

# Paul Breiding | Curriculum Vitae

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

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born 12th of May 1988, german citizenship

## Universität Osnabrück

*Professor for Mathematical Methods in Data Science*

*Since 04/2022*

## Max-Plack-Institute for Mathematics in the Sciences Leipzig

*Head of Emmy Noether Research Group:*

Numerical and Probabilistic Nonlinear Algebra

*04/2021 – 03/2022*

## 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-Plack-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*

Date of thesis defense: July 25, 2017. Evaluation 'summa cum laude'.

*12/2013 – 09/2017*

## 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*

*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  
with S. Petrović and G. Smith

2022

### **Geometry in Complexity and Computation Conference**

Granted by Foundation Compositio  
with K. Kohn

2021

### **Numerical and Probabilistic Nonlinear Algebra**

Granted by the Deutsche Forschungsgemeinschaft, €1.132.600  
Emmy Noether Research Group

2020

## Academic Leadership

### **Metric Algebraic Geometry**

*ICERM*

Organizer

02/2027 – 05/2027

Semester program

### **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*

Organizer

09/2022

(including an Abel prize winner as speaker)

### **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

<b>Workshop on Random Algebraic Geometry</b>	<b>Organizer</b>
<i>SISSA</i>	<i>11/2018</i>
<b>Max-Planck Day (Presentation of MPI MiS to a general audience)</b>	<b>Organizer</b>
<i>Munich</i>	<i>09/2018</i>
<b>Summer School on Numerical Computing in Algebraic Geometry</b>	<b>Organizer</b>
<i>Max-Planck Institute for Mathematics in the Sciences</i>	<i>08/2018</i>

## Publications

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- 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. Michałek, and N. Vannieuwenhoven. Algebraic compressed sensing. *Applied and Computational Harmonic Analysis* (2023).
  - [16] P. Breiding, R. Hodges, C. Ikenmeyer, and M. Michałek. 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](https://arxiv.org/abs/2302.08585).
- [40] P. Blagojević, P. Breiding, and A. Heaton. Facet volumes of polytopes. [arXiv:2112.08437](https://arxiv.org/abs/2112.08437).
- [41] P. Breiding. An efficient randomized homotopy method to approximate eigenpairs of tensors. [arXiv1512.03284](https://arxiv.org/abs/1512.03284).
- [42] P. Breiding, T. Brysiewicz, and H. Friedman. Homotopy iterators. [arXiv:2509.08084](https://arxiv.org/abs/2509.08084).
- [43] P. Breiding, P. Bürgisser, A. Lerario, and L. Mathis. Probabilistic intersection theory in Riemannian homogeneous spaces. [arXiv:2502.08256](https://arxiv.org/abs/2502.08256).

## Software.....

- [44] 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.....

- [45] P. Breiding and S. Fairchild. *Mathematical Methods in Data Science*. Unpublished work in progress. <https://pbrdng.github.io/MathData.pdf>.
- [46] 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.....

- [47] 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.
- [48] 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.