Hanmeng (Harmony) Zhan

CONTACT INFORMATION

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RESEARCH INTERESTS

Algebraic graph theory, quantum walks, orthogonal polynomials, equiangular lines, association schemes, covering graphs, graph embeddings

CURRENT POSITION

Assistant Professor Aug 2023 - Present

- Computer Science Department, Worcester Polytechnic Institute, Worcester, MA, USA

PREVIOUS POSITIONS

Postdoctoral Fellow Jan 2022 - May 2023

- Department of Mathematics, Simon Fraser University, Vancouver, BC, Canada
  Topic of projects: Spectral graph theory
  Supervisor: Bojan Mohar

York Science Fellow Oct 2019 - Sep 2021

- Department of Mathematics and Statistics, York University, Toronto, ON, Canada
  Topic of projects: Discrete quantum walks
  Supervisor: Ada Chan

Postdoctoral Fellow Oct 2018 - Sep 2019

- Centre de Recherches Mathématiques, Université de Montréal, Montréal, QC, Canada
  Topic of projects: Continuous quantum walks
  Supervisor: Luc Vinet

EDUCATION

University of Waterloo, Waterloo, ON, Canada

- Ph.D. May 2014 - Sep 2018
  Department of Combinatorics and Optimization, Faculty of Mathematics
  Thesis: *Discrete Quantum Walks on Graphs and Digraphs*
  Supervisor: Chris Godsil
  Thesis awards:
  - University Finalist for the Governor General's Gold Medal
  - Inaugural Mathematics Doctoral Prize
- Master of Mathematics Sep 2012 - Apr 2014
  Department of Combinatorics and Optimization, Faculty of Mathematics
  Thesis: *Uniform Mixing on Cayley Graphs over* $\mathbb{Z}_3^d$
  Supervisor: Chris Godsil
  Thesis award:
  - Outstanding Achievement in Graduate Studies

- Bachelor of Arts — Jan 2010 - Aug 2012

  Department of Economics, Faculty of Arts

  Thesis: *Second-Price Auction with Resale*

  Supervisor: Philip Curry

Xiamen University, Xiamen, Fujian, China

- Bachelor of Economics — Sep 2008 - Jun 2014

  Department of Statistics, Faculty of Economics

  Thesis: *Multi-Player Multi-State Quantum Games*

  Supervisor: Zhengming Qian

Publications

Book

1. C. Godsil, H. Zhan, *Discrete Quantum Walks on Graphs and Digraphs*. Cambridge University Press (2023).

Peer-Reviewed Papers

2. A. Chan, H. Zhan, *Pretty good state transfer in discrete-time quantum walks*. Journal of Physics A: Mathematical and Theoretical (2023). doi:10.1088/1751-8121/acc4f5

3. H. Zhan, *The average search probabilities of discrete-time quantum walks*. Quantum Information Processing (2022) 21(9): pp. 336. doi:10.1007/s11128-022-03681-9

4. A. Chan, G. Coutinho, W. Drazen, O. Eisenberg, C. Godsil, M. Kempton, G. Lippner, C. Tamon, H. Zhan, *Fundamentals of fractional revival in graphs*. Linear Algebra and its Applications (2022). doi:10.1016/J.LAA.2022.09.010

5. H. Zhan, *Factoring discrete quantum walks on distance regular graphs into continuous quantum walks*. Linear Algebra and its Applications (2022), 648: pp. 88-103. doi:10.1016/J.LAA.2022.04.017

6. A. Chan, B. Johnson, M. Liu, M. Schmidt, Z. Yin, H. Zhan, *Laplacian pretty good fractional revival*. Discrete Mathematics (2022), 345(10), 112971. doi:10.1016/J.DISC.2022.112971

7. A. Chan, B. Johnson, M. Liu, M. Schmidt, Z. Yin, H. Zhan, *Laplacian fractional revival on graphs*. Electronic Journal of Combinatorics (2021) 28(3): P3.22.

8. A. Chan, G. Coutinho, C. Tamon, L. Vinet, H. Zhan, *Fractional revival and association schemes*. Discrete Mathematics (2020) 343(11), 112018. doi:10.1016/j.disc.2020.112018

9. L. Vinet, H. Zhan, *Perfect state transfer on weighted graphs of the Johnson scheme*. Letter in Mathematical Physics (2020). doi.org/10.1007/s11005-020-01298-6

10. H. Zhan, *Quantum walks on embeddings*. Journal of Algebraic Combinatorics (2020). doi.org/10.1007/s10801-020-00958-z

11. H. Zhan, *An infinite family of circulant graphs with perfect state transfer in discrete quantum walks*. Quantum Information Processing (2019) 18(12): pp. 369.

12. G. Coutinho, L. Vinet, H. Zhan, A. Zhedanov. *Perfect state transfer in a spin chain without mirror symmetry*. Journal of Physics A: Mathematical and Theoretical (2019) 52(45), pp. 455302.

13. C. Godsil, H. Zhan, *Discrete-time quantum walks and graph structures.* Journal of Combinatorial Theory, Series A (2019), pp. 181212.

14. A. Chan, G. Coutinho, C. Tamon, L. Vinet, H. Zhan, *Quantum fractional revival on graphs.* Discrete Applied Mathematics (2019) 269, pp. 86-98.

15. G. Coutinho, C. Godsil, K. Guo, H. Zhan, *A new perspective on the average mixing matrix.* Electronic Journal of Combinatorics (2018) 25(4): P4.14.

16. C. Godsil, H. Zhan, *Uniform mixing on Cayley graphs.* Electronic Journal of Combinatorics (2017) 24(3): P3.20.

17. G. Coutinho, C. Godsil, M. Shirazi, H. Zhan, *Equiangular lines and covers of the complete graph.* Linear Algebra and its Applications (2016) 488: pp. 264-283.

18. R. Alvir, S. Dever, B. Lovitz, J. Myer, C. Tamon, Y. Xu, H. Zhan. *Perfect state transfer in Laplacian quantum walk.* Journal of Algebraic Combinatorics (2016) 43(4): pp. 801-826.

Submitted Preprints

19. Q. Chen, C. Godsil, M. Sobchuk, H. Zhan. *Hamiltonians of bipartite walks.* arXiv:2207.01673 (2022).

20. H. Kumar, B. Mohar, S. Pragada, H. Zhan. *Subdivision and Graph Eigenvalues.* arXiv:2303.10488 (2023).

Supervision Experience

Undergraduate Research Programs

- Fields Undergraduate Summer Research Program — Jul - Aug, 2020

  Co-supervised an undergraduate research project with Ada Chan on Laplacian fractional revival at the Fields Institute. This results in two papers [6] and [7]. One student was awarded the Book Prize by the Fields Institute.

- University of Waterloo — May - Aug, 2018

  Mentored one undergraduate student under the supervision of Chris Godsil. The student extended my results in the paper [10], and developed the theory of a new quantum walk called the vertex-face walk. This leads to the joint work [19].

Presentations

Invited Talks

1. *Some recent results in quantum walks.* In: Algebraic structures and special functions in theoretical physics, Ghent University, Ghent, Belgium, June 26 - June 30, 2023.

2. *Discrete Quantum Walks in Association Schemes.* In: 10th Slovenian Conference on Graph Theory, Kranjska Gora, Slovenia, June 18 - 24, 2023.

3. *Discrete quantum walks on distance regular graphs* and *Some open problems in discrete quantum walks.* In: Canadian Discrete and Algorithmic Mathematics Conference, University of Manitoba and University of Winnipeg, Winnipeg, MB, Canada, June 5 - 8, 2023.

4. *The second largest eigenvalue of a tree.* In: CMS Winter Meeting, Chelsea Hotel, Toronto, ON, Canada, December 2 - 5, 2022.

5. *The effect of marking vertices in discrete quantum walks.* In: Graph Theory, Algebraic Combinatorics and Mathematical Physics, Centre de Recherches Mathématiques, July 25 - August 19, 2022.

6. *The average search probability in a quantum walk with an oracle.* In: Algebraic Graph Theory Seminar, University of Waterloo, Waterloo, ON, Canada, August 2, 2021.

7. *Arc-reversal quantum walks.* In: Discrete Math Seminar, Simon Fraser University, Vancouver, BC, Canada, February 24, 2021.

8. *DRACKNs and their applications in quantum information.* In: Codes and Expansions, United States, September 8, 2020.

9. *Factoring discrete quantum walks into continuous quantum walks.* In: Algebraic Graph Theory Seminar, University of Waterloo, Waterloo, ON, Canada, August 3, 2020.

10. *Quantum fractional revival.* In: Discrete Math Seminar, University of Delaware, Newark, DE, United States, April 23, 2020.

11. *New advances in quantum walks.* In: AMS Joint Mathematics Meetings, Colorado Convention Center, Denver, CO, United States, January 15 - 18, 2020.

12. *State transfer via orthogonal polynomials.* In: AMS Sectional Meeting, University of Wisconsin-Madison, Madison, WI, United States, September 14 - 15, 2019.

13. *Quantum state transfer in the algebra of the Johnson scheme.* In: CMS Summer Meeting, University of Regina, Regina, SK, Canada, June 7 - 10, 2019.

14. *Some elegant results in algebraic graph theory.* In: Canadian Discrete and Algorithmic Mathematics Conference, Simon Fraser University, Vancouver, BC, Canada, May 28 - 31, 2019.

15. *Quantum walks, orthogonal polynomials, and spectral graph theory.* In: Quantum Walks and Information Tasks, Banff International Research Station for Mathematical Innovation and Discovery, Banff, AB, Canada, April 21 - 26, 2019.

16. *Generating entanglement using quantum walks.* In: David A. Walsh Seminar Series, Clarkson University, Potsdam, NY, United States, February 8, 2019.

17. *Some open problems in discrete quantum walks.* In: Algebraic Graph Theory and Quantum Walks, University of Waterloo, Waterloo, ON, Canada, April 23 - 27, 2018.

18. *Recent progress in discrete quantum walks.* In: AMS Sectional Meeting, Northeastern University, Boston, MA, United States, April 21 - 22, 2018, 2018.

19. *Graph covers and equiangular frames.* In: AMS Sectional Meeting, Ohio State University, Columbus, OH, United States, March 16 - 18, 2018.

20. *From covers to tight frames.* In: AMS Sectional Meeting, College of Charleston, Charleston, SC, United States, March 10 - 12, 2017.

21. *Spectra of discrete quantum walks.* In: CMS Summer Meeting, University of Alberta, Edmonton, AB, Canada, June 24 - 27, 2016.

22. *Lines and covers of complete graphs 2.* In: Systems of Lines: Applications of Algebraic Combinatorics, Worcester Polytechnic Institute, Worcester, MA, United States, August 10 - 14, 2015.

23. *Some open problems in uniform mixing.* In: Summer Research Program, Clarkson University, Potsdam, NY, United States, July 20, 2015.

Mini-Course

24. *Introduction to discrete quantum walks.* In: CMS Winter Meeting, Chelsea Hotel, Toronto, ON, Canada, December 2 - 5, 2022.

Contributed Talks

25. *Discrete quantum walk search on graphs.* In: Coast Combinatorics Conference 2023, SFU Harbour Centre, Vancouver, BC, Canada, March 4 - 5, 2023.

26. *How far can the quantum walker go.* In: 9th International Conference on Quantum Simulation and Quantum Walks, Centre International de Rencontres Mathématiques, Marseille, Bouches-du-Rhone, France, January 20 - 24, 2020.

27. *Discrete quantum walks on Cayley graphs.* In: CMS Winter Meeting, Chelsea Hotel, Toronto, Toronto, ON, Canada, December 6 - 9, 2019.

28. *The vertex-face walk.* In: Finite Geometry and Extremal Combinatorics, University of Delaware, Newark, DE, United States, August 21 - 24, 2019.

29. *Combinatorial aspects of quantum walks.* In: Prairie Discrete Math Workshop, Brandon University, Brandon, MB, Canada, June 12 - 15, 2018.

30. *Discrete-time quantum walks and graph embeddings.* In: CMS Winter Meeting, University of Waterloo, Waterloo, ON, Canada, December 8 - 11, 2017.

31. *Quantum walks and mixing.* In: Algebraic and Extremal Graph Theory, University of Delaware, Newark, DE, United States, August 7 - 10, 2017.

32. *Discrete-time quantum walks and graph structures.* In: Canadian Discrete and Algorithmic Mathematics Conference, Ryerson University, Toronto, ON, Canada, June 12 - 15, 2017.

33. *Uniform mixing in quantum walks.* In: 22nd Ontario Combinatorics Workshop, York University, Toronto, ON, Canada, May 16 - 17, 2014.

Teaching Experience

Simon Fraser University, Vancouver, BC, Canada

- Instructor — Spring 2023
  MACM 201: Discrete Mathematics II (class size: 180)
- Instructor — Summer 2022
  MATH 240: Algebra I: Linear Algebra (class size: 90)

Online Graduate Courses, International

- Instructor — Winter 2021
  Combinatorics and Quantum Walks (class size: 20; recordings available)

York University, Toronto, ON, Canada

- Instructor — Winter 2020, Fall 2020
  MATH 1014: Applied Calculus II (class size: 180 - 280)

University of Waterloo, Waterloo, ON, Canada

- Instructor — Winter 2018
  MATH 135: Algebra for Honors Mathematics (class size: 60)
- Substitute Instructor — Winter 2017
  CO 444/644: Algebraic Graph Theory (class size: 20)

Funding, Awards and Distinctions

Funding for Conferences Organized

- Algebraic Graph Theory and Quantum Information — 2021

Type and Source	Amount in CAD	Purpose
Fields Institute	$14250	travel funding for non-US invited speakers, at least $5000 towards ECRs, females, postdocs, students
NSF, via Fields Institute	$10000	travel funding for US invited speakers, at least 2/3 towards ECRs, females, postdocs, students
York University, via Office of Vice-President Research and Innovation	$2000	registration fees for students and postdocs

Table 1: Funding for Algebraic Graph Theory and Quantum Information

Awards and Distinctions from University of Waterloo

- *University Finalist for the Governor General's Gold Medal* — 2019
  Purpose: a medal awarded to nominees for the Governor General's Gold Medal
- *Inaugural Mathematics Doctoral Prize, First Prize ($1500)* — 2019
  Purpose: a prize awarded to recognize the achievement of graduating doctoral students in the Faculty of Mathematics
- *Outstanding Achievement in Graduate Studies* — 2015
  Purpose: an honor awarded to three University of Waterloo Master's students for their outstanding achievement in graduate studies
- *Cotton Family Women in Mathematics Graduate Scholarship ($9000)* — 2014, 2016, 2017
  Purpose: a scholarship awarded to a full-time female graduate student on the basis of academic excellence in their studies and research
- *Robin K. Banks Scholarship ($750)* — 2011 - 2012
  Purpose: a scholarship awarded to a full-time student in the Faculty of Arts who have achieved the highest overall average at the end of Year Three
- *Faculty of Arts Upper-Year Scholarship ($500)* — 2011 - 2012
  Purpose: a scholarship awarded to outstanding full-time and part-time students in the Faculty of Arts on the basis of overall average
- *Dean's Honours List* — 2011 - 2012

Service

Conference, Workshop and Seminar Organizer

- Algebraic Graph Theory and Quantum Information, Fields Institute 2021
  Co-organizers: Ada Chan, Gabriel Coutinho, Krystal Guo, Christino Tamon, Luc Vinet
- Quantum Information on Graphs, CMS Winter Meeting Dec 6 - 9, 2019
  Co-organizers: Ada Chan, Christino Tamon
- Discrete Mathematics Seminar, York University Fall 2019
  Co-organizer: Justin M. Troyka

Seminar Chair

- Algebraic Graph Theory Seminar, University of Waterloo Spring 2016, Fall 2017

Journal Reviewer

- Quantum Information Processing 2022-2023
- Algebraic Combinatorics 2022
- Discrete Mathematics 2021 - 2022
- Linear Algebra and Its Applications 2016, 2019 - 2022
- Journal of Combinatorial Theory, Series A 2021
- Electronic Journal of Combinatorics 2017 - 2021
- Linear and Multilinear Algebra 2019 - 2020
- Communications in Algebra 2019
- Journal of Physics A: Mathematical and Theoretical 2019

Conference Reviewer

- Sampling Theory and Applications 2019
- International Colloquium on Automata, Languages and Programming 2018