Robert W. Spekkens

Curriculum Vitae
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Personal Details

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Citizenship	Canadian
Date of Birth	28/08/1972

Academic Positions

11/2008 – present	Junior faculty at the Perimeter Institute for Theoretical Physics, Waterloo, Canada
1/2006 – 10/2008	Royal Society USA/Canada research fellow at University of Cambridge, Cambridge, United Kingdom
10/2005 – 1/2006	Affiliate of the Institute for Quantum Computing, Waterloo, Canada
1/2003 – 1/2006	Postdoctoral fellow at the Perimeter Institute for Theoretical Physics, Waterloo, Canada
9/2001 – 12/2002	Postdoctoral fellow in the group of John Sipe, Department of Physics, University of Toronto, Toronto, Canada
7/2002 – 12/2002	Affiliate of the Perimeter Institute for Theoretical Physics, Waterloo, Canada

Education

9/1995 – 9/2001 Awarded 11/2001	Ph.D. Physics	**University of Toronto**, Toronto, Canada Thesis: Aspects of entanglement Supervisor: Professor John E. Sipe
9/1994 – 9/1995 Awarded 11/1995	M.Sc. Physics	**University of Toronto**, Toronto, Canada
9/1989 – 9/1994 Awarded 11/1994	B.Sc. Joint Honours Physics and Philosophy	**McGill University**, Montreal, Canada

Fellowships, Scholarships and Awards

2008	Birkhoff-von Neumann Prize of the International Quantum Structures Association
2006 – 2009	Royal Society USA/Canada Research Fellowship
2002 – 2004	NSERC Postdoctoral Fellowship
1998 – 2000	Ontario Graduate Scholarship
1996 – 1998	NSERC Postgraduate Scholarship B
1997 – 1999	Walter C. Sumner Memorial Fellowship
1997 – 1998	E. F. Burton Fellowship
1995 – 1996	University of Toronto Special Open Doctoral Fellowship
1995	Edward Christie Stevens Award
1994 – 1995	University of Toronto Open Master's Fellowship
1994	NSERC Undergraduate Student Research Award
1989 – 1992	Canada Scholarship
1989	Irving Levitt Family Foundation Scholarship
1989	McGill University McConnell Entrance Award

Competitive Research Grants

Year	Project Title	Grant	Role	Value
2007	Operational Probabilistic Theories as Foils to Quantum Theory	FQXI award Foundational Questions Institute, www.fqxi.org	Principal Investigator (with Jonathan Barrett and Tony Short)	46,000 USD
2006-2009	Reference frames, contextuality, and the axiomatization of quantum theory	Royal Society USA/Canada Research Fellowship (research funds)	Principal Investigator	36,000 GBP over 3 years
2004-2006	Relative Quantum Information theory	Australian Research Council International Linkage Grant LX0455561	Principal Investigator (with Stephen Bartlett and Danny Terno)	30,500 AUD over 2 years

Research highlights

Highly cited publications

References are to the list of publications. Citation statistics from Science Citation index and from Citebase (http://citebase.eprints.org).

The article entitled "Classical and quantum communication without a shared reference frame", Ref. [4], (51 citations, 62 on-line) is the first article to consider the consequences of lacking a reference frame for quantum information-theoretic tasks, and introduced the conceptual framework that has been followed by much subsequent work on quantum

reference frames. Some of its predictions have been verified experimentally in K. Banaszek et al., Phys. Rev. Lett. 92, 257901 (2004). The 11 articles I have written on the subject of reference frames in quantum theory, Refs. [3,4,6,9,12,15,16,17,18,21,22], have together gathered 187 citations, 182 online.

Ref. [27], "Spatial fragmentation of a Bose-Einstein Condensate in a double-well potential," (46 citations, 33 on-line) is early work from my Ph.D. that demonstrated for the first time the possibility of fragmentation of a BEC, a phenomena that has since been investigated intensively, particularly in connection with the transition between Mott insulator and superfluid phases in optical lattices. The predictions have been verified experimentally by Mark Kasevich's atom optics group in C. Orzel et al. Science 291, 2386 (2001).

Ref. [24], "Degrees of concealment and bindingness in quantum bit commitment protocols," (15 citations, 27 online) demonstrated the possibility of partial security for the cryptographic primitive of bit commitment and is one of only a few results in quantum information theory that differentiates qutrits from qubits in a nontrivial manner. It inspired the experiment of Andrew White's quantum optics group, reported in N. K. Langford et al. Phys. Rev. Lett. 93, 053601 (2004). The 5 articles I have written on 2-party cryptography in quantum theory, Refs. [5,7,19,22,23], have together gathered 69 citations, 104 online.

Most significant publications

Ref. [11], "Evidence for the epistemic view of quantum states: a toy theory", is my most original and significant work. By qualitatively reproducing a long list of quantum phenomena within a theory with a classical ontology, it provides strong new evidence in favour of the notion that quantum states are states of knowledge and has helped to persuade many foundations researchers of the promise of a research program that takes this notion as its starting point.

Ref. [19], "Contextuality for preparations, transformations and unsharp measurements," provides the first truly operational definition of contextuality, and generalizes the standard notion in the process. It is fast becoming the new standard among researchers at the interface of quantum foundations and quantum information theory.

Ref. [16], "Dialogue Concerning Two Views on Quantum Coherence: Factist and Fictionist", provides the clearest explanation to date of how to resolve a significant and recurrent controversy in quantum foundations concerning whether superselection rules are axiomatic or practical restrictions for various degrees of freedom.

Media coverage

2007 Mike Perricone, "Punting in Plato's cave" FQXI website, Nov. 2007
An article commissioned by FQXI concerning my research and the workshop "Operational probabilistic theories as foils to quantum theory" that I organized.
http://www.fqxi.org/community/data/articles/Spekkens_Robert.pdf

2004 Eugenie Reich, "Which way is up?" New Scientist Oct. 2, 2004
This is a feature article inspired by the Workshop on Reference Frames and Superselection Rules in Quantum Information Theory that I co-organized in July, 2004. I was the primary consultant on its content.

2002 "Foiling quantum cheats", Nature research highlights Nov. 2002
This is a 1-page review of R. W. Spekkens and T. Rudolph, *Quantum protocol for cheat-sensitive weak coin flipping*, Phys. Rev. Lett. **89**, 227901 (2002).

Publications

Published articles

Letters

1. R. W. Spekkens, "Negativity and contextuality are equivalent notions of nonclassicality", Phys. Rev. Lett. **101**, 020401 (2008). (selected as an Editor's suggestion)
2. M. S. Leifer and R. W. Spekkens, "Pre- and Post-selection paradoxes and contextuality in quantum mechanics'', Phys. Rev. Lett. **95**, 200405 (2005).
3. J.-C. Boileau, D. Gottesman, R. Laflamme, D. Poulin, and R. W. Spekkens, "Robust polarization-based quantum key distribution over a collective-noise channel", Phys. Rev. Lett. **92**, 017901 (2004).
4. S. D. Bartlett, T. Rudolph, and R. W. Spekkens, "Classical and quantum communication without a shared reference frame", Phys. Rev. Lett. **91**, 027901 (2003).
5. R.W. Spekkens and T. Rudolph, "Quantum protocol for cheat-sensitive weak coin flipping", Phys. Rev. Lett. **89**, 227901 (2002).

Review articles

6. S. D. Bartlett, T. Rudolph and R. W. Spekkens, "Reference frames, superselection rules and quantum information", Rev. Mod. Phys. **79**, 555 (2007).

Rapid Communications

7. T. Rudolph, R. W. Spekkens, and P. S. Turner, "Unambiguous discrimination of mixed states", Phys. Rev. A **68**, 010301(R) (2003).

Regular articles

8. D. Kretschmann, D. W. Kribs, and R. W. Spekkens, "Complementarity of Private and Correctable Subsystems in Quantum Cryptography and Error Correction", Phys. Rev. A **78**, 032330 (2008).
9. G. Gour and R. W. Spekkens, "The resource theory of quantum reference frames: manipulations and monotones", New J. Phys. **10**, 033023 (2008). (chosen by editors for IOP select)

10. R. W. Spekkens and H. M. Wiseman, “Pooling quantum states obtained by indirect measurements”, Phys. Rev. A **75**, 042104 (2007).
11. R. W. Spekkens, “Evidence for the epistemic view of quantum states: a toy theory”, Phys. Rev. A **75**, 032110 (2007).
12. M. R. Dowling, S. D. Bartlett, T. Rudolph, R. W. Spekkens, “Observing a coherent superposition of an atom and a molecule”, Phys. Rev. A **74**, 052113 (2006).
13. D. W. Kribs and R. W. Spekkens, “Quantum Error Correcting Subsystems as Unitarily Recoverable Subsystems”, Phys. Rev. A **74**, 042329 (2006)
14. G. Gour and R. W. Spekkens, “Entanglement of Assistance is not an entanglement monotone”, Phys. Rev. A **73**, 062331 (2006).
15. S. D. Bartlett, T. Rudolph, R. W. Spekkens, and P. S. Turner, “Degradation of a quantum reference frame”, New J. Phys. **8**, 58 (2006).
16. S. D. Bartlett, T. Rudolph and R. W. Spekkens, “Dialogue Concerning Two Views on Quantum Coherence: Factist and Fictionist”, Int. J. Quantum Inf. **4**, 17 (2006), issue dedicated to the memory of Asher Peres; www.arxiv.org/quant-ph/0507214.
17. S. D. Bartlett, A. C. Doherty, R. W. Spekkens, and H. M. Wiseman, “Entanglement under restricted operations: an analogy to mixed state entanglement”, Phys. Rev. A **73**, 022311 (2006).
18. S. D. Bartlett, P. Hayden and R. W. Spekkens, “Random subspaces for encryption based on a private shared Cartesian frame”, Phys. Rev. A **72**, 052329 (2005).
19. R. W. Spekkens, “Contextuality for preparations, transformations and unsharp measurements,” Phys. Rev. A 71, 052108 (2005).
20. T. Rudolph and R. W. Spekkens, "Quantum state targeting”, Phys. Rev. A **70**, 052306 (2004).
21. S. D. Bartlett, T. Rudolph, R. W. Spekkens, “Optimal measurements for relative quantum information”, Phys. Rev. A **70**, 032321 (2004).
22. S. D. Bartlett, T. Rudolph, R. W. Spekkens, “Decoherence-full subsystems and the cryptographic power of a private shared reference frame,” Phys. Rev. A **70**, 032307 (2004).
23. R. W. Spekkens and T. Rudolph, “Optimization of coherent attacks in Generalizations of the BB84 quantum bit commitment protocol,” Quant. Inform. Compu. **2**, 66 (2002).
24. R. W. Spekkens and T. Rudolph, “Degrees of concealment and bindingness in quantum bit commitment protocols,” Phys. Rev. A **65**, 012310 (2001).
25. R. W. Spekkens and J. E. Sipe, “Non-orthogonal core projectors for modal interpretations of quantum mechanics,” Found. Phys. **31**, 1403 (2001).
26. R. W. Spekkens and J. E. Sipe, “A modal interpretation of quantum mechanics based on a principle of entropy minimization,” Found. Phys. **31**, 1431 (2001).
27. R. W. Spekkens and J. E. Sipe, “Spatial fragmentation of a Bose-Einstein Condensate in a double-well potential,” Phys. Rev. A **59**, 3868 (1999).

Conference Proceedings

28. M. S. Leifer and R. W. Spekkens, “Logical pre- and post-selection paradoxes, measurement-disturbance and contextuality,” www.arxiv.org/quant-ph/0412179, to appear in the proceedings of the Biennial Meeting of the International Quantum Structures Association, 2004.

29. S. D. Bartlett, A. C. Doherty, R. W. Spekkens, and H. M. Wiseman, "Mixed-State Entanglement in the Light of Pure-State Entanglement Constrained by Superselection Rules," Proceedings of the 1st Asia-Pacific Conference on Quantum Information Science, National Cheng Kung University, Taiwan 10 - 13 December 2004
30. R. W. Spekkens and J. E. Sipe, "On the Detection of Single Mode Quantum Coherence at Optical Frequencies," in *Coherence and Quantum Optics VIII*, eds. N. Bigelow et al. (Kluwer Academic, New York, 2003) p. 465.
31. R. W. Spekkens and J. E. Sipe, "Some remarks on fragmentation in Bose Condensates," Progress in Physics **46**, 873 (1998).

To be published

32. R. W. Spekkens, D. H. Buzacott, A. Keehn, B. F. Toner and G. J. Pryde, "Experimental demonstration of preparation contextuality and parity-oblivious multiplexing", submitted to Phys. Rev. Lett., arXiv:0805.1463 [quant-ph]

Submitted articles

33. S. D. Bartlett, T. Rudolph, R. W. Spekkens, and P. S. Turner, "Quantum communication using a bounded-size quantum reference frame", submitted to New J. Phys., arXiv:0812.5040 [quant-ph]
34. N. Harrigan and R. W. Spekkens, "Einstein, incompleteness, and the epistemic view of quantum states", submitted to Found. Phys., arXiv:0706.2661 [quant-ph]
35. J. Oppenheim, R. W. Spekkens and A. Winter, "A classical analogue of negative information", arXiv:quant-ph/0511247

Articles in preparation

36. S. D. Bartlett, T. Rudolph and R. W. Spekkens, "Classical Liouville mechanics with an epistemic restriction is equivalent to Gaussian quantum mechanics"
37. M. S. Leifer and R. W. Spekkens, "Quantum analogues of Bayes' theorem, sufficient statistics and the pooling problem"

Drafts are available upon request

Book in preparation

J. E. Sipe and R. W. Spekkens, "The quantum puzzle", Oxford University Press
This is a graduate level textbook on the foundations of quantum mechanics. The aim of the textbook is to provide an unbiased survey, analysis, and comparison of the various approaches to the interpretation of quantum theory.
Table of contents:

1. Introduction
2. The nature of scientific theories
3. Operational quantum mechanics
4. Realist talk
5. Hidden variable theories: possibilities and constraints
6. Two Orthodoxies
7. The Copenhagen interpretation
8. Decoherence theory

9. The deBroglie-Bohm interpretation
10. Quantum logic
11. Consistent histories
12. Many worlds
13. Modal interpretations
14. Collapse theories
15. Outlook

Draft chapters are available upon request

Scholarly contributions

Conferences organized

2007	Principal organizer (with Jonathan Barrett and Tony Short)
(2 weeks)	Workshop entitled *Operational Probabilistic Theories as Foils to Quantum Theory*, DAMTP, University of Cambridge, July 2-13, 2007 Website: http://qubit.damtp.cam.ac.uk/users/rob/foilswebpage.htm
2004	Co-organizer (with Stephen Bartlett)
(5 days)	Workshop entitled *Reference Frames and Superselection Rules in Quantum Information Theory*, Perimeter Institute, July 12-16, 2004 Website: http://www.perimeterinstitute.ca/activities/scientific/cws/PI-WORK-1/index.php

Invited talks at conferences

9/2008	QICS Workshop on Foundational Structuresfor Quantum Information and Computation, Obergurgl, Austria
6/2008	Conference on Perspective in Physics and Philosophy, Paris, France
5/2008	Workshop on Information Primitives and Laws of Nature, ETH Zurich, Switzerland
1/2008	Sydney Quantum Information Theory Workshop, Sydney, Australia
11/2007	Applied Quantum Measurement Workshop, Leyden, Netherlands
8/2007	Quantum Foundations Summer School, Perimeter Institute, Waterloo, Canada
5/2007	Vienna Symposium on Foundations of Physics, Austria
5/2007	Workshop on Operational Quantum Physics and the Quantum-classical Contrast, Perimeter Institute, Waterloo, Canada
4/2007	Philosophical and Formal Foundations of Modern Physics, Fondation des Treilles, Tourtour, France
3/2007	Invited speaker at the 2007 APS March meeting, Denver, USA
11/2006	The Eighth International Conference on Quantum Communication, Measurement and Computing, Tsukuba, Japan (talk delivered by Stephen Bartlett)
6/2006	Workshop on Quantum-Classical Transition and Quantum Information, Benasque, Spain
8/2005	Being Bayesian in a Quantum World workshop, Konstanz, Germany
7/2005	Quantum information, computation and logic workshop, Perimeter

	Institute, Waterloo, Canada
5/2005	"What's quantum in quantum computing?" workshop, Konstanz, Germany
2/2005	Tutorial at the meeting of the South-West Quantum Information Network, Tucson, USA
7/2004	The Seventh International Conference on Quantum Communication, Measurement and Computing, University of Strathclyde, Glasgow, UK
5/2004	Symposium on quantum information geometry and quantum computing, Fields Institute, Toronto, Canada
5/2004	University of Western Ontario symposium on the foundations of physics, London, Canada
2/2004	Workshop on Quantum computing, quantum information and quantum gravity, Perimeter Institute, Waterloo, Canada
6/2003	International Conference In Quantum Theory: Reconsideration of Foundations-2, Växjö, Sweden
5/2003	New Directions in the Foundations of Physics Conference, Washington D.C., USA
10/2002	Quantum Foundations in the Light of Quantum Information Workshop, Montreal, Canada

Contributed talks at conferences

8/2008	The Ninth International Conference on Quantum Communication, Measurement and Computing, Calgary, Canada
1/2008	The first Perimeter Institute Australia Foundations conference, Sydney, Australia
3/2007	The Fifteenth UK and European Meeting on the Foundations of Physics, Leeds, UK
7/2006	Kets, Cats and Cloisters conference, Oxford, UK
3/2006	APS March meeting, Baltimore, USA
7/2003	Workshop on Quantum Measurements and Quantum Stochastics, Aarhus, Denmark
9/ 2002	The Eleventh UK Conference in Foundations of Physics, Oxford University, UK
7/2000	Canadian Association of Physicists Congress, York University, Toronto, Canada
7/1998	Canadian Association of Physicists Congress, Waterloo University, Waterloo, Canada

Other talks

I have given 49 presentations as seminars in Canada, the United States, the United Kingdom, Australia, Italy, France, and Austria.

Advisory roles

2005-2006 Member of the advisory board for the topical group on quantum information, concepts and computation of the American Physical Society.

Committee work

2003 – 2004	Member of the postdoctoral fellow selection committee, Perimeter Institute
2003 –2004	Member of the quantum foundations search committee, Perimeter Institute
2001	Active in development of new joint undergraduate program in physics and philosophy at the University of Toronto

External Examination for higher degrees

2008	Ph. D. thesis of Steve Jones, Griffith University, Brisbane, Australia
2007	Ph.D. thesis of Roger Colbeck, University of Cambridge, Cambridge, UK
2003	Ph.D. thesis of Jay Gambetta, Griffith University, Brisbane, Australia

Refereeing for international journals

American Journal of Physics
Canadian Journal of Physics
Europhysics Letters
Fluctuation and Noise Letters
Foundations of Physics
Journal of Mathematical Physics
Journal of the Optical Soceity of America B
Journal of Physics A and B
Nature
New Journal of Physics
Philosophy of Science
Physics Letters A
Physical Review A
Physical Review Letters
Physica Scripta
Quantum Information and Computation
Reviews of Mathematical Physics
Studies in the History and Philosophy of Modern Physics

Outreach activities

2004, 2005, 2007, 2008	Keynote lecturer at the International Summer School for Young Physicists, Perimeter Institute
11/2007	Lecture for students at Hills Road sixth form, Cambridge, UK
2/2007	Lecture for students at Eton College, Eton, UK
4/2005	Lecture for students at Brodie high school, Tucson, Arizona
3/2005	Public lecture, Black hole series, Perimeter Institute
2000, 2002	Judge for the Toronto Regional Sci-Tech Fair

Graduate and undergraduate supervision

2007-present	Co-supervisor for Olaf Schreiber, Cambridge university, Ph.D. student
2006-2007	Co-supervisor for Roberta Rodriquez, Cambridge University, Ph.D. student (graduated 2007)
2005-2006	Supervisor for Elliot Martin, University of Waterloo undergraduate student, summer project and course research project
2004-2006	Co-supervisor (with Michele Mosca) for Lana Sheridan, University of Waterloo, Ph.D. student