

Paul Breiding | Curriculum Vitae

✉ pbreiding@mathematik.uni-kassel.de • 🌐 paulbreiding.org
born 12th of May 1988, german citizenship



Head of Emmy Noether Research Group

Numerical and Probabilistic Nonlinear Algebra

04/2021 – 03/2027

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

Postdoc in the algorithmic algebra research group

04/2019 – 10/2020

Max-Planck-Institute for Mathematics in the Sciences Leipzig

Postdoc 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*

Grants

Emmy Noether Research Group Grant

Granted by the Deutsche Forschungsgemeinschaft

Project title: Numerical and Probabilistic Nonlinear Algebra

2020

Total amount: 1.073.150 €

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. Convergence analysis of Riemannian Gauss-Newton methods and its connection with the geometric condition number. *Applied Mathematics Letters*, 78, 42–50 (2018).
- [14] P. Breiding and N. Vannieuwenhoven. On the average condition number of tensor rank decompositions. *IMA J. Num. Anal.* (2019).
- [15] P. Breiding and N. Vannieuwenhoven. A Riemannian trust region method for the canonical tensor rank approximation problem. *SIAM J. Optim.*, 28, 2435–2465 (2018). Source code for the MATLAB implementation available at <https://arxiv.org/src/1709.00033v2/anc>.

Preprints.....

- [16] C. Beltrán, P. Breiding, and N. Vannieuwenhoven. The average condition number of most tensor rank decomposition problems is infinite. *arXiv1903.05527*.
- [17] P. Breiding. An efficient randomized homotopy method to approximate eigenpairs of tensors. *arXiv1512.03284*.
- [18] 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>*.
- [19] P. Breiding, K. Rose, and S. Timme. Certifying zeros of polynomial systems using interval arithmetic. *arXiv:2011.05000*.
- [20] P. Breiding, F. Sottile, and J. Woodcock. Euclidean distance degree and mixed volume. *arXiv:2012.06350*.
- [21] P. Breiding and N. Vannieuwenhoven. The condition number of Riemannian approximation problems. *arXiv:1909.12186*.

Book projects.....

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 Unpublished work in progress.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

Software projects.....

- [23] P. Breiding and S. Timme. Homotopycontinuation.jl: A package for homotopy continuation in julia. Website: juliahomotopycontinuation.org. GitHub: github.com/JuliaHomotopyContinuation. Published in: Mathematical Software – ICMS 2018. Lecture Notes in Computer Science. Open Source software, source code freely available on github.com.

**Homotopy
Continuation.jl**

Websites.....

- [24] 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.
- [25] P. Breiding and S. Timme. juliahomotopycontinuation.org/examples/. An ongoing list of examples.

- Theses.....
- [26] P. Breiding. Zyklotomische Körper und die Fermat–Gleichung zum Exponent p^2 ., 2011. Grade: 1.0. First supervisor: Preda Mihailescu. Second supervisor: Maarten Solleveld.
- [27] 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.
- [28] 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.

Teaching experience

Lecture: Statistics for engineers <i>Universität Kassel</i>	Lecturer 11/2020–03/2021
Lecture: Computeralgebra <i>Universität Kassel</i>	Lecturer 11/2020–03/2021
Seminar: Mathematics for primary school teachers <i>Universität Kassel</i>	Lecturer 11/2020–03/2021
Lecture: Numerical algebraic geometry with Julia <i>Freie Universität Berlin</i>	Lecturer 09/2019–03/2020
Seminar: Numerical nonlinear algebra <i>Technische Universität Berlin</i>	Lecturer 04/2019–07/2019
Lecture: Condition – the geometry of numerical algorithms <i>Max-Planck Institute for Mathematics in the Sciences</i>	Lecturer 10/2018–01/2019
Mathematik für unbegleitete minderjährige Flüchtlinge <i>Stiftung SPI Berlin</i>	Teacher 03/2016–11/2016
Gewöhnliche Differentialgleichungen, Algebra <i>TU Berlin</i> Undergraduate course for students in Engineering and Mathematics	Teaching Assistant 04/2017 – 09/2017
Statistische Beratung <i>Institut für medizinische Statistik, UMG Göttingen</i>	Tutor 06/2013 – 09/2013

Organizational experience

Workshop Computational Algebra 2020 <i>Online workshop</i>	Organizer 11/2020
Minisymposium on Random Geometry and Topology <i>SIAM Conference on Applied Algebraic Geometry</i>	Organizer 07/2019
Minisymposium on Numerical Methods in Algebraic Geometry <i>SIAM Conference on Applied Algebraic Geometry</i>	Organizer 07/2019
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 <i>Munich</i> Presentation of MPI MiS to a general audience	Organizer 09/2018
Summer School on Numerical Computing in Algebraic Geometry <i>Max-Planck Institute for Mathematics in the Sciences</i>	Organizer 08/2018
Berlin-Leipzig Seminar on Algebra, Geometry and Combinatorics <i>MPI for Mathematics in the Sciences/TU Berlin/FU Berlin</i>	Organizer 10/2017 – 12/2017
EROC - European Roller Derby Organizational Conference <i>International conference with ~150 participants</i>	Organizer 2016 and 2017

Editorial work

Member of the editorial board of Numerical Algebra, Control and Optimization.

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.

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.