# MORDECAI J. WAEGELL

## WORK ADDRESS

Institute for Quantum Studies                                        Phone: (774) 200-4637
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## CURRENT RESEARCH INTERESTS

- Nonclassical structures in Hilbert spaces, proofs of the Bell-Kochen-Specker theorem and the Greenberger-Horne-Zeilinger theorem, characterization of entanglement, contextuality, and nonlocality, quantum key distribution, quantum teleportation protocols, and the development of algorithms and protocols for robust and efficient quantum information processing using these resources.
- Foundations and interpretations of quantum mechanics and quantum cosmology, particularly many-worlds-type formulations, and also the time-symmetric reformulation of quantum mechanics of Aharonov-Bergmann Lebowitz, weak values, and superoscillations.

## ADDITIONAL RESEARCH INTERESTS

- Experimental realizations of quantum computation algorithms in real physical systems including linear optics, superconducting-qubits, trapped ions, diamond NV-centers, and others.
- Nonclassical phenomena in quantum mechanics including delayed choice experiments, quantum erasers, interaction-free measurements, and quantum beats.

## EDUCATION

Worcester Polytechnic Institute, Worcester MA
**Doctor of Philosophy, Physics**     G.P.A. 3.92/4.00                    May 2013
Doctoral Thesis Title: "Nonclassical Structures within the N-qubit Pauli Group"
Advisor: Prof. P.K. Aravind, Department of Physics
**Master of Science, Physics**          G.P.A. 3.70/4.00                    February 2008
**Bachelor of Science, Physics**        G.P.A. 3.54/4.00                    February 2006

Quinsigamond Community College, Worcester MA
**Associate of Arts, Liberal Arts**     G.P.A 3.97/4.00                     May 2003

## RESEARCH EXPERIENCE

**Postdoctoral Research Associate**, Chapman University, Orange, CA       Summer 2014-present
Ongoing research at the Institute for Quantum Studies on the theoretical foundations of quantum mechanics and quantum information.

**Research Assistant**, WPI, Worcester MA                              Summer 2007-Spring 2013
Conducted research in theoretical quantum mechanics.  Studied entanglement, Bell's theorem, the Kochen-Specker theorem, the GHZ theorem, mutually unbiased bases, the Majorana representation of spin states, and other topics related to quantum information.  Developed general theoretical framework for characterizing primitive nonclassical structures within the N-qubit Pauli group.  Developed and applied optimized combinatorial search algorithms and numerous software tools for handling geometric structures in Hilbert spaces.

**Research Assistant, Major Qualifying Project**                          Summer 2005
Worked on experimental phase transition study.  Designed and constructed a cell for high pressure and temperature containing a quartz crystal microbalance (QCM) and a sapphire window for direct observation of surface wetting transitions.  Developed LabVIew software to automate repeated QCM measurements.

**LEADERSHIP EXPERIENCE**

- Organized preliminary seminar series associated with the *Concepts and Paradoxes in a Quantum Universe* in June of 2016 at The Perimeter Institute for Theoretical Physics, Waterloo, Ontario, Canada
- Organized the *Interpretations of Quantum Mechanics* conference in February of 2015 at the Institute for Quantum Studies, Chapman University, Orange CA

**INVITED TALKS**

1. M. Waegell, "Confine Contextuality: How specific paradoxes in pre- and post-selected Kochen-Specker sets give rise to experimentally observable consequences." *Presented in June 2016 at the 'Concepts and Paradoxes in a Quantum Universe' conference at The Perimeter Institute for Theoretical Physics, Waterloo, Ontario, Canada.*

2. M. Waegell, "Primitives of Nonclassicality in the N-qubit Pauli Group." *Updated and presented in June 2016 at 'Concepts and Paradoxes in a Quantum Universe' seminar series at The Perimeter Institute for Theoretical Physics, Waterloo, Ontario, Canada.*

3. M. Waegell, "Primitives of Nonclassicality in the N-qubit Pauli Group," *Presented in October 2015 at the Institut Laue-Langevin, Grenoble, France.*

4. M. Waegell, P.K. Aravind, "New Proofs of Quantum Contextuality." *Presentation at the workshop on "Quantum Information and Foundations of Quantum Mechanics," University of British Columbia, Vancouver, Canada, July 2013*

5. M. Waegell, P.K. Aravind, "The Quantum Physics of the Classically Impossible." *Colloquium Presentation in March 2013 at the Physics Department of Dartmouth College, Hanover NH*

**PUBLICATIONS IN REFEREED JOURNALS**

1. T. Denkmayr, H. Geppert, H. Lemmel, M. Waegell, J. Dressel, Y. Hasegawa, and S. Sponar, "Experimental demonstration of direct path state characterization by strongly measuring weak values in a matter-wave interferometer," *Physical Review Letters*, *118*(**1**)**,** p.010402 (2017).

2. M. Waegell, T. Denkmayr, H. Geppert, D. Ebner, T. Jenke, Y. Hasegawa, S. Sponar, J. Dressel, and J. Tollaksen, "Confined Contextuality in Neutron Interferometry: Observing the Quantum Pigeonhole Effect," *arXiv preprint arXiv:1609.06046* (2016), *pending publication in PRL.*

3. M. Waegell, Y. Aharonov, and T. L. Patti, "Interference Energy Spectrum of the Infinite Square Well," *Entropy* **18**(**4**) p149 (2016).

4. M. Waegell, P.K. Aravind, "Parity proofs of the Kochen-Specker theorem based on the Lie algebra E8," *J. Phys. A: Math. Theor.* **48**(**22**)**,** 225301 (2015)

5. C. Greganti, M.-C. Roehsner, S. Barz, M. Waegell, P. Walther "Practical and efficient experimental characterization of multi-qubit stabilizer states," *Phys. Rev. A* **91**(**2**), 022325 (2015)

6. M. Waegell, "A bonding model of entanglement for *N*-qubit graph states," *International Journal of Quantum Information*, *12*(**06**)**,** 1430005 (2014).

7. M. Waegell, "Primitive Nonclassical Structures of the *N*-qubit Pauli Group," *Phys. Rev. A* **89**, 012312 (2014)

8. M. Waegell, P.K. Aravind, "Parity proofs of the Kochen-Specker theorem based on the 120-cell," *Found Phys.* **44**,1085-1095 (2014)

9. M. Waegell, P.K. Aravind, "Proofs of the Kochen-Specker theorem based on the N-qubit Pauli group," *Phys. Rev. A* **88**, 012102 (2013)

10. M. Waegell, P.K. Aravind, "GHZ paradoxes based on an even number of qubits," *Physics Letters A* **377**, 546-549 (2013)

11. M. Waegell, P.K. Aravind, "Proofs of the Kochen-Specker theorem based on a system of three qubits," *J. Phys. A: Math. Theor.* **45** 405301 (2012)

12. M. Waegell, P.K. Aravind, "Parity proofs of the Bell-Kochen-Specker theorem based on 60 complex rays in four dimensions," *J. Phys. A: Math. Theor.***44** 505303 (2011)

13. N.D. Megill, K. Fresl, M. Waegell, P.K. Aravind, M. Pavičić, "Probabilistic Generation of Quantum Contextual Sets," *Physics Letters A* **375**, 3419-3424 (2011)

14. M. Waegell, P.K. Aravind, "Parity proofs of the Kochen-Specker theorem based on the 24 rays of Peres," *Foundations of Physics* **41**:1786-1799 (2011)

15. M. Waegell, P.K. Aravind, N.D. Megill, M. Pavičić, "Parity proofs of the Bell-Kochen-Specker theorem based on the 600-cell," *Foundations of Physics* **41**, 883-904 (2011)
16. M. Pavičić, N.D. Megill, P.K. Aravind, M. Waegell, "New Class of 4-Dim Kochen-Specker Sets," *Journal of Mathematical Physics*, Vol.**52** No. 2, pp 022104-1-9 (2011)
17. M. Waegell, P.K. Aravind, "Critical noncolorings of the 600-cell proving the Bell-Kochen-Specker theorem," *J. Phys. A: Math. Theor.* **43** 105304 (2010)


**CONFERENCE PRESENTATIONS**
1. M. Waegell, T. Denkmayr, H. Geppert, D. Ebner, T. Jenke, Y. Hasegawa, S. Sponar, J. Dressel, and J. Tollaksen, "Localizing and Measuring Contextuality through Weak Measurements & The Quantum Pigeonhole Principle," *Presentation at the 2016 APS March Meeting, Baltimore.*
2. M. Waegell, "The Clockwork Interpretation of Quantum Mechanics and Cosmology," *Presentation at the 2015 Interpretations of Quantum Mechanics conference at Chapman University, Orange CA*
3. M. Waegell, P.K. Aravind, "Entanglement and Nonclassicality in the N-qubit Pauli Group," *Presentation to the Group on Quantum Information at the 2013 APS March Meeting, Baltimore.*
4. M. Waegell, P.K. Aravind, "Minimal Proofs of the Kochen-Specker theorem within the N-qubit Pauli group." *Presentation at the 2012 APS New England Fall Meeting, Williamstown MA.*
5. M. Waegell, P.K. Aravind, "New Proofs of the Kochen-Specker theorem for a system of three qubits," *Presentation to the Group on Quantum Information at the 2012 APS March Meeting, Boston.*
6. M. Waegell, P.K. Aravind, "Proofs of the Kochen-Specker theorem based on the 600-cell," *Presentation to the Group on Quantum Information at the 2011 APS March Meeting, Dallas.*
7. P.K. Aravind, M. Waegell, "Proofs of the Kochen-Specker theorem based on two qubits," *Presentation to the Group on Quantum Information at the 2011 APS March Meeting, Dallas.*
8. R. Weiler, M. Waegell, R. Garcia, "Wetting Behavior of Nitrous Oxide Near its Critical Point," *Presentation to the Division of Chemical Physics at the 2006 APS March Meeting, Baltimore*

**POSTER PRESENTATIONS**

1. M. Waegell, "Locally Deterministic Interpretations of Quantum Mechanics: Cosmic Inflation, Parallel Lives, and Weak Values," *Poster Presented at the 2015 Emergent Quantum Mechanics conference (EmQM15) in Vienna, Austria.*
2. M. Waegell, "Down the Quantum Rabbit Hole: Contextuality, Pigeonholes, Cheshire Cats, Mean Kings, and Weak Values," *Poster presentation at the 2015 Quantum Physics of Nature conference in Vienna, Austria.*
3. M. Waegell, P.K. Aravind, "Nonclassical Structures within the N-qubit Pauli Group" *Presentation at the 2014 Gordon Research Conference on Quantum Science at Stonehill College, Easton MA.*
4. M. Waegell, "A bonding model of entanglement for N-qubit graph states." *Presentation at the 2014 Gordon Research Seminar on Quantum Science at Stonehill College, Easton MA.*

**TEACHING EXPERIENCE**
**Assistant Teaching Professor,** WPI, Worcester MA          Summer 2012 and 2013, Fall 2013-Present
Taught full courses in introductory electrodynamics and introductory wave mechanics during summer sessions, and conferences in various introductory subjects during the academic year.

**Teaching Assistant,** WPI, Worcester MA          Fall 2006-Spring 2013
Gave conference and laboratory instruction, and private tutoring. Lectured on introductory kinematics and electrodynamics. Conducted laboratory exercises in introductory kinematics, electrodynamics, and quantum mechanics.

**INTERNSHIP EXPERIENCE**
**Student Intern**, NASA Jet Propulsion Laboratory, Pasadena CA          Summer 2008 & 2009
Developed fast automatic image registration algorithms and packaged software for digital image and video processing applications.

**TECHNICAL RESEARCH**

1. M. Waegell, D.M. Palacios, "Jitter Correction," *NASA New Technology Report.* Jet Propulsion Laboratory (2011)

**SKILLS**

Proficient with MATLAB, Excel, LabVIew, LaTex, Maple, Mathematica, C++.

**PROFESSIONAL ASSOCIATIONS**

American Physical Society
Sigma Xi, The Scientific Research Society
Sigma Pi Sigma: National Physics Honor Society
Phi Theta Kappa: International Honor Society of the Two Year College
Erdős Number = 3