

# Eliana Duarte

## Curriculum Vitae

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### Synopsis

Mathematician doing research in causal inference, maximum likelihood estimation, quantum information and computational algebraic geometry with a view towards applications. Experience leading younger teams of researchers and orientation of Phd and Masters students theses. Teaching experience in statistical inference, applied statistics, graphical models, algebraic statistics, differential geometry, linear algebra and algebraic geometry. Active member of the mathematical statistics research community, organizer of international conferences and summer schools.

### Parental Leave

Birth of first son: 19.02.2024. Leave period from 19.02.2024 to 17.06.2024. The certificate from the INSS is contained in the supplementary documents.

### Employment

- 05.2023- **Faculdade de Ciências Universidade do Porto**, *Departamento de*  
present *Matemática*, Professor Auxiliar in Probability and Statistics.  
Porto, Portugal
- 01.2023- **Max-Planck-Institute for Mathematics in the Sciences**, *Leader of the*  
05.2023 *research group in Algebraic Statistics*.  
Leipzig, Germany
- 10.2021- **Centro de Matemática Universidade do Porto**, Stimulus for Sci-  
05.2023 entific Employment, Contrato Fundaçao para a Ciência e a Tecnologia  
2020.01933.CEECIND. Researcher in Algebraic Statistics.  
Porto, Portugal
- 12.2017- **Otto-Von-Guericke Universität Magdeburg**, *Complexity Reduction Re-*  
09.2021 *search Training Group*, Postdoctoral Researcher in algebraic statistics, Supervi-  
sor: Thomas Kahle.  
Magdeburg, Germany
- 03-11.2017, **Max-Planck-Institute for Mathematics in the Sciences**, *Nonlinear algebra*  
04-12.2019 *group*, Postdoctoral Researcher, Supervisor: Bernd Sturmfels.  
Leipzig, Germany
- Summer **Wolfram Research**, *Summer intern in multivariate polynomial GCDs*, Super-  
2016 visor: Daniel Lichtblau.  
Champaign, Illinois, USA

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## Education

- 08.2011–05.2017 **Ph.D. in Mathematics**, University of Illinois Urbana-Champaign, Urbana, Illinois, USA.
- **Ph.D. Thesis:** “*Syzygies and implicitization of tensor product surfaces*”, under supervision of **Prof. Hal Schenck**. Committee: Thomas Nevins, Bruce Reznick, George Francis
- 08.2009–05.2011 **M.A in Mathematics**, Binghamton University State University of New York, Binghamton, NY, USA.
- 2004–2009 **B.Sc. in Mathematics**, Universidad de los Andes, Bogotá, Colombia.

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## Publications

- 1 E. Duarte and L. Solus. *Algebraic geometry of discrete interventional models*. To appear in EMS special volume “Varieties, Polyhedra and Computation”. Forthcoming.
- 2 Y. Alexandr, E. Duarte and J. Vill. *Decomposable context-specific models*, SIAM Journal on Applied Algebra and Geometry. **8** (2024), 2 p. 363-393. DOI 10.1137/23M1575111
- 3 D. Tramontano, L. Waldmann, M. Drton and E. Duarte, *Learning Linear Gaussian Polytree Models With Interventions*, in IEEE Journal on Selected Areas in Information Theory. **4** (2023), pp. 569-578. DOI 10.1109/JSAIT.2023.3328429.
- 4 E. Duarte, B. Hollering and M. Wiesmann. *Toric Fiber Products in Geometric Modeling*, In: Nielsen, F., Barbaresco, F. (eds) Geometric Science of Information. GSI Lecture Notes in Computer Science, Springer. **14071** (2023), p. 494–503. DOI 10.1007/978-3-031-38271-049
- 5 I. Davies, E. Duarte, I. Portakal, S.M. Sorea. *Families of polytopes with rational linear precision in higher dimensions*, Foundations of Computational Mathematics. **23**, (2023), p.2151–2202. DOI: 10.1007/s10208-022-09583-7
- 6 E. Duarte and L. Solus. *A new characterization of discrete decomposable models*, Proceedings of the American Mathematical Society. **151** 3, (2023), p.1325-1338. DOI 10.1090/proc/16212
- 7 L. Ananiadi and E. Duarte. *Gröbner bases for staged trees*, Algebraic Statistics, **12** 1, (2021), p. 1-20. DOI 10.2140/astat.2021.12.1
- 8 C. Guerra, M. Delgado Baquerizo, E. Duarte, O. Marigliano, C. Görgen, F. Maestre and N. Eisenhauer. *Global projections of the soil microbiome in the anthropocene*, Global Ecology and Biogeography. **30** 5, (2021), p.987-999. DOI 10.1111/geb.13273
- 9 E. Duarte, O. Marigliano and B. Sturmfels. *Discrete statistical models with rational maximum likelihood estimator*, Bernoulli. **27** (1), (2021), p. 135-154. DOI: 10.3150/20-BEJ1231
- 10 E. Duarte and A. Seceleanu. *Implicitization of tensor product surfaces via virtual projective resolutions*, Mathematics of Computation. **89** 326, (2020), p. 3023-3056. DOI 10.1090/mcom/3548

- 11 E. Duarte and C. Görgen. *Equations defining probability tree models*, Journal of Symbolic Computation. **99** (2020), p. 127-146. DOI 10.1016/j.jsc.2019.04.001
- 12 E. Duarte. *Implicitization of tensor product surfaces in the presence of a generic set of basepoints*, Journal of Algebra and Its Applications. **16** 10,(2017): 1750189. DOI 10.1142/S0219498817501894
- 13 E. Duarte, and D. Lichtblau. *Polynomial GCDs by Syzygies*, 18th International Symposium on Symbolic and Numeric Algorithms for Scientific Computing (SYNASC), Timisoara, Romania. 2016, p. 53-59. DOI 10.1109/SYNASC.2016.021
- 14 E. Duarte and H. Schenck . *Tensor Product Surfaces and linear syzygies*, Proceedings of the American Mathematical Society. **144** 1 (2016): 65-72. DOI 10.1090/proc/12703
- 15 E. Duarte and G. Francis . *Stability of quasicrystal frameworks in 2D and 3D. Proceedings of the First Conference Transformables, Seville, Spain, 2013.*

## Preprints

- 16 E. Duarte and L. Solus. *Representation of Context-Specific Causal Models with Observational and Interventional Data*. arXiv:2101.09271. Under second round of reviews at the Journal of the Royal Statistical Society Series B, 2022.
- 17 E. Duarte, M. Wiesmann, D. Pavlov. *Algebraic geometry of quantum graphical models*, arXiv:2308.11538v1, 2023.

## Invited Talks

- 07.2025 **Minicourse on the geometry of maximum likelihood estimation**, Summer Jovens Investigadores em Matemática Days.  
Universidade de Coimbra. Portugal.
- 03.2025 **Algebraic geometry of quantum graphical models**, Algebraic Statistics 2025.  
Technische Universität München. Germany.
- 11.2024 **Algebraic statistics of probability tree models**, Trees4Cat, DIMA - Department of Mathematics.  
University of Genoa, Italy
- 07.2024 **Euler stratifications of toric varieties**, Encontro Nacional Sociedade Portuguesa de Matemática.  
Braga, Portugal
- 11.2023 **Representation of Context-Specific Causal Models**, Probability and Statistics Seminar CEMAT CEAUL.  
Instituto Superior Técnico. Online.
- 12.2022 **Staged trees and MLEs**, Algebraic Structures in Statistical Methodology, Mathematisches Forschungsinstitut Oberwolfach. .  
Oberwolfach, Germany.

- 07.2022 **Maximum Likelihood estimation for toric varieties**, Mathematical Methods in Data Analysis, CIMPA Summer School.  
Tirana, Albania.
- 10.2021 **Rational Linear precision and algebraic statistics, panel participant**, GROW Graduate Research Opportunities for Women at Bonn 2022.  
Hausdorff Center for Mathematics. Bonn, Germany.
- 10.2021 **Context-Specific Causal models**, Applied Combinatorics, Algebra, Topology & Statistics Seminar.  
KTH Royal Institute of Technology. Sweden.
- 10.2021 **Families of polytopes with rational linear precision in higher dimensions**, Nonlinear Algebra Seminar.  
Max-Planck-Institute for Mathematics in the Sciences. Leipzig, Germany.
- 07.2021 **Maximum likelihood estimation for log-linear models in 2D and 3D**, SIAM Conference in Applied Algebraic Geometry.  
Texas A&M University. Online.
- 07.2021 **Balanced staged tree models**, Conference on reasoning with asymmetric and context-specific graphs.  
Baylor University, USA.
- 03.2021 **Implicit equations via virtual projective resolutions**, AMS sectional meeting - Special Session on Commutative Algebra and its Interaction with Algebraic Geometry and Combinatorics.  
Online
- 03.2021 **Rigidity of quasicrystal bar-and-joint frameworks in 2D and 3D**, Workshop on Progress and Open Problems in Rigidity Theory.  
Fields Institute Toronto, Canada.
- 02.2021 **Algebraic Geometry of Discrete Interventional Models**, Algebraic Statistics Online Seminar.  
Online
- 04.2020 **Algebraic Geometry with a view towards applications**, Nonlinear Algebra Seminar Online .  
Max-Planck-Institute for Mathematics in the Sciences. Germany.
- 11.2019 **Gröbner bases for staged trees**, Graphical Models: Conditional Independence and Algebraic Structures, Technische Universität Munich.  
Munich, Germany.
- 08.2019 **Elimination via virtual resolutions**, Algebraic Spline Geometry Meeting,  
Swansea University. .  
Wales
- 03.2019 **Discrete Statistical Models with Rational MLE**, Deep Learning Theory Kickoff Meeting. .  
Max-Planck-Institute for Mathematics in the Sciences. Leipzig, Germany.
- 06.2018 **Graphical Models: From Mathematical Foundations to Biological Applications**, ETH Zurich..  
Basel, Switzerland.

05.2018 **Scientific Advisory Board meeting**, Max-Planck-Institute for Mathematics in the Sciences.

## Conference and Seminar talks

- 06.2020 **Applied Algebra and Analysis online Seminar**, FU Berlin
- 12.2019 **Einstein Workshop on Polytopes and Algebraic Geometry**, FU Berlin.
- 07.2019 **SIAM Conference on Applied Algebraic Geometry**, University of Bern.
- 02.2019 **Optimality in Algebraic Statistics**, Technische Universität Dortmund.
- 02.2019 **Nonlinear algebra seminar**, Max-Planck-Institute MIS.
- 11.2018 **Commutative Algebra Seminar** University of Lincoln Nebraska.
- 10.2018 **ICERM**, Semester on Nonlinear Algebra.
- 07.2018 **SIAM Annual Meeting Algebraic Statistics Minisymposia**.
- 07.2018 **Mathematical Complexity Reduction Seminar** Otto-von-Guericke Universität Magdeburg.
- 06.2018 **Algebraic Statistics in Berlin** Max-Planck-Gesellschaft Gagarinshäuser Haus.
- 04.2018 **Nonlinear algebra seminar** Max-Planck-Institute MIS.
- 01.2018 **Mathematical Complexity Reduction Seminar** Otto-von-Guericke Universität Magdeburg.
- 11.2017 **Algebraic Methods in Statistics**, Universität Osnabrück.
- 11.2017 **Non-linear algebra seminar** Max-Planck-Institute MIS.
- 09.2017 **Algebraic Statistics Day**, Max-Planck-Institute MIS, Leipzig.
- 08.2017 **SIAM conference in applied algebraic geometry**, Georgia Institute of Technology.
- 05.2017 **Nonlinear algebra seminar**, Max-Planck-Institute MIS.
- 01.2017 **Combinatorial algebra meets algebraic geometry**, Université du Québec à Montréal.
- 08.2016 **Banff International Research Station**, Computational Algebraic Geometry and Geometric Modelling. Oaxaca, Mexico.
- 01.2016 **Joint Math Meetings - AMS special session on commutative algebra**, Seattle.
- 01.2016 **Joint Math Meetings - Association for Women in Mathematics Workshop**, Seattle.
- 11.2015 **AMS special session on combinatorial and computational algebra**, Loyola University Chicago.
- 08.2015 **Midwest commutative algebra and geometry conference**, Purdue University. Poster session.
- 04.2015 **Midwest algebraic geometry graduate student conference**, University of Illinois Chicago.

- 08.2014 **Mathematical Modeling in Industry Workshop**, Pacific Institute for the mathematical sciences.
- 06.2014 **Encuentro Colombiano de combinatoria**, Universidad de los Andes.
- 09.2013 **Transformables 2013**, Seville, Spain.

## Future Research Directions

Convergence properties of maximum likelihood estimation procedures for categorical exponential families. Developing context-specific causal inference tools. Expanding the use of causal inference methodology in life sciences. Using numerical algebraic geometry for better understanding quantum information projections to quantum exponential families. The Research Plan contains more information about these research directions.

## Coordination and participation in scientific projects

- 2025 **Causal4ECO - New directions in causal inference analysis for ecological data**, *Call for Exploratory Research Projects in all Scientific Domains 2024*. Application submitted and eligible, currently under review, Fundação para a Ciência e a tecnologia, Portugal.
- 2024 **Algebra and topology in the life sciences and analysis of their structure**, *COST Action - European cooperation in science and technology, secondary proposer*. Application submitted and currently under review.
- 2021-2023 **Stimulus for Scientific Employment**, *Fundação para a Ciência e a Tecnologia 2020.01933.CEECIND*, Centro de Matemática Universidade do Porto. Portugal

## Conference Organisation

- 06.2025 **Summer Research School - New Perspectives on Discriminants and their Applications**, Co-sponsored by SLMATH - Simons Laufer Mathematical Sciences Institute and Max-Planck-Institute for Mathematics in the Sciences). Leipzig, Germany
- 10.2023 **Algebraic Statistics for Ecological and Biological Systems**, Institute for Mathematical and Statistical Innovation (IMSI). Chicago, USA
- 09.2023 **Session Computing Geometry and Algebraic Statistics**, 6th International Conference Geometric Science of Information. St. Malo, France
- 07.2023 **Minisymposium Geometric and Algebraic Structures in Quantum Information**, SIAM Conference in Applied Algebraic Geometry. Eindhoven University of Technology, Netherlands
- 12.2022 **Macaulay2 Bootcamp**, Max-Planck-Institute for Mathematics in the Sciences. Leipzig, Germany
- 04.2021 **Spring School on Mathematical Statistics**, Max-Planck-Institute for Mathematics in the Sciences, Planned for 2020, cancelled due to Covid-19. Leipzig, Germany

- 11.2018 **Complexity Reduction in Algebraic Statistics**, Otto-von-Guericke Universität Magdeburg.  
Magdeburg, Germany
- 06.2018 **Macaulay2 Workshop**, Max-Planck-Institute for Mathematics in the Sciences.  
Leipzig, Germany
- 11.2017 **Algebraic Statistics Day**, Max-Planck-Institute for Mathematics in the Sciences.  
Leipzig, Germany
- 08.2017 **Algebraic Statistics Day**, Max-Planck-Institute for Mathematics in the Sciences.  
Leipzig, Germany

## Peer Review for Journals and Conference Proceedings

Proceedings for the 26th International Conference on Artificial Intelligence and Statistics - Metrika - Advances in Applied Mathematics - Journal of Pure and Applied Algebra - Journal of Software for Algebra and Geometry - Mathematical Foundations of Computer Science - Algebraic Statistics - Journal of Computational Algebra - SIAM Journal in Applied Algebraic Geometry - Journal of Symbolic Computation

## Evaluation Committees

- External reviewer for the Promotion & Tenure Committee at Alfred University
- Expert report for PhD thesis review of Maximilian Wiesmann at Leipzig University

## Selected Multimedia Resources

- TensorVoices, together with Thomas Kahle we made a podcast where we invited experts to have conversations about tensors. <https://tensorvoices.de>
- Youtube: video abstract of my article *Representation of context-specific causal models for observational and interventional data* [https://www.youtube.com/watch?v=Vdn7F\\_dlin0](https://www.youtube.com/watch?v=Vdn7F_dlin0)
- Youtube lectures: Algebraic Geometry of discrete interventional models [https://www.youtube.com/watch?v=Vdn7F\\_dlin0](https://www.youtube.com/watch?v=Vdn7F_dlin0)
- Podcasts: Modellansatz interview <https://www.math.kit.edu/ianm4/seite/ma-algebraic-geometry/de>, Scientist for future interview <https://interviews-4-future.podigee.io/48-i4f>

## Academic Administration

- Served as part of the **Postdoc Hiring Committee** at Max-Planck-Institute for Mathematics in the Sciences. Fall 2022.
- Served as part of the **PhD Students' Hiring Committee** at Max-Planck-Institute for Mathematics in the Sciences. Fall 2022.
- Served as part of the **Postdoc Hiring Committee** at Max-Planck-Institute for Mathematics in the Sciences. Fall 2019.

- Co-organizer of the **Nonlinear Algebra Seminar**, Max-Planck-Institute for Mathematics in the Sciences. Summer 2017.
- Member of the **Graduate affairs committee** at University of Illinois Urbana-Champaign, 2017.
- **President of the Association for Women in Math Student Chapter** at University of Illinois Urbana-Champaign, 2016.
- Founder and organiser of the **Graduate Student Colloquium** in the Mathematics Department at University of Illinois Urbana-Champaign. 2016.

## Teaching Experience

- 02.2025-06.2025 **Estatística Aplicada**, *Introduction to parametric and nonparametric hypothesis testing*, Bachelor program, Universidade do Porto, Porto, Portugal.
- 02.2025-06.2025 **Differential Geometry**, *Introduction to differential geometry of curves and surfaces*, Bachelor program, Universidade do Porto, Porto, Portugal.
- 09.2024-01.2025 **Lineal Algebra and Analytic Geometry**, *Introduction to foundations of linear algebra*, Bachelor program, Universidade do Porto, Porto, Portugal.
- 09.2024-01.2025 **Algebraic Geometry**, *Introduction to algebraic geometry*, Masters program, Universidade do Porto, Porto, Portugal.
- 09.2024-01.2025 **Statistical Inference**, *Introduction to statistical inference, hypothesis testing, estimators, exponential families, bayesian statistics*, Masters program, Universidade do Porto, Porto, Portugal.
- 04.2021 **The Algebra of Tensors**, *Compact course for MathCore PhD research training group*, Otto-Von-Guericke Universität Magdeburg, Magdeburg, Germany.
- Summer 2020, 2018 **Proseminar in Algebra and Geometry**, *Mathematics seminar for bachelor's students*, Otto-Von-Guericke Universität Magdeburg, Magdeburg, Germany.
- Winter 2019 **Lectures in Algebraic Statistics**, *Compact course for PhD students and post-docs*, Max-Planck-Institute for Mathematics in the Sciences, Leipzig, Germany.
- 03.2018 **Theorems of the Alternative**, *Compact course for MathCore research training group*, Otto-Von-Guericke Universität Magdeburg, Magdeburg, Germany.
- Winter 2017 **Syzygies reading group**, *Jointly organized at Max-Planck-Institute for Mathematics in the Sciences, Leipzig and OVGU, Magdeburg*.
- 2009-2016 **Lecturer and Teaching Assistant**, *University of Illinois Urbana-Champaign, Binghamton University, Universidad de los Andes*.
- Theory of Arithmetic for Elementary School Children
  - Differential Calculus
  - Integral Calculus
  - Vector Calculus
  - Linear Algebra

## Teaching Evaluations

The next table contains a summary of teaching evaluations at Universidade do Porto. Each column represents performance in the following three categories, the value reported is the mean score; 1 is the minimum and 7 is the maximum:

**1** = Teaching support

**2** = Structure of teaching

**3** = Relation with students

Year - Unit	1	2	3
2024/2025 Statistical Inference	5.88	6.33	6.17
2024/2025 Linear Algebra	6.17	6.31	6.28
2023/2024 Linear Algebra	5.23	5.28	5.59
2023/2024 Statistical Inference	5.88	5.50	6.50
2021/2022 Statistical Inference	5.90	5.30	7.00

**Award:** 2016 List of teachers ranked as excellent. University of Illinois at Urbana-Champaign Urbana, Illinois, USA.

<https://citl.illinois.edu/docs/default-source/teachers-ranked-as-excellent/tre-2016-spring.pdf>

## Teaching Materials

- Estatística Aplicada, Lecture Notes and Exercise Notes, created in Rmarkdown to support learning of statistical hypothesis testing in R. Two documents each with approximately 36 pages each. See supporting documents.
- Statistical Inference, course webpage. <https://sites.google.com/g.upto.pt/fcupstatsinference/página-inicial>
- Algebra of Tensors, lecture notes written by myself and Thomas Kahle. See supporting documents.

## Mentoring

- Thesis Co-adviser of Maximilian Wiessman, PhD student Max-Planck-Institute for Mathematics in the Sciences. 2022-2025. Title of the thesis: *Nonlinear Algebra in Likelihood, Neurocomputing and Quantum Physics*
- Thesis Co-adviser of João Marcelino, PhD student Joint PhD program between Universidade do Porto and Universidade de Coimbra. Started 2024. Funded by the FCT PhD Fellowship. Title: *Methods for learning decomposable context-specific Bayesian networks*
- Thesis Adviser of Lucas Silva, Masters student at Universidade do Porto. Title: *Arithmetically Cohen-Macaulay sets of points in  $P^1 \times P^1$*

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## Community Outreach

I created a webpage to create a quasicrystal rigidity lab. This idea arose from my article "Rigidity of quasicrystal frameworks in 2D and 3D". In this webpage you can learn about rigidity of frameworks and it has instructions to create your own rigidity structure by using acrylic sheets and a laser cutter. I designed this activity for the Illinois Geometry Lab in Urbana-Champaign. This is the link to the webpage <https://emduart2.github.io/framework-rigidity/>

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## Creation of new courses

- 2019 **Algebra of tensors**, *This two-week intensive course was designed as part of the mandatory courses for the PhD students in the Mathematical Complexity Reduction Research Training group. The focus was on the applications of tensor methods in data science and complexity theory, Otto-von-Guericke Universität Magdeburg.*
- 2019 **Seven Lectures in Algebraic Statistics**, *These lectures were planned for PhD students and postdocs wanting to know more about the use of algebra in statistics. We covered causal inference, graphical models and maximum likelihood estimation for log-linear models, Max-Planck-Institute for Mathematics in the Sciences.*  
<https://emduart2.github.io/2019/10/15/Seven-Lectures-In-Algebraic-Statistics.html>
- 2018 **Theorems of the alternative**, *This two-week intensive course was designed as part of the mandatory courses for the PhD students in the Mathematical Complexity Reduction Research Training group. The focus was on the separation theorems in convex optimization, Otto-von-Guericke Universität Magdeburg.*

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## Relevant Skills

- **Programming**

LaTeX, Macaulay2, Mathematica, R, Sage, Python

- **Languages**

Spanish (Native speaker), English (Fluent), Portuguese (Fluent), French (Intermediate), German (Intermediate).