

# Alastair A. Abbott

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## Employment

- Dec. 2020 – present: **Research scientist (chargé de recherche)** at Inria Grenoble – Rhône-Alpes, Grenoble, France
- Sept. 2018 – Nov. 2020: **Postdoctoral researcher** at the **University of Geneva**, Switzerland, in the group of Nicolas Brunner
- Nov. 2015 – June 2018: **Postdoctoral researcher** at the **Institut Néel (CNRS)**, Grenoble, France, in the group of Cyril Branciard

## Education

- 2011 – 2015: **PhD in Computer Science and Physics**  
Joint PhD: Department of Computer Science, University of Auckland, New Zealand; and Centre Cavallès, École Normale Supérieure, Paris, France  
Thesis: *Value Indefiniteness, Randomness and Unpredictability in Quantum Foundations*  
Supervisors: Prof. Cristian S. Calude (UoA) and Prof. Giuseppe Longo (ÉNS)
- 2010: **MSc in Computer Science with First Class Honours**  
University of Auckland, New Zealand  
Thesis: *Quantum Random Numbers: Certification and Generation*  
Supervisor: Prof. Cristian S. Calude
- 2009: **BSc(Hons) in Computer Science with First Class Honours**  
University of Auckland, New Zealand  
Dissertation: *De-quantisation in Quantum Computation*  
Supervisor: Prof. Cristian S. Calude
- 2006 – 2008: **BSc in Computer Science and Physics**  
University of Auckland, New Zealand

## Fields of Research

- **Theoretical research in quantum information and foundations:** quantum causality and causal indefiniteness, entanglement, nonlocality, Bell inequalities, quantum randomness, contextuality, quantum logic, uncertainty principle
- **Quantum computing:** hybrid models of classical-quantum computation, quantum annealing, classical simulation of quantum computation
- **Theoretical computer science:** algorithmic information theory and randomness, computational complexity theory, classical (entropic) information theory
- **Philosophy of quantum mechanics:** quantum randomness, quantum causality, interpretations of quantum mechanics

## Prizes and Awards

- Department of Computer Science Poster Competition, 2nd place, 2011.
- Demonstrating Prize in Physics, 2009, for best physics lab tutor.
- Montgomery Memorial Prize in Logic, 2009, for the best Honours-year dissertation.
- New Zealand Computer Society Cup and Shield, 2009, for the top overall student in Computer Science.
- J. C. Butcher Prize in Theoretical Computer Science, 2008.
- Senior Prize in Computer Science, 2008.

## Grants

- PI of IRGA 2021 (Initiatives de Recherche à Grenoble Alpes) project CIQuP (Causally Indefinite Quantum Protocols: From Complexity to Applications), 2021–2022; 19k€.
- Collaborator to the project 2010-IRSES-269151-RANPHYS awarded under the FP7-PEOPLE-2010-IRSES Call of the Marie Curie Actions IRSES (International Research Staff Exchange Scheme) in 2010 (co-investigator along with C. S. Calude, M. J. Dinneen, G. Longo, T. Paul and K. Svozil). Awarded for four years (2011–2015); \$128,592.37 NZD.
- University of Auckland Doctoral Scholarship, 2011–2015.
- University of Auckland Masters Scholarship, 2010.
- Faculty of Science Summer Research Scholarship ( $\times 3$ ), 2007, 2008, & 2009.
- Bonded Merit Scholarship, 2007–2009 (New Zealand Government Scholarship).

## Expertise

### Languages

Fluent in English and French, intermediate Russian.

### Computer Skills

- Programming Languages: Python, C, C++, Java, Mathematica, MATLAB, UNIX scripting, Prolog.
- Convex optimisation: semidefinite and linear programming techniques, convex polytope algorithms; developing algorithms to solve discrete mathematical and physical problems; numerical and symbolic analysis in Mathematica and MATLAB.
- $\text{\LaTeX}$ : preparing documents and papers, customised formatting of books and documents.

## Publications and Presentations

### Papers in Refereed Journals

26. J. Wechs, H. Dourdent, **A. A. Abbott** and C. Branciard, *Quantum circuits with classical versus quantum control of causal order*, [PRX Quantum](#) **2**, 030335 (2021).
25. A. Tavakoli, E. Zambrini Cruzeiro, R. Uola and **A. A. Abbott**, *Bounding and simulating contextual correlations in quantum theory*, [PRX Quantum](#) **2**, 020334 (2021).
24. M. M. Taddei, J. Cariñe, D. Martínez, T. García, N. Guerrero, **A. A. Abbott**, M. Araújo, C. Branciard, E. S. Gómez, S. P. Walborn, L. Aolita and G. Lima, *Computational Advantage from the Quantum Superposition of Multiple Temporal Orders of Photonic Gates*, [PRX Quantum](#) **2**, 010320 (2021).
23. G. Rubino, L. A. Rozema, D. Ebler, H. Kristjánsson, S. Salek, P. A. Guérin, **A. A. Abbott**, C. Branciard, Č. Brukner, G. Chiribella and P. Walther, *Experimental quantum communication enhancement by superposing trajectories*, [Physical Review Research](#) **3**, 013093 (2021).
22. **A. A. Abbott**, J. Wechs, D. Horsman, M. Mhalla and C. Branciard, *Communication through coherent control of quantum channels*, [Quantum](#) **4**, 333 (2020).
21. R. Uola, T. Kraft and **A. A. Abbott**, *Quantification of quantum dynamics with input-output games*, [Physical Review A](#) **101**, 052306 (2020).
20. **A. A. Abbott**, R. Silva, J. Wechs, N. Brunner and C. Branciard, *Anomalous weak values without post-selection*, [Quantum](#) **3**, 194 (2019). [Perspective on our paper by E. Cohen: [Quantum Views](#) **3**, 27 (2019).]
19. **A. A. Abbott**, C. S. Calude, M. J. Dinneen and R. Hua, *A hybrid quantum-classical paradigm to mitigate embedding costs in quantum annealing*, [International Journal of Quantum Information](#) **17**, 1950042 (2019).
18. B. Demirel, S. Sponar, **A. A. Abbott**, C. Branciard and Y. Hasegawa, *Experimental test of an entropic measurement uncertainty relation for arbitrary qubit observables*, [New Journal of Physics](#) **21**, 013038 (2019).
17. J. Wechs, **A. A. Abbott** and C. Branciard, *On the definition and characterisation of multipartite causal (non)separability*, [New Journal of Physics](#) **21**, 013027 (2019).
16. **A. A. Abbott**, C. S. Calude, M. J. Dinneen and N. Huang, *Experimentally probing the incomputability of quantum randomness*, [Physica Scripta](#) **94**, 045103 (2019).
15. A. Tavakoli, **A. A. Abbott**, M.-O. Renou, N. Gisin and N. Brunner, *Semi-device-independent characterization of multipartite entanglement of states and measurements*, [Physical Review A](#) **98**, 052333 (2018).

14. **A. A. Abbott**, J. Wechs, F. Costa and C. Branciard, *Genuinely multipartite noncausality*, [Quantum](#) **1**, 39 (2017).
13. N. Miklin, **A. A. Abbott**, C. Branciard, R. Chaves and C. Budroni, *The entropic approach to causal correlations*, [New Journal of Physics](#) **19**, 113041 (2017).
12. **A. A. Abbott** and C. Branciard, *Noise and disturbance of qubit measurements: An information-theoretic characterization*, [Physical Review A](#) **94**, 062110 (2016).
11. **A. A. Abbott**, C. Giarmatzi, F. Costa and C. Branciard, *Multipartite causal correlations: Polytopes and inequalities*, [Physical Review A](#) **94**, 032131 (2016).
10. **A. A. Abbott**, P.-L. Alzieu, M. J. W. Hall and C. Branciard, *Tight state-independent uncertainty relations for qubits*, [Mathematics](#) **4**, 8 (2016).
9. **A. A. Abbott**, C. S. Calude and K. Svozil, *A non-probabilistic model of relativised predictability in physics*, [Information](#) **6**, 773 (2015).
8. **A. A. Abbott**, C. S. Calude and K. Svozil, *A variant of the Kochen-Specker theorem localising value indefiniteness*, [Journal of Mathematical Physics](#) **56**, 102201 (2015).
7. **A. A. Abbott**, C. S. Calude and K. Svozil, *Value-indefiniteness observables are almost everywhere*, [Physical Review A](#) **89**, 032109 (2014).
6. **A. A. Abbott**, C. S. Calude and K. Svozil, *A quantum random number generator certified by value indefiniteness*, [Mathematical Structures in Computer Science](#) **24**, e240303 (2014).
5. **A. A. Abbott**, C. S. Calude, J. Conder and K. Svozil, *Strong Kochen-Specker theorem and incomputability of quantum randomness*, [Physical Review A](#) **86**, 062109 (2012).
4. **A. A. Abbott**, M. Bechmann, C. S. Calude and A. Sebald, *A nuclear magnetic resonance implementation of a classical Deutsch-Jozsa algorithm*, [International Journal of Unconventional Computing](#) **8**, 161 (2012).
3. **A. A. Abbott** and C. S. Calude, *Von Neumann normalisation of a quantum random number generator*, [Computability](#) **1**, 59 (2012).
2. **A. A. Abbott**, *De-quantisation of the quantum Fourier transform*, [Applied Mathematics and Computation](#) **219**, 3 (2012).
1. **A. A. Abbott**, *The Deutsch-Jozsa problem: De-quantisation and entanglement*, [Natural Computing](#) **11**, 3 (2012).

## Papers in Refereed Conference Proceedings

4. **A. A. Abbott**, C. S. Calude, M. J. Dinneen and R. Hua, *A hybrid quantum-classical paradigm to mitigate embedding costs in quantum annealing – Abridged Version*, In M. Cuffaro and P. Papayannopoulos (eds), Proceedings of the 9th International Workshop on Physics and Computation (Fontainebleau, France, June 26 2018); [ETPCS](#) **273**, 1 (2018).
3. **A. A. Abbott** and I. Watson, *Ontology-aided product classification: A nearest neighbour approach*, In A. Ram and N. Wiratunga (eds), Proceedings of the 19th International Conference on Case-Based Reasoning (London, UK, September 12–15 2011); [LNAI](#) **6880**, 348 (2011).
2. **A. A. Abbott** and C. S. Calude, *Von Neumann normalisation and symptoms of randomness: An application to sequences of quantum random bits*, In C. S. Calude, J. Kari and I. Petre (eds), Proceedings of the 10th International Conference on Unconventional Computation (Turku, Finland, June 6–10 2011); [LNCS](#) **6714**, 40 (2011).
1. **A. A. Abbott** and C. S. Calude, *Understanding the quantum computational speed-up via de-quantisation*, In S. B. Cooper, E. Kashefi, P. Panangaden (eds), Proceedings of the 6th Workshop on Developments in Computational Models: Causality, Computation, and Physics (Edinburgh, UK, July 9–10 2010); [EPTCS](#) **26**, 1 (2010).

## Book Chapters

2. **A. A. Abbott**, C. S. Calude and K. Svozil, *On the unpredictability of individual quantum measurement outcomes*, In L. D. Beklemishev *et al.* (eds), Fields of Logic and Computation II: Essays Dedicated to Yuri Gurevich on the Occasion of His 75th Birthday; [LNCS](#) **9300**, 69 (Springer, Cham, 2015).
1. **A. A. Abbott**, C. S. Calude and K. Svozil, *A quantum random oracle*, In S. B. Cooper and J. van Leeuwen (eds), *Alan Turing: His Work and Impact*, pp. 206–210, (Elsevier Science, 2013).

## Preprints and Research Reports<sup>1</sup>

5. M. Ioannou, P. Sekatski, **A. A. Abbott**, D. Rosset, J.-D. Bancal and N. Brunner, *Receiver-Device-Independent Quantum Key Distribution Protocols*, [arXiv:2111.04351 \[quant-ph\]](#).
4. H. Dourdent, **A. A. Abbott**, N. Brunner, I. Šupić and C. Branciard, *Semi-device-independent Certification of Causal Nonseparability with Trusted Quantum Inputs*, [arXiv:2107.10877 \[quant-ph\]](#).
3. M. Ioannou, M. A. Pereira, D. Rusca, F. Grünenfelder, A. Boaron, M. Perrenoud, **A. A. Abbott**, P. Sekatski, J.-D. Bancal, N. Maring, H. Zbinden and N. Brunner, *Receiver-Device-Independent Quantum Key Distribution*, [arXiv:2104.14574 \[quant-ph\]](#).
2. **A. A. Abbott**, L. Bienvenu and G. Senno. Non-uniformity in the Quantis random number generator. *CDMTCS Research Report 472* (2014).
1. **A. A. Abbott** and M. J. Dinneen. *An investigation of algorithms to aesthetically draw Cayley graphs*, *CDMTCS Research Report 318* (2008).

## Edited Proceedings

1. **A. A. Abbott** and D. C. Horsman, *Proceedings of the 7<sup>th</sup> International Workshop on Physics and Computation, Manchester, U.K., 14 July 2016*, *Electronic Proceedings of Computer Science (EPTCS) 214* (2016).

## Vulgarisation and Communication

2. Invited blog post (with Prof. Cristian S. Calude) on the website [Quantum for Quants](#) about the prospects of near-term quantum computing and hybrid approaches: *The limits of quantum computing* (19 June 2016).
1. Article for a broad audience in the *Asia Pacific Mathematics Newsletter*: **A. A. Abbott**, C. S. Calude and K. Svozil. *On Demons and Oracles*, *Asia Pacific Mathematics Newsletter* **2**(1), 25 (2012).

## Invited Conference Presentations

5. The Causal Structure of Quantum Information. *Spring School in Theoretical Computer Science (EPIT)*, CIRM, Marseille, France, May 2021.
4. Coherent Control of Quantum Channels. *The Quantum Information Structure of Spacetime*, Hong Kong, January 2020.
3. Causal Nonseparability in Multipartite Scenarios. *Quantum Maiwar*, Brisbane, Australia, November 2018.
2. Localising Value Indefiniteness with the (Strong) Kochen-Specker Theorem. *Solstice of Foundations: Contextuality Workshop*, Zürich, Switzerland, June 2017.
1. From Preparation to Measurement Through the Eyes of Entropic Uncertainty Relations. *2nd International Conference on Quantum Foundations*, Patna, India, October 2016.

## Regular Conference Presentations

18. Device-Independent Quantification of Quantum Resources (poster). *Vienna Quantum Foundations Conference (VQF-CON)*, Vienna (hybrid), Austria, September 2021.
17. Bounding and simulating contextual correlations in quantum theory. *Quantum Physics and Logic (QPL)*, Gdansk (virtual), Poland, June 2021.
16. Computational Advantage from Quantum Superposition of Multiple Temporal Orders of Gates. *GDR IQFA (Quantum Engineering, Fundamental Aspects to Applications)*, Grenoble (virtual), France, December 2020.
15. Quantum Information Processing with Indefinite Causal Orders. *Swiss QSIT (Quantum Science and Technology) General Meeting*, Arosa, Switzerland, February 2020.
14. Communication through coherent control of quantum channels (poster). *GDR IQFA (Quantum Engineering, Fundamental Aspects to Applications)*, Paris, France, November 2019.
13. Communication through coherent control of quantum channels. *AQIS (Asian Quantum Information Science Conference)*, Seoul, South Korea, August 2019.
12. Indefinite causal relations in multipartite scenarios (poster). *GDR IQFA (Quantum Engineering, Fundamental Aspects to Applications)*, Nice, France, November 2017.
11. Genuinely multipartite noncausality. *Quantum Networks*, Oxford, England, August 2017.

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<sup>1</sup>Centre for Discrete Mathematics and Theoretical Computer Science (CDMTCS) reports are available online at <http://www.cs.auckland.ac.nz/CDMTCS/researchreports/>.

10. Multipartite causal correlations, polytopes and inequalities. *Quantum Networks*, Natal, Brazil, November 2016.
9. Noise and disturbance of qubit measurements: An information-theoretic characterisation. *Quantum Physics and Logic (QPL)*, Glasgow, Scotland, June 2016.
8. A variant of the Kochen-Specker theorem locating value indefiniteness. *Quantum theory: From foundations to technology*, Växjö, Sweden, June 2015.
7. Quantum information inside and outside the quantum. *Weaving the understanding of information*, Vienna, June 2015.
6. Locating value indefiniteness with a variant of the Kochen-Specker theorem. *Randomness in Quantum Physics and Beyond*, Barcelona, Spain, May 2015.
5. Von Neumann normalisation and symptoms of randomness: An application to sequences of quantum random bits. *Unconventional Computation*, Turku, Finland, June 2011.
4. Ontology-aided product classification: A nearest neighbour approach. *New Zealand Computer Science Research Student Conference*, Palmerston North, New Zealand, April 2011.
3. De-quantisation of the quantum Fourier transform. *3rd International Workshop on Physics and Computation*, the Nile, Luxor–Aswan, Egypt, September 2010.
2. De-quantisation in quantum computing: An overview and an application to the quantum Fourier transform. *New Zealand Computer Science Research Student Conference*, Wellington, New Zealand, April 2010.
1. The Deutsch-Jozsa problem: De-quantisation and entanglement, *Workshop on Physics and Computation*, Ponta Delgada, Portugal, September, 2009.

## Research Seminars

15. Laboratoire d'Informatique de Grenoble (LIG), 30 January 2020. *Communication through coherently controlled quantum channels*.
14. University of Tokyo (Japan), 26 August 2019. *Quantum circuits with classical and quantum control of causal orders*.
13. Quantum Information Theory Seminar, ETH Zürich, Zürich (Switzerland), 28 May 2019. *Quantum circuits with classical and quantum control of causal orders*.
12. Faculty of Informatics, Università della Svizzera italiana, Lugano (Switzerland), 15 May 2019. *Quantum circuits with classical and quantum control of causal orders*.
11. Institute for Quantum Optics and Quantum Information, University of Vienna (Austria), 9 April 2019. *Quantum circuits with classical and quantum control of causal orders*.
10. Laboratoire de Physique et Modélisation des Milieux Condensés (France), 16 January 2019. *Quantum information beyond the circuit model*.
9. Invited talk in the seminar series “Fondements et implications sociétales de la mécanique quantique”, Institut Néel (France), 29 March 2017. *Randomness, indeterminism and unpredictability in quantum mechanics*.
8. Invited talk in the seminar series “Logique, Informatique, Mathématiques, Raisonnement”, Université Lyon 3 (France), 15 March 2017. *Randomness and unpredictability at the heart of quantum mechanics*.
7. Invited talk in the seminar series “Séminaires de philosophie et Mathématiques: Temps et Hasard”, École Normale Supérieure de Paris (France), 6 February 2017. *Randomness and unpredictability at the heart of the foundations of quantum mechanics*.
6. Talk in seminar the series “Journal Club Foundations”, Institut Néel (France), 8 October 2015. *An introduction to quantum contextuality*.
5. Technical University of Vienna (Austria), 30 May 2015. *A variant of the Kochen-Specker theorem locating value indefiniteness*.
4. École Normale Supérieure (France), 28 November 2014. *Randomness and unpredictability: Their meaning in quantum mechanics*.
3. Technical University of Vienna (Austria), 11 September 2013. *From value indefiniteness to quantum randomness*.
2. University of Bologna (Italy), 11 June 2013. *Strong incomputability of quantum randomness*.
1. Université de Paris 7 Diderot (France), 28 November 2012. *Quantum randomness: In search of an algorithmic description*.

## Other Research Experience

- 2009–2010: *UNSPSC Product Classifier with Case Based Reasoning*. Working on a paid research grant to develop a system to classify consumer products into a class-hierarchy ontology using a Case Based Reasoner with conversational elements.
- 2008–2009: *Diode Laser Modulation to excite Raman transitions between hyperfine-states in Rubidium atoms*. Experimental work with Dr. M. D. Hoogerland in the UoA Quantum Information Laboratory on quantum gates implemented with super-cooled Rubidium atoms.

## Teaching and Thesis Supervision

- PhD supervision:
  - Raphaël Mothe, “*Causal superpositions in quantum information and thermodynamics*”, co-supervised with Cyril Branciard; UGA 2021–2024.
- Master’s student supervision:
  - Raphaël Mothe; ENS Lyon pre-thesis internship 2021.
  - Pierre Pocreau, “*Improving quantum social welfare by relaxing pseudo-telepathic constraints in non-collaborative games*”; ENSIMAG M1 Lab project, 2021.
  - Océane Koska, “*Simulation of the superposition of multiple temporal gates orders in quantum circuits*”; ENSIMAG M1 Lab project, 2021.
  - Eleftherios Tselentis, “*Anomalous Weak Values and Indefinite Causal Order*” (thesis defended October 2019; external Master’s thesis from ETH, Zürich).
- Lecturer (preparing and giving lectures, writing and marking exams) for the following courses (stars indicate organisation of course):

### University of Grenoble Alpes:

2021, 2022\*: Fundamental Computer Science (graduate, 4<sup>th</sup> year)

### University of Auckland:

2012, 2013: Principles of Programming (undergraduate, 1<sup>st</sup> year)

- Teaching assistant (tutorials, marking assignments and exams) for the following courses:

### University of Geneva:

2020: Quantum Information (graduate, 4<sup>th</sup> year)  
2018–2020: Mathematical Methods for Physicists (undergraduate, 1<sup>st</sup> year)

### University of Auckland:

2012, 2013: Mathematical Foundations of Computer Science (undergraduate, 3<sup>rd</sup> year)  
2009–2012: Advanced Physics Laboratory (undergraduate, 2<sup>nd</sup>, 3<sup>rd</sup> year)  
2011: Algorithm Design and Analysis (undergraduate, 3<sup>rd</sup> year)  
2008–2010: UNIX, Operating Systems and Data Communication (undergraduate, 2<sup>nd</sup> year)  
2008, 2009: Principles of Programming (undergraduate, 1<sup>st</sup> year)  
2008: Planets, Stars and Galaxies (undergraduate, 1<sup>st</sup> year)  
2008: First Year Physics Laboratory (undergraduate, 1<sup>st</sup> year)

## Service and Administration

### Conference Organising Committees

- *Workshop on Physics and Computation 2016*, Manchester, UK, July 2016.
- *Workshop on Physics and Computation 2015*, Auckland, New Zealand, August/September 2015.

### Conference Programme Committees

- *Conference for Young Quantum Information Scientists 2019*, Sopot, Poland 2019.
- *Workshop on Physics and Computation 2017*, Fayetteville AR, USA, June 2017.
- *Workshop on Physics and Computation 2016*, Manchester, UK, July 2016.



- *Workshop on Physics and Computation 2015*, Auckland, New Zealand, August/September 2015.
- *Workshop on Physics and Computation 2011*, Turku, Finland, June 2011.

## Evaluation Committees

- Selection committee for LANEF and La Fondation Nanosciences PhD scholarships, UGA, 2021.

## PhD Defence Committees

- Don Jean-Baptiste Anoman, “*Contributions relatives à la génération quantique d’aléa*”, Université de Limoges, 2 December 2021.

## Referee for Journals and Conferences

- Referee for the journals: *Nature Communications*, *APS Journals (PRL, PRX, PRA)*, *New Journal of Physics*, *Quantum*, *Scientific Reports*, *Journal of Mathematical Physics*, *Journal of Physics Communications*, *Quantum Information Processing*, *Photonics Research*, *Canadian Journal of Physics*, *Mathematical Structures in Computer Science*, *Natural Computing*, *Fundamenta Informaticae*, *Classical and Quantum Gravity*, *Algorithms*.
- Referee for the conferences: *BIID 2021*, *QPL 2020*, *QIP 2020*, *TAMC 2012*.
- IOP Trusted Reviewer.

## Miscellaneous

- 2020–: Organisation of the regular series of lectures on Quantum Computing as part of the QuEnG (Quantum Engineering Grenoble) network.
- 2013–2015: Proofreading and editing for the New Zealand Mathematical Society Newsletter.