

William J. Cunningham

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Summary

I have worked on projects in high performance computational physics for nine years. After working in Lattice QCD during my undergraduate education, I moved to the field of Network Science, concentrating on the statistical physics of random graphs and Causal Set Quantum Gravity. I also studied computer architecture and design during my Ph.D. education, which led to the development of some of the most efficient causal set algorithms to date. I am currently employed at Perimeter Institute, where I research discrete computational geometry, advanced Monte Carlo methods, causal set and spinfoam quantum gravity, spin glasses, and foundations of quantum mechanics. In a subsequent position, I am eager to challenge myself in new areas while contributing the experience and perspective I have gained from diverse interdisciplinary collaborations.

Employment

Agnostiq Quantum Algorithms Researcher	TORONTO, ON, CANADA 2020 –
Perimeter Institute for Theoretical Physics Postdoctoral Research Fellow, Discretuum to Continuum Initiative	WATERLOO, ON, CANADA 2018 – 2020

Education

Northeastern University Ph.D. in Physics Dissertation: High Performance Algorithms for Quantum Gravity and Cosmology Advisor: Dmitri Krioukov, Associate Professor of Physics	BOSTON, MA, UNITED STATES 2015 – 2018
M.S. in Physics Concentration: Complex Systems and Network Science	2013 – 2015
Rensselaer Polytechnic Institute B.S. in Physics Concentration: Lattice Quantum Chromodynamics Minor in Astrophysics	TROY, NY, UNITED STATES 2009 – 2013

Publications

Peer Reviewed Articles

- [1] W. J. Cunningham, B. Dittrich & S. Steinhaus, Tensor Network Renormalization with Fusion Charges: Applications to 3D Lattice Gauge Theory. *Universe* **6**, 97 (2020).
- [2] W. J. Cunningham & S. Surya, Dimensionally Restricted Causal Set Quantum Gravity: Examples in Two and Three Dimensions. *Class. Quantum Grav.* **37**, 054002 (2020).
- [3] B. Bahr, W. J. Cunningham, B. Dittrich, L. Glaser, D. Lang, E. Schnetter & S. Steinhaus, Data on Sharing Data. *Nat. Phys.* **15**, 724 (2019).
- [4] J. Carifio, W. J. Cunningham, J. Halverson, D. Krioukov, C. Long & B. D. Nelson, Vacuum Selection from Cosmology on Networks of String Geometries. *Phys. Rev. Lett.* **121**, 101602 (2018).
- [5] W. J. Cunningham & D. Krioukov, Causal Set Generator and Action Computer. *Comput. Phys. Commun.* **233**, 123 (2018).
- [6] W. J. Cunningham, Inference of Boundaries in Causal Sets. *Class. Quantum Grav.* **35**, 094002 (2018).
- [7] W. J. Cunningham, D. Rideout, J. Halverson & D. Krioukov, Exact Geodesic Distances in FLRW Spacetimes. *Phys. Rev. D* **96**, 103538 (2017).
- [8] W. Cunningham, K. Zuev & D. Krioukov, Navigability of Random Geometric Graphs in the Universe and Other Spacetimes. *Sci. Rep.* **7**, 8699 (2017).

- [9] W. Cunningham & J. Giedt, Eguchi-Kawai Reduction with One Flavor of Adjoint Möbius Fermion. *Phys. Rev. D* **93**, 045006 (2016).

Submitted for Publication

- [10] P. van der Hoorn, W. J. Cunningham, G. Lippner, C. Trugenberger & D. Krioukov, Ollivier-Ricci Curvature Convergence in Random Geometric Graphs. *Submitted to Physical Review Letters* (2020).

In Preparation

- [11] S. Stanojevic, M. Toomey, W. J. Cunningham, L. Smolin, S. Alexander, D. Wecker & J. Lanier. Protocols for Autodidactic Systems (2020).
- [12] W. J. Cunningham, L. Glaser, I. Jubb & B. Kulchytskyy, Quantum Growth Models for Discrete Spacetimes (2020).
- [13] W. J. Cunningham, Monte Carlo Methods for Causal Sets (2020).
- [14] W. J. Cunningham, F. Caravelli & Y. Subasi, Geometry of Hamiltonian Parallel Tempering (2020).
- [15] W. J. Cunningham & I. Jubb, Timelike Hypersurfaces in Causal Set Quantum Gravity (2020).

Open-Source Code

- [16] W. J. Cunningham, Graph Curvature Toolkit. *To appear.* (2018–2020).
- [17] W. J. Cunningham, Causal Set Generator. *Bitbucket: CausalSetGenerator* (2017–2020).
- [18] W. J. Cunningham, FastMath Library. *Bitbucket: FastMath* (2015–2020).

Awards and Affiliations

Member of CanCOVID Modelling Group	2020
Affiliate of Waterloo Institute for Complexity and Innovation	2020
Member of Sigma Pi Sigma National Physics Honor Society, United States	2013
Member of Phi Sigma Kappa Gamma Tetarton Chapter, United States	2010
Recipient of the Rensselaer Medal Undergraduate Merit Scholarship of USD \$100,000	2009 – 2013

Conferences and Meetings

Invited Talks

Quantum Dynamics of Total Orders	<i>CP3-ORIGINS (VIRTUAL) (Apr. 2020)</i>
Classical and Quantum Growth Models for Causal Sets	<i>CP3-ORIGINS (Feb. 2020)</i>
Classical and Quantum Growth Models for Discrete Spacetime	<i>LOS ALAMOS (Dec. 2019)</i>
Restricted Sample Spaces in Causal Set Theory	<i>RADBOUD UNIVERSITEIT NIJMEGEN (Sept. 2019)</i>
Inference of Boundaries in Causal Sets	<i>UNIVERSITÄT HEIDELBERG (Jun. 2018)</i>
Deep Learning in Quantum Gravity Quantum Gravity on the Computer	<i>NORDITA (Mar. 2018)</i>
Vacuum Selection from Cosmology Using Networks of String Geometries	<i>RENSSELAER POLYTECHNIC INSTITUTE (Jan. 2018)</i>
The Big Data Approach to Quantum Gravity	<i>PERIMETER INSTITUTE (Dec. 2017)</i>
Network Science: Data and Algorithms 2017 Workshop on Data Science and String Theory	<i>NORTHEASTERN UNIVERSITY (Nov. 2017)</i>
Timelike Boundaries in Directed Acyclic Graphs Working Meeting on Causal Sets	<i>RAMAN RESEARCH INSTITUTE (Dec. 2016)</i>
Boundary Terms in Causal Sets Working Meeting on the Quantum Measure and Causal Sets	<i>RAMAN RESEARCH INSTITUTE (Jan. 2016)</i>

Introduction to GPU Programming

Working Meeting on the Quantum Measure and Causal Sets

RAMAN RESEARCH INSTITUTE (Jan. 2016)

Contributed Talks

Timelike Hypersurfaces in Causal Sets

Quantum and Gravity in Okinawa

OKINAWA INSTITUTE OF SCIENCE & TECHNOLOGY (Jul. 2019)

Inference of Boundaries in Causal Sets

International School and Conference on Network Science

PARIS (Jun. 2018)

Recovering the Einstein-Hilbert Action from Causal Sets

International School and Conference on Network Science

SEOUL (Jun. 2016)

Attended

Virtual Causal Set Meeting

VIRTUAL (Aug. 2020)

Quantum Gravity 2020

PERIMETER INSTITUTE (Jun. 2020)

Quantum Gravity and Matter

UNIVERSITÄT HEIDELBERG (Sept. 2019)

Working Meeting on Causal Sets

PERIMETER INSTITUTE (Sept. 2017)

Making Quantum Gravity Computable

PERIMETER INSTITUTE (Jun. 2017)

2016 ACM/IEEE Supercomputing Conference

SALT LAKE CITY (Nov. 2016)

XXVI IUPAP Conference on Computational Physics

BOSTON UNIVERSITY (Aug. 2014)

International School and Conference on Network Science

U.C. BERKELEY (Jun. 2014)

Academic Service

Leadership / Initiatives

Frontiers in Interdisciplinary Physics (Review Editor)

2020

Encyclopedia of Quantum Geometries (Co-Founder)

2018 – 2020

Journal Reviews

Classical and Quantum Gravity

2017 – 2020

Astrophysics and Space Science

2017

EPJ Data Science

2017

Proposal Reviews

National Science Foundation

Departmental Seminars

Deep Learning with Causal Sets

Nov. 2018

High Performance Algorithms for Quantum Gravity and Cosmology

May 2018

Recovering the Einstein-Hilbert Action from Causal Sets

Apr. 2016

Navigability and Dark Energy in Causal Set Networks

Feb. 2015

Technical Skills

Expert

C, CUDA (GPU Programming), Intel SSE/AVX, MPI, OpenMP, Bash, RedHat/Centos Linux, LSF and SLURM, Mathematica, \LaTeX

Proficient

C++, Python, C#, Gentoo Linux, Ubuntu/Debian Linux, Git, Systems Administration

Working Knowledge

Intel x64 Assembly, Julia, TensorFlow, MATLAB, OpenCL, POSIX Threading, Adobe Photoshop/Illustrator, Java, Google Cloud

Limited Experience

Fortran 77, Perl, PHP, MySQL, HTML, Regular Expressions, Xeon Phi Programming, Intel MKL, Arch Linux

Teaching

Guest Lecturer

Computational Geometry for Quantum Gravity
An Overview of Computational Linear Algebra
Why Computer Architecture Matters for HPC

RENSSELAER POLYTECHNIC INSTITUTE (Jun. 2020)
RENSSELAER POLYTECHNIC INSTITUTE (Jul. 2019)
RENSSELAER POLYTECHNIC INSTITUTE (Jul. 2019)

Teaching Assistant

Introduction to Network Science
Physics 1 and 2 Laboratory
Physics 2 Laboratory

NORTHEASTERN UNIVERSITY (Spring 2014)
NORTHEASTERN UNIVERSITY (2013 – 2014)
RENSSELAER POLYTECHNIC INSTITUTE (Fall 2011)

Professional References

[Bianca Dittrich](#)

PERIMETER INSTITUTE

Faculty Member
Relationship: Mentor
Contact: bdittrich@perimeterinstitute.ca, +1.519.569.7600 x7504

[Lee Smolin](#)

PERIMETER INSTITUTE

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[Dmitri Krioukov](#)

NORTHEASTERN UNIVERSITY

Associate Professor of Physics, Mathematics, and Electrical & Computer Engineering
Relationship: Ph.D. Advisor
Contact: dima@northeastern.edu, +1.617.373.2934

[Sumati Surya](#)

RAMAN RESEARCH INSTITUTE

Professor of Physics
Relationship: Collaborator
Contact: ssurya@rri.res.in, +91.948.083.6226

Fun Facts

- I am an avid HPC homelabber. I built and now manage a heterogeneous Gentoo-based cluster to test parallel algorithms and micro-optimizations. From this I have learned a host of topics, including SLURM configuration, Infiniband verbs, NFS/RDMA, NUMA, and load balancing on heterogeneous multi-core systems.
- I have a one-year-old golden retriever, Winnie, who watches for mistakes while I program.
- My Erdős number is 4.