

## Hanmeng (Harmony) Zhan

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CONTACT INFORMATION	Computer Science Department 100 Institute Rd, Worcester, MA 01609, USA	hzhan@wpi.edu hanmengzhan.com
RESEARCH INTERESTS	Algebraic graph theory, discrete quantum walks, continuous quantum walks, graph spectra, association schemes, orthogonal polynomials, equiangular lines	
CURRENT POSITION	<b>Assistant Professor</b> <ul style="list-style-type: none"><li>Computer Science Department, Worcester Polytechnic Institute, Worcester, MA, USA</li></ul>	Aug 2023 - Present
PREVIOUS POSITIONS	<b>Postdoctoral Fellow</b> <ul style="list-style-type: none"><li>Department of Mathematics, Simon Fraser University, Vancouver, BC, Canada Topic of projects: Spectral graph theory Supervisor: Bojan Mohar</li></ul> <b>York Science Fellow</b> <ul style="list-style-type: none"><li>Department of Mathematics and Statistics, York University, Toronto, ON, Canada Topic of projects: Discrete quantum walks Supervisor: Ada Chan</li></ul> <b>Postdoctoral Fellow</b> <ul style="list-style-type: none"><li>Centre de Recherches Mathématiques, Université de Montréal, Montréal, QC, Canada Topic of projects: Continuous quantum walks Supervisor: Luc Vinet</li></ul>	Jan 2022 - May 2023  Oct 2019 - Sep 2021  Oct 2018 - Sep 2019
EDUCATION	<b>University of Waterloo</b> , Waterloo, ON, Canada <ul style="list-style-type: none"><li>Ph.D. Department of Combinatorics and Optimization, Faculty of Mathematics Thesis: <i>Discrete Quantum Walks on Graphs and Digraphs</i> Supervisor: Chris Godsil <b>Thesis awards:</b><ul style="list-style-type: none"><li>University Finalist for the Governor General's Gold Medal</li><li>Inaugural Mathematics Doctoral Prize</li></ul></li><li>Master of Mathematics Department of Combinatorics and Optimization, Faculty of Mathematics Thesis: <i>Uniform Mixing on Cayley Graphs over <math>\mathbb{Z}_3^d</math></i> Supervisor: Chris Godsil <b>Thesis award:</b><ul style="list-style-type: none"><li>Outstanding Achievement in Graduate Studies</li></ul></li></ul>	May 2014 - Sep 2018  Sep 2012 - Apr 2014

- 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. 181–212.
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. H. Zhan.  *$\epsilon$ -uniform mixing in discrete quantum walks*. arXiv:2311.18797 (2023).
20. Q. Chen, C. Godsil, M. Sobchuk, H. Zhan. *Hamiltonians of bipartite walks*. arXiv:2207.01673 (2022).
21. H. Kumar, B. Mohar, S. Pragada, H. Zhan. *Subdivision and graph Eigenvalues*. arXiv:2303.10488 (2023).

### MENTORING EXPERIENCE

#### Graduate Research Programs

- WPI Graduate Independent Studies Project Jan - Present, 2024  
Supervised a graduate research project on discrete quantum walks.

#### Undergraduate Research Programs

- WPI STAR Summer Research Training Program May - Aug, 2024  
Supervising an undergraduate research project on continuous quantum walks.
- 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. *Generating quantum uniform mixing in association schemes.* In: CMS Summer Meeting, University of Saskatchewan, Saskatoon, SK, Canada, May 31 - June 3, 2024.
2. *Discrete quantum walks in schemes.* In: AMS Sectional Meeting, University of Wisconsin-Milwaukee, Milwaukee, WI, United States, April 20 - 21, 2024.
3. *Quantum walks: from continuous to discrete.* In: Godsil75, University of Waterloo, Waterloo, ON, Canada, March 15 - 17, 2024.
4. *Strongly cospectral vertices and their phantom mates.* In: Joint Mathematics Meetings, Moscone Center, San Francisco, CA, United States, January 3 - 6, 2024.
5. *Quantum search: an averaging perspective.* In: Joint Mathematics Meetings, Moscone Center, San Francisco, CA, United States, January 3 - 6, 2024.
6. *Spectra of line digraphs and their applications.* In: CMS Winter Meeting, DoubleTree by Hilton Montréal, Montréal, QC, Canada, December 1 - 4, 2023.
7. *How graph spectra determine the behavior of discrete quantum walks.* In: 10th International Workshop of Quantum Simulation and Quantum Walks, Tsukuba International Congress Center, Tsukuba, Japan, November 10 - 12, 2023.
8. *Some recent results in quantum walks.* In: Algebraic structures and special functions in theoretical physics, Ghent University, Ghent, Belgium, June 26 - 30, 2023.
9. *Discrete quantum walks in association schemes.* In: 10th Slovenian Conference on Graph Theory, Kranjska Gora, Slovenia, June 18 - 24, 2023.
10. *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.
11. *Discrete quantum walks on distance regular graphs.* In: Canadian Discrete and Algorithmic Mathematics Conference, University of Manitoba and University of Winnipeg, Winnipeg, MB, Canada, June 5 - 8, 2023.
12. *The second largest eigenvalue of a tree.* In: CMS Winter Meeting, Chelsea Hotel, Toronto, ON, Canada, December 2 - 5, 2022.
13. *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.
14. *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.
15. *Arc-reversal quantum walks.* In: Discrete Math Seminar, Simon Fraser University, Vancouver, BC, Canada, February 24, 2021.
16. *DRACKNs and their applications in quantum information.* In: Codes and Expansions, United States, September 8, 2020.
17. *Factoring discrete quantum walks into continuous quantum walks.* In: Algebraic Graph Theory Seminar, University of Waterloo, Waterloo, ON, Canada, August 3, 2020.

18. *Quantum fractional revival*. In: Discrete Math Seminar, University of Delaware, Newark, DE, United States, April 23, 2020.
19. *New advances in quantum walks*. In: AMS Joint Mathematics Meetings, Colorado Convention Center, Denver, CO, United States, January 15 - 18, 2020.
20. *State transfer via orthogonal polynomials*. In: AMS Sectional Meeting, University of Wisconsin-Madison, Madison, WI, United States, September 14 - 15, 2019.
21. *Quantum state transfer in the algebra of the Johnson scheme*. In: CMS Summer Meeting, University of Regina, Regina, SK, Canada, June 7 - 10, 2019.
22. *Some elegant results in algebraic graph theory*. In: Canadian Discrete and Algorithmic Mathematics Conference, Simon Fraser University, Vancouver, BC, Canada, May 28 - 31, 2019.
23. *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.
24. *Generating entanglement using quantum walks*. In: David A. Walsh Seminar Series, Clarkson University, Potsdam, NY, United States, February 8, 2019.
25. *Some open problems in discrete quantum walks*. In: Algebraic Graph Theory and Quantum Walks, University of Waterloo, Waterloo, ON, Canada, April 23 - 27, 2018.
26. *Recent progress in discrete quantum walks*. In: AMS Sectional Meeting, Northeastern University, Boston, MA, United States, April 21 - 22, 2018, 2018.
27. *Graph covers and equiangular frames*. In: AMS Sectional Meeting, Ohio State University, Columbus, OH, United States, March 16 - 18, 2018.
28. *From covers to tight frames*. In: AMS Sectional Meeting, College of Charleston, Charleston, SC, United States, March 10 - 12, 2017.
29. *Spectra of discrete quantum walks*. In: CMS Summer Meeting, University of Alberta, Edmonton, AB, Canada, June 24 - 27, 2016.
30. *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.
31. *Some open problems in uniform mixing*. In: Summer Research Program, Clarkson University, Potsdam, NY, United States, July 20, 2015.

#### **Mini-Course**

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

#### **Contributed Talks**

30.  *$\epsilon$ -uniform mixing in discrete quantum walks*. In: CMS Winter Meeting, DoubleTree by Hilton Montréal, Montréal, QC, Canada, December 1 - 4, 2023.
31. *Discrete quantum walk search on graphs*. In: Coast Combinatorics Conference 2023, SFU Harbour Centre, Vancouver, BC, Canada, March 4 - 5, 2023.

32. *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.
33. *Discrete quantum walks on Cayley graphs.* In: CMS Winter Meeting, Chelsea Hotel, Toronto, Toronto, ON, Canada, December 6 - 9, 2019.
34. *The vertex-face walk.* In: Finite Geometry and Extremal Combinatorics, University of Delaware, Newark, DE, United States, August 21 - 24, 2019.
35. *Combinatorial aspects of quantum walks.* In: Prairie Discrete Math Workshop, Brandon University, Brandon, MB, Canada, June 12 - 15, 2018.
36. *Discrete-time quantum walks and graph embeddings.* In: CMS Winter Meeting, University of Waterloo, Waterloo, ON, Canada, December 8- 11, 2017.
37. *Quantum walks and mixing.* In: Algebraic and Extremal Graph Theory, University of Delaware, Newark, DE, United States, August 7 - 10, 2017.
38. *Discrete-time quantum walks and graph structures.* In: Canadian Discrete and Algorithmic Mathematics Conference, Ryerson University, Toronto, ON, Canada, June 12 - 15, 2017.
39. *Uniform mixing in quantum walks.* In: 22nd Ontario Combinatorics Workshop, York University, Toronto, ON, Canada, May 16 - 17, 2014.

TEACHING  
EXPERIENCE

**Worcester Polytechnic Institute, Worcester, MA, USA**

- Instructor Spring 2024  
CS 503: Foundations of Computer Science (class size: 25)
- Instructor Spring D-term 2024  
CS 4123: Theory of Computation (class size: 40)

**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)

**Federal Research Grants**

- NSF CRII: FET: Quantum Advantages through Discrete Quantum Walks 2024 - 2026  
Award number: 2348399  
Amount: \$174420.00

**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* 2019  
Purpose: a prize awarded to recognize the achievement of graduating doctoral students in the Faculty of Mathematics  
Amount: \$1500
- *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* 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  
Amount: \$9000
- *Robin K. Banks Scholarship* 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  
Amount: \$750
- *Faculty of Arts Upper-Year Scholarship* 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  
Amount: \$500

## SERVICE

### Conference, Workshop and Seminar Organizer

- Algebraic Graph Theory for Walking on Graphs, CMS Winter Meeting 2023  
Co-organizers: Sooyeong Kim, Hermie Monderde, Christopher Van Bommel, Xiaohong Zhang
- 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
- Discrete Mathematics 2021 - 2023
- Linear Algebra and Its Applications 2016, 2019 - 2023
- Linear and Multilinear Algebra 2019 - 2020, 2023
- Algebraic Combinatorics 2022
- Journal of Combinatorial Theory, Series A 2021
- Electronic Journal of Combinatorics 2017 - 2021
- 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