Noah Fleming Assistant Professor Department of Computer Science, Memorial University of Newfoundland and Labrador e-mail: nfleming@mun.ca www: cs.mun.ca/`noahfleming Google Scholar : dblp

Research Interests

Complexity Theory. Including proof complexity, circuit complexity, TFNP, interactions between them, and similar topics. *Algorithm Design and Analysis.* Applications of proof complexity to the design and analysis of practical algorithms including SAT and integer programming solvers, property testing, and low-sensitivity algorithms.

Education and Employment

| Assistant Professor Memorial University of Newfoundland and Labrador, St. John's, Canada | 2022 – Present |
|---|----------------|
| Postdoctoral Research Fellow | 2021 - 2022 |
| UC San Diego, USA. | |
| Hosted by Russell Impagliazzo and Samuel Buss | 2021 |
| – M.V. Kaghunathan Research Fellow | 2021 |
| Simons Institute, UC Berkeley, California, USA. | |
| Satisfiability: Theory, Practice, and Beyond Program. | 2017 2021 |
| – Ph.D. in Computer Science | 2017 - 2021 |
| University of Toronto, Toronto, Canada. | |
| Advisor: Toniann Pitassi | |
| Title: The Proof Complexity of Integer Programming. | |
| – M.Sc. in Computer Science | 2015 - 2017 |
| University of Toronto, Toronto, Canada. | |
| Advisor: Toniann Pitassi | |
| Project Title: Linear Threshold Proof Systems. | |
| B.Sc. Double Major in Computer Science and Pure Mathematics | 2010 - 2015 |
| Memorial University of Newfoundland, St. John's, Canada. | |
| Visiting Positions | |
| - Simons Institute, UC Berkely, California, U.S.A. | Fall 2023 |
| Visiting Researcher. | |
| Satisfiability: Extended Reunion Program. | |
| National Institute of Informatics, Tokyo, Japan | Summer 2019 |
| Research intern in Theoretical Computer Science. | |
| Supervisor: Yuichi Yoshida. | |
| - Simons Institute, UC Berkely, California, U.S.A. | Fall 2018 |
| Visiting Graduate Student. | |
| Lower Bounds in Computational Complexity Program. | |
| - Institute for Advanced Study, Princeton, U.S.A. | Fall 2017 |
| Visiting Graduate Student. | |
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Research Funding

| _ | NSERC Discovery Grant (\$205,000) | 2023 - 2028 |
|---|--|----------------------|
| | Principal Canadian research grant. 58% success rate with an average award of \$173,000 for early | y career researchers |
| | (ECR) in my application year of 2023. | |
| _ | NSERC Discovery Launch Supplement (\$12, 500) | 2023 |
| _ | Memorial University Startup grant (\$40,000) | 2022 - 2025 |

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Awards and Honours

| UCSD CSE Postdoctoral Fellowship (\$124,000 USD) | 2021 - 2023 |
|---|-------------|
| - Invited special issue journal article "On the Power and Limitations of Branch and Cut" at CCC 2021. | 2021 |
| Honour reserved for the top 5-10 papers in the conference. | |
| NSERC Postdoctoral Fellowship (PDF) (\$90,000 CAD) | 2021 - 2023 |
| - Graduate Completion Award (\$1,600 CAD) | 2021 |
| Acres Productive Technologies Inc./Joseph Yonan Memorial Fellowship (\$2,000 CAD) | 2020 |
| Ontario Graduate Scholarship (\$15,000 CAD) | 2020 |
| Walter C. Sumner Memorial Fellowship (\$8,000 CAD) | 2020 |
| – Walter C. Sumner Memorial Fellowship (\$8,000 CAD) | 2019 |
| Mitacs Globalink Research Award - Japan Society for the Promotion of Science | 2019 |
| (¥534,000 YEN) | |
| NSERC Alexander Graham Bell Canada Graduate Scholarship - Doctoral (CGSD) | 2017 - 2020 |
| (\$105,000 CAD) | |
| NSERC Alexander Graham Bell Canada Graduate Scholarship - Master's (CGSM) | 2015 - 2016 |
| (\$17,500 CAD) | |

Publications

Author order in theoretical computer science is alphabetical. The exception to this rule, below, are the papers published in *Theory and Applications of Satisfiability Testing* (SAT), in which authors are listed according to contribution. Co-authors who are students of mine are underlined.

Peer Reviewed Conference Publications

- Susanna de Rezende, Noah Fleming, Duri Andrea Janett, Jakob Nordström, Shuo Pang. Truly Supercritical Tradeoffs for Resolution, Cutting Planes, Monotone Circuits, and Weisfeiler-Leman. Accepted to Symposium on Theory of Computing (STOC 2025).
- Noah Fleming, Stefan Grosser, Toniann Pitassi, Robert Robere. Black-Box PPP is not Turing Closed. *Proceedings of the 56th Annual ACM Symposium on Theory of Computing* (STOC 2024). doi: 10.1145/3618260.3649769
- Vipul Arora, Arnab Bhattacharyya, Noah Fleming, Esty Kelman, Yuichi Yoshida. Low Degree Testing over the Reals. *Proceedings of the 2023 Symposium on Discrete Algorithms* (SODA 2023). doi: 10.1137/1.9781611977554.ch31
- Marc Vinyals, Chunxiao Li, Noah Fleming, Antonina Kolokolova, Vijay Ganesh. Limits of CDCL Learning via Merge Resolution. Proceedings of the 26th International Conference on the Theory and Applications of Satisfiability Testing (SAT 2023). doi: 10.4230/LIPIcs.SAT.2023.27
- Sam Buss, Noah Fleming, Russell Impagliazzo. TFNP Characterizations of Proof Systems and Monotone Circuits. *Proceedings of the 14th Innovations in Theoretical Computer Science* (ITCS 2023). doi: 10.4230/LIPIcs.ITCS.2023.30
- Noah Fleming, Toniann Pitassi, Robert Robere. Extremely Deep Proofs. Proceedings of the 13th Innovations in Theoretical Computer Science (ITCS 2022). doi: 10.4230/LIPIcs.ITCS.2022.70
- Noah Fleming, Mika Göös, Stefan Grosser, Robert Robere. On Semi-Algebraic Proofs and Algorithms. *Proceedings of the 13th Innovations in Theoretical Computer Science* (ITCS 2022). doi: 10.4230/LIPIcs.ITCS.2022.69
- Noah Fleming, Mika Göös, Russell Impagliazzo, Toniann Pitassi, Li-Yang Tan, Robert Robere, Avi Wigderson. On the Power and Limitations of Branch and Cut. *Proceedings of the 36th Computational Complexity Conference* (CCC 2021). doi: 10.4230/LIPIcs.CCC.2021.6

Invited to the special journal issue for CCC 2021.

9. Chunxiao Li, Jonathan Chung, Soham Mukherjee, Marc Vinyals, Noah Fleming, Antonina Kolokolova, Alice Mu, Vijay Ganesh. On the Hierarchical Community Structure of Practical SAT Formulas.

Proceedings of the 24th International Conference on the Theory and Applications of Satisfiability Testing (SAT 2021). doi: 10.1007/978-3-030-80223-3_25

- Chunxiao Li, Noah Fleming, Marc Vinyals, Toniann Pitassi, Vijay Ganesh. Towards a Complexity-Theoretic Understanding of Restarts in SAT Solvers. *Proceedings of the 23rd International Conference on the Theory and Applications* of Satisfiability Testing (SAT 2020). doi: 10.1007/978-3-030-51825-7_17
- Noah Fleming, Yuichi Yoshida. Distribution-Free Testing of Linear Functions on ℝⁿ. Proceedings of the 11th Innovations in Theoretical Computer Science Conference (ITCS 2020). doi: 10.4230/LIPIcs.ITCS.2020.22
- Paul Beame, Noah Fleming, Russell Impagliazzo, Antonina Kolokolova, Denis Pankratov, Toniann Pitassi, Robert Robere. Stabbing Planes. *Proceedings of the 9th Innovations in Theoretical Computer Science Conference* (ITCS 2018). doi: 10.4230/LIPIcs.ITCS.2018.10
- 13. Noah Fleming, Denis Pankratov, Toniann Pitassi, Robert Robere. Random $\Theta(\log n)$ -CNFs are Hard for Cutting Planes. *Proceedings of the 58th annual IEEE Symposium on Foundations of Computer Science* (FOCS 2017). doi: 10.1109/FOCS.2017.19

In Submission

- 1. Noah Fleming, Yuichi Yoshida. Sensitivity Lower Bounds for Approximation Algorithms.
- 2. Noah Fleming, <u>Deniz Imrek</u>, Christophe Marciot. Provably Total Functions in the Polynomial Hierarchy.

Peer Reviewed Journal Publications

- 1. Noah Fleming, Mika Göös, Russell Impgaliazzo, Toniann Pitassi, Li-Yang Tan, Robert Robere, Avi Wigderson. On the Power and Limitations of Branch and Cut. *Theory of Computing* (ToC 2024).
- 2. Noah Fleming, Denis Pankratov, Toniann Pitassi, Robert Robere. Random $\Theta(\log n)$ -CNFs are Hard for Cutting Planes. Journal of the ACM (JACM 2022). doi: 10.1145/3486680
- Noah Fleming, Pravesh Kothari, Toniann Pitassi. Semialgebraic Proofs and Efficient Algorithm Design. Foundations and Trends[®] in Theoretical Computer Science, 14 (1-2): 1-229 (2019). doi: 10.1561/040000086
- Noah Fleming, Antonina Kolokolova, Renesa Nizamee. Complexity of Alignment and Decoding Problems: Restrictions and Approximations. *Machine Translation, 29 (3-4): 163-187* (2015). doi: 10.1007/s10590-015-9172-5

In Submission

- 1. Sam Buss, Noah Fleming, Russell Impagliazzo. TFNP Characterizations of Proof Systems and Monotone Circuits. In submission to *SIAM Journal of Computing*.
- 2. Vipul Arora, Arnab Bhattacharyya, Noah Fleming, Esty Kelman, Yuichi Yoshida. Low Degree Testing over the Reals. In submission to *Algorithmica*.

Book Chapters

 Noah Fleming, Toniann Pitassi. Reflections on Proof Complexity and Counting Principles. In Ivo Düntsch and Edwin Mares, editors, *Alasdair Urquhart on Nonclassical and Algebraic Logic and Complexity of Proofs*, Outstanding Contributions to Logic. Springer International Publishing (2022). doi: 10.1007/978-3-030-71430-7

Supervision

Graduate Students

| Christophe Marciot (Memorial University, Ph.D.) Deniz Imrek (University of Austin, Ph.D., co-supervised with Anna Gal) Jordan Kilfoy (Memorial University, MSc., co-supervised with Antonina Kolokolova) | 2023 – Present 2023 – Present 2024 – Present |
|--|--|
| Undergraduate Students | |
| Michael Gregory (Memorial University) | 2024 – Present |
| Honours Thesis on generalized Polynomial Calculus lower bounds. | |
| - Grey Seaward (Memorial University) | 2023 - Present |
| Honours Thesis on Meta-complexity and TFNP. | |
| - Parsa Esmkhani (Memorial University, co-supervised with Antonina Kolokolova) | 2023 - Present |
| Honours Thesis on Algorithmic Game Theory and TFNP. | |
| – Gavin Hull (Memorial University). | Winter 2023 |
| Research project on communication complexity. | |
| - Felipe Heap (University of Toronto, co-supervised with Toniann Pitassi). | 2019 |
| Research project on monotone circuit lower bounds and the sensitivity conjecture. | |
| Postdocs and Researcher Scientists | |
| - Marc Vinyals, Researcher Scientist (Memorial University, co-hosted with Antonina Kolokolova) | 2022 |
| | |

Professional Service

- Program Committee Member
 - 28th International Conference on Theory and Applications of Satisfiability Testing (SAT 2025).
- External Reviewer
 - Conferences: FOCS, STOC, CCC, ITCS, SODA, SAT, ISAAC, ICALP, LICS, ESA, STACS, Random.
 - Journals: Journal of the ACM, Theory of Computing, Information Processing Letters, TheoretiCS, Computational Complexity, Logical Methods in Computer Science, Journal of Artificial Intelligence.
- Thesis Examiner
 - Omran Khalifa. MSc. Title: A Study in Orthogonal Latin Squares and Strong Starters. Department of Computer Science, Memorial University.
- Faculty Search Committee. Department of Computer Science, Memorial University.

-2022 - 2023, 2023 - 2024, 2024 - 2025.

- Graduate Student Admissions Committee. Department of Computer Science, Memorial University.

-2022 - 2023.

- Faculty of Science representative to the Faculty of Business Faculty Council. Memorial University.
 - 2022 2023.
- Head Coach, University of Toronto International Collegiate Programming Contest (ICPC) Team. University of Toronto. 2018 – 2021

Organized and ran programming competitions, problem sessions, and practices for the three University of Toronto ICPC teams. Organized logistics and transportation to regional championships. Secured funding to run the teams from the University of Toronto.

- Teaching Assistant. University of Toronto.

- CSC438/2404 (1 appt.), CSC165 (9 appt.), CSC373 (1 appt.), CSC363 (1 appt.), CSC263 (1 appt.)

2015 - 2021

2016

- Lead Mentor, Undergraduate Summer Research Program. University of Toronto

Held weekly mentoring sessions for undergraduate students participating in the Department of Computer Science Undergraduate Summer Research Program to guide them on their research project.

Teaching

In the following I list the courses which I have been an instructor for. In all of the courses below, the instruction was in the form of standard lecture-based classroom teaching, and the language of instruction was in English.

- Comp 3602: Introduction to the Theory of Computing. Memorial University.

Third year undergraduate course which gives students a formal introduction to theoretical computer science, with a focus on computational complexity theory. This includes automata theory, Turing Machines, the P versus NP problem, and related topics. Not required for BSc in Computer Science.

- Fall 2024. Class size: 24.
- Fall 2023. Class size: 27.
- Comp 6901: Applied Algorithms. Memorial University.

Graduate-level course providing students with an introduction to the formal study of algorithms. This includes standard algorithmic paradigms such as greedy algorithms, graph algorithms, dynamic programming, network flows, and linear programming. Required for MSc/PhD in Computer Science.

- Fall 2024. Class size: 67.
- Fall 2023. Class size: 79.
- Fall 2022. Class size: 49.
- Comp 6902/COMP 4742: Theory of Computation. Memorial University.

Cross-listed fourth-year undergraduate/graduate course covering topics in complexity theory. Not required for degrees in Computer Science.

- Winter 2025. Class size: 18.
- Winter 2023. Class size: 10.
- CSC165: *Mathematical Expression and Reasoning*. University of Toronto.

First-year undergraduate course, which introduces students to formal mathematical reasoning. Topics include formalizing mathematical ideas, structuring proofs, and proof techniques such as induction. As well, it covers the analysis of algorithms including asymptotic notation.

- Winter 2017. Co-taught with Toniann Pitassi. Class size: >200.

Seminars and Reading Series

| _ | Theory Reading Group. Memorial University | 2022 – Present |
|---|---|----------------------|
| | Weekly seminar series on topics in theoretical computer science. | |
| _ | CSC199: Special topics in Computer Science. University of California, San-Diego. | Fall 2021 |
| | Seminar on the Theory of SAT. Covering topics in propositional and algebraic proof systems, | and SAT Solvers. Co- |
| | organized with Sam Buss, Sicun Gao, and Russell Impagliazzo. | |

Invited Talks

These do not include presentations for accepted papers at conferences.

| _ | Theory Seminar | |
|---|---|------|
| | Columbia University, New York, USA. | 2025 |
| | Seminar Title: Supercritical Trade-offs. | |
| _ | Theory Seminar | |
| | University of Chicago, Chicago, IL, USA. | 2025 |
| | Seminar Title: Proofs, Circuits, and Total Functions. | |
| — | Theory Seminar | |
| | University of Toronto, Toronto, Canada. | 2024 |
| | Seminar Title: Supercritical Trade-offs. | |
| — | MIAO Seminar | |
| | University of Copenhagen, Copenhagen, Denmark. | 2024 |
| | Seminar Title: PPP is not Turing Closed in the Black-Box Setting. | |

| _ | Proof Complexity and Beyond Workshop MFO Oberwolfach, Germany. | 2024 |
|---|---|------|
| | Seminar Title: PPP is not Closed for Turing Reductions. | |
| _ | Theory Seminar | |
| | National Institute of Informatics Tokyo Japan | 2024 |
| | Saminar Title: Black Bar DDD is not Turing Closed | 2024 |
| | Math Colleguium | |
| _ | Man Conoquium | 2022 |
| | Memorial University, Newfoundland, Canada. | 2023 |
| | Seminar Title: A Logical Approach to P vs. NP. | |
| — | Theory Seminar | |
| | University of Toronto, Toronto, Canada. | 2023 |
| | Invited Speaker. | |
| | Seminar Title: Proofs, Circuits, and Total Functions. | |
| _ | Extended Reunion: Satisfiability Program | |
| | Simons Institute, Berkeley, California, USA. | 2023 |
| | Seminar Title: The Proof Complexity of Integer Programming. | |
| _ | Meta-Complexity Program | |
| | Simons Institute Berkeley California USA | 2023 |
| | Simons Institute, Derectey, Camolinia, USA. | 2023 |
| | Seminar The. TFNF, Froof Complexity and Monotone Circuit Complexity. | |
| _ | North American Annual Meeting of the Association for Symbolic Logic | 2022 |
| | University of California, Irvine, California, USA. | 2023 |
| | Seminar Title: The Proof Complexity of Integer Programming. | |
| — | Satisfiability: Theory, Practice, and Beyond Reunion Program | |
| | Simons Institute, Berkeley, California, USA. | 2022 |
| | Seminar Title: Extremely Deep Proofs. | |
| _ | Online SAT Seminar | |
| | Online. | 2022 |
| | Seminar Title: <i>Extremely Deep Proofs</i> . | |
| _ | UCSD Theory Seminary, University of California, San Diego | |
| | San Diego California USA | 2022 |
| | Seminar Title: Semi-Algebraic Proofs and Algorithms | 2022 |
| | Oxford Warwick Complexity Magting | |
| _ | | 2021 |
| | | 2021 |
| | Seminar Title: Extremely Deep Proofs. | |
| _ | MIAO Video Seminar, University of Copenhagen | |
| | Copenhagen, Denmark. | 2021 |
| | Seminar Title: On the Complexity of Branch-and-Cut. | |
| _ | Simons Institute | |
| | Berkeley, California, USA. | 2021 |
| | Seminar Title: The Proof Complexity of Integer Programming Solvers. | |
| _ | Simons Institute | |
| | Berkeley, California, USA. | 2021 |
| | Seminar Title: The Proof Complexity of Practical Integer Programming | |
| _ | Institute for Advanced Study | |
| | Dringston New Jersey USA | 2020 |
| | Indeton, New Jersey, USA. | 2020 |
| | | |
| | Seminar Title: Recent Progress on Cutting Planes Proofs. | |
| _ | BIRS Proof Complexity Workshop 20w5144 | |
| | BIRS Centre, Banff, Canada. | 2020 |
| | Seminar Title: Semialgebraic Proofs and Efficient Algorithm Design. | |
| — | Simon Fraser University Theory Seminar | |
| | Simon Fraser University, Vancouver, Canada. | 2019 |
| | Seminar Title: Stabbing Planes. | |
| _ | Memorial University of Newfoundland Computer Science Seminar. | |
| | Memorial University of Newfoundland, St. John's, Canada. | 2018 |
| | Seminar Title: Random CNF formulas are hard to refute in Cutting Planes | _010 |
| | Proof Complexity Workshop | |
| _ | TION COMPLEXITY WORKSHOP | |

| Dagstuhl, Germany. | 2018 |
|---|------|
| Seminar Title: Stabbing Planes. | |
| Proof Complexity and Beyond Workshop | |
| MFO Oberwolfach, Germany. | 2017 |
| Seminar Title: Random $\Theta(\log n)$ -CNF formulas Are Hard for Cutting Planes. | |

Short-Term Visiting Researchers

| - Stefan Grosser. (Co-hosted with Antonina Kolokolova). | Fall 2024 |
|--|-------------|
| – Morgan Shirley. | Fall 2024 |
| – Jiawei Li. | Summer 2024 |
| – Ian Mertz. | Winter 2024 |
| Chunxiao Li. (Co-hosted with Antonina Kolokolova). | Fall 2022 |
| - Vijay Ganesh. (Co-hosted with Antonina Kolokolova). | Fall 2022 |