

Paul Breiding | Curriculum Vitae

Universität Osnabrück, FB Mathematik/Informatik, Albrechtstr. 28a, D-49076 Osnabrück

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born 12th of May 1988, german citizenship

Universität Osnabrück

Professor for Mathematical Methods in Data Science

Since 04/2022

Max-Planck-Institute for Mathematics in the Sciences Leipzig

*Head of Emmy Noether Research Group:
Numerical and Probabilistic Nonlinear Algebra*

04/2021 – 03/2022

University of Kassel

Substitute Professor for Computeralgebra

11/2020 – 03/2021

Akademie der Wissenschaften und der Literatur Mainz

Speaker of the Junge Akademie | Mainz

02/2022 – 02/2023

Akademie der Wissenschaften und der Literatur Mainz

Member of the Junge Akademie | Mainz

04/2020 – 03/2024

Parental leave

7 months

10/2019 – 11/2019 and 04/2020 – 10/2020

Technische Universität Berlin

Postdoctoral researcher in the algorithmic algebra research group

04/2019 – 10/2020

Max-Planck-Institute for Mathematics in the Sciences Leipzig

Postdoctoral researcher in the nonlinear algebra research group

10/2017 – 03/2019

Technische Universität Berlin

PhD student with Prof. Dr. Bürgisser

Date of thesis defense: July 25, 2017. Evaluation 'summa cum laude'.

12/2013 – 09/2017

Simons Institute for the Theory of Computing

Visiting graduate student

Algorithms and Complexity in Algebraic Geometry

08/2014 – 10/2014

Education

Georg-August-Universität Göttingen

Master of Science

10/2011 – 11/2013

Evaluation: excellent.

Universidad de Sevilla

Undergraduate studies, part of the Erasmus exchange program

02/2011 – 09/2011

Georg-August Universität Göttingen

Bachelor of Science

10/2008 – 09/2011

Languages.....

German: *fluent, native*

English: *fluent*

Awards

SIAG/AG Early Career Prize

Awarded by the SIAM Activity Group on Algebraic Geometry

2021

External Funding

Maßnahme “Digitalisierung sicher gestalten”

Granted by MWK Niedersachsen, €49.780

2022

with T. Römer

Maßnahme “Unterstützung der Digitalisierung der Lehre für die Digitalisierungsprofessuren”

Granted by MWK Niedersachsen, €104.125

2022

with T. Römer

Emmy Noether Research Group Grant

Granted by the Deutsche Forschungsgemeinschaft, €1.132.600

2020

Project title: Numerical and Probabilistic Nonlinear Algebra

Service

Peer reviewing for the following journals: SIAM Journal on Applied Algebra and Geometry, Linear Algebra and its Applications, Journal Foundations of Computational Mathematics, Proceedings of the Royal Society A, Journal of the American Mathematical Society, Mathematics of Computation.

Editorial board member of Numerical Algebra, Control and Optimization.

Publications

Journal articles.....

- [1] C. Beltrán, P. Breiding, and N. Vannieuwenhoven. The average condition number of most tensor rank decomposition problems is infinite. *Foundations of Computational Mathematics* (2022).
- [2] C. Beltrán, P. Breiding, and N. Vannieuwenhoven. Pencil-based algorithms for tensor rank decomposition are not stable. *SIAM J. Matrix Anal. and Appl.* (2019).
- [3] V. Borovik and P. Breiding. A short proof for the parameter continuation theorem. *Journal of Symbolic Computation* (2025).
- [4] V. Borovik, P. Breiding, J. del Pino, M. Michałek, and O. Zilberberg. Khovanskii bases for semimixed systems of polynomial equations - a case of approximating stationary nonlinear Newtonian dynamics. *J. Mathématiques Pures et Appliquées* (2023).
- [5] P. Breiding. An algebraic geometry perspective on topological data analysis. *SIAM News* (2020).
- [6] P. Breiding. The expected number of eigenvalues of a real gaussian tensor. *SIAM J. Appl. Algebra Geometry* (2017).
- [7] P. Breiding. How many eigenvalues of a random symmetric tensor are real? *Trans. Amer. Math. Soc.* (2019).
- [8] P. Breiding and P. Bürgisser. Distribution of the eigenvalues of a random system of homogeneous polynomials. *Linear Algebra and its Applications* (2016).
- [9] P. Breiding, P. Bürgisser, A. Lerario, and L. Mathis. The zonoid algebra, generalized mixed volumes, and random determinants. *Adv. in Math.* 402 (2022).
- [10] P. Breiding, T. Çelik, T. Duff, A. Heaton, A. Maraj, A. Sattelberger, L. Venturello, and O. Yürük. Nonlinear algebra and applications. *Numerical Algebra, Optimization and Control* (2021).
- [11] P. Breiding, T. Duff, L. Gustafsson, F. Rydell, and E. Shehu. Line multiview ideals. *Communications in Algebra* (to appear).
- [12] P. Breiding, S. Fairchild, P. Santarsiero, and E. Shehu. Average degree of the essential variety. *La Matematica* (to appear).
- [13] P. Breiding, F. Gesmundo, M. Michałek, and N. Vannieuwenhoven. Algebraic compressed sensing. *Applied and Computational Harmonic Analysis* (2023).
- [14] P. Breiding, R. Hodges, C. Ikenmeyer, and M. Michałek. Equations for GL invariant families of polynomials. *Vietnam Journal of Mathematics* (2022).
- [15] P. Breiding, H. Keneshlou, and A. Lerario. Quantitative singularity theory for random polynomials. *International Mathematical Research Notices* (2020).
- [16] P. Breiding, K. Kozhasov, and A. Lerario. On the geometry of the set of symmetric matrices with repeated eigenvalues. *Arnold Math J.*
- [17] P. Breiding, K. Kozhasov, and A. Lerario. Random spectrahedra. *SIAM J. Optim.* (2019).
- [18] P. Breiding, J. Lindberg, G. Ong, and L. Sommer. Real circles tangent to 3 conics. *Le Matematiche* (2023).
- [19] P. Breiding and O. Marigliano. Random points on an algebraic manifold. *SIAM J. Mathematics of Data Science* (2020).

- [20] P. Breiding, K. Rose, and S. Timme. Certifying zeros of polynomial systems using interval arithmetic. *Trans. Math. Software* (2023).
- [21] P. Breiding, F. Rydell, E. Shehu, and A. Torres. Line multiview varieties. *SIAM J. Appl. Algebra Geometry* (2023).
- [22] P. Breiding, F. Sottile, and J. Woodcock. Euclidean distance degree and mixed volume. *Foundations of Computational Mathematics* (2021).
- [23] P. Breiding, B. Sturmfels, S. Kalisnik Verovsek, and M. Weinstein. Learning algebraic varieties from samples. *Revista Matemática Complutense* (2018).
- [24] P. Breiding, B. Sturmfels, and S. Timme. 3264 conics in a second. *Not. Amer. Math. Soc.* (2020). *Article is featured on the title page.*
- [25] P. Breiding and N. Vannieuwenhoven. The condition number of join decompositions. *SIAM J. Matrix Anal. and Appl.* (2018).
- [26] P. Breiding and N. Vannieuwenhoven. The condition number of Riemannian approximation problems. *SIAM J. Optim.* (2021).
- [27] P. Breiding and N. Vannieuwenhoven. Convergence analysis of Riemannian Gauss-Newton methods and its connection with the geometric condition number. *Applied Mathematics Letters* (2018).
- [28] P. Breiding and N. Vannieuwenhoven. On the average condition number of tensor rank decompositions. *IMA J. Num. Anal.* (2019).
- [29] P. Breiding and N. Vannieuwenhoven. A Riemannian trust region method for the canonical tensor rank approximation problem. *SIAM J. Optim.* (2018).
- [30] P. Breiding and N. Vannieuwenhoven. Sensitivity of low-rank matrix recovery. *Numerische Math.* (2022).
- [31] N. Dewaele, P. Breiding, and N. Vannieuwenhoven. The condition number of many tensor decompositions is invariant under Tucker compression. *Numerical Algorithms* (2023).
- [32] N. Dewaele, P. Breiding, and N. Vannieuwenhoven. Three decompositions of symmetric tensors have similar condition numbers. *Linear Algebra and its Applications* (2023).

Preprints.....

- [33] D. Bates, P. Breiding, T. Chen, J. Hauenstein, A. Leykin, and F. Sottile. Numerical nonlinear algebra. *arXiv:2302.08585*.
- [34] P. Blagojević, P. Breiding, and A. Heaton. Facet volumes of polytopes. *arXiv:2112.08437*.
- [35] P. Breiding. An efficient randomized homotopy method to approximate eigenpairs of tensors. *arXiv:1512.03284*.
- [36] P. Breiding and S. Eggleston. Reach of segre-veronese manifolds. *arXiv:2307.04224*.
- [37] P. Breiding, S. Eggleston, and A. Rosana. Typical ranks of random order-three tensors. *arXiv:2407.08371*.
- [38] P. Breiding, M. Michałek, L. Monin, and S. Telen. The algebraic degree of coupled oscillators. *arXiv:2208.08179*.
- [39] P. Breiding, K. Ranestad, and M. Weinstein. Critical curvature of algebraic surfaces in three-space. *arXiv:2206.09130*.
- [40] P. Breiding and P. Santarsiero. Degree of the subspace variety. *arXiv:2402.12217*.

Software.....

- [41] P. Breiding and S. Timme. Homotopycontinuation.jl: A package for homotopy continuation in Julia.  juliahomotopycontinuation.org.  github.com/JuliaHomotopyContinuation. Open Source software.

**Homotopy
Continuation.jl**

Lecture notes.....

- [42] P. Breiding and S. Fairchild. *Mathematical Methods in Data Science*. Unpublished work in progress. <https://pbrdng.github.io/MathData.pdf>.
- [43] P. Breiding, K. Kohn, and B. Sturmfels. *Metric Algebraic Geometry*. Oberwolfach Seminars, Birkhäuser, Basel, 2024. <https://link.springer.com/content/pdf/10.1007/978-3-031-51462-3.pdf>.

Theses.....

- [44] P. Breiding. Zyklotomische Körper und die Fermat-Gleichung zum Exponent p^2 , 2011. Grade: 1.0. First supervisor: Preda Mihailescu. Second supervisor: Maarten Solleveld.
- [45] P. Breiding. On a p-adic newton method. Master's thesis, Georg-August Universität Göttingen, 2013. Grade: 1.0. First supervisor: Preda Mihailescu. Second supervisor: Peter Bürgisser.
- [46] P. Breiding. *Numerical and Statistical Aspects of Tensor Decompositions*. PhD thesis, TU Berlin, 2017.

Grade: summa cum laude. First supervisor: Peter Bürgisser. Second supervisor: Felipe Cucker.