

Alastair A. Abbott

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Employment

- Dec. 2020 – present: **Research scientist (chargé de recherche)** at Inria Grenoble – Rhône-Alpes, Grenoble, France, in the QINFO team
- 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

Current Research Interests

- **Quantum information:** quantum information processing with indefinite causal orders, certification of quantum resources, quantum cryptography, convex optimisation in quantum information theory
- **Quantum foundations:** quantum causal indefiniteness, entanglement, nonlocality, contextuality, quantum randomness
- **Quantum computing:** extended models of quantum computation (including coherent control), hybrid classical-quantum computation
- **Theoretical computer science:** algorithmic information theory and randomness
- **Philosophy of quantum mechanics:** quantum randomness, quantum causality

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.

Publications and Presentations

Papers in Refereed Journals

28. M. Ioannou, M. A. Pereira, D. Rusca, F. Grönenfelder, 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*, *Quantum*, to appear (2022); [arXiv:2104.14574 \[quant-ph\]](#).
27. M. Ioannou, P. Sekatski, **A. A. Abbott**, D. Rosset, J.-D. Bancal and N. Brunner, *Receiver-device-independent quantum key distribution protocols*, *New Journal of Physics* **24**, 063006 (2022).
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 Reports¹

3. 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 \[quant-ph\]](#).

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

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 7th 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

17. Device-Independent Quantification of Quantum Resources (poster). *Vienna Quantum Foundations Conference (VQF-CON)*, Vienna (hybrid), Austria, September 2021.
16. Bounding and simulating contextual correlations in quantum theory. *Quantum Physics and Logic (QPL)*, Gdansk (virtual), Poland, June 2021.
15. Computational Advantage from Quantum Superposition of Multiple Temporal Orders of Gates. *GDR IQFA (Quantum Engineering, Fundamental Aspects to Applications)*, Grenoble (virtual), France, December 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.
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.

Invited Research Seminars

19. Laboratoire d'Informatique de Grenoble (LIG) Research Days, Autrans (France), 22 June 2022. *Quantum control structures in quantum information processing*.
18. QuantAlps kickoff meeting, Grenoble, 25 March 2022. *Certifying Quantum Resources with Minimal Assumptions*.
17. Inria challenge “EQIP” kickoff meeting, Paris, 19 November 2021. *Certification of Dynamical Quantum Resources*.
16. Swiss QSIT (Quantum Science and Technology) General Meeting, Arosa (Switzerland), 5 February 2020. *Quantum Information Processing with Indefinite Causal Orders*.
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:
 - Pierre Pocreau, “*Query complexity for higher order quantum computation*”; Ensimag M2 Internship, 2022.
 - Elliot Renel, “*Computational advantages with causally indefinite quantum circuits*”; MoSIG M1 Internship, 2022.
 - 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, 4th year)

University of Auckland:

2012, 2013: Principles of Programming (undergraduate, 1st year)

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

University of Geneva:

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

University of Auckland:

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

Direction and Steering Committees

- Governing board of **QuantAlps** (2022–)
- Steering committee of **QuantAlps** (for research axis “Quantum Information and Software” and joint-lead of the “Quantum Communication” federative project; 2022–)

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*, *Fundamenta Informaticae*, *Mathematical Structures in Computer Science*, *Natural Computing*, *Theoretical Computer Science*, *Classical and Quantum Gravity*, *Algorithms*.
- Referee for the conferences: *LICS*, *SIGGRAPH*, *BIID*, *QPL*, *QIP*, *TAMC*.
- IOP Trusted Reviewer.

Miscellaneous

- 2022–: Organisation of the QuantAlps research seminars on Quantum Information and Computing.
- 2020–2021: 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.