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Davide Lonigro

CURRICULUM VITAE

PERSONAL DATA

SURNAME	LONIGRO
NAME	DAVIDE
DATE OF BIRTH	2 APRIL 1993

QUALIFICATIONS**DEGREE**

Laurea magistrale (Master's degree), Physics, curriculum “**Theoretical Physics**”, at Università degli Studi di Bari Aldo Moro, Dipartimento di Fisica. 20 September 2017. Final grade: 110/110 cum laude. Thesis: “**Quantum decay and Friedrichs-Lee models**”. Supervisor: prof. Paolo Facchi.

Laurea triennale (Bachelor's degree), Physics, at Università degli Studi di Bari Aldo Moro, Dipartimento di Fisica. 16 September 2015. Final grade: 110/110 cum laude. Thesis: “**Calcolo del coefficiente di diffusione per mappe caotiche lineari a tratti**” (in Italian). Supervisor: prof. Giuseppe Gonnella.

DOCTORAL DEGREE OR EQUIVALENT QUALIFICATION EARNED IN ITALY OR ABROAD / MEDICAL SPECIALISATION DIPLOMA OR EQUIVALENT QUALIFICATION, FOR THE RELEVANT SECTORS, EARNED IN ITALY OR ABROAD

Dottorato di ricerca (Ph.D.), Theoretical Physics, at Università degli Studi di Bari Aldo Moro, under the convention with Istituto Nazionale di Fisica Nucleare. 19 May 2021. Dissertation: “**Spectral and dynamical properties of quantum systems**”. Supervisor: prof. Paolo Facchi.

RESEARCH CONTRACTS, RESEARCH FELLOWSHIP CONTRACTS, POSTDOCTORAL SCHOLARSHIPS OR SIMILAR CONTRACTS

January 2024 - current: **Scientific Assistant** (Wissenschaftlicher Mitarbeiter), Friedrich-Alexander-Universität Erlangen-Nürnberg, Department of Physics.

September 2021 - February 2023: **Assegnista di ricerca**, Università degli Studi di Bari Aldo Moro, Dipartimento di Fisica.

February 2021 - August 2021: **Contratto di lavoro autonomo**, Università degli Studi di Bari Aldo Moro, Dipartimento di Fisica.

QUALIFICATIONS UNDER ART.24, PARAGRAPH 3.a AND 3.b, OF LAW No.240/2010 OF 30 DECEMBER 2010

February 2023 - January 2024: **Ricercatore a tempo determinato di tipo A (MAT/07)**, Università degli Studi di Bari Aldo Moro, Dipartimento di Matematica.

TEACHING ACTIVITIES AT ITALIAN OR FOREIGN UNIVERSITIES

Summer 2025 (upcoming): titular of the course (26h) **“Mathematical methods for quantum mechanics”**, Friedrich-Alexander-Universität Erlangen-Nürnberg, Department of Physics.

Winter 2024 (ongoing): assistant for the class **“Functional Analysis II”** (titular: prof. G. Lechner), Friedrich-Alexander-Universität Erlangen-Nürnberg, Department of Mathematics. Exercise class (26h) plus weekly homework correction.

Winter 2024 (ongoing): Co-titular (with Prof. D. Burgarth and M. Wiedmann) of the seminar course (26h) **“Seminar on Quantum Control”**. Friedrich-Alexander University of Erlangen-Nuremberg, Department of Physics.

Summer 2024: assistant for the class **“Functional Analysis I”** (titular: prof. G. Lechner), Friedrich-Alexander-Universität Erlangen-Nürnberg, Department of Mathematics. Exercise class (26h) plus weekly homework correction.

Summer 2024: co-titular, with prof. D. Burgarth, of the seminar course (26h) **“Mathematical methods for quantum mechanics and quantum control”**, Friedrich-Alexander-Universität Erlangen-Nürnberg, Department of Physics.

Summer 2023: titular of short course (8h) **“Singular perturbations of self-adjoint operators”**, Università degli Studi di Bari Aldo Moro, Dipartimento di Matematica.

CO-SUPERVISING ACTIVITIES

2024-25: **Felix Fischer** (with Prof. D. Burgarth). Friedrich-Alexander-Universität Erlangen-Nürnberg, Master's degree in Physics. Topic: Galerkin approximations of unbounded operators in quantum mechanics.

2024-25: **Leonhard Richter** (with Prof. D. Burgarth). Friedrich-Alexander-Universität Erlangen-Nürnberg, Master's degree in Physics. Topic: Error bounds for the rotating-wave approximation of the Dicke model.

2024: **Jonathan Bör** (with Prof. D. Burgarth). Friedrich-Alexander-Universität Erlangen-Nürnberg, Bachelor degree in Physics. Topic: Dynamical decoupling and Friedrichs-Lee model.

2024: **Benedikt Wenzel** (with Prof. G. Lechner). Friedrich-Alexander-Universität Erlangen-Nürnberg, Bachelor degree in Physics. Topic: scattering theory for Sturm-Liouville operators.

IMPLEMENTATION OF PROJECTS

2023-2024: Participant to the project **“Mathematical methods for the study of quantum systems and applications to quantum information and quantum computation”** funded by European Union - NextGenerationEU (CN00000013 - “National Centre for HPC, Big Data and Quantum Computing”). P.I.: Marilena Ligabò.

2019-2020: Participant to the project **“Spectral properties of the singular Friedrichs-Lee Hamiltonian”**, Progetto Giovani GNFM 2019. P.I.: Marilena Ligabò.

WORKSHOP AND CONFERENCE ORGANIZATION

2024: Organizer (with Daniel Burgarth) of the international workshop **“Control of Quantum Systems @Erlangen 2024”** (ConQuEr24), Max Planck for the Science of Light, Erlangen, on 11-13 December 2024. 41 participants, of which 13 invited speakers and 15 poster presenters.

SPEAKING AT NATIONAL AND INTERNATIONAL CONFERENCES AND CONVENTIONS

INVITED TALKS

23 Oct 2024: **Mathematical Perspectives on Quantum Mechanics: Decoherence, Open Systems, and Infinite-Dimensional Hilbert Spaces.** FAU Physikalisches Kolloquium, FAU Erlangen-Nürnberg, Erlangen, Germany.

17 Oct 2024: **Global approximate controllability of quantum systems by form perturbations.** New trends in quantum control, Université Côte d'Azur, Nice, France.

09 Oct 2024: **Efficiency of Dynamical Decoupling for (Almost) Any Spin-Boson Model.** Quantum Photonics Spotlight 2024, Universität Paderborn, Paderborn, Germany.

04 Oct 2024: **Efficiency of Dynamical Decoupling for (Almost) Any Spin-Boson Model.** Seminar KFM, Nicolaus Copernicus University in Toruń, Toruń, Poland.

22 June 2024: **Double or nothing: a Kolmogorov extension theorem for multitime (bi)probabilities in quantum mechanics.** 55th Symposium on Mathematical Physics, Nicolaus Copernicus University in Toruń, Toruń, Poland.

22 February 2024: **Double or nothing: a Kolmogorov extension theorem for multitime (bi)probabilities in quantum mechanics.** VI International Workshop on Information Geometry, Quantum Mechanics and Applications 2024, Leganés, Madrid, Spain.

21 November 2023: **Self-adjointness of generalized spin-boson models with ultraviolet divergences.** Complex Quantum Systems Research Seminar, University of Paderborn, Paderborn, Germany.

11 July 2023: **Self-adjointness of a class of spin-boson models with ultraviolet divergences.** Itinerant Quantum Math Meetings, Università degli Studi di Milano, Milano, Italy.

22 June 2023: **Some remarks on quantum measure theory and its potential applications to quantum foundations.** VI International Workshop on Information Geometry, Quantum Mechanics and Applications, San Rufo, Salerno, Italy.

08 June 2023: **Markovianity and classicality of pure dephasing phenomena.** 54th Symposium on Mathematical Physics, Nicolaus Copernicus University in Toruń, Toruń, Poland.

18 April 2023: **Self-adjointness of a class of spin-boson models with ultraviolet divergences.** Q-Math Seminar, University Carlos III of Madrid, Leganés, Madrid, Spain.

11 October 2022: **Excitation-damping quantum channels.** Seminar KFM, Nicolaus Copernicus University in Toruń, Toruń, Poland.

21 June 2022: **Deviations from exponential decay in quantum mechanics: from survival probabilities to generic observables.** Quantum Theory and Applications 2022, San Rufo, Salerno, Italy.

31 May 2022: **Quantum regression in dephasing phenomena.** Seminar KFM, Nicolaus Copernicus University in Toruń, Toruń, Poland.

19 October 2021: **Hidden non-Markovianity in open quantum systems.** Seminar KFM, Nicolaus Copernicus University in Toruń, Toruń, Poland (online).

21 December 2020: **Deviations from the exponential law for a generic quantum observable.** XMaths Workshop 2020, Università degli Studi di Bari Aldo Moro, Bari, Italy (online).

30 September 2020: **Bound states in the continuum in arrays of quantum emitters.** Young Italian Quantum Science Conference 2020, online.

01 April 2020: **The Friedrichs-Lee Hamiltonian: singular coupling, renormalization, and spectral properties.** Q-Math Seminar, University Carlos III of Madrid, Leganés, Madrid, Spain (online).

27 February 2020: **Time-dependent Schrödinger equation and applications to quantum boundary conditions.** Information Geometry, Quantum Mechanics and Applications 2020, University Carlos III of Madrid, Leganés, Madrid, Spain.

17 October 2019: **Quantum emitters in networks.** Quantum Technologies 2019, Università degli Studi di Bari Aldo Moro, Bari, Italy.

CONTRIBUTED TALKS

21 March 2024: **Double or nothing: a Kolmogorov extension theorem for multitime (bi)probabilities in quantum mechanics.** Spring Meeting of the German Physical Society 2024, Berlin, Germany.

24 May 2022: **Generalized spin-boson models with non-normalizable form factors.** INdAM Quantum Meetings - Workshop II, Università degli Studi di Milano, Milano, Italy.

17 June 2019: **The Friedrichs-Lee model and its singular coupling limit.** 51th Symposium on Mathematical Physics, Nicolaus Copernicus University in Toruń, Toruń, Poland.

28 June 2018: **Qubit-field interactions as singular Hamiltonian perturbations.** Information Geometry, Quantum Mechanics and Applications 2018, San Rufo, Salerno, Italy.

22 February 2018: **A generalization of the Friedrichs-Lee Hamiltonian and its singular coupling limit.** Mathematical Challenges in Quantum Mechanics, Università degli Studi di Roma "La Sapienza", Roma, Italy.

POSTERS

09 October 2023: **Self-adjointness of generalized spin-boson models with ultraviolet divergences.** Workshop for young researchers in analysis and mathematical physics, Ludwig Maximilian University of Munich, Munich, Germany.

08 September 2021: **Stationary excitation waves and multimerization in arrays of quantum emitters.** Quantum Optics X, Nicolaus Copernicus University in Toruń, Toruń, Poland.

23 June 2021: **Photon-emitter dressed states in infinite and closed waveguides.** 2nd workshop on waveguide QED, online conference.

02 March 2021: **Bound states in photonic waveguides.** Quantum Nanophotonics 2021, online conference.

11 September 2019: **Bound states in the continuum for an array of quantum emitters.** 12th Italian Quantum Information Science conference, Università degli Studi di Milano, Milano, Italy.

18 September 2018: **The Friedrichs-Lee model and its singular coupling limit.** 11th Italian Quantum Information Science conference, Università degli Studi di Catania, Catania, Italy.

NATIONAL AND INTERNATIONAL AWARDS AND ACCOLADES FOR RESEARCH ACTIVITY

FAU Leistungsprämie (performance bonus)

In October 2024 I have been awarded a Leistungsprämie (performance bonus) from FAU for the year 2024, due to my research and supervision activities during the year and the creation and maintenance of the webpage of the ConQuEr research group at FAU.

Emerging Talent Initiative (FAUeti)

In July 2024 I have won a competitive funding call at FAU, Emerging Talent Initiative, with the project proposal “Approximations and control of models of matter-field interaction”. The funding (15000 €) is meant to support researchers for “any measures required to prepare their application for external third-party funding”.

EELISA retreat funding

In June 2024 I have been won a competitive funding call at FAU in the context of the “European Engineering Learning Innovation and Science Alliance” (EELISA) to organize a research retreat.

CIRM “Research in pairs” program

In May 2024, in collaboration with Benjamin Alvarez (CPT Toulon) and Sascha Lill (Univ. Milan), I have won a competitive call for a scientific visit in the context of the “Research in Pairs” program at Centro Internazionale per la Ricerca Matematica (CIRM), Fondazione Bruno Kessler, Trento. The research stay took place in July 2024.

MSCA European Fellowship

In February 2024 I was awarded a “Marie Skłodowska-Curie European Postdoctoral Fellowship” (HORIZON-MSCA-2022-PF-01) by the European Commission for the project proposal “**Quantum boundary conditions for infinite-dimensional control**” (QuBiCo), in collaboration with University Carlos III of Madrid.

MSCA Seal of Excellence

In April 2023 I have been awarded a “Seal of Excellence” by the European Commission for the project proposal “**Quantum boundary conditions for infinite-dimensional control**” (QuBiCo), in collaboration with University Carlos III of Madrid.

SCIENTIFIC PRODUCTION

SCIENTIFIC PUBLICATIONS

[29] A. Balmaseda, D. Lonigro, J.M. Pérez-Pardo, “Global approximate controllability of quantum systems by form perturbations and applications”. SIAM Journal on Control and Optimization, in press. arXiv:2402.02955 [math.OC].

[28] D. Lonigro, A. Hahn, D. Burgarth, “On the Liouville-von Neumann equation for unbounded Hamiltonians”. Open Systems & Information Dynamics **31** (2024), 2450018.
<https://dx.doi.org/10.1142/S1230161224500185>

[27] D. Lonigro, F. Sakuldee, Ł. Cywiński, D. Chruściński, P. Szańkowski, “Double or nothing: a Kolmogorov extension theorem for multitime (bi)probabilities in quantum mechanics”. Quantum **8** (2024), 1447.

[26] A. Balmaseda, D. Lonigro, J.M. Pérez-Pardo, “On a sharper bound on the stability of non-autonomous Schrödinger equations and applications to quantum control”. J. Funct. Anal. **287** (2024), 110563.

[25] A. Balmaseda, D. Lonigro, J.M. Pérez-Pardo, “On Global Approximate Controllability of a Quantum Particle in a Box by Moving Walls”. SIAM J. Control Optim. **62** (2024), 826-852.
<http://dx.doi.org/10.1137/22M1518980>

[24] D. Lonigro, “Renormalization of spin-boson interactions mediated by singular form factors”. In: M. Correggi, M. Falconi (eds), Quantum Mathematics II. INdAM 2022. Springer INdAM Series, vol. 58, pp. 103-122, 2023. https://doi.org/10.1007/978-981-99-5884-9_3

[23] P. Facchi, D. Lonigro, “Positive Hamiltonians cannot give exponential decay of positive observables”. J. Phys. A: Math. Theor. **57** (2024), 015302. <https://doi.org/10.1088/1751-8121/ad0f48>

- [22] A. Balmaseda, D. Lonigro, J.M. Pérez-Pardo, “Quantum controllability on graph-like manifolds through magnetic potentials and boundary conditions”. *J. Phys. A: Math. Theor.* **56** (2023), 325201. <https://doi.org/10.1088/1751-8121/ace505>
- [21] D. Lonigro, “Self-Adjointness of a Class of Multi-Spin-Boson Models with Ultraviolet Divergences”. *Math. Phys. Anal. Geom.* **26** (2023), 15. <https://doi.org/10.1007/s11040-023-09457-6>
- [20] D. Lonigro and D. Chruściński, “Excitation-damping quantum channels”. *J. Phys. A: Math. Theor.* **56** (2023), 255301. <https://doi.org/10.1088/1751-8121/acd734>
- [19] D. Lonigro, R. Maggi, G. Angelone, E. Ercolessi, P. Facchi, G. Marmo, S. Pascazio, and F.V. Pepe, “Dimensional reduction of the Dirac equation in arbitrary spatial dimensions”. *Eur. Phys. J. Plus* **138** (2023), 324. <http://dx.doi.org/10.1140/epjp/s13360-023-03919-0>
- [18] G. Angelone, E. Ercolessi, P. Facchi, D. Lonigro, R. Maggi, G. Marmo, S. Pascazio, and F.V. Pepe, “Dimensional reduction of the Dirac theory”. *J. Phys. A: Math. Theor.* **56** (2023), 065201. <https://dx.doi.org/10.1088/1751-8121/acb869>
- [17] S. Longo, D. Lonigro, G. Lerario, C. Stripoli, and G. Micca Longo, “Quantum states of H_2^+ and H_2 in an icosahedral potential well”. *Eur. Phys. J. D* **77** (2023), 29. <https://doi.org/10.1140/epjd/s10053-023-00610-y>
- [16] D. Chruściński, S. Hesabi, and D. Lonigro, “On Markovianity and classicality in multilevel spin-boson models”. *Sci. Rep.* **13** (2023), 1518. <https://doi.org/10.1038/s41598-023-28606-z>
- [15] G. Angelone, M. Asorey, P. Facchi, D. Lonigro, and Y. Martinez, “Boundary conditions for the quantum Hall effect”. *J. Phys. A: Math. Theor.* **56** (2023), 025301. <https://doi.org/10.1088/1751-8121/acb026>
- [14] D. Lonigro and D. Chruściński, “On the classicality of quantum dephasing processes”. *Front. Quantum Sci. Technol* **1** (2022), 1090022. <https://doi.org/10.3389/frqst.2022.1090022>
- [13] D. Lonigro, “Generalized spin-boson models with non-normalizable form factors”. *J. Math. Phys.* **63** (2022), 072105. <http://doi.org/10.1063/5.0085576>
- [12] G. Angelone, P. Facchi, and D. Lonigro, “Quantum magnetic billiards: boundary conditions and gauge transformations”. *Ann. Phys.* **442** (2022), 168914. <https://doi.org/10.1016/j.aop.2022.168914>
- [11] D. Lonigro and D. Chruściński, “Quantum regression beyond the Born-Markov approximation for generalized spin-boson models”. *Phys. Rev. A* **105** (2022), 052435. <https://doi.org/10.1103/PhysRevA.105.052435>
- [10] D. Lonigro and D. Chruściński, “Quantum regression in dephasing phenomena”. *J. Phys. A Math. Theor.* **55** (2022), 225308. <http://doi.org/10.1088/1751-8121/ac6a2d>
- [9] D. Lonigro, “The self-energy of Friedrichs-Lee models and its applications to bound states and resonances”. *Eur. Phys. J. Plus* **137** (2022), 492. <https://doi.org/10.1140/epjp/s13360-022-02690-y>
- [8] A. Balmaseda, D. Lonigro, and J.M. Pérez-Pardo, “On the Schrödinger Equation for Time-Dependent Hamiltonians with a Constant Form Domain”. *Mathematics* **10** (2022), 218. <https://doi.org/10.3390/math10020218>
- [7] D. Burgarth, P. Facchi, D. Lonigro, and K. Modi, “Quantum non-Markovianity elusive to interventions”. *Phys. Rev. A* **104** (2021), L050404. <https://doi.org/10.1103/PhysRevA.104.L050404>
- [6] D. Lonigro, P. Facchi, A. Greentree, S. Pascazio, F.V. Pepe, and D. Pomarico, “Photon-emitter dressed states in a closed waveguide. *Phys. Rev. A* **104** (2021), 053702. <https://doi.org/10.1103/PhysRevA.104.053702>

- [5] D. Lonigro, P. Facchi, S. Pascazio, F.V. Pepe, and D. Pomarico, “Stationary excitation waves and multimerization in arrays of quantum emitters”. *New J. Phys.* **23** (2021), 103033. <https://dx.doi.org/10.1088/1367-2630/ac2ce0>
- [4] P. Facchi, M. Ligabò, and D. Lonigro, “Spectral properties of the singular Friedrichs-Lee Hamiltonian”. *J. Math. Phys.* **62** (2021), 032102. <https://doi.org/10.1063/5.0013032>
- [3] D. Burgarth, P. Facchi, M. Ligabò, and D. Lonigro, “Hidden non-Markovianity in open quantum systems”. *Phys. Rev. A* **103** (2021), 012203. <https://doi.org/10.1103/PhysRevA.103.012203>
- [2] P. Facchi, D. Lonigro, S. Pascazio, F.V. Pepe, and D. Pomarico, “Bound states in the continuum for an array of quantum emitters”. *Phys. Rev. A* **100** (2019), 023834. <https://doi.org/10.1103/PhysRevA.100.023834>
- [1] D. Lonigro, P. Facchi, and M. Ligabò, “The Friedrichs-Lee Model and its Singular Coupling Limit”. *Proceedings* **12** (2019), 17. Proceedings of the 11th Italian Quantum Information Science conference (IQIS2018). <https://doi.org/10.3390/proceedings2019012017>

PREPRINTS

- [33] L. Richter, D. Burgarth, D. Lonigro, “Quantifying the rotating-wave approximation of the Dicke model”. arXiv:2410.18694 [quant-ph].
- [32] P. Szańkowski, D. Lonigro, F. Sakuldee, Ł. Cywiński, D. Chruściński, “Phenomenological quantum mechanics: deducing the formalism from experimental observations”. arXiv:2410.14410 [quant-ph]
- [31] A. Hahn, D. Burgarth, D. Lonigro, “Efficiency of Dynamical Decoupling for (Almost) Any Spin-Boson Model”. arXiv:2409.15743 [quant-ph]
- [30] S. Lill, D. Lonigro, “Self-adjointness and domain of generalized spin-boson models with mild ultraviolet divergences”. arXiv:2307.14727 [math-ph]. <https://doi.org/10.48550/arXiv.2307.14727>

SUMMARY OF RESEARCH ACTIVITIES

Spin-boson models: mathematical aspects

During my Master’s thesis, I started investigating the mathematical properties of Friedrichs models—simple Hamiltonians describing resonance phenomena in Quantum Mechanics, corresponding to the single-excitation sector of a particular spin-boson model. Using methods borrowed from the theory of singular perturbations, I have characterized the spectral properties of such models, and addressed the case in which the coupling is mediated by a non-normalizable function [1, 4, 9]. Afterwards, I reconsidered the problem in a second quantization scenario, addressing the rigorous description of generalized spin-boson models with ultraviolet divergences [13, 21, 24, 27], in particular focusing on models whose interaction exhibits a rotating-wave structure.

Spin-boson models: applications in quantum electrodynamics

A natural testbed for the formalism above is waveguide quantum electrodynamics—the study of quantum emitters confined in quasi-one-dimensional geometries, which exhibit interesting phenomena like the emergence of bound states in the continuum (BICs). I have characterized BICs for $N > 2$ identical emitters in a linear waveguide [2,5] (also see [9]), unearthing two phenomena which are lost under perturbative approximations: first, the preferred configurations for the emitters are collective ones, in which the excitation is shared between them in a sinusoidal or quasi-sinusoidal way; secondly, under suitable conditions, the excitation amplitude displays a modular repetition of quasi-decoupled components (multimers). I have also investigated finite-size effects, studying bound states in a closed waveguide [6]. Further studies about boundary effects are also ongoing.

Infinite-dimensional quantum control and time-dependent Schrödinger problems

Starting with a visiting period at University Carlos III of Madrid, I have been addressing topics in quantum control theory. My research activities in this field have been focused on the highly nontrivial extension

of finite-dimensional control results to the infinite-dimensional scenario, seeking novel control schemes based on the manipulation of the boundary of the system (Quantum Control at the Boundary) rather than on external fields. I have found sufficient conditions for the approximate controllability of a quantum particle by time-dependent boundary conditions in graph-like manifolds [22] and by moving walls [25]; besides, sufficient spectral conditions for the approximate controllability of the Schrödinger equation with form perturbations have been found [29]. This line of work has been requiring a careful investigation of the mathematical properties of non-autonomous Schrödinger equations generated by Hamiltonians with possibly time-dependent domain, which led to a critical analysis of different approaches on the subject [8], as well as to ongoing studies about the stability properties of these equations [26].

Quantum boundary conditions

Quantum particles in manifolds with boundaries are greatly influenced by the boundary conditions imposed on them. Aside from their potential usefulness for control purposes (see above), I have investigated the influence of boundary conditions on quantum systems subject to the action of magnetic fields, classifying gauge-covariant boundary conditions in a quantum magnetic billiard [12] and investigating the influence of finite-size effects, with different boundary conditions, on the quantum Hall effect in a strip [15].

Markovianity and classicality in open quantum systems

My activities on spin-boson models and decay phenomena eventually led me to the study of open quantum systems—in particular, the (non-)Markovian properties of their behavior. I started this journey by unearthing the surprising phenomenon of hidden non-Markovianity: quantum systems can behave in a perfectly Markovian way in a finite time window, but eventually divert from it [3]. This was also shown to possibly happen when taking into account the role of external interventions on the system [7]. Eventually, my interest in the subject led me, starting from a visiting period at the Nicolaus Copernicus University in Toruń, to a detailed and ongoing study of the Markovianity and classicality of spin-boson models [11,16] and dephasing phenomena [10,14]. Finally, I recently proved a generalization of the Kolmogorov extension theorem for complex measures, and applied it to show that multitime probability distributions in quantum mechanics can be obtained from the sampling of one pair of trajectories [28]. Research on the physical implications of this result is ongoing.

Dimensional reduction of physical theories

Lately, I have been interested in the subtle dependence of physical theories on the dimensionality of the spacetime, which can enter the theory in a nontrivial way. Low-dimensional theories can be conceived as a specialization of higher-dimensional ones that are uniform along the additional spatial coordinate (dimensional reduction). In this framework, I have investigated the behavior of the Dirac equation, both in the absence and presence of an electromagnetic field, under dimensional reduction from a (3+1)-dimensional to a (2+1)-dimensional Minkowski spacetime [18], unveiling the splitting of the theory in two inequivalent sectors. I also extended this program to a spacetime with an arbitrary number of space dimensions [19], which allows for a better understanding of the different behavior of odd and even-dimensional spacetimes. Similar studies on other theories (Klein-Gordon, Yang-Mills) are currently ongoing.

Other activities

I have been studying the properties of quantum channels describing decay phenomena, denoted as excitation-damping quantum channels [20], finding necessary and sufficient conditions for the positivity and complete positivity of these maps. Besides, generalizing a classic argument by Khalfin, I have shown that large-time deviations from the exponential law are to be expected, other than for survival probabilities, for the average value of any quantum observable converging to an extremal point of its spectrum [23].

SCIENTIFIC VISITS

Oct 2024: **Nicolaus Copernicus University in Toruń**, Institute of Physics, Faculty of Physics, Astronomy and Informatics, Toruń, Poland (1 week). Host: D. Chruściński.

Jul 2024: **Centro Internazionale per la Ricerca Matematica**, Trento, Italy (1 week), in the context of the “Research in pairs” program. Collaborators: B. Alvarez, S. Lill.

Nov 2023: **University of Paderborn**, Department of Mathematics, Germany (1 week). Host: B. Hinrichs.

Sep 2023: **Friedrich-Alexander-Universität Erlangen-Nürnberg**, Department of Physics, Erlangen, Germany (1 week). Host: D. Burgarth.

Jul 2023: **Università degli Studi di Milano**, Department of Mathematics, Milan, Italy (1 week). Hosts: N. Benedikter, S. Lill.

Apr 2023: **University Carlos III of Madrid**, Department of Mathematics, and **Institute of Mathematical Sciences (ICMAT)**, Madrid, Spain (1 week). Hosts: J.M. Pérez-Pardo, F. Lledó.

Mar 2023: **Nicolaus Copernicus University in Toruń**, Institute of Physics, Faculty of Physics, Astronomy and Informatics, Toruń, Poland (1 week). Host: D. Chruściński.

Oct 2022: **Nicolaus Copernicus University in Toruń**, Institute of Physics, Faculty of Physics, Astronomy and Informatics, Toruń, Poland (2 weeks). Host: D. Chruściński.

Jun 2022: **Nicolaus Copernicus University in Toruń**, Institute of Physics, Faculty of Physics, Astronomy and Informatics, Toruń, Poland (2 weeks). Host: D. Chruściński.

Sep-Oct 2021: **Nicolaus Copernicus University in Toruń**, Institute of Physics, Faculty of Physics, Astronomy and Informatics, Toruń, Poland (2 months). Host: D. Chruściński.

Jan-Mar 2020: **University Carlos III of Madrid**, Department of Mathematics, Leganés, Madrid, Spain (2 months). Host: J.M. Pérez-Pardo.

PEER-REVIEW ACTIVITIES

I reviewed scientific articles for the following journals: *Journal of Mathematical Physics*; *Physical Review Letters*; *Physical Review A*; *Physical Review B*; *Quantum*; *Proceedings of the Royal Society A*; *The European Physical Journal Plus*; *Mathematical Physics, Analysis and Geometry*; *Journal of Physics Communications*; *Nanophotonics*; *Entropy*; *Mathematics*; *Symmetry*.

SCIENTIFIC AFFILIATIONS

2023-curr.: Member of the **International Association of Mathematical Physics (IAMP)**.

2023-curr.: Member of the **German Physical Society** (Deutsche Physikalische Gesellschaft, DPG).

2017-2023: Affiliated member of the Italian **National Institute for Nuclear Physics** (Istituto Nazionale di Fisica Nucleare, INFN) in the context of the project "QUANTUM".

2017-2023: Affiliated member of the Italian **National Group for Mathematical Physics** (Gruppo Nazionale di Fisica Matematica, GNFM).

Data

19/12/2024

Luogo

Erlangen, Germania