# Melanie Weber

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## Academic Positions

**University of Oxford, Mathematical Institute** — **Oxford, UK**
*Hooke Research Fellow* — *Fall 2021-*

**University of Oxford, Brasenose College** — **Oxford, UK**
*Nicolas Kurti Junior Research Fellow* — *Fall 2021-*

## Education

**Princeton University** — **Princeton, NJ**
*PhD, Applied Mathematics* — *2016 – 2021*

Thesis: *On geometric optimization, learning and control*; advised by Charles Fefferman.

**University of Leipzig** — **Leipzig, Germany**
*Diplom (joint BSc / MSc) in Mathematics, BSc in Physics* — *2011 – 2016*

Undergraduate research on Discrete Geometry (advised by Jürgen Jost) and Deep Learning approaches to event classification at the ATLAS experiment at CERN's Large Hadron Collider (advised by Michael Kobel).

**University of Washington** — **Seattle, WA**
*MSc, Applied Mathematics* — *2014 – 2015*

Exchange Student. Research in Computational Neuroscience, advised by J. Nathan Kutz.

## Other Research Experience

### Short-term positions & Visits

**Simons Institute for the Theory of Computing** — **Berkeley, CA**
*Research Fellow* — *Fall 2021*

Participant in Program *Geometric Methods in Optimization and Sampling*.

**Microsoft Research** — **Redmond, WA**
*Research Intern* — *Summer 2021*

Contrastive Learning and Geometry. Hosted by Phil Bachman.

**Google Research** — **New York, NY**
*Research intern* — *Summer 2019*

Role of geometry in learning robust classifiers. Adversarial learning in non-Euclidean spaces. Hosted by Manzil Zaheer, Ankit Singh Rawat, Aditya Menon and Sanjiv Kumar.

**Massachusetts Institute of Technology** — **Cambridge, MA**
*Visiting Student/ Ivy Exchange Scholar* — *Summer 2017, Spring 2019*

Riemannian Frank-Wolfe Methods for Optimization on Manifolds. Hosted by Suvrit Sra.

**Facebook Artificial Intelligence Research** — **New York, NY**
*Research Intern* — *Summer 2018*

Representation trade-offs in non-Euclidean embeddings. Hosted by Maximilian Nickel.

### Entrepreneurship

**Claudius Legal Intelligence** — **Princeton, NJ**
*Chief Scientist* — *2020-*

Claudius leverages Artificial Intelligence to process legal case data, identify key legal issues and produce data-driven valuations. I lead a team of researchers that works to advance Legal Artificial Intelligence through research in Trustworthy Machine Learning, Natural Language Processing and Data-driven Modeling.
**Funding/ Memberships:** NSF SBIR Grant (2021-), NSF Innovation Corps (2020), Creative Destruction Lab (AI Stream) at University of Toronto (2020), Princeton's Keller Center eLab Incubator and Accelerator (2020).

### Earlier Research Experience

**Max Planck Institute for Mathematics in the Sciences** **Leipzig, Germany**
*Student Researcher* *2015 - 2016*

Discrete Ricci curvature and applications in network analysis. Adviced by Jürgen Jost.

**TU Dresden/ CERN** **Dresden, Germany**
*Student Researcher* *Spring/ Summer 2016*

Event classification at CERN's ATLAS experiment with ConvNets. Advised by Michael Kobel.

**Cold Spring Harbor Laboratory, Stanley Institute** **Cold Spring Harbor, NY**
*Visiting Student* *Summer 2015*

Machine Learning methods for gene function prediction. Adviced by Jesse Gillis.

**Max Planck Institute for Evolutionary Anthropology** **Leipzig, Germany**
*Research Assistant* *2013 - 2014*

Statistical learning methods for identifying introgressed Neanderthal regions in the human genome. Adviced by Kay Prüfer.

## Publications & Preprints

∗ *alphabetic order* | # *co-first authors* | + *student supervised by me*

### Geometric Methods for Optimization and Machine Learning

18. **Riemannian Optimization via Frank-Wolfe Methods.** M. Weber, S. Sra. (2022+) Under Review at *Mathematical Programming* (minor revisions).
17. **Projection-free nonconvex stochastic optimization on Riemannian manifolds.** M. Weber, S. Sra. (2021) *IMA Journal on Numerical Analysis*, to appear.
16. **Robust large-margin learning in hyperbolic space.** M. Weber, M. Zaheer, A. Singh Rawat, A. Menon, S. Kumar. (2020) *Advances in Neural Information Processing Systems* (*NeurIPS*).
15. **Neighborhood Growth Determines Geometric Priors for Relational Representation Learning.** M. Weber. (2020) *Proceedings of the Twenty Third International Conference on Artificial Intelligence and Statistics* (*AISTATS*), PMLR 108:266-276.
14. **Forman's Ricci Curvature – From Networks to Hypernetworks.** E. Saucan#, M. Weber# (2019) *Seventh Conference on Complex Networks and Their Applications.* Appeared in: Studies in Computational Intelligence, vol 812. Springer, Cham.
13. **Curvature and Representation Learning: Identifying Embedding Spaces for Relational Data.** M. Weber, M. Nickel (2018) *NeurIPS Workshop on Relational Representation Learning.*
12. **Detecting the coarse geometry of networks.** M. Weber, E. Saucan, J. Jost. (2018) *NeurIPS Workshop on Relational Representation Learning.*
11. **Discrete Curvatures and Network Analysis.** E. Saucan, A. Samal, M. Weber and J. Jost (2018) *MATCH*, vol. 80 (3), pp. 605–622.
10. **Coarse Geometry of Evolving Networks.** M. Weber, E. Saucan and J. Jost (2018) *Journal of Complex Networks.* vol. 6(5), pp. 706-732.
9. **Characterizing Complex Networks with Forman-Ricci Curvature and Associated Geometric Flows.** M. Weber, E. Saucan and J. Jost. (2017) *Journal of Complex Networks*, vol. 5 (4), 527-550.
8. **Forman-Ricci Flow for Change Detection in Large Dynamic Data Sets.** M. Weber, J. Jost and E. Saucan. (2016) *Axioms.* Special issue on Discrete Geometry and Applications, vol. 5(4), 26.

### Learning with little data

7. **Controlling Unknown Linear Dynamics with Bounded Multiplicative Regret** J. Carruth∗, M. Eggl∗, C. Fefferman∗, C. Rowley∗, M. Weber∗ (2022+) *Revista Matemática Iberoamericana*, to appear.
6. **Optimal Control with Learning on the fly: A toy problem.** C. Fefferman∗, B. Guillen Pegueroles∗, C. W. Rowley∗, M. Weber∗. (2021) *Revista Matemática Iberoamericana*, vol. 37(1).

### Applied and Interdisciplinary Research

5. **Identifying biases in legal data: An algorithmic fairness perspective.** J. Sargent+, M. Weber. (2021) *ACM Conference on Equity and Access in Algorithms, Mechanisms, and Optimization* (*EAAMO*)

4. **Exploration of the sputum methylome and omics deconvolution by quadratic programming in molecular profiling of asthma and COPD: the road to sputum omics 2.0.** E. Groth, M. Weber, T. Bahmer, F. Pedersen, D. Börnigen, K. Rabe, H. Watz, O. Ammerpohl, T. Goldmann (2020) *Respiratory Research* 21:274.

3. **Curvature-based Methods for Brain Network Analysis.** M. Weber, J. Stelzer, E. Saucan, A. Naitsat, G. Lohmann, J. Jost (2017) *Technical Report*. arXiv: 1707.00180

2. **Estimating Memory Deterioration Rates Following Neurodegeneration and Traumatic Brain Injuries in a Hopfield Network Model.** M. Weber, P. D. Maia, J. N. Kutz (2017) *Frontiers in Neuroscience*, DOI: 10.3389/fnins.2017.00623.

1. **EGAD – Ultrafast Analysis of Genetic Networks.** S. Ballouz#, M. Weber#, P. Pavlidis, J. Gillis (2016) *Bioinformatics*, vol. 33 (4): 612-614.

## Patents

**Systems and Methods for Machine Learning in Hyperbolic Space** A. Singh Rawat, M. Zaheer, A. Menon, S. Kumar, M. Weber. *US Patent App. 17/227,817* (pending)

## Selected Communications

### Invited Talks

| | |
|---|---|
| Oxford, Numerical Analysis Seminar | 2022 |
| Simons Institute, Workshop "Optimization under Symmetry" | 2021 |
| KU Leuven Institute for Artificial Intelligence, Research Seminar | 2021 |
| INFORMS Annual Meeting, Session "Optimization on Manifolds" | 2021 |
| AMS Fall Western Sectional Meeting, Session "Theoretical & Applied Perspectives in ML" | 2021 |
| Simons Institute, "Meet the Fellows" Series | 2021 |
| Microsoft Research Montreal | 2021 |
| Oxford, Data Science Seminar | 2021 |
| SIAM Conference on Applied Linear Algebra, Session "Linear Algebra & Differential Geometry" | 2021 |
| Oxford, Networks Seminar | 2021 |
| Stitch Fix, Algo-Hour | 2021 |
| One World Seminar Series: Mathematics of Machine Learning | 2021 |
| Joint Mathematics Meeting, Session "Geometry in the Mathematics of Data Science" | 2021 |
| NeurIPS Workshop "Differential Geometry meets Deep Learning" | 2020 |
| Microsoft Research, Foundations of Machine Learning Seminar | 2020 |
| Stanford University, Hazy Lab | 2020 |
| Princeton University, Graduate Student Seminar | 2020 |
| Google Research, BigML Group | 2019 |
| EPFL, Applied Topology Seminar | 2018 |
| Max Planck Institute for Mathematics in the Sciences, Research Seminar | 2018 |
| New York Machine Learning Meetup | 2018 |
| MIT, Machine Learning Group | 2017 |

### Contributed Talks

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|---|---|
| Conference on Mathematical Theory of Deep Learning (DeepMath) | 2020 |
| Conference on Network Sciences (NetSci) | 2020 |
| International Conference on Artificial Intelligence and Statistics (AISTATS) | 2020 |
| Conference on Network Sciences (NetSci) | 2017 |
| Machine Learning on Networks (NetSci Satellite) | 2017 |
| Connectomics | 2017 |

## Honors & Awards

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|---|---|
| Alan Turing Post-Doctoral Enrichment Award | 2022 |
| Kovalevskaya Grant/ EPSRC Travel Grant, London Mathematical Society | 2022 |
| Rising Stars in EECS | 2021 |
| Simons-Berkeley Fellowship | 2021 |

Hooke Fellowship 2021
US Junior Oberwolfach Fellowship 2018
Microsoft Azure Research Award 2017
Dean's Grant, Princeton University 2016
C. V. Starr Fellowship, Princeton University 2016
Fellowship, Konrad Adenauer Foundation 2012

### Student Travel Grants

Joint Mathematics Meeting (2021), WiML (2021, 2019), NetSci (2020), IPAM (2018), ICERM (2017)

## Teaching

Completed comprehensive teaching training through **Princeton's Teaching Transcript**.

### Tutor/ Preceptor

**B6.2 Optimization for Data Science** (Oxford), two biweekly 90-minute section. Winter 2022
**ORF 350 Analysis of Big Data** (Princeton), biweekly 50-minute section. Spring 2021
**COS 126 Introduction to Computer Science** (Princeton), two weekly 80-minute sections. Fall 2018

### Teaching Assistant

Homework/ exam grading, held office hours.
**MAT 321/ APC 321 Numerical Methods** (Princeton) Fall 2020
**MAT 588/ APC 588 Optimization on Smooth Manifolds** (Princeton), graduate course Spring 2020
**MAT 103 Calculus** (Princeton) Fall 2017, Fall 2019
**ORF 407 Fundamentals of Queuing Theory** (Princeton) Spring 2018
**Numerical Methods** (University of Leipzig) Spring 2016

## Professional Activities

### Invited Participant

Program *Mathematics of Deep Learning*, Isaac Newton Institute, Cambridge UK (virtual) 2021
Program *Geometric Methods in Optimization and Sampling*, Simons Institute, Berkeley CA 2021
Workshop *Whitney Extension Problems* 2018, 2021
Oberwolfach Seminar *Mathematics of Deep Learning* 2018
Workshop *Woman in Data Science Research*, ICERM, Providence RI 2017

### Invited Panels

Florida Women in Mathematics Day 2022
NeurIPS Workshop "Differential Geometry meets Deep Learning" 2020

### Reviewing

**Journals:** Algorithmica, Axioms, Discrete & Computational Geometry, Entropy, Information and Inference, Mathematical Programming, PlosOne, Physica A
**Conferences:** Algorithmic Learning Theory (ALT, external), Conference on Decision and Control (CDC), International Conference on Learning Representations (ICRL), International Conference on Machine Learning (ICML), Neural Information Processing Systems (NeurIPS)

### Service and Outreach

**Oxford Data Science Seminar**, Organizer 2021 –
**ECR Committee, Oxford Mathematical Institute**, Member 2021 –
**Skype a Scientist**, Volunteer Scientist 2018 –
**WiML Un-Workshop at ICML**, Breakout session leader (Topic: Geometry and Machine Learning) 2021
**Mentoring Möbius**, Mentor for Princeton Undergraduate Mathematics Majors 2017 – 20
**Graduate Student Seminar**, Organizer 2016 – 17

## Software (publicly available)

**EGAD** Machine Learning Toolbox for Functional Analysis of Genetic Networks and Gene Function Prediction. *Bioconductor* R package (10.18129/B9.bioc.EGAD)

**Other** `https://github.com/MelWe`

**Languages** Python, R, Matlab,Java