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Alessandro Tosini

Curriculum Vitae

Personal details

sex: male

nationality: Italian

date and place of birth: 27^{th} June 1985, Brescia (IT)

Fields of interest

Quantum field theory, quantum information, foundations of quantum theory.

Academic Positions

2016– **Postdoctoral Researcher**, *Quantum information theory group, University of Pavia*, Italy.
Project: quantum causal structures. Supervisors: Professor G.M. D'Ariano and PhD Paolo Perinotti.

2013–2016 **Postdoctoral Researcher**, *Quantum information theory group, University of Pavia*, Italy.
Project: quantum cellular automata and informational approach to quantum field theory. Supervisor: Professor G.M. D'Ariano.

2012–2013 **Research grant**, *University of Pavia*, Italy.

Education

2009–2013 **PhD in Theoretical Physics**, *University of Pavia*, Italy.
Thesis title: A QUANTUM CELLULAR AUTOMATA FRAMEWORK FOR QUANTUM FIELDS DYNAMICS.
Supervisor: Prof. G. M. D'Ariano.
Thesis evaluated positively by the external referees, Prof. Dr. G. Amelino Camelia and Prof. João Magueijo.

June 2011 11^{th} **Canadian Summer School on Quantum Information**, *Sherbrooke University*, Canada, Final exam evaluation: A+.

2007–2009 **M.Sc. in Theoretical Physics**, *University of Pavia*, Italy, *110/110 cum laude*.
Thesis title:PROBABILISTIC THEORIES AS MODELS FOR EXPLORING OPERATIONAL AXIOMATIZATIONS OF QUANTUM MECHANICS.
Supervisor: Professor G. M. D'Ariano.

2004–2007 **B. Sc. in Physics**, *University of Pavia*, Italy, *110/110 cum laude*.
Thesis title: SOLUZIONI DELL'EQUAZIONE DI SCHRÖDINGER IN SENSO DISTRIBUZIONALE E LORO COMPORTAMENTO ASINTOTICO
Supervisor: Prof. F. Capuzzi.

Teaching

2017–2018 **Teaching Assistant**, *University of Pavia*, Italy.
Taught exercises of FISICA GENERALE 2 (electromagnetism) to mathematics students
Taught exercises of FISICA to biology students.

2016–2017 **Teaching Assistant**, *University of Pavia*, Italy.
Taught exercises of FISICA GENERALE 2 (electromagnetism) to mathematics students.

2015–2016 **Teaching Assistant**, *University of Pavia*, Italy.
Taught exercises of FISICA GENERALE 2 (electromagnetism) to mathematics students
Taught exercises of FISICA to biology students.

2014–2015 **Teaching Assistant**, *University of Pavia*, Italy.
Taught exercises of FISICA GENERALE 2 (electromagnetism) to mathematics students.
Taught exercises of FISICA to biology students.

2013–2014 **Teaching Assistant**, *University of Pavia*, Italy.
Taught exercises of FISICA GENERALE 2 (electromagnetism) to mathematics students.
Taught exercises of FISICA to biology students.

13^{th} Feb 2013 **Students orientation**, *University of Pavia*, Italy.
Delivered seminar on TEORIA QUANTISTICA DELL'INFORMAZIONE to high-school students.

2011–2013 **Teaching Assistant**, *University of Pavia*, Italy.
Taught exercises of FISICA to medicine students.

Co-supervised thesis

2017 M. Lugli, Bachelor thesis, University of Pavia, Italy, thesis title: MASS AND PROPER TIME AS CONJUGATED OBSERVABLES.

2014 N. Mosco, Master thesis, University of Pavia, Italy, thesis title: EXACT SOLUTIONS OF THE WEYL AND DIRAC QUANTUM CELLULAR AUTOMATON.

2014 M. Erba, Master thesis, University of Pavia, Italy, thesis title: NON-ABELIAN QUANTUM WALKS AND RENORMALIZATION.

Editorial activities

- Guest editor of the Special Issue on "Quantum Cellular Automata and Quantum Walks" link to be published in journal Condensed Matter.

Other academic activities

- Co-organizer of the "Quantum Foundations Workshop", June 21-22, 2016, University of Pavia, Italy.
- Reviewer for journals: Phys. Rev. Letter, Phys. Rev. A, Proc. Roy. Soc, IOP New J. of Phys., J. Phys. A, IEEE Transactions on Cybernetics, Entropy, ROMP, Symmetry, others.

Computer skills

OS	Unix, Mac-OS, Windows
Software	Wolfram Mathematica, Office, Photo-editing
Programming languages	Pascal (high-school), Perl (B. Sc), C/C++ (B. Sc), LaTeX, HTML

Languages

Italian	**Native language**
English	**Advanced**

Presentations at conferences

July 16-21, 2018	14th Biennial Conference on Quantum Structures, Kazan, Russia
July 2-5, 2018	Is quantum theory exact? The quest for the spin-statistics connection violation and related items, Frascati, Itay (invited talk)
November 29-December 1, 2017	Workshop Quantum Foundations: New frontiers in testing quantum mechanics from underground to the space, Frascati, Itay (invited talk)
July 3-7, 2017	14th International Conference on Quantum Physics and Logic, Nijmegen, The Netherlands (talk)
June 12, 2017	Quantum Simulation Models Workshop, Marseille, France, (invited talk)
March 20, 2017	Seminar on quantum computation, Sia S.p.a., Milan, Italy (invited talk)
December 1-4, 2016	EMN Meeting on Quantum& Mesoscopic Physics 2016, Mauritius, Africa (invited talk regretfully declined)
August 23-26, 2016	EMN Meeting on Quantum Communication and Mövenpick Hotel Berlin, Germany (invited talk regretfully declined)
July 11-15, 2016	Conference Quantum Algebras, Quantum Integrable Models and Quantum Information, The Lovén Centre Kristineberg, Sveden (talk)
December 6-13, 2015	Visit at the Centre for Quantum Technology, National University of Singapore, Singapore (invited talk)
November 16-18, 2015	Workshop of quantum Simulation and Quantum Walks, Yokohama National University, Japan (talk)
July 13-17, 2015	12th International Workshop on Quantum Physics and Logic, Oxford, England (talk)
June 15-17, 2015	47 Symposium on Mathematical Physics, Torun, Poland (talk)
September 15-19, 2014	Seventh International Workshop DICE2014, Castiglioncello, Italy (talk)

July 15-18, 2014 — Frontiers of Fundamental Physics 14, Marseille, France (talk)

June 5-8, 2014 — Central European Quantum Information Processing Workshop, Znojmo, Czech Republic (talk)

February 6-7, 2014 — Meeting on Relativistic Quantum Walks, UniversitÃĭ de Grenoble, France (talk)

June 16-17, 2011 — 8th Canadian Student Conference on Quantum Information, Sherbrooke University, Canada (poster)

May 9-13, 2011 — Conceptual Foundations and Foils for Quantum Information Processing, Perimeter Institute, Waterloo Canada (poster)

List of publications

1 Alessandro Bisio, Giacomo Mauro D'Ariano, Nicola Mosco, Paolo Perinotti, Alessandro Tosini, *Solutions of a two-particle interacting quantum walk*, Entropy 20(6), 435 (2018)

2 Alessandro Bisio, Giacomo Mauro D'Ariano, Paolo Perinotti, Alessandro Tosini, *The Thirring quantum cellular automaton*, Phys. Rev. A **97**, 032132 (2018)

3 Giacomo Mauro D'Ariano, Nicola Mosco, Paolo Perinotti, Alessandro Tosini, *Path-sum solution of the Weyl Quantum Walk in 3+1*, Philosophical Transactions A **375** 2106 (2017)

4 Michele Dall'Arno, Sarah Brandsen, Alessandro Tosini, Francesco Buscemi, Vlatko Vedral, *No-hypersignaling principle*, Phys. Rev. Lett. **119** 020401 (2017)

5 Giacomo Mauro D'Ariano, Marco Erba, Paolo Perinotti, Alessandro Tosini, *Virtually Abelian Quantum Walks*, J. Phys. A, **50**, 035301 (2017)

6 Giacomo Mauro D'Ariano, Nicola Mosco, Paolo Perinotti, Alessandro Tosini, *Discrete time Dirac quantum walk in 3+1 dimensions*, Entropy **18** 228 (2016)

7 A. Bisio, G. M. D'Ariano, M. Erba, P. Perinotti, A. Tosini, *Quantum walks with a one-dimensional coin*, Phys. Rev. A **93** 062334 (2016)

8 A. Bisio, G. M. D'Ariano, P. Perinotti, A. Tosini, *Free quantum field theory from quantum cellular automata. Derivation of Weyl, Dirac and Maxwell Quantum Cellular Automata*, Foundations of Physics, Volume **45**, Issue 10, pp 1137-1152 (2015)

9 A. Bisio, G. M. D'Ariano, P. Perinotti, A. Tosini, *Weyl, Dirac and Maxwell Quantum Cellular Automata. Analytical Solutions and Phenomenological Predictions of the Quantum Cellular Automata Theory of Free Fields*, Foundations of Physics, Volume **45**, Issue 10, pp 1203-1221 (2015)

10 A. Bibeau-Delisle, A. Bisio, G. M. D'Ariano, P. Perinotti, A. Tosini, *Doubly-Special Relativity from Quantum Cellular Automata*, EPL **109** 50003 (2015)

11 G. M. D'Ariano, N. Mosco, P. Perinotti, A. Tosini, *Discrete Feynman propagator for the Weyl quantum walk in 2+1 dimensions*, EPL **109** 40012 (2015)

12 A. Bisio, G. M. D'Ariano, A. Tosini, *Quantum Field as a Quantum Cellular Automaton: the Dirac free evolution in one dimension*, Annals of Physics **354** 244 (2015)

13 G. M. D'Ariano, N. Mosco, P. Perinotti, A. Tosini, *Path-integral solution of the one-dimensional Dirac quantum cellular automaton*, Phys. Lett. A **378** 3165 (2014)

14 G. M. D'Ariano, F. Manessi, P. Perinotti, A. Tosini, *The Feynman problem and Fermionic entanglement: Fermionic theory versus qubit theory*, Int. J. Mod Phys. A **17** 1430025 (2014)

15 G. M. D'Ariano, F. Manessi, P. Perinotti, A. Tosini, *Fermionic computation is non-local tomographic and violates monogamy of entanglement*, EPL **107** 20009 (2014)

16 A. Bisio, G. M. D'Ariano, A. Tosini, *Dirac quantum cellular automaton in one dimension: Zitterbewegung and scattering from potential*, Phys. Rev A **88** 032301 (2013)

17 A. Tosini, *A Quantum Cellular Automata Framework for Quantum Fields Dynamics*, Scientifica Acta 7, No. 1, Ph 21-30 (2013)

18 G. M. D'Ariano, A. Tosini, *Emergence of Space-Time from Topologically Homogeneous Causal Networks*, Studies in History and Philosophy of Modern Physics **44** 294 (2013)

19 G. M. D'Ariano and Alessandro Tosini, *Space-time and special relativity from causal networks*, arXiv:1008.4805 (2010)

20 G. M. D'Ariano, A. Tosini, *Testing axioms for Quantum Theory on Probabilistic toy-theories*, Quant. Inf. Proc. **9** 95-141 (2010)

Summary of the scientific results

Quantum information and foundations of quantum theory

The notion of *operational probabilistic theories* (OPT) stems from the will of shedding light on the apparently odd features of quantum theory, which is arguably the most fra-reaching and experimentally tested physical theory known nowadays. OPT are a very general framework for describing an arbitrary physical probabilistic theory. Within this scenario the characteristic quantum traits can be compared to other admissible behaviours, with the final goal of seeking for the physical principles at the basis of the quantumness of nature. The framework recently led to the axiomatization of quantum theory from *informational axioms*, namely from axioms regarding how information can or cannot by manipulated in physical processes. My contribution in this research line has been the study of probabilistic toy-models, more general than the quantum one, gaining insights on the physical axioms needed to single out quantum theory among the whole class of probabilistic models. I contributed to i) one of the first thorough formalization of the Popescu-Rohrlich boxes as a consistent probabilistic theory, ii) the construction of a general probabilistic theory having Fermions as elementary systems, and iii) the introduction of a toy model theory that, though being perfectly compatible with classical and quantum theories at the level of space-like correlations, displays an anomalous behavior, denoted *hypersignaling*, in its time-like correlations.

Reconstruction of quantum field theory

In the last decades the mission of creating a quantum computer has been a focal point for research in theoretical and experimental physics as well as in computer science and mathematics, with quantum information theory rising as the interdisciplinary science connecting all these fields. The ambition of this research is to develop our ability in implementing and processing elementary quantum systems, say qubits, via the accurate control of different types of physical systems. In many cases the physical systems used to mimic a set of qubits are far from elementary nevertheless this is clearly not an issue in view of engineering quantum computation. The idea is to revers the perspective and explore the possibility of seeking physical systems and their dynamics within an elementary computational framework, emphasising the role of quantum information in fundamental physics. In this sense history provides a precedent on the classical computation side, when Wilson gained deep insights about quantum field theory trying to reproduce its laws of on a classical computer. We wish to learn more about the nature and foundations of quantum field theory pursuing the quantum counterpart of the Wilson program. A special kind of circuit architecture, respecting the hypothesis of *homogeneity* and *locality* of the computation, is that of *quantum cellular automata* (QCA), which describe the discrete time evolution of a lattice of finite-dimensional quantum systems. The automaton dynamics exhibits a strict notion of causality: any quantum system interacts with a finite number of neighbours. The project proposes QCA as a microscopical dynamical theory recovering the usual relativistic theory of quantum fields in the large-scale limit. I contributed i) to develop the QCA theory for free quantum fields, ii) to derive the deformed Poincaré symmetry compatible with the invariance of the automaton dynamics under change of reference frame, iii) to study the relation between the properties of the lattice and the admissibility of QCA over it, and iv) to analytically solve a QCA model for the four-fermion interaction.

I, ALESSANDRO TOSINI, born in BRESCIA (BS) on 27/06/1985, resident in via Buzio n.8, PAVIA (IT), declare under penalty of perjury subject to all applicable laws (art.76 D.P.R. 28/12/2000 n.445), that the information provided is true and correct to the best of my knowledge, information and belief.
I authorize the use of my personal data in compliance with D.L. 196/03.