Paul Breiding | Curriculum Vitae

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

pbreiding@uni-osnabrueck.de • paulbreiding.org • PBrdng
Paul Breiding • @_pbrdng • born 12th of May 1988, german citizenship

Universität Osnabrück
Professor for Mathematical Methods in Data Science *Since 04/2022*

Max-Plack-Institute for Mathematics in the Sciences Leipzig
Head of Emmy Noether Research Group: *04/2021 – 03/2022*
Numerical and Probabilistic Nonlinear Algebra

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 in total *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-Plack-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 *12/2013 – 09/2017*
Date of thesis defense: July 25, 2017. Evaluation 'summa cum laude'.

Simons Institute for the Theory of Computing
Visiting graduate student *08/2014 – 10/2014*
Algorithms and Complexity in Algebraic Geometry

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

BIRS Workshop on Random Algebraic Geometry
Granted by the Banff International Research Station *2022*
with S. Petrović and G. Smith

Geometry in Complexity and Computation Conference
Granted by Foundation Compositio *2021*
with K. Kohn

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.

Teaching experience

Lecture: Analysis 1 **Lecturer**
Universität Osnabrück *10/2022–02/2023*

Lecture: Elemente der Datenanalyse **Lecturer**
Universität Osnabrück *10/2022–02/2023*

Lecture: Mathematische Grundlagen der Datenanalyse **Lecturer**
Universität Osnabrück *04/2022–07/2022*

Lecture: Random Algebraic Geometry **Lecturer**
Universität Leipzig *10/2021–03/2022*

IMPRS Ringvorlesung **Lecturer**
Max-Planck Institute for Mathematics in the Sciences *04/2021–06/2021*

Lecture: Statistics for engineers **Lecturer**
Universität Kassel *11/2020–03/2021*

All lectures and exercises are available on YouTube and GitHub

Lecture: Grundlagen der Algebra und Computeralgebra **Lecturer**
Universität Kassel *11/2020–03/2021*

All lectures are available on YouTube and GitHub; lecture for high school teachers

Seminar: Mathematics for primary school teachers **Lecturer**
Universität Kassel *11/2020–03/2021*

Lecture: Numerical algebraic geometry with Julia **Lecturer**
Freie Universität Berlin *09/2019–03/2020*

Lecture: Condition – the geometry of numerical algorithms **Lecturer**
Max-Planck Institute for Mathematics in the Sciences *10/2018–01/2019*

Mathematik für unbegleitete minderjährige Flüchtlinge **Teacher**
Stiftung SPI Berlin *03/2016–11/2016*

Statistische Beratung **Tutor**
Institut für medizinische Statistik, UMG Göttingen *06/2013 – 09/2013*

Organizational experience

Applied Algebra in Data Science — **Organizer**
Universität Osnabrück — *09/2023*

Random Algebraic Geometry — **Organizer**
BIRS Workshop — *04/2023*

Stochastic Geometry — **Organizer**
Universität Osnabrück — *11/2023*

Geometry in Complexity and Computations — **Organizer**
Universität Konstanz — *09/2022*

The 1st and 2nd East German Tensor Day — **Organizer**
Workshop — *09/2021 and 12/2021*

Workshop on Software and Applications of Numerical Nonlinear Algebra — **Organizer**
Online workshop — *06/2021*

Workshop Computational Algebra 2020 — **Organizer**
Online workshop — *11/2020*

Summer School on Randomness and Learning in Nonlinear Algebra — **Organizer**
Max-Planck Institute for Mathematics in the Sciences — *07/2019*

Workshop on Random Algebraic Geometry — **Organizer**
SISSA — *11/2018*

Max-Planck Day (presentation of MPI MiS to a general audience) — **Organizer**
Munich — *09/2018*

Summer School on Numerical Computing in Algebraic Geometry — **Organizer**
Max-Planck Institute for Mathematics in the Sciences — *08/2018*

EROC - European Roller Derby Organizational Conference — **Organizer**
International conference with ∼150 participants; topics included diversity and inclusion — *2016 and 2017*

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. 40(2), 739–773 (2019).*

[3] P. Breiding. An algebraic geometry perspective on topological data analysis. *SIAM News 53(1) (2020).*

[4] P. Breiding. The expected number of eigenvalues of a real gaussian tensor. *SIAM J. Appl. Algebra Geometry, 1(1), 254–271 (2017).*

[5] P. Breiding. How many eigenvalues of a random symmetric tensor are real? *Trans. Amer. Math. Soc. 372, 7857–7887 (2019).*

[6] P. Breiding and P. Bürgisser. Distribution of the eigenvalues of a random system of homogeneous polynomials. *Linear Algebra and its Applications, 497, 88–107 (2016).*

[7] P. Breiding, P. Bürgisser, A. Lerario, and L. Mathis. The zonoid algebra, generalized mixed volumes, and random determinants. *Adv. in Math. 402 (2022).*

[8] 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).*

[9] P. Breiding, F. Gesmundo, M. Michalek, and N. Vannieuwenhoven. Algebraic compressed sensing. *Applied and Computational Harmonic Analysis (to appear).*

[10] P. Breiding, R. Hodges, C. Ikenmeyer, and M. Michalek. Equations for GL invariant families of polynomials. *Vietnam Journal of Mathematics (2022).*

[11] P. Breiding, H. Keneshlou, and A. Lerario. Quantitative singularity theory for random polynomials. *International Mathematical Research Notices (2020).*

[12] P. Breiding, K. Kozhasov, and A. Lerario. On the geometry of the set of symmetric matrices with repeated eigenvalues. *Arnold Math J. 1(4), 423–443 (2018).*

[13] P. Breiding, K. Kozhasov, and A. Lerario. Random spectrahedra. *SIAM J. Optim. 29(4), 2608–2624 (2019).*

[14] P. Breiding and O. Marigliano. Random points on an algebraic manifold. *SIAM J. Mathematics of Data Science 2(3), 683–704 (2020).*

[15] P. Breiding, K. Rose, and S. Timme. Certifying zeros of polynomial systems using interval arithmetic. *Trans. Math. Software (2023).*

[16] P. Breiding, F. Rydell, E. Shehu, and A. Torres. Line multiview varieties. *SIAM J. Appl. Algebra Geometry (to appear).*

[17] P. Breiding, F. Sottile, and J. Woodcock. Euclidean distance degree and mixed volume. *Foundations of Computational Mathematics (2021).*

[18] P. Breiding, B. Sturmfels, S. Kalisnik Verovsek, and M. Weinstein. Learning algebraic varieties from samples. *Revista Matemática Complutense, 31, 545–593 (2018).*

[19] P. Breiding, B. Sturmfels, and S. Timme. 3264 conics in a second. *Not. Amer. Math. Soc. 67, 30–37 (2020). Article is featured on the title page.*

[20] P. Breiding and N. Vannieuwenhoven. The condition number of join decompositions. *SIAM J. Matrix Anal. and Appl., 39(1), 287–309 (2018).*

[21] P. Breiding and N. Vannieuwenhoven. The condition number of Riemannian approximation problems. *SIAM J. Optim. 31(1), 1049–1077 (2021).*

[22] P. Breiding and N. Vannieuwenhoven. Convergence analysis of Riemannian Gauss-Newton methods and its connection with the geometric condition number. *Applied Mathematics Letters, 78 , 42–50 (2018).*

[23] P. Breiding and N. Vannieuwenhoven. On the average condition number of tensor rank decompositions. *IMA J. Num. Anal. (2019).*

[24] P. Breiding and N. Vannieuwenhoven. A Riemannian trust region method for the canonical tensor rank approximation problem. *SIAM J. Optim., 28, 2435-2465 (2018).*

[25] P. Breiding and N. Vannieuwenhoven. Sensitivity of low-rank matrix recovery. *Numerische Math. (2022).*

[26] N. Dewaele, P. Breiding, and N. Vannieuwenhoven. The condition number of many tensor decompositions is invariant under Tucker compression. *Numerical Algorithms (to appear).*

[27] N. Dewaele, P. Breiding, and N. Vannieuwenhoven. Three decompositions of symmetric tensors have similar condition numbers. *Linear Algebra and its Applications (2023).*

Preprints

[28] D. Bates, P. Breiding, T. Chen, J. Hauenstein, A. Leykin, and F. Sottile. Numerical nonlinear algebra. *arXiv:2302.08585.*

[29] P. Blagojević, P. Breiding, and A. Heaton. Facet volumes of polytopes. *arXiv:2112.08437.*

[30] V. Borovik and P. Breiding. A short proof for the parameter continuation theorem. *arXiv:2302.14697.*

[31] P. Breiding. An efficient randomized homotopy method to approximate eigenpairs of tensors. *arXiv1512.03284.*

[32] P. Breiding, S. Fairchild, P. Santarsiero, and E. Shehu. Average degree of the essential variety. *arXiv:2212.01596.*

[33] P. Breiding, J. Lindberg, G. Ong, and L. Sommer. Real circles tangent to 3 conics. *arXiv:2211.06876.*

[34] P. Breiding, M. Michałek, L. Monin, and S. Telen. The algebraic degree of coupled oscillators. *arXiv:2208.08179.*

[35] P. Breiding, K. Ranestad, and M. Weinstein. Enumerative geometry of curvature of algebraic hypersurfaces. *arXiv:2206.09130.*

Software projects

[36] 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

[37] P. Breiding and S. Fairchild. *Mathematical Methods in Data Science.* Unpublished work in progress. Available at `https://pbrdng.github.io/MathData.pdf`.

[38] P. Breiding and A. Lerario. *Lectures on Random Algebraic Geometry.* Unpublished work in progress. Available at `https://pbrdng.github.io/rag.html`.

Websites

[39] P. Breiding, B. Sturmfels, and S. Timme. juliahomotopycontinuation.org/do-it-yourself/. A website, where the user can compute and plot the conics which are tangent to their 5 own conics.

Theses

[40] P. Breiding. Zyklotomische Körper und die Fermat–Gleichung zum Exponent p^2., 2011. Grade: 1.0. First supervisor: Preda Mihailescu. Second supervisor: Maarten Solleveld.

[41] 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.

[42] 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.

References

Carlos Beltrán: beltranc@unican.es
Universidad de Santander, Av. de los Castros, 39005 Santander, Spain

Peter Bürgisser: pbuerg@math.tu-berlin.de
Technische Universität Berlin, Straße des 17. Juni 136, 10623 Berlin, Germany.

Antonio Lerario: lerario@sissa.it
SISSA, Via Bonomea 265 Trieste, Italy.

Bernd Sturmfels: bernd@mis.mpg.de
MPI für Mathematik in den Naturwissenschaften, Inselstraße 22, 04103 Leipzig, Germany

Nick Vannieuwenhoven: nick.vannieuwenhoven@cs.kuleuven.be
KU Leuven, Celestijnenlaan 200 A, B-3001 Heverlee, Belgium.