Brendan **Keith**

Room 303, 182 George Street, Providence RI 02912

✉ brendan_keith@brown.edu | 🏠 brendankeith.github.io

Appointments

Division of Applied Mathematics
Brown University — *Providence, Rhode Island*
Morton E. Gurtin Assistant Professor of Applied Mathematics — *July 2024 – present*
Assistant Professor of Applied Mathematics — *July 2022 – June 2024*

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*

Education

Oden Institute for Computational Engineering and Sciences
University of Texas at Austin — *Austin, Texas*
Ph.D. Computational Science, Engineering, & Mathematics — *2018*

Department of Mathematics and Statistics
McGill University — *Montréal, Quebec*
M.Sc. Applied Mathematics — *2013*

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 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*

Manuscripts and Publications

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

34. 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. Robison[1], B. K. (2011). *The Wave Equation and Multi-Dimensional Time*. The Waterloo Mathematics Review, **1**(1), 32–42.

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[1]Personal 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) *(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), SIAM Review

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
- Peter Sentz (2022 – present)
- Dohyun Kim (2023 – present)
- Rami Masri (2024 – present)

Ph.D. students
- Noe Reyes Rivas (2024 – present)

Master's students
- Summan Sohail (2020)
- Jonas Kipfstuhl (2020)
- Simon Urbainczyk (2020)

Undergraduate students
- 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*