

Paul Breiding | Curriculum Vitae

Max-Planck-Institute for Mathematics in the Sciences, Inselstr. 22, 04103 Leipzig, Germany

✉ paul.breiding@mis.mpg.de • 🌐 paulbreiding.org • 📺 PBrDng
📺 Paul Breiding • 🐦 @_pbrdng • born 12th of May 1988, german citizenship

Universität Osnabrück

Professor for Mathematical Methods in Data Science

From 04/2022 on

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

Member of the Junge Akademie

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

Emmy Noether Research Group Grant

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

Total amount: €1.132.600

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: 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

Seminar: Numerical nonlinear algebra

Technische Universität Berlin

Lecturer

04/2019–07/2019

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

The 1st and 2nd East German Tensor Day

One-day workshop

Organizer

09/2021 and 12/2021

Workshop on Software and Applications of Numerical Nonlinear Algebra

Online workshop

Organizer

06/2021

Workshop Computational Algebra 2020

Online workshop

Organizer

11/2020

Minisymposium on Random Geometry and Topology

SIAM Conference on Applied Algebraic Geometry

Organizer

07/2019

Minisymposium on Numerical Methods in Algebraic Geometry

SIAM Conference on Applied Algebraic Geometry

Organizer

07/2019

Summer School on Randomness and Learning in Nonlinear Algebra

Max-Planck Institute for Mathematics in the Sciences

Organizer

07/2019

Workshop on Random Algebraic Geometry
SISSA

Organizer
11/2018

Max-Planck Day (Presentation of MPI MiS to a general audience)
Munich

Organizer
09/2018

Summer School on Numerical Computing in Algebraic Geometry
Max-Planck Institute for Mathematics in the Sciences

Organizer
08/2018

Berlin-Leipzig Seminar on Algebra, Geometry and Combinatorics
MPI for Mathematics in the Sciences/TU Berlin/FU Berlin

Organizer
10/2017 – 12/2017

EROC - European Roller Derby Organizational Conference
International conference with ~150 participants; topics included diversity and inclusion

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 (to appear)*.
 - [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, T. Çelik, T. Duff, A. Heaton, A. Maraj, A. Sattelberger, L. Venturello, and O. Yürük. Nonlinear algebra and applications. *Numerical Algebra, Optimization and Control (to appear)*.
 - [8] P. Breiding, R. Hodges, C. Ikenmeyer, and M. Michalek. Equations for GL invariant families of polynomials. *Vietnam Journal of Mathematics (to appear)*.
 - [9] P. Breiding, H. Keneshlou, and A. Lerario. Quantitative singularity theory for random polynomials. *International Mathematical Research Notices* (2020).
 - [10] 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).
 - [11] P. Breiding, K. Kozhasov, and A. Lerario. Random spectrahedra. *SIAM J. Optim.* 29(4), 2608–2624 (2019).
 - [12] P. Breiding and O. Marigliano. Random points on an algebraic manifold. *SIAM J. Mathematics of Data Science* 2(3), 683–704 (2020).
 - [13] P. Breiding, F. Sottile, and J. Woodcock. Euclidean distance degree and mixed volume. *Foundations of Computational Mathematics*, 2021.
 - [14] P. Breiding, B. Sturmfels, S. Kalisnik Verovsek, and M. Weinstein. Learning algebraic varieties from samples. *Revista Matemática Complutense*, 31, 545–593 (2018).
 - [15] 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.
 - [16] P. Breiding and N. Vannieuwenhoven. The condition number of join decompositions. *SIAM J. Matrix Anal. and Appl.*, 39(1), 287–309 (2018).
 - [17] P. Breiding and N. Vannieuwenhoven. The condition number of Riemannian approximation problems. *SIAM J. Optim.* 31(1), 1049–1077 (2021).
 - [18] 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).
 - [19] P. Breiding and N. Vannieuwenhoven. On the average condition number of tensor rank decompositions. *IMA J. Num. Anal.* (2019).
 - [20] P. Breiding and N. Vannieuwenhoven. A Riemannian trust region method for the canonical tensor rank approximation problem. *SIAM J. Optim.*, 28, 2435–2465 (2018).

Preprints.....

- [21] P. Blagojević, P. Breiding, and A. Heaton. Facet volumes of polytopes. *arXiv:2112.08437*.
- [22] P. Breiding. An efficient randomized homotopy method to approximate eigenpairs of tensors. *arXiv:1512.03284*.
- [23] P. Breiding, P. Bürgisser, A. Lerario, and L. Mathis. The zonoid algebra, generalized mixed volumes, and random determinants. *arXiv:2109.14996*.
- [24] P. Breiding, F. Gesmundo, M. Michalek, and N. Vannieuwenhoven. Algebraic compressed sensing. *arXiv:2108.13208*.
- [25] P. Breiding, K. Rose, and S. Timme. Certifying zeros of polynomial systems using interval arithmetic. *arXiv:2011.05000*.
- [26] P. Breiding and N. Vannieuwenhoven. Sensitivity of low-rank matrix recovery. *arXiv:2103.00531*.
- [27] N. Dewaele, P. Breiding, and N. Vannieuwenhoven. The condition number of many tensor decompositions is invariant under Tucker compression. *arXiv:2106.13034*.
- [28] N. Dewaele, P. Breiding, and N. Vannieuwenhoven. Three decompositions of symmetric tensors have similar condition numbers. *arXiv:2110.04172*.

Software projects.....

- [29] 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.....

- [30] P. Breiding and A. Lerario. *Lectures on Random Algebraic Geometry*. Unpublished work in progress. Available at <https://pbrdng.github.io/rag.html>.
- [31] P. Breiding and E. Shehu. *Condition and Geometry*. Unpublished work in progress. Available at https://pbrdng.github.io/condition_and_geometry_lecture_notes.pdf.

Websites.....

- [32] 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.....

- [33] P. Breiding. Zyklotomische Körper und die Fermat–Gleichung zum Exponent p^2 ., 2011. Grade: 1.0. First supervisor: Preda Mihailescu. Second supervisor: Maarten Solleveld.
- [34] 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.
- [35] 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

Bernd Sturmfels: bernd@mis.mpg.de

MPI für Mathematik in den Naturwissenschaften, Inselstraße 22, 04103 Leipzig, Germany

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.

Nick Vannieuwenhoven: nick.vannieuwenhoven@cs.kuleuven.be

KU Leuven, Celestijnenlaan 200 A, B-3001 Heverlee, Belgium.