MANUELA GIROTTI

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Current position

Saint Mary's University 07/2021–now
Department of Mathematics and Computing Science, Halifax, NS
Assistant Professor

Professional Affiliations

Isaac Newton Institute for Mathematical Sciences 07/2022–12/2022
University of Cambridge, UK
Research Member, Simons Foundation Fellowship

Simons Laufer Mathematical Sciences Institute (SLMath) 08/2021–12/2021
(former Mathematical Sciences Research Institute - MSRI)
University of California – Berkeley, CA
Research Member

Mila – Québec Artificial Intelligence Institute 08/2021–now
Université de Montréal, Montréal, QC
Associate Member / Collaborator

Concordia University 10/2017–now
Department of Mathematics and Statistics, Montréal, QC
Affiliate Assistant Professor

Past positions

Mila – Québec Artificial Intelligence Institute 08/2020–06/2021
Université de Montréal, Montréal, QC
Postdoctoral Fellow

John Abbott College 03/2019–01/2020
Department of Mathematics, Sainte-Anne-de-Bellevue, QC
Mathematics professor

Colorado State University 01/2017–12/2018
Department of Mathematics, Fort Collins, CO
Postdoctoral Fellow

Institut de Recherche en Mathématique et Physique 11/2014–10/2016
Université catholique de Louvain, Louvain-la-neuve, Belgium
Postdoctoral Fellow / Assistante de recherche

Education

Concordia University, Montréal, QC Canada 2010–2014
Ph.D. in Mathematics, supervisor Prof. Marco Bertola
Thesis title: *"Riemann-Hilbert approach to Gap Probabilities of Determinantal Point Processes"*.
External examiner: Prof. Alexander R. Its (IUPUI). Thesis ranking: excellent.

Università degli Studi di Milano, Milan, Italy 2008–2010
Laurea Magistrale (M.Sc.) in Mathematics, supervisor Prof. Elisabetta Rocca
Thesis title: *"Time relaxation of a phase-field model with entropy balance"*.

Thesis grade: 110/110 *cum laude**.

Università degli Studi di Milano, Milan, Italy 2005–2008
Laurea Triennale (B.Sc.) in Mathematics, supervisor Prof. Silke (Dietmar) Klemm
Thesis title: *"Dirac's magnetic monopole"*.
Thesis grade: 110/110 *cum laude**.

Math Publications

- "Universality and Law of Large Numbers of a random N-soliton KdV potential", in preparation (with K. McLaughlin).
- "Soliton versus the gas: Fredholm determinants, analysis, and the rapid oscillations behind the kinetic equation", *arXiv:2205.02601*, submitted (with T. Grava, R. Jenkins, K. McLaughlin and A. Minakov).
- "Rigorous asymptotics of a KdV soliton gas", *Comm. Math. Phys.*, 384, 2021 (with T. Grava, R. Jenkins and K. McLaughlin).
- "Fredholm determinant solutions of the Painlevé II hierarchy and gap probabilities of determinantal point processes", *Internat. Math. Res. Notices*, rnz168, 2019 (with T. Claeys and M. Cafasso).
- "Large gap asymptotics at the hard edge for product random matrices and Muttalib-Borodin ensembles", *Internat. Math. Res. Notices*, rnx202, 2017 (with T. Claeys and D. Stivigny).
- "Riemann-Hilbert approach to gap probabilities for the Bessel process", *Phys. D*, 295-296C, 103-121, 2015.
- "Asymptotics of the Tacnode process: a transition between the gap probabilities from the Tacnode to the Airy process", *Nonlinearity* **27**, 1937-1968, 2014.
- "Riemann-Hilbert approach to gap probabilities for the Generalized Bessel process", *Math. Phys. Anal. Geom.* **17** (1), 183-211, 2014.
- "Vanishing time-relaxation for a phase-field model with entropy balance", *Adv. Math. Sci. Appl.*, 22(**2**), 553-575, 2012.

ML Publications

- "Neural Networks Efficiently Learn Low-Dimensional Representations with SGD", *arXiv:2209.14863*, submitted (with M. Erdogdu, I. Mitliagkas, A. Mousavi, S. Park).

  Spotlight presentation at the workshop on Optimization for Machine Learning OPT 2022 - NeurIPS.
- "Convergence Analysis and Implicit Regularization of Feedback Alignment for Deep Linear Networks", *arXiv:2110.10815*, submitted (with G. Gidel, I. Mitliagkas).

  Spotlight talk at the workshop Beyond First-Order Methods in ML Systems - ICML 2021.
- "A study of condition numbers for first-order optimization", *Proceedings of The 24th International Conference on Artificial Intelligence and Statistics*, PMLR 130:1261-1269, 2021 (with C. Guille-Escuret, B. Goujaud and I. Mitliagkas).

  Spotlight presentation and *Student Paper Award* at the workshop on Optimization for Machine Learning OPT 2020 - NeurIPS.

*Performance in the final examination is graded from 66 to 110. A *cum laude* can be added to the maximum grade as a special distinction.

Grants

- *NSERC Discovery Grant – Early Career Researcher*, 2022–2027;
  project title: "Integrable Probability and Universality in Mathematical Physics and Machine Learning".
  role: Principal Investigator.
- *University Grant in Aid of Research* of Saint Mary's University, 2021–2022;
  project title: "Integrable Probability Models".
  role: Principal Investigator.
- *CIFAR AI Catalyst Grant*
  with Ioannis Mitliagkas (Mila, Université de Montréal) and Murat Erdogdu (Vector Institute, University of Toronto), 2020–2022;
  project title: "Rethinking generalization and model diagnostics in modern Machine Learning".
  role: co-applicant.

Student supervision

- supervisor of one NSERC USRA student, Saint Mary's University, Summer 2022;
  project title: "The Aztec Diamond: enumeration, random tilings and integrable probability";
  contributed talk at the Mathematics Science Atlantic Conference 2023.
- supervisor for a Honor project of the course MATH 345, Colorado State University, Spring 2018;
  project title: "The Van der Pol oscillator".

Teaching activities

- MATH 2303 - Differential Equations I (*course coordinator)*, Saint Mary's University, Spring 2023;
- MATH 3441 - Real Analysis I, Saint Mary's University, Fall 2022;
- MATH 3406 - Differential Equations II, Saint Mary's University, Spring 2022;
- MATH 4442 - Real Analysis II, Saint Mary's University, Spring 2022;
- MATH 3441 - Real Analysis I, Saint Mary's University, Fall 2021;
- MATH 015 - Algebra&Trigonometry, John Abbott College, Winter 2019 and Fall 2019;
- MATH NYB - Calculus II, John Abbott College, Winter 2019 and Fall 2019;
- MATH 530 - Mathematics for Scientists and Engineers, Colorado State University, Fall 2018;
- MATH 345 - Differential Equations (Honors option), Colorado State University, Spring 2018;
- MATH 317 - Advanced Calculus of one variable, Colorado State University, Fall 2017;
- MATH 369 - Linear Algebra I, Colorado State University, Spring 2017;
- MATH 201 - Elementary Functions, Concordia University, Fall 2013;
- technical assistant of WeBWorK for the courses MATH 200, 201, 202, 203, 204, 205, Concordia University, Fall 2012 - Summer 2014;
- MATH 205 - Differential and Integral Calculus II, Concordia University, Winter 2011 and Fall 2011.

Invited lectures

- lectures on Random Matrix Theory, Saint Mary's University, Spring 2022;
- lectures on Determinantal Point Processes and Random Matrices, Tulane University, Fall 2019;
- lectures on Determinantal Point Processes and Random Matrices, Colorado State University, Fall 2017.

Service activities

- member of the scientific and organizing committee for the PIICQ Annual Meeting (Probabilités Intégrables, Intégrabilité Classique et Quantique), Angers, May 2023.
- member of the hiring committee (comité de sélection) at Université d'Angers (France), Spring 2022.
- co-organizer of the T-time seminar and social meetings, Saint Mary's University, 2022–now.
- member of the Students selection Committee, Mila Insitute, 2020–2021.
- organizer of the Job Market Panel Series, Mila Institute, 2020–2021.
- Lab Representative, Mila Institute, 2020–2021.
- organizer of the Postdoc Seminar series, Colorado State University, 2017–2018.
- organizer of seminar series of the Mathematical Physics group, UC Louvain, 2015–2016.
- organizer of the Graduate Students Seminar series, Concordia University, 2012–2013.
- member of the Departmental Appraisal Committee, Concordia University, 2012–2013.
- president of the Mathematics&Statistics Graduate Students Association (MASGSA) and Graduate Students Representative, Concordia University, 2011–2013.

Editorial activities

Referee to the following journals:

- SIAM Journal on Mathematical Analysis
- Annales Henri Poincaré
- Symmetry, Integrability and Geometry: Methods and Applications (SIGMA)
- Journal of Machine Learning Research
- European Physical Journal Plus
- Communications in Mathematical Physics

Referee to the following (Machine Learning) conferences:

- Conference on Neural Information Processing Systems 2021 (NeurIPS), workshop Optimization for Machine Learning
- International Conference on Learning Representations 2022 (ICLR), Blog Post Track

Academic outreach

- coordinator of the Halifax pod (local chapter) of the network "500 Women Scientists", 2022–ongoing.
- organizer of the Math outreach event "Mathematics down to Earth", during the Science Literacy Week, Saint Mary's University, 2022.
- invited panelist to the event "Work/life balance in academia", within the Connection and Introductory Workshop: Universality and Integrability in Random Matrix Theory and Interacting Particle Systems, MSRI, Berkeley (CA), 2021.
- invited talk *"Solitons 101"* at $(MD)^2$ Math Day, John Abbott College, 2019.
- invited talk *"A Peek into the Math world: randomness and matrices"* for the International Presidential Fellow program, 2018.
- volunteer for Math Day 2017 and Math Day 2018, Colorado State University, 2017–2018.
- co-organizer of the Mathematics installations at Exposcience - Stewart Hall Science&Technology Exhibition (Concordia University), Pointe-Claire (QC), 2012–2013.
- invited talk *"A Peek into the Math world: from abstraction to applications"* at the Institut Italien de Culture de Montréal, 2012.

Mentoring

- mentor for the Association for Women in Mathematics (AMW).

Certifications

Mental Health Commission of Canada 2021–now
Mental Health First Aider

Membership

Member of the following associations:
- Canadian Mathematical Society (CMS)
- American Mathematical Society (AMS)
- Society for Industrial and Applied Mathematics (SIAM)

Academic visits

(for periods going from one to four weeks)

- May 2022, Université d'Angers (France), upon invitation of Prof. Mattia Cafasso.
- February 2022, Colorado State University (CO), upon invitation of Prof. Ken McLaughlin.
- August 2020, visitor of École de Physique des Houches (France) during the workshop *Statistical Physics and Machine Learning*.
- June 2018, SISSA (Italy), upon invitation of Prof. Tamara Grava.
- October 2019, Tulane University (LA), upon invitation of Prof. Victor Moll.
- May 2018, Université catholique de Louvain (Belgium), upon invitation of Prof. Tom Claeys.
- June 2017, SISSA (Italy), upon invitation of Prof. Marco Bertola and Prof. Tamara Grava.
- May 2015 and February 2016, Université d'Angers (France), upon invitation of Prof. Mattia Cafasso.
- March 2014, Université catholique de Louvain (Belgium), upon invitation of Prof. Tom Claeys.
- June 2012, *PIMS-Mprime Summer School in Probability*, University of British Columbia (Canada).

Scholarships and awards

2000–2005 (high school)

- SKF Industrie S.p.A. scholarship, 2000–2005.
- 2nd qualified for Certamen Taurinense (Latin literature provicial competition), May 2005.

2005–2008 (undergraduate)

- Fondo per il sostegno dei giovani e per favorire la mobilità degli studenti (partial tuition waiver), Università degli Studi di Milano, 2005–2008.

2010–2014 (doctorate)

- Faculty of Arts&Science Graduate Fellowship, Concordia University, 2010–2013.
- Concordia University Partial Tuition Graduate Scholarship for International Students, Concordia University, 2010–2011.
- ISM Scholarship, Institut des Sciences Mathématiques (ISM, Montréal), 2011–2012.
- ISM Travel Scholarship, Institut des Sciences Mathématiques (ISM, Montréal), June 2011;
- Exemption des frais de scolarité supplémentaires (MEQ), Ministère de l'Éducation, du Loisir et du Sport du Québec, 2011–2013.
- Concordia Merit Scholarship, Concordia University, 2012–2013.
- Campaign for a New Millennium Graduate Scholarship - Faculty of Arts&Science, Concordia University, 2013-2014.
- Concordia Accelerator Award, Concordia University, 2014.

2017–2018 (postdoc)

- International Presidential Fellow program, Colorado State University, 2017–2018.
- SIAM OPSFA (Orthogonal Polynomials and Special Functions) bursary, 2017.

2019 (college professor)

- Professional Development funding, John Abbott College, 2019.

2021–... (assistant professor)

- Simons Foundation Fellowship, Isaac Newton Institute, Cambridge (UK), 2022.

Status

Italy - citizen, **Canada** - permanent resident.

Computer skills

Languages: Python, Java, C++, HTML, Perl.
Software: WebWork, MatLab, LaTeX, Maple.
Python libraries: PyTorch, SciKitLearn, Numpy, Matplotlib, Pandas.

Languages

- Italian (native)
- English (full professional proficiency, C2)
- French (full professional proficiency, C2)

Conferences talks (Math)

- *Random matrices, random solitons, and random rational functions, and soliton gasses*, special session "Orthogonal Polynomials and Applications" during the Joint Mathematics Meeting, Boston (MA), 2023.
- *Random matrices, random solitons, and soliton gasses*, XVIII Brunel–Bielefeld Workshop on Random Matrix Theory, Brunel (UK), 2022.
- *The dynamics soliton gasses: Fredholm determinants, asymptotics, and kinetic equations*, special session "Recent advances on nonlinear evolution equations" during the Canadian Mathematical Society winter meeting, Toronto (ON), 2022.
- *Soliton versus the gas: Fredholm determinants, asymptotics, and kinetic equations*, "Analysis of dispersive systems" workshop, Isaac Newton Institute, Cambridge (UK), 2022.
- *Soliton versus the gas: Fredholm determinants, asymptotics, and kinetic equations*, 2022 SIAM Conference on Nonlinear Waves and Coherent Structures, session on "Recent Advances on Integrable Nonlinear Wave Equations", Bremen (Germany), 2022.
- *Soliton v. the gas: Fredholm determinants, analysis, and finer details*, "Women in Dispersive Hydrodynamics" workshop, Isaac Newton Institute, Cambridge (UK), 2022.
- *Soliton v. the gas: Fredholm determinants, analysis, and the rapid oscillations behind the kinetic equation*, workshop "Excursions in Integrability", SISSA, Trieste (Italy), 2022.
- *Fredholm Determinant Solutions of the Painlevé II Hierarchy and Gap Probabilities of Determinantal Point Processes*, Connections Workshop: Universality and Integrability in Random Matrix Theory and Interacting Particle Systems, MSRI (UC Berkeley), 2021.
- *A KdV soliton gas: asymptotic analysis via Riemann–Hilbert problem*, workshop New horizons in dispersive hydrodynamics -virtual-, Isaac Newton Institute, Cambridge (UK), 2021.
- *A KdV soliton gas: asymptotic analysis via Riemann–Hilbert problem*, workshop Integrable Systems in Newcastle -virtual-, Newcastle (UK), 2021.
- *Fredholm Determinant Solutions of the Painlevé II Hierarchy and Gap Probabilities of Determinantal Point Processes*, CRM Mathematical Physics Lab virtual seminar series, Montréal (QC), 2020.
- *Rigorous asymptotics of a KdV soliton gas*, workshop "Analysis of dispersive systems", Isaac Newton Institute for Mathematical Sciences, Cambridge (UK), 2020 *(cancelled due to COVID-19)*.

- *Fredholm Determinant Solutions of the Painlevé II Hierarchy and Gap Probabilities of Determinantal Point Processes*, SIAM annual meeting, Toronto (ON), 2020 *(cancelled due to COVID-19)*.
- *A KdV soliton gas: asymptotic analysis via Riemann–Hilbert problems*, Midwestern Workshop on Asymptotic Analysis, Indiana University, Bloomington (IN), 2018.
- *Rigorous asymptotics of a KdV soliton gas*, International Conference in Mathematical Physics, Montréal (QC), 2018.
- *Rigorous asymptotics of a KdV soliton gas*, workshop "Hamiltonian systems & applications", Università degli Studi Milano-Bicocca, Milano (Italy), 2018.
- *Rigorous asymptotics of the soliton gas*, special session "Probabilistic Models in Mathematical Physic" at the AMS Spring Meeting, Vanderbilt University, Nashville (TN), 2018.
- *Asymptotics of gap probabilities via Riemann-Hilbert approach*, AMS Joint Mathematics Meeting, San Diego (CA), 2018.
- *Integrable gap probabilities for the Generalized Bessel process*, workshop "Painlevé Equations and Applications: A Workshop in Memory of A. A. Kapaev", Michigan Center for Applied and Interdisciplinary Mathematics (MCAIM), Ann Arbor (MI), 2017.
- *Smallest singular value distribution and large gap asymptotics for products of random matrices*, 14th International Symposium on Orthogonal Polynomials, Special Functions and Applications (OPSFA14), University of Kent (UK), 2017.
- *"Integrable" gap probabilities for the Generalized Bessel process*, workshop "Painlevé Equations and Discrete Dynamics", Banff International Research Station (BIRS), 2016.
- *Smallest singular value distribution and large gap asymptotics for products of random matrices*, workshop "Six-vertex model, dimers, shapes, and all that", Simons Center for Geometry and Physics, Stony Brook University (NY), 2016.

Colloquium and seminars (Math)

- *The dynamics of random KdV solitons and soliton gasses*, Applied Mathematics Colloquium, Fields Institute, Toronto (ON), 2022.
- *Asymptotic Analysis of the Interaction Between a Soliton and a Regular Gas of Solitons (a.k.a. Gulliver and the Lilliputians)*, AARMS Analysis-Applied Math-Physics seminar, Dalhousie University, Halifax (NS), 2022.
- *Asymptotic Analysis of the Interaction Between a Soliton and a Regular Gas of Solitons (a.k.a. Gulliver and the Lilliputians)*, Integrable Systems and Random Matrix Theory seminar series -virtual-, University of Michigan, Ann Arbor (MI), 2021.
- *Fredholm Determinant Solutions of the Painlevé II Hierarchy and Gap Probabilities of Determinantal Point Processes*, CRM Mathematical Physics Lab virtual seminar series, Montréal (QC), 2020.
- *Fredholm Determinant Solutions of the Painlevé II Hierarchy and Gap Probabilities of Determinantal Point Processes*, Orthogonal Polynomials, Special Functions, Operator Theory and Applications (OPSFOTA) virtual seminar series, 2020.
- *Waves and solitons: the case of a Korteweg-de Vries solitonic gas*, Departmental Colloquium at Tulane University, New Orleans (LA), 2019.
- *Smallest singular value distribution and large gap asymptotics for products of random matrices*, Integrable Systems and Random Matrix Theory seminar series, University of Michigan (MI), 2017.
- *Riemann-Hilbert approach to Gap Probabilities of Determinantal Point Processes*, Classical Analysis seminar, KU Leuven (Belgium), 2015.
- *Gap Probabilities of the Tacnode process*, Mathematical Physics seminar, Centre de Recherche Mathématiques (CRM), Montréal, 2014.

- *Gap probabilities and Isomonodromic τ-function: from integrable systems to non-intersecting Brownian motion*, Mathematical Physics seminar, Università degli Studi Milano-Bicocca, Milan (Italy).

Conference talks (ML)

- *Neural Networks Efficiently Learn Low-Dimensional Representations with SGD*, special session "Mathematics of Machine Learning" during the Canadian Mathematical Society winter meeting, Toronto (ON), 2022.
- *Convergence Analysis and Implicit Regularization of Feedback Alignment for Deep Linear Networks*, special session "Scientific Machine Learning" during the Canadian Mathematical Society summer meeting, Memorial University of Newfoundland, St. John's (NL), 2022.
- *Convergence Analysis and Implicit Regularization of Feedback Alignment for Deep Linear Networks*, Beyond First-Order Methods in ML Systems workshop -virtual-, International Conference on Machine Learning, 2021.
- *Condition numbers for first-order optimization*, East Coast Optimization Meeting -virtual-, Fairfax (VA), 2021.
- *A note on condition numbers of first-order optimization*, at the workshop "Statistical Physics and Machine Learning", École de Physique des Houches (France), 2020.

Colloquium and seminars (ML)

- *Physics Informed Neural Networks and Dispersive PDEs*, Early Career Researchers meetings, Isaac Newton Institute, Cambridge (UK), 2022.
- *Convergence Analysis and Implicit Regularization of Feedback Alignment for Deep Linear Networks*, LightOn AI Meetup -virtual-, Paris, 2021.
- *Random Matrix Theory for uninitiated (and ML applications)*, Montréal Machine Learning and Optimization (MTL MLOpt), Montréal, 2020.

Other outreach

- volunteer at the nonprofit restaurant FoCo Cafe, Fort Collins (CO), 2017–2018.
- volunteer at the events Café Scientique 2012 and Café Scientique 2013 (sponsored by CIHR – McGill University Health Center; organized by Comunità Scientifica Italiana in Canada), Montréal, 2012–2013.
- volunteer for the project "Test di usabilità sulla Biblioteca Digitale dell'Università degli Studi di Milano" (test of usability of the university Digital Library), Milano, 2010.
- volunteer at the event amfAR Milano 2009, amfAR - The Foundation for AIDS research, Milano, 2009.
- journalist for the high-school magazine "Il Salice", Torino, 2000–2005.

Other interests

- sailing:
  Passeport Voile, Niveau 3 Croisière, Fédération Française de Voile, 2019,
  Pleasure Craft Operator Card, Transport Canada, 2021;
- singing: part of the following choirs as alto singer
  Schola Gregoriana Mediolanensis (2009–2010),
  Stella Matutina (2014–2016),
  Concordia University Choir (2010–2014 and 2019–2020),
  Dalhousie Collegium Cantorum (2022–now);
- skiing (nordic and downhill):
  SKF Ski competition, category "Junior Women", Sestriere (Italy), 2000;
  Valsalice Ski competition, category "Women", Sestriere (Italy), 2001;
  Canadian Ski Marathon, category "Randonneur/Tourer", 2021.