Paul Breiding | Curriculum Vitae

p.breiding@tu-berlin.de • paulbreiding.org, github.com/PBrdng
born 12th of May 1988 in Witzenhausen, Germany, german citizenship

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*

Technische Universität Berlin
Postdoc in the algorithmic algebra research group *Since 04/2019*

Max-Plack-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'.

Scuola Internazionale Superiore di Studi Avanzati (SISSA)
Regular research visits *Since 01/2017*

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, Grade: 1,1. *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, Grade: Sehr Gut (1,5) *10/2008 – 09/2011*

Otto-Hahn-Gymnasium Göttingen
Abitur, Grade: Sehr Gut (1,4) *06/2007*

Languages

German: *fluent, native*

English: *fluent*

Grants

Emmy Noether Research Group Grant
Granted by the Deutsche Forschungsgemeinschaft *2021*

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, to appear.*

[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, to appear.*

[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 and N. Vannieuwenhoven. The condition number of Riemannian approximation problems. *arXiv:1909.12186.*

Book projects

[19] P. Breiding and A. Lerario. *Lectures on Random Algebraic Geometry.* Unpublished work in progress. Available at page.math.tu-berlin.de/∼breiding/rag.html.

Software projects

[20] 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

Internet publications

[21] 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.

[22] P. Breiding and S. Timme. juliahomotopycontinuation.org/examples/. An ongoing list of examples where polynomial systems are solved numerically.

Theses

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

[24] 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.

[25] 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

Numerical Algebraic Geometry with Julia — **Lecturer**
Freie Universität Berlin — *09/2019–03/2020*

Seminar: Numerical Nonlinear Algebra — **Lecturer**
Technische Universität Berlin — *04/2019–07/2019*

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*

Gewöhnliche Differentialgleichungen — **Teaching Assistant**
TU Berlin — *04/2017 – 09/2017*
Undergraduate course for students in Engineering

Algebra, Multivariate Polynomials — **Teaching Assistant**
TU Berlin — *12/2013 – 04/2017*
Undergraduate courses for students in Mathematics

Analysis, Lineare algebra — **Tutor**
TU Berlin — *12/2013 – 04/2017*
Undergraduate courses for students in Engineering

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

Lineare Algebra 1 & 2, Mikroökonomik 1 & 2 — **Tutor**
Georg-August-Universität Göttingen — *10/2010 – 03/2013*

Organizational experience

Minisymposium on Random Geometry and Topology — **Organizer**
SIAM Conference on Applied Algebraic Geometry — *07/2019*

Minisymposium on Numerical Methods in Algebraic Geometry — **Organizer**
SIAM Conference on Applied Algebraic Geometry — *07/2019*

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 — **Organizer**
Munich — *09/2018*
Presentation of MPI MiS to a general audience

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

Berlin-Leipzig Seminar on Algebra, Geometry and Combinatorics — **Organizer**
MPI for Mathematics in the Sciences/TU Berlin/FU Berlin — *10/2017 – 12/2017*

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

Invited talks

Symmetry, Randomness, and Computations in Real Algebraic Geometry
ICERM — *08/2020*

Mathematics for Complex Data
KTH Stockholm — *06/2020*

Mathematical Software Day
Max-Planck Institute for Mathematics in the Sciences *12/2019*

Complexity of Numerical Computation
Berlin-Brandenburgische Akademie der Wissenschaften *08/2019*
Conference in honor of Felipe Cucker

SIAM Conference on Applied Algebraic Geometry
University of Bern *07/2019*
Minisymposium on the algebra and geometry of tensors

Workshop on Geometry, Topology, and Computation
Mathematikon, Universität Heidelberg *06/2019*

Computeralgebra Tagung
Universität Kassel *05/2019*

Low-Rank Optimization and Applications
Max-Planck Institute for Mathematics in the Sciences *04/2019*

Complexity Reduction in Algebraic Statistics
OvGU Magdeburg *11/2018*

Workshop on Random Real Geometry
SISSA *10/2018*

Seminar za Numeričku Matematiku i Znan. Računanje
University of Zagreb *10/2018*

TENSORS
University of Torino *09/2018*

International Symposium on Mathematical Programming (ISMP)
University of Bordeaux *07/2018*

Numerical Methods for Curves
University of Rennes *02/2018*

9th polymake conference and developer meeting
TU Berlin *02/2018*

Seminar Numerische Lineare Algebra
University of Osnabrück *01/2018*

Open Source Computer Algebra Research (OSCAR)
Max-Planck Institute for Mathematics in the Sciences *12/2017*

2nd Algebraic Statistics Day
Max-Planck Institute for Mathematics in the Sciences *11/2017*

Algebra meets Numerics: Condition and Complexity
TU Berlin *11/2017*

SIAM Conference on Applied Algebraic Geometry
Georgia Tech, Atlanta. *07/2017*
Minisymposium on Random Algebraic Geometry

Reading Group on Real Algebraic Geometry
Max-Planck Institute for Mathematics in the Sciences *07/2017*

Foundations of Computational Mathematics Conference
University of Barcelona *07/2017*
Real Number Complexity workshop

"What is ...?" seminar
TU Berlin *07/2017*
Live recording available at vimeo.com/256622174

Tensors: Algebra meets Numerics
Max-Planck Institute for Mathematics in the Sciences *12/2016*

Algorithms and Complexity in Algebraic Geometry reunion meeting
Simons Institute for the Theory of Computing, Berkeley *12/2015*