

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

Max-Planck-Institute for Mathematics in the Sciences Leipzig

Head of Emmy Noether Research Group: Numerical and Probabilistic Nonlinear Algebra Since 04/2021

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

Total amount: €1.132.600

Granted by the Deutsche Forschungsgemeinschaft

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: 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

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. Pencil-based algorithms for tensor rank decomposition are not stable. *SIAM J. Matrix Anal. and Appl.* 40(2), 739–773 (2019).
- [2] P. Breiding. An algebraic geometry perspective on topological data analysis. *SIAM News* 53(1) (2020).
- [3] P. Breiding. The expected number of eigenvalues of a real gaussian tensor. *SIAM J. Appl. Algebra Geometry*, 1(1), 254–271 (2017).
- [4] P. Breiding. How many eigenvalues of a random symmetric tensor are real? *Trans. Amer. Math. Soc.* 372, 7857–7887 (2019).
- [5] 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).
- [6] P. Breiding, H. Keneshlou, and A. Lerario. Quantitative singularity theory for random polynomials. *International Mathematical Research Notices* (2020).
- [7] 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).
- [8] P. Breiding, K. Kozhasov, and A. Lerario. Random spectrahedra. *SIAM J. Optim.* 29(4), 2608–2624 (2019).
- [9] P. Breiding and O. Marigliano. Random points on an algebraic manifold. *SIAM J. Mathematics of Data Science* 2(3), 683–704 (2020).
- [10] P. Breiding, B. Sturmfels, S. Kalisnik Verovsek, and M. Weinstein. Learning algebraic varieties from samples. *Revista Matemática Complutense*, 31, 545–593 (2018).
- [11] 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.
- [12] P. Breiding and N. Vannieuwenhoven. The condition number of join decompositions. *SIAM J. Matrix Anal. and Appl.*, 39(1), 287–309 (2018).
- [13] P. Breiding and N. Vannieuwenhoven. The condition number of Riemannian approximation problems. *SIAM J. Optim.*, to appear.
- [14] 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).
- [15] P. Breiding and N. Vannieuwenhoven. On the average condition number of tensor rank decompositions. *IMA J. Num. Anal.* (2019).
- [16] P. Breiding and N. Vannieuwenhoven. A Riemannian trust region method for the canonical tensor rank approximation problem. *SIAM J. Optim.*, 28, 2435–2465 (2018).

Software projects.....

- [17] 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**

Preprints.....

- [18] C. Beltrán, P. Breiding, and N. Vannieuwenhoven. The average condition number of most tensor rank decomposition problems is infinite. *arXiv*1903.05527.
- [19] P. Breiding. An efficient randomized homotopy method to approximate eigenpairs of tensors. *arXiv*1512.03284.
- [20] P. Breiding, T. Çelik, T. Duff, A. Heaton, A. Maraj, A. Sattelberger, L. Venturello, and O. Yürük. Nonlinear algebra and applications. *arXiv*:2103.16300.
- [21] P. Breiding, C. Ikenmeyer, R. Hodges, and M. Michalek. Equations for gl invariant families of polynomials. Preprint available at <http://pcwww.liv.ac.uk/~iken/GL-paper/GL-paper.pdf>.
- [22] P. Breiding, K. Rose, and S. Timme. Certifying zeros of polynomial systems using interval arithmetic. *arXiv*:2011.05000.
- [23] P. Breiding, F. Sottile, and J. Woodcock. Euclidean distance degree and mixed volume. *arXiv*:2012.06350.
- [24] P. Breiding and N. Vannieuwenhoven. Sensitivity of low-rank matrix recovery. *arXiv*:2103.00531.

- Book projects.....
- [25] P. Breiding and A. Lerario. *Lectures on Random Algebraic Geometry*. Unpublished work in progress. Available at <https://pbrdng.github.io/rag.html>.
- Websites.....
- [26] 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.....
- [27] P. Breiding. Zyklotomische Körper und die Fermat–Gleichung zum Exponent p^2 ., 2011. Grade: 1.0. First supervisor: Preda Mihailescu. Second supervisor: Maarten Solleveld.
- [28] 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.
- [29] 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.