

# Robert I. Booth

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British and French nationality

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## Profile

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I am a researcher with a particular interest in the mathematical foundations of quantum information theory. In no particular order, I have worked on: diagrammatic calculi for higher-dimensional quantum systems, measurement-based quantum computation beyond qubits, measures of non-classicality in quantum theory, and quantum computational advantages in continuous variables. Beyond continuing to develop these techniques, I am interested in applying them to more practical problems for near-term quantum computation. A particular focus at the moment is developing algorithms and techniques for the execution of quantum computations on restricted architectures.

## Research experience

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| 04/2022–09/2024<br><i>ongoing</i> | <b>Research Associate</b><br>School of Informatics, University of Edinburgh<br>School of Mathematics, University of Bristol<br>Working with <a href="#">Chris Heunen</a> and <a href="#">Noah Linden</a> <ul style="list-style-type: none"><li>• <i>Optimisation and distribution of quantum circuits</i></li><li>• <i>Resources for distributed quantum computation.</i></li><li>• <i>Diagrammatic reasoning and applied category theory.</i></li></ul>  |
| 11/2018–02/2022                   | <b>PhD in Quantum Computation</b><br>Laboratoire d'Informatique de Paris 6, Sorbonne Université, Paris<br>Laboratoire Lorrain de Recherche en Informatique et ses Applications, Nancy<br>Title: <i>Measurement-based quantum computation beyond qubits</i><br>Supervised by <a href="#">Damian Markham</a> and <a href="#">Simon Perdrix</a> <ul style="list-style-type: none"><li>• <i>Formal models of measurement-based quantum computation with qudits and continuous variables</i></li><li>• <i>Quantum circuit extraction algorithms and the qudit ZX-calculus</i></li><li>• <i>Contextuality in continuous-variable systems and its connection with other notions of non-classicality.</i></li></ul> |
| Mar.–Jul. 2018                    | <b>Research Internship in Quantum Information Theory</b><br>Laboratoire d'Informatique de Paris 6, Université Pierre et Marie Curie, Paris<br>Supervised by <a href="#">Damian Markham</a> <ul style="list-style-type: none"><li>• <i>Contextuality and negativity of the Wigner function for preparation procedures in continuous-variable models of quantum computation</i></li><li>• <i>Quantum advantages in sub-universal models of quantum computation and applications in quantum optics.</i></li></ul>  |
| Apr.–Jul. 2017                    | <b>Research Internship in Experimental Quantum Optics</b><br>Università degli Studi Roma Tre, Rome<br>Supervised by <a href="#">Marco Barbieri</a><br><i>Calculated bounds for the production of irreversible entropy in a qubit interacting with a bosonic thermal bath, with experimental demonstration using a photonic simulator.</i>   |
| Feb.–May 2016                     | <b>Research Internship in Experimental Physical Chemistry</b><br>Laser Chemistry, Spectroscopy and Dynamics Laboratory<br>University of Bristol, United Kingdom<br>Supervised by <a href="#">Prof. Michael N. R. Ashfold FRS</a>  |

## Teaching experience

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| Spring 2024 | <b>Introduction to Quantum Programming and Semantics</b><br><i>Guest Lectures and Tutorials</i><br>University of Edinburgh |
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## Education

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- 2016–2018 | **Master’s Degree in Fundamental Physics**  
Université Pierre et Marie Curie, Paris  
*Quantum Information Theory, Quantum Optics, Quantum Mechanics*
- 2016 | **Double Honours Bachelor’s Degree in Physics and Chemistry**  
Université Paris-Sud, Orsay, France
- 2012 | **Scientific Baccalaureate**, France

## Publications

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### Journal articles

- Robert I. Booth and Damian Markham (Oct. 19, 2023). “Flow conditions for continuous variable measurement-based quantum computing”. In: *Quantum* 7. Publisher: Verein zur Förderung des Open Access Publizierens in den Quantenwissenschaften, p. 1146. DOI: [10.22331/q-2023-10-19-1146](https://doi.org/10.22331/q-2023-10-19-1146)
- Robert I. Booth, Aleks Kissinger, Damian Markham, Clément Meignant, and Simon Perdrix (Feb. 2023). “Outcome determinism in measurement-based quantum computation with qudits”. In: *Journal of Physics A: Mathematical and Theoretical* 56.11. Publisher: IOP Publishing, p. 115303. DOI: [10.1088/1751-8121/acbace](https://doi.org/10.1088/1751-8121/acbace)
- Robert I. Booth, Ulysse Chabaud, and Pierre-Emmanuel Emeriau (Nov. 29, 2022). “Contextuality and Wigner negativity are equivalent for continuous-variable quantum measurements”. In: *Physical Review Letters* 129.23, p. 230401. DOI: [10.1103/PhysRevLett.129.230401](https://doi.org/10.1103/PhysRevLett.129.230401). arXiv: [2111.13218](https://arxiv.org/abs/2111.13218)[[math-ph](https://arxiv.org/abs/2111.13218), [physics:quant-ph](https://arxiv.org/abs/2111.13218)]
- Vasco Cavina, Luca Mancino, Antonella De Pasquale, Ilaria Gianani, Marco Sbroscia, Robert I. Booth, Emanuele Rocca, Roberto Raimondi, Vittorio Giovannetti, and Marco Barbieri (Nov. 9, 2018). “Bridging thermodynamics and metrology in nonequilibrium quantum thermometry”. In: *Physical Review A* 98.5. DOI: [10.1103/PhysRevA.98.050101](https://doi.org/10.1103/PhysRevA.98.050101)
- Luca Mancino, Vasco Cavina, Antonella De Pasquale, Marco Sbroscia, Robert I. Booth, Emanuele Rocca, Ilaria Gianani, Vittorio Giovannetti, and Marco Barbieri (Oct. 17, 2018). “Geometrical Bounds on Irreversibility in Open Quantum Systems”. In: *Physical Review Letters* 121.16. DOI: [10.1103/PhysRevLett.121.160602](https://doi.org/10.1103/PhysRevLett.121.160602)

### Conference proceedings

- Boldizsár Poór, Robert I. Booth, Titouan Carrette, John Van De Wetering, and Lia Yeh (Aug. 29, 2023). “The Qupit Stabiliser ZX-travaganza: Simplified Axioms, Normal Forms and Graph-Theoretic Simplification”. In: *Electronic Proceedings in Theoretical Computer Science*. Twentieth International Conference on Quantum Physics and Logic. Vol. 384. Paris, France, pp. 220–264. DOI: [10.4204/EPTCS.384.13](https://doi.org/10.4204/EPTCS.384.13)
- Robert I. Booth and Titouan Carrette (2022). “Complete ZX-Calculi for the Stabiliser Fragment in Odd Prime Dimensions”. In: *47th International Symposium on Mathematical Foundations of Computer Science (MFCS 2022)*. Ed. by Stefan Szeider, Robert Ganian, and Alexandra Silva. Vol. 241. Leibniz International Proceedings in Informatics (LIPIcs). ISSN: 1868-8969. Dagstuhl, Germany: Schloss Dagstuhl – Leibniz-Zentrum für Informatik, 24:1–24:15. DOI: [10.4230/LIPIcs.MFCS.2022.24](https://doi.org/10.4230/LIPIcs.MFCS.2022.24)

### Preprints

- Robert I. Booth, Titouan Carrette, and Cole Comfort (Jan. 30, 2024b). *Graphical Symplectic Algebra*. DOI: [10.48550/arXiv.2401.07914](https://doi.org/10.48550/arXiv.2401.07914). arXiv: [2401.07914](https://arxiv.org/abs/2401.07914)[[quant-ph](https://arxiv.org/abs/2401.07914)]

- Robert I. Booth, Titouan Carrette, and Cole Comfort (Mar. 15, 2024a). *Complete equational theories for classical and quantum Gaussian relations*. arXiv: 2403.10479[quant-ph]

## In preparation

- Robert I. Booth and Cole Comfort (2024). “Picturing stabiliser codes”

## Dissemination

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### Invited workshops

- “Distributing quantum circuits with the ZX-calculus”, National Center for Quantum Computing Launch Event, University of Edinburgh, December 13th, 2022
- “Outcome determinism in measurement-based quantum computing with qudits”, Workshop on recent advances on quantum computing, Collège de France, June 17th, 2021
- “Flow conditions for continuous-variable measurement-based quantum computation”, Workshop on Quantum Networks and Information 2020, National Institute of Informatics, Tokyo
- “Convergence of continuous-variable measurement-based quantum computations”, Edinburgh-Paris Joint Quantum Workshop, Edinburgh, July, 2019

### Invited seminars

- “Graphical Symplectic Algebra”, Weekly ZX seminar, 2024, online Video: [YouTube](#)
- “ZX-calculus: (my) past, present... future?”, LIP6 QI team seminar, Paris, 2023
- “Complete ZX-calculi for the stabiliser fragment in odd prime dimensions”, Weekly ZX seminar, 2022, online Video: [YouTube](#)
- “Contextuality and Wigner negativity are equivalent for continuous-variable measurements”, Online Quantum and Linear Optical Computation seminar, 2022
- “Outcome determinism in measurement-based quantum computing with qudits”, Weekly ZX seminar, 2021, online
- “F-flow: determinism in measurement-based quantum computing with qudits”, Weekly ZX seminar, 2020, online

### Conferences

- “The Qubit Stabiliser ZX-travaganza: Simplified Axioms, Normal Forms, and Graph-theoretic Simplification”, 21st International Conference on Quantum Physics and Logic, Paris, 2023 (Boldizsár Poór)
- “Complete ZX-calculi for the stabiliser fragment in odd prime dimensions”, 47th International Symposium on Mathematical Foundations of Computer Science, Vienna, 2022
- “Complete ZX-calculi for the stabiliser fragment in odd prime dimensions”, 20th International Conference on Quantum Physics and Logic, Oxford, 2022 Video: [YouTube](#)
- “Contextuality and Wigner negativity are equivalent for continuous-variable measurements”, 20th International Conference on Quantum Physics and Logic, Oxford, 2022 (Pierre-Emmanuel Emeriau) Video: [YouTube](#)
- “Extracting reversible quantum circuits from measurement-based quantum computations with qudits”, 20th International Conference on Quantum Physics and Logic, Oxford, 2022 Video: [YouTube](#)
- “Contextuality and Wigner negativity are equivalent for continuous-variable measurements”, 20th European Conference on Foundations of Physics, Ecole Normale Supérieure Paris, October 30th, 2021
- “F-flow: determinism in measurement-based quantum computing with qudits”, 19th International Conference on Quantum Physics and Logic, University of Gdansk, June 9th, 2021, Video: [YouTube](#)
- “F-flow: determinism in measurement-based quantum computing with qudits”, Sixth International Conference for Young Quantum Information Scientists, Michigan State University, April 15th, 2021

- “Flow conditions for continuous variable measurement-based quantum computation”, 18th International Conference on Quantum Physics and Logic, Paris, June 15th, 2021, Video: [YouTube](#)

## Academic Service

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- Organiser of the Edinburgh’s Quantum Software Lab Seminar, Autumn 2023
- Member of the Program Committee for *PLanQC 2022*
- Reviewer for the US Department of Energy grant call “Express: 2023 Exploratory Research for Extreme-Scale Science”
- Reviewer for the journal *Quantum*
- Reviewer for the conferences *QPL 2023*, *QPL 2022*, *QPL 2021*
- Held the “Quantum Spies” stand at Edinburgh Science Festival 2022, and alongside the Doctor Who Worlds of Wonder exhibition, both at the National Museum of Scotland

## Other

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Languages | **English and French, bilingual**

Computing | Python, Mathematica, UNIX,  $\LaTeX$