

# Paul Breiding | Curriculum Vitae

Universität Osnabrück, FB Mathematik/Informatik, Albrechtstr. 28a, D-49076 Osnabrück

✉ pbreiding@uni-osnabrueck.de • 🌐 paulbreiding.org • 📷 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*

*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

---

### Kähler Package for the Zonoid Algebra

Granted by the Deutsche Forschungsgemeinschaft, €164.822

2024

### Maßnahme “Digitalisierung sicher gestalten”

Granted by MWK Niedersachsen, €49.780

2022

with T. Römer

### Maßnahme “Unterstützung der Digitalisierung der Lehre für die Digitalisierungsprofessuren”

Granted by MWK Niedersachsen, €104.125

2022

with T. Römer

### BIRS Workshop on Random Algebraic Geometry

Granted by the Banff International Research Station

2022

with S. Petrović and G. Smith

### Geometry in Complexity and Computation Conference

Granted by Foundation Compositio

2021

with K. Kohn

### Numerical and Probabilistic Nonlinear Algebra

Granted by the Deutsche Forschungsgemeinschaft, €1.132.600

2020

Emmy Noether Research Group

## Academic Leadership

---

### Metric Algebraic Geometry

ICERM

Semester program

Organizer

02/2027 – 05/2027

### Conference on Applied Algebra

Universität Osnabrück

Organizer

09/2023

### Metric Algebraic Geometry

Oberwolfach Seminar

Organizer

05/2023

### Random Algebraic Geometry

BIRS Workshop, financial support by the Banff International Research Station

Organizer

04/2023

### Stochastic Geometry

Universität Osnabrück

Organizer

11/2022

### Geometry in Complexity and Computations

Universität Konstanz, financial support by Foundation Compositio

(including an Abel prize winner as speaker)

Organizer

09/2022

### Podiumsdiskussion zur Diversität in der Wissenschaft

Akademie der Wissenschaft und der Literatur Mainz

Organizer

04/2022

### The 1st East German Tensor Day

Max-Planck Institute for Complex Technical Systems

Organizer

09/2021

### Minisymposium on Random Algebraic Geometry

SIAM Conference on Applied Algebraic Geometry

Organizer

08/2021

### Minisymposium on Convex Bodies in Real Geometry

SIAM Conference on Applied Algebraic Geometry

Organizer

08/2021

### Workshop on Software and Applications of Numerical Nonlinear Algebra

Max-Planck Institute for Mathematics in the Sciences

Organizer

06/2021

### 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

## 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.* (2019).
- [3] V. Borovik and P. Breiding. A short proof for the parameter continuation theorem. *Journal of Symbolic Computation* (2025).
- [4] 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. *J. Mathématiques Pures et Appliquées* (2023).
- [5] P. Breiding. An algebraic geometry perspective on topological data analysis. *SIAM News* (2020).
- [6] P. Breiding. The expected number of eigenvalues of a real gaussian tensor. *SIAM J. Appl. Algebra Geometry* (2017).
- [7] P. Breiding. How many eigenvalues of a random symmetric tensor are real? *Trans. Amer. Math. Soc.* (2019).
- [8] P. Breiding and P. Bürgisser. Distribution of the eigenvalues of a random system of homogeneous polynomials. *Linear Algebra and its Applications* (2016).
- [9] P. Breiding, P. Bürgisser, A. Lerario, and L. Mathis. The zonoid algebra, generalized mixed volumes, and random determinants. *Adv. in Math.* 402 (2022).
- [10] 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).
- [11] P. Breiding, T. Duff, L. Gustafsson, F. Rydell, and E. Shehu. Line multiview ideals. *Communications in Algebra* (2024).
- [12] P. Breiding and S. Eggleston. Reach of segre-veronese manifolds. *Acta Univ. Sapientiae Math* (to appear).
- [13] P. Breiding, S. Eggleston, and A. Rosana. Typical ranks of random order-three tensors. *International Mathematical Research Notices* (2025).
- [14] P. Breiding, S. Fairchild, P. Santarsiero, and E. Shehu. Average degree of the essential variety. *La Matematica* (2023).
- [15] P. Breiding, F. Gesmundo, M. Michalek, and N. Vannieuwenhoven. Algebraic compressed sensing. *Applied and Computational Harmonic Analysis* (2023).
- [16] P. Breiding, R. Hodges, C. Ikenmeyer, and M. Michalek. Equations for GL invariant families of polynomials. *Vietnam Journal of Mathematics* (2022).
- [17] P. Breiding, H. Keneshlou, and A. Lerario. Quantitative singularity theory for random polynomials. *International Mathematical Research Notices* (2020).
- [18] P. Breiding, K. Kozhasov, and A. Lerario. On the geometry of the set of symmetric matrices with repeated eigenvalues. *Arnold Math J.*
- [19] P. Breiding, K. Kozhasov, and A. Lerario. Random spectrahedra. *SIAM J. Optim.* (2019).
- [20] P. Breiding, J. Lindberg, G. Ong, and L. Sommer. Real circles tangent to 3 conics. *Le Matematiche* (2023).
- [21] P. Breiding and O. Marigliano. Random points on an algebraic manifold. *SIAM J. Mathematics of Data Science* (2020).
- [22] P. Breiding, M. Michałek, L. Monin, and S. Telen. The algebraic degree of coupled oscillators. *Advances in Mathematics* (2025).
- [23] P. Breiding, K. Ranestad, and M. Weinstein. Critical curvature of algebraic surfaces in three-space. *Acta Univ. Sapientiae Math* (to appear).
- [24] P. Breiding, K. Rose, and S. Timme. Certifying zeros of polynomial systems using interval arithmetic. *Trans. Math. Software* (2023).
- [25] P. Breiding, F. Rydell, E. Shehu, and A. Torres. Line multiview varieties. *SIAM J. Appl. Algebra Geometry* (2023).
- [26] P. Breiding and P. Santarsiero. Degree of the subspace variety. *Collectanea Mathematica* (to appear).

- [27] P. Breiding, F. Sottile, and J. Woodcock. Euclidean distance degree and mixed volume. *Foundations of Computational Mathematics* (2021).
- [28] P. Breiding, B. Sturmfels, S. Kalisnik Verovsek, and M. Weinstein. Learning algebraic varieties from samples. *Revista Matemática Complutense* (2018).
- [29] P. Breiding, B. Sturmfels, and S. Timme. 3264 conics in a second. *Not. Amer. Math. Soc.* (2020). *Article is featured on the title page.*
- [30] P. Breiding, B. Sturmfels, and K. Wang. Computing arrangements of hypersurfaces. *Journal of Software and Algebra* (to appear).
- [31] P. Breiding and N. Vannieuwenhoven. The condition number of join decompositions. *SIAM J. Matrix Anal. and Appl.* (2018).
- [32] P. Breiding and N. Vannieuwenhoven. The condition number of Riemannian approximation problems. *SIAM J. Optim.* (2021).
- [33] P. Breiding and N. Vannieuwenhoven. Convergence analysis of Riemannian Gauss-Newton methods and its connection with the geometric condition number. *Applied Mathematics Letters* (2018).
- [34] P. Breiding and N. Vannieuwenhoven. On the average condition number of tensor rank decompositions. *IMA J. Num. Anal.* (2019).
- [35] P. Breiding and N. Vannieuwenhoven. A Riemannian trust region method for the canonical tensor rank approximation problem. *SIAM J. Optim.* (2018).
- [36] P. Breiding and N. Vannieuwenhoven. Sensitivity of low-rank matrix recovery. *Numerische Math.* (2022).
- [37] N. Dewaele, P. Breiding, and N. Vannieuwenhoven. The condition number of many tensor decompositions is invariant under Tucker compression. *Numerical Algorithms* (2023).
- [38] N. Dewaele, P. Breiding, and N. Vannieuwenhoven. Three decompositions of symmetric tensors have similar condition numbers. *Linear Algebra and its Applications* (2023).

## Preprints.....

- [39] D. Bates, P. Breiding, T. Chen, J. Hauenstein, A. Leykin, and F. Sottile. Numerical nonlinear algebra. *arXiv:2302.08585*.
- [40] P. Blagojević, P. Breiding, and A. Heaton. Facet volumes of polytopes. *arXiv:2112.08437*.
- [41] P. Breiding. An efficient randomized homotopy method to approximate eigenpairs of tensors. *arXiv:1512.03284*.
- [42] P. Breiding, P. Bürgisser, A. Lerario, and L. Mathis. Probabilistic intersection theory in Riemannian homogeneous spaces. *arXiv:2502.08256*.

## Software.....

- [43] P. Breiding and S. Timme. Homotopycontinuation.jl: A package for homotopy continuation in Julia.  
 [juliahomotopycontinuation.org](https://juliahomotopycontinuation.org).  [github.com/JuliaHomotopyContinuation](https://github.com/JuliaHomotopyContinuation). Open Source software.  
**Homotopy Continuation.jl**

## Lecture notes.....

- [44] P. Breiding and S. Fairchild. *Mathematical Methods in Data Science*. Unpublished work in progress. <https://pbrdng.github.io/MathData.pdf>.
- [45] P. Breiding, K. Kohn, and B. Sturmfels. *Metric Algebraic Geometry*. Oberwolfach Seminars, Birkhäuser, Basel, 2024. <https://link.springer.com/content/pdf/10.1007/978-3-031-51462-3.pdf>.

## Theses.....

- [46] 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.
- [47] 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.