CURRICULUM VITAE

Josiah Sinclair, Ph.D.

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RESEARCH & TEACHING INTERESTS

I am an experimental physicist researching atomic physics platforms for quantum computing. My research focuses on harnessing the power of nonlocal entanglement to build scalable modular fault-tolerant quantum computers with atom arrays and optical cavities. I am also interested in quantum error correction in distributed architectures, quantum foundations, and teaching quantum mechanics. I have authored 16 papers and two patents, with seven as first-author.

EDUCATION & TRAINING

2021 - 24 **Postdoctoral Fellowship,** MIT-Harvard Center for Ultracold Atoms, Massachusetts Institute of Technology, Cambridge, MA
Faculty Advisor: Vladan Vuletić, Lester Wolfe Professor of Physics

2021 **Ph.D. in Physics,** University of Toronto, Toronto, ON
Thesis title: "Weakly measuring the time a transmitted photon causes atoms to spend in the excited state."
Faculty Advisor: Aephraim M. Steinberg, Professor of Physics

2013 **B.Sc. in Physics,** Calvin University, Grand Rapids, MI

RESEARCH EXPERIENCE

2021 - **Postdoctoral Fellow,** MIT-Harvard Center for Ultracold Atoms, Massachusetts Institute of Technology, Cambridge, MA
Faculty Advisor: Vladan Vuletić, Lester Wolfe Professor of Physics

- Led a team composed of six physicists in building one of the first experiments to interface an atom array with an optical cavity.
- Developed a scalable modular fault-tolerant architecture for quantum computing based on Rydberg atom arrays and optical cavities.

2013 - 21 **Ph.D. Candidate,** University of Toronto, Toronto, ON
Faculty Advisor: Aephraim M. Steinberg, Professor of Physics

- Proposed and implemented the first measurement of the time transmitted photons spend as atomic excitations while traversing a cloud of atoms.
- Designed and built an apparatus capable of exciting and harnessing ultra-cold Rydberg atoms for quantum nonlinear optical experiments.

PUBLICATIONS

Peer-Reviewed Papers

1. J. Ramette, **J. Sinclair**, N.P. Breuckmann, and V. Vuletić. Fault-tolerant connection of error-corrected qubits with noisy links. *npj Quantum Inf* 10, 58 (2024). doi.org/10.1038/s41534-024-00855-4.
2. A. Rudelis, B. Hu, **J. Sinclair**, E. Bytyqi, A. Schwartzman, R. Brenes, T.K. Zhitomirsky, M. Schleier-Smith, and V. Vuletić, "Degradation of Ta2O5 / SiO2 dielectric cavity mirrors in ultra-high vacuum," *Opt. Express* 31, 39670-39680 (2023).
3. Z. Vendeiro, J. Ramette, A. Rudelis, M. Chong, **J. Sinclair**, L. Stewart, A. Urvoy, V. Vuletić. "Machine-learning-accelerated Bose-Einstein Condensation" *Phys. Rev. Research* 4, 043216 (2022).

4. J. Ramette, **J. Sinclair**, Z. Vendeiro, A. Rudelis, M. Cetina, V. Vuletić. "Any-to-any connected cavity-mediated architecture for quantum computing with trapped ions or Rydberg arrays" *PRX Quantum* **3,** 010344 (2021), featured by PRX as an Editors Suggestion.
5. **J. Sinclair**, D. Angulo, K. Thompson, K. Bonsma-Fisher, A. Brodutch and A. M. Steinberg. "Measuring the time atoms spend in the excited state due to a photon they don't absorb," *PRX Quantum* 3, 030314 (2020), featured in Physics World link, Scientific American link, Popular Mechanics link, and the Independent link.
6. **J. Sinclair**, D. Angulo, N Lupu-Gladstein, K. Bonsma-Fisher and A.M. Steinberg. "Observation of a large, resonant, cross-Kerr nonlinearity in a cold Rydberg gas," *Phys. Rev. Research* 1, 033193 (2019).
7. **J. Sinclair**, D. Spierings, A. Brodutch and A. M. Steinberg. "Interpreting weak value amplification with a toy realist model," *Physics Letters A* 383, 2839 (2019).
8. **J. Sinclair**, M. Hallaji, A. M. Steinberg, J. Tollaksen and A. N. Jordan, "Weak-value amplification and optimal parameter estimation in the presence of correlated noise," *Phys. Rev. A* 96, 052128 (2017).
9. M. Hallaji, A. Feizpour, G. Dmochowski, **J. Sinclair** and A. M. Steinberg, "Weak-value amplification of the nonlinear effect of a single photon," *Nature Phys* 13, 540-544 (2017).
10. **J. Sinclair** and M. Walhout, "Dielectric-Barrier Discharges in Two-Dimensional Lattice Potentials," *Phys. Rev. Lett*. 108, 035005 (2012).

Papers Under Review

11. B. Hu*, **J. Sinclair***, E. Bytyqi, M. Chong, A. Rudelis, J. Ramette, Z. Vendairo, V. Vuletić. "Site-selective cavity readout and classical error correction of a 5-bit atomic register," (2024) *arXiv*:2408.15329 [quant-ph] (*contributed equally).
12. **J. Sinclair**, J. Ramette, B. Grinkemeyer, D. Bluvstein, M.D. Lukin, V. Vuletić. "Fault-tolerant optical interconnects for neutral-atom arrays," (2024) *arXiv*:2408.08955 [quant-ph].
13. J. Ramette**,** J**. Sinclair**, and V. Vuletić. "Counter-factual carving exponentially improves entangled-state fidelity," (2024) *arXiv*: 2401.11407 [quant-ph].
14. K. Thompson, K. Li, D. Angulo, V.M. Nixon, **J. Sinclair**, A.V. Sivakumar, H.M. Wiseman, A.M. Steinberg, "How much time does a photon spend as an atomic excitation before being transmitted?" (2023), *arXiv*:23100.00432 [quant-ph].

Non-refereed papers

15. J. Taylor, **J. Sinclair**, K. Bonsma-Fisher, D. England, M. Spanner and K. Heshami. "Generation of doubly excited Rydberg states based on Rydberg antiblockade in a cold atomic ensemble," (2019) *arXiv*:1912.05675 [atom-ph].
16. H. Pimenta, A.Z. Goldberg, **J. Sinclair** and K. Bonsma-Fisher, "Simulating one-dimensional systems with stationary Rydberg dark polaritons," (2018), *arXiv*:1803.07565 [quant-ph].

Patents

1. J. Ramette, J. Sinclair, V. Vuletić. "Modular Rydberg Architectures for Fault-Tolerant Quantum Computing," (2024) US Patent No. 155291. Available online at link.
2. J. Ramette, J. Sinclair, V. Vuletić. "All-Connected, Cavity-Mediated Quantum Computing with Local Quantum Processors," (2022) US Patent No. 0138608A1. Available online at link.

SELECTED PRESENTATIONS

Invited Talks

1. Fault-tolerant scalability for neutral atom arrays
   Princeton Quantum Technology Conference, Princeton, NJ (USA) 2024
2. Modular quantum error correction for neutral atom arrays
   CIFAR Quantum Information Science Program Meeting, Montreal, QC (Canada) 2024
3. Programmable arrays of single atoms inside an optical cavity
   University of Connecticut Physics Colloquium, Storrs, CT (USA) 2024
4. Progress towards quantum error correction with atom arrays in an optical cavity
   ITAMP-Harvard Seminar, Cambridge, MA (USA) 2023
5. Progress towards quantum error correction with atom arrays in an optical cavity
   Quantum Innovators 2023, Institute for Quantum Computing, Waterloo, ON (Canada) 2023
6. Any-to-any connected cavity-mediated architecture for quantum computing
   University of Toronto CQIQC Seminar, Toronto, ON (Canada) 2021
7. Weakly measuring the time a transmitted photon causes atoms to spend in the excited state
   Calvin University Physics Colloquium, Grand Rapids, MI (USA) 2021

Selected Conference Talks

8. Connecting surface code modules with noisy links
   Division of Atomic, Molecular and Optical Physics (DAMOP), Spokane, WA (USA) 2023
9. Any-to-any connected cavity-mediated architecture for quantum computing
   DAMOP, Orlando, FL, (USA) 2022
10. Weakly measuring the time atoms spend in the excited state due to a photon they don't absorb
    APS March Meeting, online 2021
11. Excitation without loss
    DAMOP, online 2020
12. Observation of a large cross-Kerr nonlinearity based on interacting Rydberg atoms and EIT
    DAMOP, Milwaukee, WI (USA) 2019
13. Is weak value amplification useful for precision measurement?
    Photonics North, Ottawa, ON, (Canada) 2017
14. How a single photon can act like many photons
    DAMOP, Columbus, OH, (USA) 2015

Selected Conference Posters

1. Fault-tolerant scaling of Rydberg arrays
   DAMOP, Spokane, WA (USA) 2023
2. A modular, scalable, fault-tolerant quantum computer based on Rydberg arrays and cavities
   International Conference of Atomic Physics (ICAP), Toronto, ON (Canada) 2022
3. Observation of a large per-photon nonlinear cross-phase shift in a free-space Rydberg medium
   ICAP, Barcelona (Spain) 2018
4. An enhanced Kerr nonlinearity using Rydberg EIT
   DAMOP, Fort Lauderdale, FL (USA) 2018
5. How a single photon can act like many photons
   Conference on Quantum Information and Quantum Control, Toronto, ON (Canada) 2016

TEACHING & MENTORING EXPERIENCE

Student Supervising and Mentoring

6 Ph.D. Students – Massachusetts Institute of Technology (MIT), USA	2021-
1 B.Sc. Student – Massachusetts Institute of Technology (MIT), USA	2021-23
2 Ph.D. Students – University of Toronto, Canada	2017-20
1 B.Sc. Student – University of Toronto, Canada	2019-20
1 High School Student	2019-21

Teaching Assistant (tutorial)

Responsibilities included developing new tutorial materials, delivering lectures, leading discussions, and developing activities for biweekly tutorials.

- Introduction to Quantum Mechanics (Fall 2018, Fall 2019), University of Toronto, 25 undergraduates.

Teaching Assistant (lab)

Responsibilities included assisting students in performing laboratory experiments, explaining relevant physics concepts, rewriting experiment manuals, and upgrading laboratory equipment.

- Holography (Spring 2017, Spring 2018, Spring 2019), University of Toronto, 20 undergraduates.
- 2nd-3rd Year Physics Labs (Fall 2016, Fall 2017, Spring 2020), 20 undergraduates.
- 1st Year Physics Labs (Fall 2013, Spring 2014, Fall 2014, Spring 2015, Spring 2016), 20 undergraduates

SELECTED FELLOWSHIPS & AWARDS

NSERC Postdoctoral Fellowship, Natural Sciences and Engineering Research Council of Canada, 2021
Ontario Graduate Scholarship, Government of Ontario, 2018
Ontario Graduate Scholarship, Government of Ontario**,** 2017
E.F. Burton Fellowship in Physics, University of Toronto, 2015
Calvin University Student Leader of the Year Award, Calvin University, 2012

PROFESSIONAL OUTREACH & COMMUNITY SERVICE

- Reviewer for *Nature Communications, Physical Review A,* and *Applied Physics Letters*.
- Co-led the Quantum Computing stream of 10K+ member online AI community (Aggregate Intellect).
- Mentored multiple undergraduates now at top physics graduate programs around the country.
- Mentored for Girls SySTEM Program, a program aimed at supporting girls in going into STEM.
- Organized a monthly interdisciplinary research event hosted by CQIQC.
- Organized a weekly seminar in which AMO graduate students and postdocs present research to peers.
- Organized a half-day field trip and lab tour for Grade 5-6 students from a local elementary school.
- Organized a half-day field trip and lab tour for Grade 11 physics students from a local high school.

REFERENCES

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