Giovanni Scala

Theoretical Physics | Academic Curriculum Vitae

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Research Profile

Quantum correlations: from foundations to applications. Theoretical physicist connecting quantum foundations, entanglement theory and Bell nonlocality with quantum communication, quantum key distribution (QKD) and quantum technologies. My work combines mathematical methods with experimentally relevant questions in quantum optics, quantum metrology and error correction.

Research direction. My research programme, "Quantum correlations: from foundations to applications," connects foundational questions in entanglement, contextuality and nonlocality with experimentally accessible certification, quantum communication and quantum technologies. As Principal Investigator of the NCN SONATA 21 project DyResQ, I am extending this programme toward the dynamics of multipartite quantum resources in noisy many-body systems.

Research Areas

Quantum Information · Quantum Communication & Cryptography · Quantum Foundations · Entanglement Theory · Quantum Optics · Mathematical Physics

Competitive Grants & Fellowships

2026–2029 **NCN SONATA 21 – Principal Investigator**
Dynamical Resources of Multipartite Quantum Systems (DyResQ). National Science Centre (NCN), Poland; host institution: University of Toruń. 36-month independent research project on dynamical multipartite entanglement, open quantum systems, algebraic invariants and temporal quantum correlations.

2025/26 **SAIA Research Scholarship**
Research collaboration with the Slovak Academy of Sciences, Slovakia.

Jan–Feb 2020 **PROM International Exchange Fellowship**
Nicolaus Copernicus University, Toruń; mathematical physics and quantum optics.

Aug 2018 **TAPS Research Internship**
Toruń Astrophysics / Physics Summer Program, Nicolaus Copernicus University; light interactions with asymmetric quantum systems.

Academic Positions

Aug 2023–Jul 2026 **Assistant Professor, Politecnico di Bari & INFN, Italy**
Department of Physics/Quantum group. Quantum communication, metrology, error correction and mitigation; undergraduate and postgraduate teaching.

Apr 2022–Jul 2023 **Postdoctoral Researcher, ICTQT, University of Gdańsk, Poland**
Quantum foundations, Bell nonlocality, cybersecurity and quantum communication.

Jul 2021–Mar 2022 **Postdoctoral Researcher, University of Warsaw, Poland**
Bayesian quantum metrology.

Jan–Jun 2021 **Independent Researcher, ICTQT, University of Gdańsk, Poland**
Contextuality and Bell inequalities.

Feb–Oct 2017 **Quantum Optics Research Intern, INFN, Bari Section, Italy**
Higher-order interferometric setups.

Education

2021 **PhD in Theoretical Physics**, University of Bari. Thesis: *Quantum Correlations: from Foundations to Applications*.

2017 **MSc in Theoretical Physics**, University of Bari; **110/110 *cum laude***. Thesis: *Quantum Correlation and Plenoptic Imaging*.

2015 **BSc in Physics**, University of Bari; **110/110 *cum laude***. Thesis: *Evoluzione temporale di Sistemi Quantistici*.

Selected Publications

J4 **Device-independent quantum cryptography**
S. A. Ghoreishi, **G. Scala**, R. Renner, L. L. Tacca, J. Bouda, S. P. Walborn and M. Pawłowski, "The future of secure communications: Device independence in quantum key distribution," *Phys. Rep.* **1149**, 1–97 (2025).
Review connecting security proofs, nonlocality and experimental challenges.

J15 **Quantum foundations and contextuality**
L. Catani, M. Leifer, **G. Scala**, D. Schmid and R. W. Spekkens, "What is Nonclassical about Uncertainty Relations?," *Phys. Rev. Lett.* **129**, 240401 (2022).
How the form of uncertainty relations can witness contextuality under a symmetry condition.

J6 **Self-testing and Bell nonlocality**
N. Gigena, E. Panwar, **G. Scala**, M. Araújo, M. Farkas and A. Chaturvedi, "Self-testing tilted strategies for maximal loophole-free nonlocality," *npj Quantum Inf.* **11**, 82 (2025).
Self-testing doubly tilted CHSH strategies relevant to inefficient detectors.

J3 **Entanglement from randomized measurements**
G. Scala, A. Bera and G. Sarbicki, "Entanglement detection via third-order local invariants from randomized measurements," *Quantum Sci. Technol.* **11**, 015022 (2026).
Local-unitary invariants for experimentally accessible entanglement detection.

J23 **Entanglement theory**
G. Sarbicki, **G. Scala** and D. Chruściński, "Family of multipartite separability criteria based on a correlation tensor," *Phys. Rev. A* **101**, 012341 (2020).
Unified correlation-tensor separability criteria and entanglement witnesses.

J21 **Quantum optics and light–matter interaction**
G. Scala, F. V. Pepe, P. Facchi, S. Pascazio and K. Słowik, "Light interaction with extended quantum systems in dispersive media," *New J. Phys.* **22**, 123047 (2020).
Description of spatially extended quantum systems in dispersive environments.

J5 **Quantum technologies and noise mitigation**
A. Ali, **G. Scala** and C. Lupo, "Optimal and robust error filtration for quantum information processing," *Phys. Rev. A* **112**, 042418 (2025).
Optimized probabilistic error filtration for quantum information and sensing.

Scientific Leadership

2026–2029 **Principal Investigator, NCN SONATA 21 (DyResQ).** Leading a 36-month research programme at the University of Toruń on dynamical multipartite quantum resources, with funded postdoctoral and PhD positions and senior co-investigator support; responsible for scientific direction, recruitment, team coordination, project management and dissemination.

Research **Development of a coherent research programme** connecting first-author work on quantum optics, entanglement criteria and randomized measurements with collaborative advances in quantum foundations and secure communication.

Teaching **Principal-lecturer responsibility** for undergraduate, master's and doctoral courses in Italy, Poland and Slovakia.

Collaboration **Sustained international research links**, including recurring collaborations in Toruń and Warsaw and remote work with Chapman University and Perimenter Istitute since 2020.

Awards & Distinctions

Sep 2023 **Rector's Award**, University of Gdańsk; recognition of research and graduate teaching.

2021 **Distinguished Referee recognition**, *The European Physical Journal Plus*.

Research Projects & International Consortia

2025 **AccessQKD**, Politecnico di Bari – project member; quantum key distribution and future-proof data protection.

Sep 2023–Aug 2026 **Quantum Secure Networks Partnership (QSNP)**, Politecnico di Bari – project member; European Quantum Flagship research on secure quantum communication.

2022 **QuantERA-supported research**, ICTQT, University of Gdańsk – Quantum Cybersecurity and Communication.

Teaching

Courses as Principal Lecturer

2026 **Group Theory – Doctoral Course**
University of Bari, Italy. Principal lecturer.

2026 **Information Theory – Doctoral Course**
Research Center for Quantum Information, Bratislava, Slovakia. Invited principal lecturer under the SAIA programme.

2024/25; 2025/26 **Physics I – Bachelor's Programme**
Politecnico di Bari, Italy. Principal lecturer, Engineering of Digital Creativity.

2024/25 **Theories beyond Quantum Mechanics: General Probabilistic Theories**
University of Bari, Italy. Principal lecturer, doctoral programme (XL cycle).

2022/23 **Probability for Quantum Information – Master's Programme**
University of Gdańsk, Poland. Principal lecturer, Quantum Information Technologies.

Invited Teaching & Schools

2025 **(Device-independent) QKD and Quantum Communication**
Summer School in Quantum Technologies, Sharda University, Greater Noida, India. Invited lecturer.

2025 **Entanglement via Machine Learning**
QCamp Summer School in Quantum Artificial Intelligence, University of Gdańsk, Poland. Invited lecturer.

Teaching Assistance

2024/25; 2025/26 **Quantum Cryptography and Communication**
University of Bari, Italy. Teaching assistant, master's programme in Quantum Technologies.

2023/24 **Physics II – Bachelor's Programme in Physics**
University of Bari, Italy. Problem-solving instruction in electromagnetism and optics.

2016–2020 **Physics Tutoring**
University of Bari, Italy. Three competitively awarded tutoring appointments for undergraduate students in biotechnology and physics.

2015–2024 **Physics Examination Assistance**
University of Foggia, San Giovanni Rotondo, Italy. Examination assistance in Medical Science over seven academic years.

Academic Service & Outreach

Since 2020 **Peer reviewing** for international journals in physics and mathematics. Distinguished Referee recognition is listed under Awards & Distinctions.

2024; 2025 **FameLab Bari**, University of Bari, Italy. Participation in public science communication events.

Selected Research Visits

Aug 2026 **QuEST Group, Koç University**, Turkey. Host: Özgür E. Müstecaplıoğlu. Research on enlarged Bell scenarios.

Jul 2025 **QUTE.sk**, Bratislava, Slovakia. Host: M. Ziman. Enlarged Bell scenarios.

Sep–Oct 2024 **Universidad de Concepción**, Chile. Hosts: S. P. Walborn and G. Lima. Device-independent QKD and quantum tomography.

Jul 2024 **International Iberian Nanotechnology Laboratory (INL)**, Portugal. Hosts: E. Galvão and L. Catani.

Jun–Jul 2024 **QUTE.sk**, Bratislava, Slovakia. Host: M. Ziman. Device-independent QKD.

2018–2025 **Nicolaus Copernicus University**, Toruń, Poland. Recurring visits: entanglement theory and algebraic invariants with D. Chruściński and G. Sarbicki; light–matter interaction with K. Słowik.

2022–2025 **University of Warsaw**, Poland. Recurring visits with R. Demkowicz-Dobrzański on quantum metrology.

Remote Research Collaboration

Since 2020 **Chapman University and Perimeter Institute**, USA / Canada. Collaboration with M. Leifer and R. W. Spekkens on quantum contextuality.

Complete Publications

Peer-reviewed Journal Articles

J1 G. Staffieri, **G. Scala** and C. Lupo, "Finite-size security of QKD: comparison of three proof techniques," *Eur. Phys. J. Plus* **141**, 754 (2026).

J2 G. Staffieri, **G. Scala** and C. Lupo, "Finite-size secret-key rates of discrete modulation continuous-variable quantum key distribution under Gaussian attacks," *Phys. Rev. A* **113**, 022445 (2026).

J3 **G. Scala**, A. Bera and G. Sarbicki, "Entanglement detection via third-order local invariants from randomized measurements," *Quantum Sci. Technol.* **11**, 015022 (2026).

J4 S. A. Ghoreishi, **G. Scala**, R. Renner, L. L. Tacca, J. Bouda, S. P. Walborn and M. Pawłowski, "The future of secure communications: Device independence in quantum key distribution," *Phys. Rep.* **1149**, 1–97 (2025).

J5 A. Ali, **G. Scala** and C. Lupo, "Optimal and robust error filtration for quantum information processing," *Phys. Rev. A* **112**, 042418 (2025).

J6 N. Gigena, E. Panwar, **G. Scala**, M. Araújo, M. Farkas and A. Chaturvedi, "Self-testing tilted strategies for maximal loophole-free nonlocality," *npj Quantum Inf.* **11**, 82 (2025).

J7 A. Bera, **G. Scala**, G. Sarbicki and D. Chruściński, "Generalizing Choi map in M_3 beyond circulant scenario," *Linear Multilinear Algebra* **73**, 177–192 (2025).

J8 **G. Scala**, G. Massaro, G. Borreggine, C. Lupo, M. D'Angelo and F. V. Pepe, "Robustness of chaotic-light correlation imaging against turbulence," *Eur. Phys. J. Plus* **139**, 1010 (2024).

J9 **G. Scala**, A. Bera, G. Sarbicki and D. Chruściński, "Optimality of generalized Choi maps in M_3," *J. Phys. A: Math. Theor.* **57**, 195301 (2024).

J10 **G. Scala**, S. A. Ghoreishi and M. Pawłowski, "Advantages of quantum communication revealed by the reexamination of hyperbit theory limitations," *Phys. Rev. A* **109**, 022230 (2024).

J11 **G. Scala** and A. Mandarino, "Insights into Quantum Contextuality and Bell Nonclassicality: a Study on Random Pure Two-Qubit Systems," *Int. J. Theor. Phys.* **63**, 17 (2024).

J12 L. Catani, M. Leifer, **G. Scala**, D. Schmid and R. W. Spekkens, "Aspects of the phenomenology of interference that are genuinely nonclassical," *Phys. Rev. A* **108**, 022207 (2023); **Editors' Suggestion**.

J13 N. Gigena, **G. Scala** and A. Mandarino, "Revisited aspects of the local set in CHSH Bell scenario," *Int. J. Quantum Inf.* **21**, 2340005 (2023).

J14 A. Mandarino and **G. Scala**, "On the Fidelity Robustness of CHSH–Bell Inequality via Filtered Random States," *Entropy* **25**, 94 (2023).

J15 L. Catani, M. Leifer, **G. Scala**, D. Schmid and R. W. Spekkens, "What is Nonclassical about Uncertainty Relations?," *Phys. Rev. Lett.* **129**, 240401 (2022).

J16 G. Massaro, **G. Scala**, M. D'Angelo and F. V. Pepe, "Comparative analysis of signal-to-noise ratio in correlation plenoptic imaging architectures," *Eur. Phys. J. Plus* **137**, 1123 (2022); *G. Massaro and G. Scala contributed equally*.

J17 M. Karczewski, **G. Scala**, A. Mandarino, A. B. Sainz and M. Żukowski, "Avenues to generalising Bell inequalities," *J. Phys. A: Math. Theor.* **55**, 384011 (2022).

J18 F. V. Pepe, **G. Scala**, G. Chilleri, D. Triggiani, Y.-H. Kim and V. Tamma, "Distance sensitivity of thermal light second-order interference beyond spatial coherence," *Eur. Phys. J. Plus* **137**, 647 (2022).

J19 G. Sarbicki, **G. Scala** and D. Chruściński, "Detection power of separability criteria based on a correlation tensor: a case study," *Open Syst. Inf. Dyn.* **28**, 2150010 (2021).

J20 **G. Scala**, K. Słowik, P. Facchi, S. Pascazio and F. V. Pepe, "Beyond the Rabi model: Light interactions with polar atomic systems in a cavity," *Phys. Rev. A* **104**, 013722 (2021).

J21 **G. Scala**, F. V. Pepe, P. Facchi, S. Pascazio and K. Słowik, "Light interaction with extended quantum systems in dispersive media," *New J. Phys.* **22**, 123047 (2020).

J22 G. Sarbicki, **G. Scala** and D. Chruściński, "Enhanced realignment criterion vs linear entanglement witnesses," *J. Phys. A: Math. Theor.* **53**, 455302 (2020).

J23 G. Sarbicki, **G. Scala** and D. Chruściński, "Family of multipartite separability criteria based on a correlation tensor," *Phys. Rev. A* **101**, 012341 (2020).

J24 **G. Scala**, M. D'Angelo, A. Garuccio, S. Pascazio and F. V. Pepe, "Signal-to-noise properties of correlation plenoptic imaging with chaotic light," *Phys. Rev. A* **99**, 053808 (2019).

Conference Proceedings

C1 K. Słowik, P. Gładysz, **G. Scala**, P. Wcisło, F. V. Pepe, P. Facchi and S. Pascazio, "Interactions of polar quantum systems with light," *CLEO: Applications and Technology*, JTu3A.1 (2022).

C2 **G. Scala**, G. Massaro, M. D'Angelo, A. Garuccio, S. Pascazio and F. V. Pepe, "Signal-to-noise ratio in correlation plenoptic imaging," *Proc. SPIE* **11347**, 1134713 (2020).

C3 **G. Scala**, "Two-Level Systems with Broken Inversion Symmetry," *Proceedings* **12**, 49 (2019).

Preprints & Manuscripts under Review

P1 **G. Scala**, C. C. Mattiacci, D. Pietryka, and G. Sarbicki, "Third-Order Local Randomized Measurements for Finite-size Entanglement Certification," arXiv:2604.13165 (2026); *submitted*.

P2 G. Staffieri, G. D'Ambruoso, **G. Scala** and C. Lupo, "Preprocessing noise in finite-size quantum key distribution," arXiv:2603.18213 (2026); *submitted*.

P3 A. Ali, **G. Scala**, C. Lupo and A. Mandarino, "Finite-size resource scaling for learning quantum phase transitions with fidelity-based support vector machines," arXiv:2603.18211 (2026); *submitted*.

P4 P. J. Cavalcanti, **G. Scala**, A. Mandarino and C. Lupo, "Information theoretical perspective on the method of Entanglement Witnesses," arXiv:2308.07744 (2023); *under peer review*.

P5 **G. Scala**, C. Lupo, "Recovery-Free CHSH Nonlocality with Particle Loss," arXiv:2608.26407 (2026); *submitted*.

Selected Invited and Contributed Talks

Invited Talks

Jan 2022 **University of Warsaw**, Poland – invited research talk.

Jun 2026 **QuOI**, Vienna, Austria – research talk: "Entanglement detection from randomized measurements."

Sep 2026 **QUTE**, Bratislava, Slovakia – research talk: "Maximal violation in general Bell scenarios."

Contributed and Other Research Talks

Jun 2026 **SMP57**, Toruń, Poland – research talk: "Entanglement detection from randomized measurements."

Aug 2025 **QCrypt 2025**, Sanya, China – contributed talk: "Self-testing tilted strategies for maximal loophole-free nonlocality."

Feb 2024 **VI IWIGQMA**, Madrid, Spain – research talk: "Error mitigation in metrology and nonlocality."

Sep 2023 **18th CEQIP Workshop**, Smolenice, Slovakia – research talk: "What is nonclassical about uncertainty relations?"

Jul 2023 **Quantum Physics and Logic**, Paris, France – research talk: "Generalizing Choi map in M_3 beyond circulant scenario."

Mar 2023 **V IWIGQMA**, Madrid, Spain – contributed talk: "Generalizing Choi map in M_3 beyond circulant scenario."

Selected Posters

Jun 2024 **QSNP + Internet Alliance**, Barcelona, Spain – "Robust self-testing of Bell inequalities tilted for maximal loophole-free nonlocality."

Jan 2024 **Quantum meets Classical Cryptography**, Paris, France – "Robust self-testing of Bell inequalities tilted for maximal loophole-free nonlocality."

Nov 2023 **QUACC**, Warsaw, Poland – two posters: "Generalizing Choi map in M_3 beyond circulant scenario" and "Information theoretical perspective on the method of Entanglement Witnesses."

Consortium Presentations and Research Meetings

2025 **QSNP research updates**: General Assembly, Brussels (20–21 May), and "Advancing QKD from theory to technology," Padua (14–15 April). Talks: "Updates from Poliba."

2025 **Other meetings**: QuICS, Bari (1–3 September); Quantum Foundations, Gdańsk; AccessQKD kick-off, Copenhagen (27–28 May).

A fuller record of talks and conference contributions is available on the research website.