

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-Planck-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-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

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
with T. Römer

2022

Maßnahme “Unterstützung der Digitalisierung der Lehre für die Digitalisierungsprofessuren”

Granted by MWK Niedersachsen, €104.125
with T. Römer

2022

BIRS Workshop on Random Algebraic Geometry

Granted by the Banff International Research Station
with S. Petrović and G. Smith

2022

Geometry in Complexity and Computation Conference

Granted by Foundation Compositio
with K. Kohn

2021

Emmy Noether Research Group Grant

Granted by the Deutsche Forschungsgemeinschaft, €1.132.600
Project title: Numerical and Probabilistic Nonlinear Algebra

2020

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

Universität Osnabrück

Lecturer

10/2022–02/2023

Lecture: Elemente der Datenanalyse

Universität Osnabrück

Lecturer

10/2022–02/2023

Lecture: Mathematische Grundlagen der Datenanalyse

Universität Osnabrück

Lecturer

04/2022–07/2022

Lecture: Random Algebraic Geometry

Universität Leipzig

Lecturer

10/2021–03/2022

IMPRS Ringvorlesung

Max-Planck Institute for Mathematics in the Sciences

Lecturer



04/2021–06/2021

Lecture: Statistics for engineers

Universität Kassel

Lecturer

11/2020–03/2021

All lectures and exercises are available on  and 

Lecture: Grundlagen der Algebra und Computeralgebra

Universität Kassel

Lecturer

11/2020–03/2021

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

Seminar: Mathematics for primary school teachers

Universität Kassel

Lecturer

11/2020–03/2021

Lecture: Numerical algebraic geometry with Julia

Freie Universität Berlin

Lecturer

09/2019–03/2020

Lecture: Condition – the geometry of numerical algorithms

Max-Planck Institute for Mathematics in the Sciences

Lecturer

10/2018–01/2019

Mathematik für unbegleitete minderjährige Flüchtlinge

Stiftung SPI Berlin

Teacher

03/2016–11/2016

Statistische Beratung

Institut für medizinische Statistik, UMG Göttingen

Tutor

06/2013 – 09/2013

Organizational experience

Applied Algebra in Data Science <i>Universität Osnabrück</i>	Organizer 09/2023
Random Algebraic Geometry <i>BIRS Workshop</i>	Organizer 04/2023
Stochastic Geometry <i>Universität Osnabrück</i>	Organizer 11/2023
Geometry in Complexity and Computations <i>Universität Konstanz</i>	Organizer 09/2022
The 1st and 2nd East German Tensor Day <i>Workshop</i>	Organizer 09/2021 and 12/2021
Workshop on Software and Applications of Numerical Nonlinear Algebra <i>Online workshop</i>	Organizer 06/2021
Workshop Computational Algebra 2020 <i>Online workshop</i>	Organizer 11/2020
Summer School on Randomness and Learning in Nonlinear Algebra <i>Max-Planck Institute for Mathematics in the Sciences</i>	Organizer 07/2019
Workshop on Random Algebraic Geometry <i>SISSA</i>	Organizer 11/2018
Max-Planck Day (presentation of MPI MiS to a general audience) <i>Munich</i>	Organizer 09/2018
Summer School on Numerical Computing in Algebraic Geometry <i>Max-Planck Institute for Mathematics in the Sciences</i>	Organizer 08/2018
EROC - European Roller Derby Organizational Conference <i>International conference with ~150 participants; topics included diversity and inclusion</i>	Organizer 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, J. Lindberg, G. Ong, and L. Sommer. Real circles tangent to 3 conics. *Le Matematiche* (2023).
- [15] P. Breiding and O. Marigliano. Random points on an algebraic manifold. *SIAM J. Mathematics of Data Science* 2(3), 683–704 (2020).
- [16] P. Breiding, K. Rose, and S. Timme. Certifying zeros of polynomial systems using interval arithmetic. *Trans. Math. Software* (2023).
- [17] P. Breiding, F. Rydell, E. Shehu, and A. Torres. Line multiview varieties. *SIAM J. Appl. Algebra Geometry* (2023).
- [18] P. Breiding, F. Sottile, and J. Woodcock. Euclidean distance degree and mixed volume. *Foundations of Computational Mathematics* (2021).
- [19] P. Breiding, B. Sturmfels, S. Kalisnik Verovsek, and M. Weinstein. Learning algebraic varieties from samples. *Revista Matemática Complutense*, 31, 545–593 (2018).
- [20] 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.*
- [21] P. Breiding and N. Vannieuwenhoven. The condition number of join decompositions. *SIAM J. Matrix Anal. and Appl.*, 39(1), 287–309 (2018).
- [22] P. Breiding and N. Vannieuwenhoven. The condition number of Riemannian approximation problems. *SIAM J. Optim.* 31(1), 1049–1077 (2021).
- [23] 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).
- [24] P. Breiding and N. Vannieuwenhoven. On the average condition number of tensor rank decompositions. *IMA J. Num. Anal.* (2019).
- [25] P. Breiding and N. Vannieuwenhoven. A Riemannian trust region method for the canonical tensor rank approximation problem. *SIAM J. Optim.*, 28, 2435–2465 (2018).
- [26] P. Breiding and N. Vannieuwenhoven. Sensitivity of low-rank matrix recovery. *Numerische Math.* (2022).
- [27] N. Dewaele, P. Breiding, and N. Vannieuwenhoven. The condition number of many tensor decompositions is invariant under Tucker compression. *Numerical Algorithms (to appear)*.
- [28] N. Dewaele, P. Breiding, and N. Vannieuwenhoven. Three decompositions of symmetric tensors have similar condition numbers. *Linear Algebra and its Applications* (2023).

Preprints.....

- [29] D. Bates, P. Breiding, T. Chen, J. Hauenstein, A. Leykin, and F. Sottile. Numerical nonlinear algebra. *arXiv:2302.08585*.
- [30] P. Blagojević, P. Breiding, and A. Heaton. Facet volumes of polytopes. *arXiv:2112.08437*.
- [31] V. Borovik and P. Breiding. A short proof for the parameter continuation theorem. *arXiv:2302.14697*.
- [32] 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. *arXiv:2306.07897*.
- [33] P. Breiding. An efficient randomized homotopy method to approximate eigenpairs of tensors. *arXiv:1512.03284*.
- [34] P. Breiding, T. Duff, L. Gustafsson, F. Rydell, and E. Shehu. Line multiview ideals. *arXiv:2303.02066*.
- [35] P. Breiding and S. Eggleston. Reach of segre-veronese manifolds. *arXiv:2307.04224*.
- [36] P. Breiding, S. Fairchild, P. Santarsiero, and E. Shehu. Average degree of the essential variety. *arXiv:2212.01596*.
- [37] P. Breiding, M. Michałek, L. Monin, and S. Telen. The algebraic degree of coupled oscillators. *arXiv:2208.08179*.
- [38] P. Breiding, K. Ranestad, and M. Weinstein. Enumerative geometry of curvature of algebraic hypersurfaces. *arXiv:2206.09130*.

Software projects.....

- [39] 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.....
- [40] P. Breiding and S. Fairchild. *Mathematical Methods in Data Science*. Unpublished work in progress. Available at <https://pbrdng.github.io/MathData.pdf>.
- [41] P. Breiding and A. Lerario. *Lectures on Random Algebraic Geometry*. Unpublished work in progress. Available at <https://pbrdng.github.io/rag.html>.
- Websites.....
- [42] 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.....
- [43] P. Breiding. Zyklotomische Körper und die Fermat–Gleichung zum Exponent p^2 ., 2011. Grade: 1.0. First supervisor: Preda Mihailescu. Second supervisor: Maarten Solleveld.
- [44] 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.
- [45] 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.