

Mihai Nica

Email: nicam@uoguelph.ca. Website: [Link](#). Google Scholar: [Link](#). Last updated: Mar 2023

EMPLOYMENT

2020 - now Assistant Professor, University of Guelph
Vector Institute Faculty Affiliate
CARE-AI Faculty Affiliate

2019 - 2020 Postdoctoral Fellow, University of Toronto

2017 - 2019 NSERC Postdoctoral Fellow, University of Toronto

EDUCATION

2017 PhD, Courant Institute of Mathematical Sciences, New York University
Advisor: Gérard Ben Arous

2011 BMath, University of Waterloo, Canada
Recipient of the Faculty of Mathematics Alumni Gold Medal for academic excellence

REFEREED PUBLICATIONS

1. Floto G, Kremer S and **Nica M**. (2023).
“The exponentially tilted Gaussian prior for variational autoencoders”
International Conference on Learning Representations (ICLR) 2023. [Open Review link](#).
2. Mohammad N, Kraus D, Levere K M, **Nica M** and Okner R. (2023).
“Promoting engagement via engaged mathematics labs and supportive learning”
International Electronic Journal of Mathematics Education DOI [link](#).
3. Galloway A, Golubeva A, Salem M, **Nica M**, Ioannou Y and Taylor G. (2022).
“Bounding generalization error with input compression: An empirical study with infinite-width networks”
Transactions on Machine Learning Research. [OpenReview link](#).
4. Dauvergne D, **Nica M** and Virág B. (2022).
“Uniform convergence to the Airy line ensemble”
Preprint [arXiv:1907.10160](https://arxiv.org/abs/1907.10160), 49 pages.
To appear in *Annales de l'Institut Henri Poincaré (B) Probabilités et Statistiques*
5. Li M, **Nica M** and Roy D. (2022).
“The neural covariance SDE: Shaped infinite depth-and-width networks at initialization”
Conference on Neural Information Processing Systems (NeurIPS) 2022. [OpenReview link](#).
Oral-designated paper (Top 200 out of 2672 accepted papers)
6. Dauvergne D, **Nica M** and Virág B. (2022).
“RSK in last passage percolation: a unified approach”
Probability Surveys 19:65-112. DOI [link](#).
7. Li M, **Nica M** and Roy D. (2021).
“The future is log-Gaussian: ResNets and their infinite-depth-and-width limit at initialization”
Conference on Neural Information Processing Systems (NeurIPS) 2021. [OpenReview link](#).
8. **Nica M**. (2021).
“Intermediate disorder limits for multi-layer semi-discrete directed polymers”.
Electronic Journal of Probability, 26:1-50. DOI [link](#).

9. Martin C, Zhang H, Costacurta J, **Nica M** and Stinchcombe A. (2021).
“Solving elliptic equations with Brownian motion: Bias reduction and temporal difference learning”.
Methodology and Computing in Applied Probability, 24:1603-1626. DOI [link](#).
10. Han J, **Nica M** and Stinchcombe A. (2020).
“A derivative-free method for solving elliptic PDEs with deep neural networks”.
Journal of Computational Physics, 419. DOI [link](#).
11. **Nica M**, Quastel J and Remenik D. (2020).
“One-sided reflected Brownian motions and the KPZ fixed point”.
Forum of Mathematics, Sigma, 8:E63 DOI [link](#).
12. Hanin B and **Nica M**. (2020).
“Finite depth and width corrections to the neural tangent kernel”.
International Conference on Learning Representations (ICLR) 2020, [OpenReview link](#)
Spotlight Presentation (Top 155 out of 697 accepted papers).
13. **Nica M**, Quastel J and Remenik D. (2020).
“Solution of the Kolmogorov equation for TASEP”.
Annals of Probability, 48:2344–2358. DOI [link](#).
14. Hanin B and **Nica M**. (2020).
“Products of many large random matrices and gradients in deep neural networks”.
Communications in Mathematical Physics, 376:287–322. DOI [link](#).
15. Ben Arous G, Mei S, Montanari A and **Nica M**. (2019).
“The landscape of the spiked tensor model”.
Communications on Pure and Applied Mathematics, 72:2282–2330. DOI [link](#).
16. Corwin I and **Nica M**.(2017).
“Intermediate disorder directed polymers and the multi-layer extension of the stochastic heat equation”.
Electronic Journal of Probability, 22:1–49. DOI [link](#).
17. **Nica M**. (2017).
“Decorated Young tableaux and the Poissonized Robinson-Schensted process”.
Stochastic Processes and their Applications, 127:449–474. DOI [link](#).
18. **Nica M**. (2016).
“Optimal strategy in ‘Guess Who?’: Beyond binary search”.
Probability in the Engineering and Informational Sciences, 30: 576–592. DOI [link](#).
19. Funk J, **Nica M** and Noyes M. (2015).
“Stabilization time for a type of evolution on binary strings”.
Journal of Theoretical Probability, 28: 848–865. DOI [link](#).
20. **Nica M**. (2011).
“Eigenvalues and eigenfunctions of the Laplacian”.
The Waterloo Mathematics Review, 1: 23–34. [Direct link](#).

PUBLICATIONS IN PREPARATION

1. Jakub C and **Nica M**. (2023).
“Depth Degeneracy in Neural Networks: Vanishing Angles in Fully Connected ReLU Networks on Initialization ”
Preprint [arXiv:2302.09712](#), 37 pages.

2. Lasby M, Golubeva A, Evci U, **Nica M** and Ioannou Y. (2023)
“Dynamic Sparse Training with Structured Sparsity”
3. Mohammad N, Kraus D, Levere K M, **Nica M** and Okner R. (2021).
“Student experience using synchronous and asynchronous learning in mathematics classes”

GRANTS, FELLOWSHIPS AND OTHER FUNDING

- 2022 NSERC INTER-MATH-AI Grant**, Funding for graduate students working on mathematics of AI
- 2021-26 NSERC Discovery Grant**, *Random Matrix Limit Theorems for Deep Neural Networks*, \$130,000
- 2020-22** Sub-contractor on **Guaranteeing AI Robustness against Deception (GARD)**, DARPA grant, sub-contracted under Prof. Graham Taylor.
- 2021 PSEER Promoting Engagement Via Engaged Mathematics Labs and Supportive Learning** (joint with Prof. Nagham Mohammad and Prof. Kimberly Levere) \$4,000
<https://www.uoguelph.ca/ceps/news/2021/07/new-pseer-projects-improve-teaching>
- 2017-19 NSERC Postdoctoral Fellowship**, \$90,000. Held at the University of Toronto.
- 2011-16 MacCraken Fellowship**, New York University, support for PhD studies
- 2011 NSERC Canada Graduate Scholarship**, funding for PhD studies, [declined due to MacCraken]
- 2009 Arthur Beaumont Memorial Scholarship**, University of Waterloo, awarded to an outstanding student in the Applied Mathematics Department
- 2008-10 USRA Scholarship**, NSERC, awarded for undergraduate research (held three times)
- 2007-11 William T. Tutte National Scholarship**, one of sixteen national scholarships awarded to incoming students in the Faculty of Mathematics at the University of Waterloo

AWARDS & DISTINCTIONS

- 2020 Vector Institute Postgraduate Affiliate Program**, Vector Institute [declined due to Guelph faculty position]
- 2018 F. V. Atkinson teaching award**, honours outstanding teaching by post-doctoral fellows and other junior research faculty at the University of Toronto math department
- 2014 Harold Grad prize**, awarded for outstanding performance and promise as a graduate student by the Courant Institute.
- 2011 Alumni gold medal**, Awarded to one graduating student in the Faculty of Mathematics at the University of Waterloo in recognition of outstanding academic achievements
- 2010 Putnam competition**, ranked in the top 220 out of 4,296 contestants
- 2010,11 University of Waterloo applied math speaker award**, award for the best speaker among undergraduate researchers as voted by peers (awards in two consecutive years)
- 2008 President’s Research Award**, University of Waterloo, for undergraduate summer research

INVITED TALKS

- Dec 2022 The neural covariance SDE: shaped infinite depth-and-width networks at initialization**, NeurIPS 2022 deep dive session, New Orleans [Virtual]
- May 2022 Random matrix problems in deep neural networks**, Politechnika Warszawska [Virtual]
- Apr 2022 Random matrix problems in deep neural networks**, KTH, Sweden [Virtual]
- Feb 2022 How do infinitely large neural networks behave?**, Vector Institute, Toronto [Virtual]

- Mar 2021** **Log-normal behaviour in deep neural networks and products of random matrices**, Probability Seminar, University of Waterloo, Waterloo [Virtual]
- Jan 2020** **A neural network method for solving elliptic and parabolic PDEs**, Modelling and Computational Science seminar, Ontario Tech University, Oshawa
- Nov 2019** **Scaling limits of deep neural networks**, University of Guelph, Guelph
- Jul 2019** **Gradients of ReLU networks on initialization**, Workshop on Theoretical Advances in Deep Learning at Istanbul Center for Mathematical Sciences, Istanbul
- Jun 2019** **Phase transitions in random matrices and the spiked tensor model**, Fields Institute workshop on Applications to Random Matrices and Free Probability, Toronto
- Mar 2019** **Deep neural networks and products of random matrices**, Workshop on Free Probability: the applied perspective, Centre de Recherches Mathématiques, Montreal
- Nov 2018** **A central limit theorem for deep neural networks and products of random matrices**, Centre de Recherches Mathématiques Probability Seminar, Montreal
- Nov 2018** **A central limit theorem for deep neural networks and products of random matrices**, Fields Institute Probability Seminar, Toronto
- May 2018** **On the complexity of random functions**, Physics of Information Lab, Applied Math Department, University of Waterloo
- Mar 2018** **Phase transitions in the spiked tensor model**, Colloquium, Department of Mathematics and Statistics, Queen's University
- Jan 2018** **Phase transitions in the spiked tensor model**, Fields Institute Probability Seminar, Toronto
- May 2017** **Intermediate disorder limits for multi-layer random polymers**, University of Wisconsin Madison Probability Seminar
- Feb 2017** **Intermediate disorder limits for multi-layer random polymers**, Northwestern University Probability Seminar
- Jan 2017** **Intermediate disorder limits for multi-layer random polymers**, Probability Seminar at the Centre de Recherches Mathématiques, Montreal
- Sep 2016** **Intermediate disorder limits for multi-layer random polymers**, Toronto Probability Seminar at the Fields Institute, Toronto
- Apr 2016** **Intermediate disorder directed polymers and the multi-layer stochastic heat equation**, Finger Lakes Probability Seminar at Cornell University
- Nov 2015** **Convergence of non-intersecting random walks**, AMS Sectional Meeting (special session on "Probability, Combinatorics, and Statistical Mechanics") at Rutgers University
- May 2015** **Three ways to think about a certain model of vicious walkers**, Clay Math Institute Workshop on Random Polymers and Algebraic Combinatorics at University of Oxford
- Nov 2014** **Exactly solvable Young diagram processes related to last passage percolation**, Northeast Probability Seminar at Columbia University
- Nov 2014** **Exactly solvable Young diagram processes related to last passage percolation**, Cornell Probability Seminar at Cornell University
- Jul 2014** **Exactly solvable Young diagram processes related to last passage percolation**, Seminar on KPZ at the University of California, Berkeley

OTHER PRESENTATIONS

- Oct 2020** **Computing moments of deep neural nets**, One World Probability Symposium, Online Conference [Virtual]
- Aug 2019** **Adapting Inquiry Based Learning questions for large classrooms**, MAA Mathfest, Cincinnati

- Aug 2019 Starting a Calculus Community of Practice**, with Sarah Mayes-Tang, MAA Mathfest, Cincinnati
- Feb 2019 Overfitting and Regularization**, Ritual Technology Co. Data Science Workshop, Toronto
- Aug 2018 Gradients of neural nets and products of random matrices**, Poster presentation at workshop “Statistical Physics and Machine Learning back together”, Institut d’Études Scientifiques de Cargèse, Corsica
- July 2017 Intermediate disorder limits for multi-layer random polymers**, Poster presentation at Park City Math Institute Random Matrices Workshop
- Nov 2016 Intermediate disorder limits for multi-layer random polymers**, Guest lecturer for advanced topics graduate course, University of California, Berkeley
- Sep 2016 Intermediate disorder limits for multi-layer random polymers**, Poster presentation, conference on “Quantum integrable systems, conformal field theories and stochastic processes” at Institut d’Études Scientifiques de Cargèse, Corsica
- Jul 2015 Random processes from the Robinson-Schensted-Knuth correspondence**, CRM-PIMS summer school at McGill University
- Jul 2014 Poissonized Robinson-Schensted tableaux**, Cornell Probability Summer School

UNREFEREED NOTES AND VIDEO PRESENTATIONS

- Aug 2022 Heads-Tails and Heads-Heads are different?**
The ABRACADABRA Theorem for coin flips and dice
 Video (~ 20 min) [YouTube link](#).
 Top100 finalist in 3Blue1Brown Summer of Math Exposition Contest 2022
 (Top 100 out of ~ 1000 entries)
- Jul 2022 Introduction to Infinite Neural Networks and the Neural Tangent Kernel**
 Video series (~ 3 hours): These notes were used for a 4 week mini-course given at the Vector Institute in Summer 2022.
[YouTube link](#). Notes: [PDF link](#)
- Aug 2021 Why is pi here? Find π by Buffon’s needle noodle!**
 Video (~ 10 min) [YouTube link](#).
 Honourable mention in 3Blue1Brown Summer of Math Exposition Contest 2021
 (Top 30 out of ~ 1200 entries)
- Jun 2021 Introduction to Infinite Depth-and-Width Limits of Deep Neural Networks**
 Video (~ 30 min): [YouTube link](#). Notes: [PDF link](#)
- Apr 2021 Binet’s formula for the Fibonacci Numbers**
 Videos (~ 1 hour): [YouTube link](#). Notes: [PDF link](#) and [link](#).
 (Aimed at advanced high school/early undergrad audience)

HIGHLY QUALIFIED PERSONNEL TRAINING

UNDERGRADUATE RESEARCH SUPERVISION

2022 A simple version of AlphaZero: Learning with self play in Connect Four

Student: Sam Vermeulen

Creating an AI agent that learns to play Connect 4 through a simplified version of the AlphaZero algorithm. Research done for advanced undergraduate research project MATH*4600. Sam wants to continue on to do an MSc at Guelph. Code available at <https://github.com/sam-vermeulen/connectfourproject>.

2022 Fields Undergraduate Summer Research Program (FUSR): Boundary Integral Equations with Random Walks and Reinforcement Learning.

(Joint supervision with Prof. Adam Stinchcombe, University of Toronto)

Students: Quinn Arbolante, Charles Beal, Amandin Chyba, Diba Heydari

Research on combining properties of random walks and ML methods to obtain numerical solutions to certain PDEs.

2021 University of Guelph URA: Path Counting Approaches to Neural Net Architecture Search.

Student: Valeria Telles

Research on using mathematical techniques to predict properties of neural network architectures. Valeria plans to stay at the University of Guelph for an MSc with an anticipated start date of F22.

2021 University of Guelph URA: Generalized Nash Games and AI methods.

Co-supervision with Prof. Monica Cojocaru.

Student: Nickolas Hoover

Research on applying neural network methods to generalized Nash games.

2021 University of Guelph URA: Exponentially tilted Gaussian autoencoders.

(Informal mentorship and collaboration).

Student: Griffin Floto

Research on improving autoencoders and out of distribution detection for neural networks using exponentially tilted Gaussian priors. This project continued a project that Griffin began with Professor S Kremer and began spontaneously when Griffin reached out to me. This led to a submitted publication # 19.

2019 Fields Undergraduate Summer Research Program (FUSR): Machine Learning Methods for Numerical Solutions of Partial Differential Equations.

(Joint supervision with Prof. Adam Stinchcombe, University of Toronto)

Students: Cameron Martin, Hongyuan Zhang and Julia Costacurta

FUSR is a competitive undergraduate research Funded by the Fields institute. I co-supervised a team of three undergraduate students. Our work led to the publication of the paper as #4 listed in publications.

GRADUATE STUDENT SUPERVISION

- PhD** Courtney Allen. F22-now. Co-supervised with Prof. Hermann Eberl.
Using numerical methods to solve the anaerobic digestion model 1 with the inclusion of biofilms
- MSc** Valeria Telles. F22-now. Co-supervised with Prof. Bill Smith.
Developing AI methods to speed up the search for more effective CO₂ capture solvents.
- MSc** David Lyver. W22-now. Co-supervised with Prof. Monica Cojocaru.
Developing AI methods to predict and understand disease spread.
- PhD** Matthew Kreitzer. W22-now. Co-supervised with Prof. Rajesh Pereira.
Generalization of DeBruijn Sequences
- MSc** Cam Jakub. F21-now. *Recipient of the Vector Scholarships in Artificial Intelligence.*
Research on fluctuations of the Neural Tangent Kernel and limits of deep neural networks.

TEACHING ACTIVITIES

AWARDS

- 2018 F. V. Atkinson teaching award**, honours outstanding teaching of post-doctoral fellows and other junior research faculty at the University of Toronto math department.

COURSES TAUGHT

Winter 2023 Instructor & coordinator, MATH*1030, Business Mathematics, University of Guelph

Fall 2022 Instructor, DATA*6100

Introduction to Data Science, University of Guelph.

My code examples for this course available at [GitHub link](#)

Winter 2022 Instructor, MATH*4060/MATH*6181

Topics in Math: Introduction to Reinforcement Learning, University of Guelph.

My code examples for this course available at [GitHub link](#)

Fall 2020, 21 Instructor & coordinator, MATH*1200, Calculus 1, University of Guelph

Winter 2019, 20 Instructor & coordinator, MAT234, Differential Eqns for Mech. Eng., University of Toronto

Winter 2019 Instructor, MAT223, Linear Algebra 1, University of Toronto

Fall 2018 Instructor, MAT135, Calculus 1A, University of Toronto

Winter 2018 Instructor, MAT136, Calculus 1B, University of Toronto

Fall 2017 Instructor, MAT135, Calculus 1A, University of Toronto

Summer 2016 Instructor, Math-UA.121, Calculus I, New York University

OTHER TEACHING ACTIVITIES

Spring 2021 University of Guelph Virtual Interaction Conference on *Mysteries of the Fibonacci numbers*.

Fall 2019 Instructor, MAT1128HF, Topics in Probability. Introduction (6 hours of lectures) to a graduate course (11 students) on KPZ universality, University of Toronto. Notes available at https://www.math.toronto.edu/mnica/KPZ_notes.pdf

Fall 2019 TA Training Coordinator, organize and run training workshops for 100 TAs at the University of Toronto

Fall 2019 “Active Learning 101: A guide for new instructors in large classrooms”, co-author (with Yvon Verberne and Melissa Emory) of a 17 page guide to creating active learning questions that work well in large classrooms. Available at http://www.math.toronto.edu/mnica/CoP_Guide.pdf

Summer 2019 “Adapting Inquiry Based Learning questions for large classrooms”, Presentation at MAA Mathfest, Cincinnati

Summer 2019 “Starting a Calculus Community of Practice”, with Sarah Mayes-Tang, Presentation at MAA Mathfest, Cincinnati

2018-2019 Facilitator: Teaching Community of Practice, organized and facilitated a Community of Practice for early career instructors at the University of Toronto

2012-14 Volunteer Instructor for Courant Splash (annual outreach program for high school students) <http://www.math.toronto.edu/mnica/csplash.html>