares Finite Element Methods	Portland, OR
2017	USNCCM14 , US National Congress on Computational Mechanics	Montréal, QC
2017	Oberwolfach , Seminar on Discontinuous Petrov–Galerkin Methods	Oberwolfach, DE
2017	ACSE , Advances in Computational Science and Engineering (in honor of the 80th birthday of Prof. J.T. Oden)	Austin, TX
2017	SIAM CSE17 , SIAM Conference on Computational Science and Engineering	Atlanta, GA
2016	MAFELAP 2016 , Mathematics of Finite Elements and Applications	Uxbridge, UK
2016	AMFE , Advances in Mathematics for Finite Elements (in honor of the 90th birthday of Prof. Ivo Babuška)	Austin, TX
2015	POEMs , Polytopal Element Methods in Mathematics and Engineering	Atlanta, GA
2015	Oberwolfach , Workshop on Computational Engineering	Oberwolfach, DE
2015	USNCCM13 , US National Congress on Computational Mechanics	San Diego, CA

Academic Service

Departmental Service

Brown University Faculty Advisor to Division of Applied Mathematics Student Groups (2022 – present)

Peer Review (Journals)

(Five to ten manuscripts per year)

Computational Methods in Applied Mathematics (CMAM), Computer Methods in Applied Mechanics and Engineering (CMAME), Computers and Mathematics with Applications (CAMWA), IMA Journal of Numerical Analysis (IMAJNA), Mathematical Models and Methods in Applied Sciences (M3AS), Mathematics of Computation (Math. Comp.), Nature, SIAM Journal on Scientific Computing (SISC)

Peer Review (Funding Agencies)

Agence Nationale de la Recherche, Army Research Office (ARO), Department of Energy (DOE), National Science Center, Poland (Panel ST8)

Conference Organization

Texas Applied Mathematics and Engineering Symposium (2017)

Workshop in Honor of Leszek F. Demkowicz's 70th Birthday (2023)

Banff International Research Station (BIRS) Workshop on Scientific Machine Learning (2023)

Campus Government

Vice-President: UT Austin SIAM chapter. (01/2018 – 08/2018)

President: UT Austin SIAM chapter. (09/2015 – 12/2017)

Treasurer: UT Austin SIAM chapter. (09/2013 – 08/2015)

Research Community Membership

Society for Industrial and Applied Mathematics (SIAM)

United States Association for Computational Mechanics (USACM)

Research Supervision

Postdocs

- Peter Sentz (2022 – present)
- Dohyun Kim (2023 – present)

Ph.D. students

Please reach out to me if you are an admitted APMA student in search of a supervisor

Master's students

- Summan Sohail (2020)
- Jonas Kipfstuhl (2020)
- Simon Urbainczyk (2020)

Undergraduate students

- Alexey Izmailov (2023 – present)
- Matthew Meeker (2023)
- Yuechuan Yang (2023 – present)
- Rohit Panse (2023 – present)

Selected Honors & Awards

2023	Brilliant 10 , Popular Science Magazine's List of 10 Brilliant Early Career Researchers	
2023	ECRP , DOE office of Science Early Career Research Program Award	
2020	Fellowship , ICERM postdoctoral fellowship for the program "Advances in Computational Relativity"	<i>Providence, RI</i>
2018	Finalist , Student Poster Competition for the 13th World Congress on Computational Mechanics	<i>New York, NY</i>
2017	Recognition of service , SIAM Student Certificate of Recognition for 2017	<i>Austin, TX</i>
2017	2nd Place , Best Mathematically Oriented Poster at USNCCM14	<i>Montréal, QC</i>
2017	Fellowship , University of Texas at Austin University Graduate Continuing Fellowship	<i>Austin, TX</i>
2013	Award , University of Texas at Austin College Recruitment Fellowship Award	<i>Austin, TX</i>
2011	USRA , Undergraduate student research award. Supervisor: Ray McLenaghan	<i>Waterloo, ON</i>
2010	USRA , Undergraduate student research award. Supervisor: David Siegel	<i>Waterloo, ON</i>