

Brendan Keith

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Appointments

Division of Applied Mathematics Brown University

MORTON E. GURTIN ASSISTANT PROFESSOR OF APPLIED MATHEMATICS
ASSISTANT PROFESSOR OF APPLIED MATHEMATICS

Providence, Rhode Island

July 2024 – present

July 2022 – June 2024

Center for Applied Scientific Computing Lawrence Livermore National Laboratory

POSTDOCTORAL RESEARCHER

Livermore, California

Feb. 2021 – June 2022

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

POSTDOCTORAL FELLOW

Providence, Rhode Island

Sept. 2020 – Dec. 2020

Chair of Numerical Mathematics Technische Universität München

POSTDOCTORAL RESEARCHER

Garching, Germany

Sept. 2018 – Aug. 2020

Education

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

PH.D. COMPUTATIONAL SCIENCE, ENGINEERING, & MATHEMATICS

Austin, Texas

2018

Department of Mathematics and Statistics McGill University

M.SC. APPLIED MATHEMATICS

Montréal, Quebec

2013

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

B.MATH HONOURS APPLIED MATHEMATICS WITH PHYSICS OPTION

B.MATH HONOURS PURE MATHEMATICS

Waterloo, Ontario

2011

2011

Teaching Experience

APMA 1160 An Introduction to Numerical Optimization

APMA 2560 Numerical Solution of Partial Differential Equations II

APMA 2570B Numerical Solution of Partial Differential Equations III

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"

Providence, RI

2017 **Recognition of service**, SIAM Student Certificate of Recognition for 2017

Austin, TX

Current Research Funding as Lead PI

2023–'28 **DOE SC ECRP**, REASON-3D: Randomized, Entropic, Adaptive, and Scalable Optimization for Non-Intrusive Data-Driven Design

\$875k

2024–'27 **NSF CDS&E**, Data-Driven Discovery of Neural ODE Dynamics, Astrophysical Models, and Orbits (Neural ODE DynAMO)

\$376k

Preprints

1. Fu, G., Keith, B., and Masri, R. (2024). *A locally-conservative proximal Galerkin method for pointwise bound constraints*. arXiv: 2412.21039 [math.NA].
2. Kim, D., Lazarov, B. S., Surowiec, T. M., and Keith, B. (2024). *A simple introduction to the SiMPL method for density-based topology optimization*. arXiv: 2411.19421 [math.OC].
3. Keith, B., Kim, D., Lazarov, B. S., and Surowiec, T. M. (2024). *Analysis of the SiMPL method for density-based topology optimization*. arXiv: 2409.19341 [math.OC].

Scientific Journal Articles

4. Keith, B. and Surowiec, T. M. (2024). *Proximal Galerkin: A structure-preserving finite element method for pointwise bound constraints*. Found. Comput. Math., 1–97. DOI: 10.1007/s10208-024-09681-8.
5. 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*. Comput. Methods Appl. Mech. Engrg., **429**, 117146. DOI: 10.1016/j.cma.2024.117146.
6. 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*. Int. J. High Perform. Comput. Appl., **38** (5), 447–467. DOI: 10.1177/10943420241261981.
7. 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>.
8. 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.
9. 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.
10. 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.
11. 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.
12. 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.
13. 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.
14. 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.
15. 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.
16. 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.
17. 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.
18. 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.
19. 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.
20. 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.
21. 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.
22. 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.
23. 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.

24. 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.
25. 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.
26. 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.
27. 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.

Scientific Software

28. Izmailov, A., Meeker, M., Deskos, G., and Keith, B. (2024). *DRDMannTurb: A python package for scalable, data-driven synthetic turbulence*. J. Open Source Softw. DOI: 10.21105/joss.06838. URL: <https://github.com/METHODS-Group/DRDMannTurb>.

Conference Proceedings

29. Sit, H., Keith, B., and Bergen, K. (2024). *Improving explainability of softmax classifiers using a prototype-based joint embedding method*. Workshop on Explainable AI at International Joint Conference on Artificial Intelligence (IJCAI). arXiv: 2407.02271 [cs.LG].
30. 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>.
31. 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

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

Theses

33. 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.
34. Keith, B. (2014). *Lagrangian Coherent Structures in Three-dimensional Steady Flows*. Master's Thesis. Montreal, Quebec: McGill University.

Other Writings

35. Keith, B., O'Leary-Roseberry, T., Sanderse, B., Scheichl, R., and Bloemen Waaders, B. van (2025). *Scientific machine learning: A symbiosis*. **7** (1), i–x. DOI: 10.3934/fods.2024051.
36. Keith, B., O'Leary-Roseberry, T., Lu, L., Mishra, S., and Mao, Z. (2023). *BIRS Workshop Report 23w5129 Scientific Machine Learning*. URL: <http://stats.birs.ca/workshops/2023/23w5129/report23w5129.pdf>.
37. 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.
38. Robison¹, B. K. (2011). *The Wave Equation and Multi-Dimensional Time*. The Waterloo Mathematics Review, **1**(1), 32–42.

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

Selected Conference Presentations and Invited Talks

2024	ICTAM26 , International Congress on Theoretical and Applied Mechanics	Daegu, KR
2024	Yonsei , CSE Department Seminar (two talks)	Seoul, KR
2024	WCCM16 , World Congress on Computational Mechanics	Vancouver, BC
2024	ECCOMAS9 , European Congress on Computational Methods in Applied Sciences and Engineering	Lisbon, PT
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
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

Faculty Advisor to Brown University's SIAM Chapter (2024 – present)

Faculty Advisor to the Student Groups of the Division of Applied Mathematics (2022 – 2024)

Peer Review (Journals)
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, Numerische Mathematik, SIAM Journal on Scientific Computing (SISC), SIAM Review

(Five to ten manuscripts per year)

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
Banff International Research Station (BIRS) Workshop on Scientific Machine Learning (2023)
Workshop in Honor of Leszek F. Demkowicz's 70th Birthday (2023)
Texas Applied Mathematics and Engineering Symposium (2017)

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	Ph.D. students	Master's students	Undergraduate students
<ul style="list-style-type: none">• Peter Sentz (2022 – present)• Dohyun Kim (2023 – present)• Rami Masri (2024 – present)	<ul style="list-style-type: none">• Noe Reyes Rivas (2024 – present)	<ul style="list-style-type: none">• Summan Sohail (2020)• Jonas Kipfstuhl (2020)• Simon Urbainczyk (2020)	<ul style="list-style-type: none">• Alexey Izmailov (2023 – 2024)• Matthew Meeker (2023)• Yuechuan Yang (2023 – 2024)• Rohit Panse (2023 – 2024)• Lucas Chan (2024 – present)

Expired Research Funding as Lead PI

2023 –'24	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