Calum MacRury

Contact Information

Columbia University
Graduate School of Business
Kravis Hall
655 West 130th Street
New York, NY 10027

`https://cmacrury.github.io/`
`cm4379@columbia.edu`

Research Interests

I am interested in algorithm design under uncertainty. This includes:

- **Online algorithms**
- **Stochastic probing and optimization**
- **Prophet inequalities and contention resolution schemes**

I am especially interested in these settings in relation to the classic maximum matching problem.

I have also worked on a number of other topics which intersect between discrete math and probability theory:

- **Adaptive random graph processes**
- **Discrepancy theory of random set systems**
- **Graph limits via Benjamini-Schramm convergence**

Education

University of Toronto

Toronto, Ontario
Ph.D. in Computer Science, Sept. 2018- Feb. 2023

- Dissertation: Online Decision-Making in a Randomized Environment: Stochastic Matching and Adaptive Random Graph Processes
- Supervisor: Dr. Allan Borodin

McGill University

Montreal, Quebec
Master's of Science, Mathematics, 2016-2018

- Dissertation: Approximation Algorithms for Network Flow and Minimum Cut Problems
- Supervisor: Dr. Dmitry Jakobson

Dalhousie University

Halifax, Nova Scotia
Bachelor of Science, Honours in Mathematics with a Minor in Computer Science, 2012-2016

- Honour's Thesis: The Spectral Theorem
- Supervisor: Dr. Keith Taylor

Employment History

Columbia University, Graduate School of Business

Postdoctoral Research Scholar
New York, New York

March 2023 – Present

- Postdoctoral research position supervised by Dr. Will Ma in the Decision, Risk, and Operations (DRO) division.
- Work on problems in online matching with a focus on prophet inequalities and online contention resolution schemes.

Toronto Metropolitan University, Department of Mathematics

Toronto, Ontario
May 2021 – August 2021

- Research internship supervised by Dr. Paweł Prałat.
- Worked on an agent-based empirical model for simulating the spread of contagious diseases in an urban environment.
- Personally focused on analyzing a simpler theoretical model using tools from probability theory.

Chatter Research

Toronto, Ontario
Summer 2018–January 2021

- Research scientist on a part-time consultant basis.
- Analyzed customer service data trends using regression models.

Toronto Metropolitan University, Department of Mathematics

Toronto, Ontario
Summer 2014, 2015 and 2016

- Research assistant for Dr. Paweł Prałat from 2014-2015, and Dr. Konstantinos Georgiou in 2016.
- Supported by NSERC undergraduate research grants in 2015 and 2016.

Scholarships and Awards

All award and scholarship amounts listed in Canadian dollars.

2024-2026	NSERC Postdoctoral Fellowships Program (PDF)	$140,000
2023	Alfred B. Lehman Graduate Scholarship	$5,000
2021-2022	Ontario Graduate Scholarship	$15,000
2018-2021	NSERC CGS Doctoral Award	$63,000
2017-2018	NSERC CGS Master's Award	$17,500
2016	NSERC Undergraduate Student Research Award	$6,000
2015	NSERC Undergraduate Student Research Award	$6,000
2012-2016	Seymour Schulich Scholarship Renewable	$39,000

Preprints in Submission

24. *Improved Approximations for Free-Order Prophet Matching with Patience Constraints*, M. Derakhshan, A. Ghasemi, and C. MacRury, (2025).

Refereed Publications In Press

23. *Online Contention Resolution Schemes for Network Revenue Management and Combinatorial Auctions,* W. Ma, C. MacRury, and J. Zhang. In Proceedings of the 17th Innovations in Theoretical Computer Science (**ITCS 2026**), preprint arXiv:2403.05378.
    - Major revision in **Operations Research**.
22. *Forward-backward Contention Resolution Schemes for Fair Rationing,* W. Ma, C. MacRury, and C. Stein. In Proceedings of the 26th ACM Conference on Economics and Computation (**EC 2025**), 945, preprint arXiv:2502.09521.
    - Journal version submitted to **Operations Research**.
21. *Proportionally Fair Matching Algorithms via Randomized Rounding*, S. Duppala, N. Grammel, J. Luque, C. MacRury, and A. Srinivasan. In the Annual AAAI Conference on Artificial Intelligence (**AAAI 2025**) as an **oral presentation**, preprint arXiv:2412.11238.
    - Journal version submitted to **Operations Research**.

Available Refereed Publications

20. *Extending Wormald's Differential Equation Method to One-sided Bounds*, P. Bennett and C. MacRury. **Combinatorics, Probability and Computing**, 1-14 (2025), preprint arXiv:2302.12358.
19. *Building Hamiltonian Cycles in the Semi-Random Graph Process in Less Than* $2n$ *Rounds*, A. Frieze, P. Gao, C. MacRury, P. Prałat, and G. Sorkin. **European Journal of Combinatorics**, 126: 104122 (2025), preprint arXiv:2311.05533.
18. *Online Bipartite Matching in the Probe-Commit Model*, A. Borodin and C. MacRury. **Mathematical Programming** (2025), preprint arXiv:2303.08908.
    - Journal version of *Secretary Matching Meets Probing with Commitment* and *Prophet Matching Meets Probing with Commitment*.
17. *Online Matching and Contention Resolution for Edge Arrivals with Vanishing Probabilities*, W. Ma, C. MacRury, and P. Nuti. In Proceedings of the 25th ACM Conference on Economics and Computation (**EC 2024**), 159, preprint arXiv:2406.14506.
    - Minor revision in **Operations Research**.
16. *On (Random-order) Online Contention Resolution Schemes for the Matching Polytope of (Bipartite) Graphs*, C. MacRury, W. Ma, and N. Grammel. **Operations Research** 73(2): 689-703 (2025), preprint arXiv:2209.07520.
    - Conference version appeared in the ACM-SIAM Symposium on Discrete Algorithms (**SODA 2023**).
15. *Random-order Contention Resolution via Continuous Induction: Tightness for Bipartite Matching under Vertex Arrivals*, C. MacRury and W. Ma. Annual ACM Symposium on Theory of Computing (**STOC 2024**): 1629-1640, preprint arXiv:2310.10101.
    - Minor revision in **Mathematics of Operations Research**.
14. *Optimizing Transport Frequency in Multi-layered Urban Transportation Networks for Pandemic Prevention*, C. MacRury, N. Polituchyi, P. Prałat, K. Siuta, and P. Szufel, **Public Transport** 16:381-418 (2024).

13. *Sharp Thresholds in Adaptive Random Graph Processes*, C. MacRury, and E. Surya, **Random Structures and Algorithms** 64, 741-767 (2024), preprint arXiv:2207.14469.

12. *The Phase Transition of Discrepancy in Random Hypergraphs*, C. MacRury, T. Masařík, L. Pei, and X. Pérez-Giménez, **SIAM Journal on Discrete Mathematics** 37(3): 1818-1841 (2023), preprint arXiv:2102.07342.

11. *Algorithms for p-Faulty Search on a Half-Line*, A. Bonato, K. Georgiou, C. MacRury, and P. Prałat. Special edition of **Algorithmica** 85, 2485-2514 (2023), preprint arXiv:2002.07797.

    - Conference version titled *Probabilistically Faulty Searching on a Half-Line* appeared in the Latin American Theoretical Informatics Symposium (**LATIN 2020**).

10. *A Fully Adaptive Strategy for Hamiltonian Cycles in the Semi-random Graph Process*, P. Gao, C. MacRury, and P. Prałat, International Conference on Randomization and Computation (**RANDOM 2022**), 245: 22pp, preprint arXiv:2205.02350.

9. *Prophet Matching in the Probe-Commit Model*, A. Borodin, C. MacRury, and A. Rakheja, International Conference on Approximation Algorithms for Combinatorial Optimization Problems (**APPROX 2022**), 245: 24pp, preprint arXiv:2102.04325.

    - ArXiv version titled *Prophet Matching Meets Probing with Commitment*.

8. *Perfect Matchings in the Semi-random Graph Process*, P. Gao, C. MacRury, and P. Prałat, **SIAM Journal on Discrete Mathematics**, 36(2): 1274–1290 (2022), preprint arXiv:2105.13455.

7. *Localization Game for Random Graphs*, A. Dudek, S. English, A. Frieze, C. MacRury, and P. Prałat, **Discrete Applied Mathematics**, 309: 202–214 (2022), preprint arXiv:1910.11225.

6. *Hamilton Cycles in the Semi-random Graph Process*, P. Gao, B. Kaminski, C. MacRury, and P. Prałat, **European Journal of Combinatorics**, 99: 103423 (2022), preprint arXiv:2006.02599.

5. *Secretary Matching Meets Probing with Commitment*, A. Borodin, C. MacRury, and A. Rakheja, International Conference on Approximation Algorithms for Combinatorial Optimization Problems (**APPROX 2021**), 207: 23pp, preprint arXiv:2008.09260.

    - ArXiv version titled *Greedy Approaches to Online Stochastic Matching*.

4. *Zero Forcing Number of Random Regular Graphs*, D. Bal, P. Bennett, S. English, C. MacRury, and P. Prałat, **Journal of Combinatorics**, 12(1): 85-116 (2021), preprint arXiv:1812.06477.

3. *Probabilistic Zero Forcing on Random Graphs*, S. English, C. MacRury, and P. Prałat, **European Journal of Combinatorics**, 91: 103207 (2021), preprint arXiv:1909.06568.

2. *The Robot Crawler Graph Process*, A. Bonato, R.M. del Rio-Chanona, C. MacRury, J. Nicolaidis, X. Perez-Gimenez, P. Prałat, and K. Ternovsky, **Discrete Applied Mathematics**, 247: 23–36 (2018).

    - Conference version appeared in the Workshop on Algorithms and Models for the Web-Graph (**WAW2015**).

1. *Distribution of Coefficients of Rank Polynomials for Random Sparse Graphs*, D. Jakobson, C. MacRury, S. Norin, and L. Turner, **Electronic Journal of Combinatorics**, 25(4): P4.50 (2018).

Non-Refereed Manuscripts

Bipartite Stochastic Matching: Online, Random Order, and I.I.D. Models, A. Borodin, C. MacRury, and A. Rakheja, arXiv preprint arXiv:2004.14304, 2020.

- Preliminary version of *Online Bipartite Matching in the Probe-Commit Model*.

Injective Colouring of Binomial Random Graphs, R.M. del Rio-Chanona, C. MacRury, J. Nicolaidis, X. Perez-Gimenez, P. Prałat, K. Ternovsky, 2016.

Theses

Online Decision-Making in a Randomized Environment: Stochastic Matching and Adaptive Random Graph Processes, Doctoral Thesis at University of Toronto, Available here.

Approximation Algorithms for Network Flow and Minimum Cut Problems, Master's Thesis at McGill University.

Selected Invited Talks

Improved Approximations for Free-Order Prophet Matching with Patience Constraints, INFORMS Annual Meeting, Cluster Session: Online/Sequential Allocation for Discrete Optimization Problems, Atlanta, USA, October 2025.

Forward-backward Contention Resolution Schemes for Fair Rationing, Revenue, Management and Pricing (RMP), New York City, USA, July 2025.

Random-order Contention Resolution via Continuous Induction: Tightness for Bipartite Matching under Vertex Arrivals, Dynamic Allocation and Matching, Banff, Canada, March 2025. Recorded presentation.

Online Contention Resolution Schemes for the Matching Polytope of Graphs, Graphs @ TMU Seminar, Toronto, Canada, February 2025.

Random-order Contention Resolution via Continuous Induction: Tightness for Bipartite Matching under Vertex Arrivals, Junior Theorists Workshop at Northwestern University/Toyota Technological Institute, Chicago, USA, December 2024.

Random-order Contention Resolution via Continuous Induction: Tightness for Bipartite Matching under Vertex Arrivals, INFORMS Annual Meeting, Cluster Session: Online Resource Allocation: New Models and Methods, Seattle, USA, October 2024.

Online Contention Resolution Schemes for Network Revenue Management and Combinatorial Auctions, Revenue, Management and Pricing (RMP), Los Angeles, USA, July 2024.

Online Matching and Contention Resolution for Edge Arrivals with Vanishing Probabilities, EC 2024, New Haven, USA, July 2024.

Random-order Contention Resolution via Continuous Induction: Tightness for Bipartite Matching under Vertex Arrivals, STOC 2024, Vancouver, Canada, June 2024. Recorded presentation.

Online Contention Resolution Schemes for the Matching Polytope of Graphs, the Capital Area Theory Seminar (CATS) at the University of Maryland (UMD), College Park, USA, April 2024. Recorded presentation.

Online Contention Resolution Schemes for the Matching Polytope of Graphs, INFORMS Optimization Society (IOS) conference, Cluster Session: Emerging Topics in Assortment Optimization and Matchings, Houston, USA, March 2024.

Online Contention Resolution Schemes for the Matching Polytope of Graphs, Graphs @ TMU Seminar, Toronto, Canada, November 2023.

Online Contention Resolution Schemes for the Matching Polytope of Graphs, INFORMS Annual Meeting, Cluster Session: Pricing and Simple Mechanisms for Combinatorial Allocation Problems, Phoenix, USA, October 2023.

Sharp Thresholds in Adaptive Random Graph Processes, Social Networks and Complex Systems Workshop, Warsaw, Poland, June 2023.

Sharp Thresholds in Adaptive Random Graph Processes, Canadian Discrete and Algorithmic Mathematics (CanaDAM). Minisymposium: Random Structures and Random Processes, Winnepeg, Canada, June 2023.

Online Contention Resolution Schemes for the Matching Polytope of Graphs, Marketplace Innovation Workshop 2023, virtual, May 2023.

On (Random-order) Online Contention Resolution Schemes for the Matching Polytope of (Bipartite) Graphs, SODA 2023, Florence, Italy, January 2023.

Prophet Matching in the Probe-Commit Model, APPROX 2022, virtual, September 2022. Recorded presentation.

A Fully Adaptive Strategy for Hamiltonian Cycles in the Semi-random Graph Process, RANDOM 2022, virtual, September 2022. Recorded presentation.

The Semi-random Graph Process, University of California San Diego, virtual, October 2021.

Secretary Matching Meets Probing with Commitment, APPROX 2021, virtual, August 2021. Recorded presentation.

The Discrepancy of Random Hypergraphs, University of Kansas, Lawrence, Kansas, June 2019.

Selected Workshops and Programs Attended

Combinatorial Optimization for Online Platforms at the Banff International Research Station (Banff, Canada), April 2024.

Graph Limits and Processes on Networks: From Epidemics to Misinformation at the Simon's Institute (Berkeley, USA), Fall 2022.

Mathematics of Online Decision Making, virtual, formerly at the Simon's Institute (Berkeley, USA), October 2020.

17th Workshop on Algorithms and Models for the Web Graph (WAW), virtual (formerly at SGH Warsaw School of Economics, Warsaw, Poland), September 2020.

Graduate Research Workshop in Combinatorics, University of Kansas, Lawrence, Kansas, June 2019.

American Mathematical Society Sectional Meeting, University of Michigan, Ann Arbor, Michigan October 2018.

Summer School on Random Graphs and Probabilistic Methods, Field's Institute, Toronto,

Ontario, June 2017.

13th Workshop on Algorithms and Models for the Web Graph (WAW), Universite de Montreal, Montreal, Quebec, December 2016.

CRM Summer School on Spectral Theory and Applications, Universite Laval, Quebec City, Quebec, July 2016.

Professional Service

As a program committee member:

- Economics and Computation (EC), 2025.

As a reviewer:

- Conference on Integer Programming and Combinatorial Optimization (IPCO).
- Mathematics of Operations Research.
- Operations Research.
- International Symposium on Theoretical Aspects of Computer Science (STACS).
- Journal of Combinatorial Theory, Series B (JCTB).
- Symposium on Discrete Algorithms (SODA).
- Electronic Journal of Combinatorics.
- Foundations of Computer Science (FOCS).
- European Symposium on Algorithms (ESA).
- Symposium on Theory of Computing (STOC).
- Australasian Journal of Combinatorics.
- European Journal of Combinatorics.
- Discrete Mathematics.
- International Colloquium on Automata, Languages and Programming (ICALP).
- Proceedings of the 14th Latin American Theoretical Informatics Symposium (LATIN).

I have served on the Canadian Mathematical Olympiad (CMO) for 3 years, 2022–present.

Teaching Experience

I have been a TA for **14** courses as a graduate student/postdoc. My duties included:

- Facilitating both lecture style tutorials, as well collaborative tutorials.
- Substituting in for the regular instructor for a series of lectures.
- Designing marking schemes and grading student work.

Winter	2024	Supply Chain Management (at Columbia Business School), B8108
Fall	2022	Algorithm Design, Analysis and Theory, CSC2420
Fall	2022	Design and Analysis of Algorithms, CSC373.
Winter	2022	Online and Other Myopic Algorithms, CSC2421.
Winter	2022	Design and Analysis of Algorithms, CSC373.
Fall	2021	Design and Analysis of Algorithms, CSC373.
Fall	2020	Advanced Algorithms, CSC473.
Winter	2020	Advanced Algorithms, CSC473.
Winter	2020	Statistical Learning Theory, CSC 2532 (graduate course).
Fall	2019	Game Theory, CSC304H1.
Winter	2019	Advanced Algorithms, CSC473.
Fall	2018	Design and Analysis of Algorithms, CSC373.
Winter	2018	Linear Algebra for Engineers, MAT188.
Fall	2017	Calculus I, MAT137.

Technical Skills

Programming Languages: C, Java, Python
Software Packages: Matlab, Mathematica, LaTeX

Research References

My research references are labelled according to my preferred order of contact.

1. **Dr. Will Ma**, Associate Professor, Columbia University,
   Columbia Business School (New York, New York), wm2428@gsb.columbia.edu
2. **Dr. Paweł Prałat**, Professor, Toronto Metropolitan University,
   Department of Mathematics (Toronto, Ontario), pralat@torontomu.ca
3. **Dr. Cliff Stein**, Professor, Columbia University,
   Departments of IEOR and Computer Science (New York, New York), cliff@ieor.columbia.edu
4. **Dr. Aravind Srinivasan**, Professor, University of Maryland,
   Department of Computer Science (College Park, Maryland), asriniv1@umd.edu
5. **Dr. Allan Borodin**, Professor, University of Toronto,
   Department of Computer Science (Toronto, Ontario), bor@cs.toronto.edu

Teaching Reference

Dr. Aleksandar Nikolov, Associate Professor, University of Toronto,
Department of Computer Science (Toronto, Ontario), anikolov@cs.toronto.edu