

Nathan Shammah

Date of Birth: 12 April 1987
Place of Birth: Milan, Italy
Nationality: Italian

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Research Interests

My research focus is on open quantum systems dynamics, and the interplay between cooperative effects and dissipative mechanisms in many-body quantum systems, including on how to mitigate errors introduced by noise in quantum computing devices. I investigate how errors can be mitigated on noisy quantum computers. I have characterized novel light-matter physics phenomena for current devices, such as superconducting circuits and semiconductor quantum wells, for technology applications such quantum information processing and THz emission. I develop open-source software for quantum physics research and quantum technology. I used it to study noisy quantum information processing and light-matter interaction in solid-state cavity quantum electrodynamics (cQED).

Analytical Techniques: Dissipative master equations and their symmetries, fermionic and bosonic many-body systems in second quantization, input-output theory, mean-field theories, continuous-variable quantum mechanics.

Numerical Techniques: Superoperator formalism, symmetric methods in Liouvillian space, development of open-source libraries in Python, such as Mitiq, PIQS, QuTiP.

Work Experience

- Mar 2020 – Now *Chief Technology Officer* – Unitary Fund *Milan, Italy*
Head of the Technical Staff. We perform in-house research on quantum computing projects and support the open-source scientific ecosystem.
- May 2020 – Now *Visiting Scientist* – Theoretical Quantum Physics Lab, RIKEN *Wako-shi, Japan*
- Jan 2019 – Now *Visiting Scientist* – Applied Quantum Mechanics Group, Dept. Physics, Università degli Studi di Milano, *Milan, Italy*
- Aug 2016 – Mar 2020 *Postdoctoral Research Scientist* – Theoretical Quantum Physics Lab, RIKEN *Wako-shi, Japan*
- Jul 2017 – Mar 2020 *Co-founder* – Quantika, consulting hub quantika.co.

Education

- Apr 2013 – Jul 2016 **PhD in Physics** University of Southampton, School of Physics and Astronomy *UK*
Thesis: *Resonance Fluorescence and Superfluorescence of Intersubband Transitions*
- Apr 2010 – Mar 2012 **MSc in Physics** (Laurea Magistrale). Final Grade: 110/110 *cum laude*
Università degli Studi di Milano *Milan, Italy*
Thesis: *Quantifying the nonlinearity of a quantum oscillator*
- Dec 11 – Apr 12 *MSc Erasmus Placement Student*, Controlled Quantum Dynamics Group
Imperial College London *London, United Kingdom*
- Sep 10 – Apr 11 *MSc Erasmus Student* University of Copenhagen *Copenhagen, Denmark*
- Oct 2006 – Apr 2010 **BSc in Physics** (Laurea Triennale) Università degli Studi di Milano *Milan, Italy*
Thesis: *Diamagnetism and De Haas-van Alphen oscillations in the electronic gas*

Publications

16 published papers in peer-reviewed journals, 8 as first/last author, 511 citations, h-index 13 (GScholar 01/23).

[18] Testing platform-independent quantum error mitigation on noisy quantum computers Vincent Russo, Andrea Mari, Nathan Shammah, Ryan LaRose, William J. Zeng. arXiv:2210.07194

[17] Diagnosing quantum chaos with out-of-time-ordered-correlator quasiprobability in the kicked-top model José Raúl González Alonso, Nathan Shammah, Shahnawaz Ahmed, Franco Nori, Justin Dressel

<https://arxiv.org/abs/2201.08175>

[16] Automated quantum error mitigation based on probabilistic error reduction, Benjamin McDonough, Andrea Mari, Nathan Shammah, Nathaniel T. Stemen, Misty Wahl, William J. Zeng, Peter P. Orth arXiv:2210.08611, 2022 IEEE/ACM Third International Workshop on Quantum Computing Software (QCS)

[15] *Impact of time-correlated noise on zero-noise extrapolation* Kevin Schultz, Ryan LaRose, Andrea Mari, Gregory Quiroz, Nathan Shammah, B. David Clader, William J. Zeng, Phys. Rev. A 106, 052406 (2022)

<https://arxiv.org/abs/2201.11792>

[14] *Mitiq: A software package for error mitigation on noisy quantum computers*

Ryan LaRose, Andrea Mari, Sarah Kaiser, Peter J. Karalekas, Andre A. Alves, Piotr Czarnik, Mohamed El Mandouh, Max H. Gordon, Yousef Hindy, Aaron Robertson, Purva Thakre, Misty Wahl, Danny Samuel, Rahul Mistri, Maxime Tremblay, Nick Gardner, Nathaniel T. Stemen, Nathan Shammah, William J. Zeng

Quantum **6**, 774 (2022) [Link https://arxiv.org/abs/2009.04417](https://arxiv.org/abs/2009.04417)

[13] *Pulse-level noisy quantum circuits with QuTiP*

Boxi Li, Shahnawaz Ahmed, Sidhant Saraogi, Neill Lambert, Franco Nori, Alex Pitchford, and Nathan Shammah

Quantum **6**, 630 (2022) [Link https://arxiv.org/abs/2105.09902](https://arxiv.org/abs/2105.09902)

[12] *Pulser: An open-source package for the design of pulse sequences in programmable neutral-atom arrays*

Henrique Silvério, Sebastián Grijalva, Constantin Dalyac, Lucas Leclerc, Peter J. Karalekas, Nathan Shammah, Mourad Beji, Louis-Paul Henry, and Loïc Henriët

Quantum **6**, 629 (2022) [Link https://arxiv.org/abs/2104.15044](https://arxiv.org/abs/2104.15044)

[11] *Extending quantum probabilistic error cancellation by noise scaling*

Andrea Mari, Nathan Shammah, and William J. Zeng

Phys. Rev. A **104**, 052607 (2021) [Link https://arxiv.org/abs/2108.02237](https://arxiv.org/abs/2108.02237).

[10] *Symmetries and conserved quantities of boundary time crystals in generalized spin models*

Giulia Piccitto*, Matteo Wauters*, Franco Nori, and Nathan Shammah

Phys. Rev. B **104**, 014307 (2021) [Link https://arxiv.org/abs/2101.05710](https://arxiv.org/abs/2101.05710) *equal contribution.

[9] *Exceptional point and cross-relaxation effect in a hybrid quantum system*

Zhen Chen, Guo-Qiang Zhang, Da Xu, Nathan Shammah, Shuai-Peng Wang, Meiyong Liao, Xin-You Lu, Tie-Fu Li, Yi-Pu Wang, Franco Nori, and J. Q. You, *PRX Quantum* **2**, 020307 (2021) <https://arxiv.org/abs/2104.09811>

<https://journals.aps.org/prxquantum/abstract/10.1103/PRXQuantum.2.020307>

[8] *Mean-field validity in a dissipative critical system: Liouvillian gap, $\mathbb{P}\mathbb{T}$ -symmetric antigap, and permutational symmetry in the XYZ model*

Dolf Huybrechts, Fabrizio Minganti, Franco Nori, Michiel Wouters, and Nathan Shammah

Phys. Rev. B **101**, 214302 (2020) [Link https://arxiv.org/abs/1912.07570](https://arxiv.org/abs/1912.07570)

[7] *Dissipation-induced bistability in the two-photon Dicke model*

Louis Garbe, Peregrine Wade, Fabrizio Minganti, Nathan Shammah, Simone Felicetti, and Franco Nori

Scientific Reports **10**, 13408 (2020) [Link https://arxiv.org/abs/1911.11694](https://arxiv.org/abs/1911.11694)

[6] *Multielectron Ground State Electroluminescence*

Mauro Cirio*, Nathan Shammah*, Neill Lambert, Simone De Liberato, and Franco Nori
Physical Review Letters, **122** 190403 (2019) [Link arXiv](#). *equal contribution.

[5] *Open quantum systems with local and collective incoherent processes: Efficient numerical simulation using permutational invariance*

Nathan Shammah, Shahnawaz Ahmed, Neill Lambert, Simone De Liberato, and Franco Nori
Physical Review A **98**, 063815 (2018) [Link arXiv](#)

[4] *Superradiance with local phase-breaking effects*

Nathan Shammah, Neill Lambert, Franco Nori, and Simone De Liberato
Physical Review A **96**, 023863 (2017) [Link arXiv](#)

[3] *Theory of intersubband resonance fluorescence*

Nathan Shammah and Simone De Liberato
Physical Review B **92**, 201402 Rapid Comm. (2015) [Link arXiv](#)

[2] *Terahertz emission from ac Stark-split asymmetric intersubband transitions*

Nathan Shammah, Chris C. Phillips, and Simone De Liberato
Physical Review B **89**, 235309 (2014) [Link arXiv](#)

[1] *Quantifying the nonlinearity of a quantum oscillator*

Matteo G.A. Paris, Marco G. Genoni, Nathan Shammah, and Berihu Teklu
Physical Review A **90**, 012104 (2014) [Link arXiv](#)

Terahertz emission from asymmetric, doped quantum wells under resonant pumping

Nathan Shammah, Chris C. Phillips, and Simone De Liberato
Journal of Physics: Conf. Series **619**, 012021 (2015). Peer-reviewed proceeding.

Open Source Libraries:

- The [Unitary Fund](#)'s organization repositories
- [Mitiq](#): A Python toolkit for error mitigation on quantum computers
- [QuTiP](#), The Quantum Toolbox in Python
- [PIQS](#), The Permutational Invariant Quantum Solver
- [Make your Code Count](#), A Guide to building your open-source scientific computing project in Python.
- [Metriq](#), the platform for community-driven quantum benchmarks
- Commits to: Metriq, Qiskit, Cirq, PyEPR, Bokeh, Sphinx, Conda-Forge

Languages and IT Skills

Fluent: Italian (*Native*), English, French, Spanish. *Beginner*: Japanese.

Programming: Python, C/C++, Mathematica, MATLAB.

Python Libraries: Mitiq, QuTiP, Matplotlib, Cython, Numpy, Scipy, Jupyter, Cirq, Qiskit

Talks at International Meetings

- 2022 Jul 23th Invited lecture at the Summer School “[Advances in AI](#)”, Lake Como School of Advanced Studies, Como, Italy
- 2022 Jul 28th Invited lecture at the Summer School “[SOMS/GGI SOMS/GGI Summer School on Quantum Simulation of Field Theories](#)”, Galileo Galilei Institute, Florence, Italy
- 2021 Sep 13th Invited lecture at the Summer School “[SOMS/GGI SOMS/GGI Summer School on Quantum Simulation of Field Theories](#)”, Galileo Galilei Institute, Florence, Italy
- 2021 Jun 21st – Jun 29th Invited talk at [QEAM21](#) Quantum Computing on the cloud – Early Adopters Meeting, *Bar Ilan U., Israel*
- 2019 Dec 20th Two Invited seminars at the [GGI School: Quantum computing and sensing](#), INFN Galileo Galilei Institute for Theoretical Physics (INFN GGI), Nat. Center for Advanced Studies, *Florence, Italy*
- 2019 Sep 11th Invited talk at the 4th AQM Meeting *Milan, Italy*
- 2019 Sep 4th IQIS Conference *Milan, Italy*
- 2019 Jan 26th EuroScipy 2019 *Bilbao, Spain*
- 2018 Aug 31st Invited talk: RIKEN-Berkeley Quantum Information Science Workshop, *Berkeley, USA*
- 2018 Jul 16th EuroScipy 2018 – 11th European Conference on Python in Science *Trento, Italy*
- 2018 Jun 29th Current Trends in Open and Nonequilibrium Quantum Optical Systems, Max Planck Institute for the Science of Light *Erlangen, Germany*
- 2018 Apr 18th ImPACT JST Quantum Simulation Meeting *Wako-shi, Japan*
- 2017 Feb 13th C3QS – Coherent Control of Complex Quantum Systems, OIST *Okinawa, Japan*
- 2015 Jul 12th VSI Workshops – Quantum Steering and Time Correlations Workshop *Tokyo, Japan*
- 2015 Mar 12th PIERS Conference, Solid State Photonics Focus Session *Prague, Czech Republic*
- 2014 Jul 31st Advanced Polaritonics Workshop (the British Council funded my participation) *Suzdal, Russia*
- ICOOPMA14 – Intl. Conference on Optical, Optoelectronic and Photonic Materials *Leeds, UK*

Poster Presentations at International Meetings

- 2022 SQMS Annual Meeting, Fermilab, *Batavia, IL, USA*
- 2020 Dynamics, criticality, and universality in random quantum circuits [Workshop](#) Max Planck Institute for the Physics of Complex Systems *Dresden, Germany*
- 2019 Coherent Network Computing Conference *Atsugi, Japan*
- 2018 JST Meeting on Quantum Computing (Cabinet of the Government of Japan)
- 2018 QFS 2018 – International Symposium on Quantum Fluids and Solids *Tokyo, Japan*
- 2018 C3QS – Coherent Control of Complex Quantum Systems, OIST *Okinawa, Japan*
- 2018 DAQS2018 – International Symposium on Dynamics in Artificial Quantum Systems *Tokyo, Japan*
- 2017 ISNTT 2017 – International School and Symposium on Nanoscale Transport and Photonics *Atsugi, Japan*
- 2017 QFML 2017 – Quantum Fluids of Light and Matter Conference *Cargèse, France*
- 2013 ISNP 2013 – International School of Nanophotonics and Photovoltaics *Maratea, Italy* **Best Poster Award**
- 2013 QUICC 2013 – International School on Quantum Information, Computing and Control *London, UK*
- 2013 International School of Photonics, Scuola Normale Superiore di Pisa e NEST *Cortona, Italy*

Talks at Research Centers

2022 Oct 28 th	Seminar, Harvard University, <i>Cambridge, USA</i>
2022 Oct 24 th	Seminar, IBM Research, <i>NYC, USA</i>
2022 Oct 21 st	Seminar, super.tech, <i>Chicago, USA</i>
2022 Oct 20 th	Seminar, Northwestern University, <i>Evanston, USA</i>
2020 Nov 26 th	Seminar, QSEM, University of Milan, <i>Milan, Italy</i>
2019 Sep 25 th	Seminar, Google Quantum A.I. Lab, Google. Host: Alan Ho. <i>Los Angeles, USA</i>
2019 Jul 1 st -5 th	6 Lectures on open quantum systems and open source, SISSA. Host: M. Dalmonte. <i>Trieste, Italy</i>
2019 Mar 25 th	Seminar, Univ. of Antwerp. Host: M. Wouters. <i>Antwerp, Belgium</i>
2019 Mar 21 st	Seminar, Vandersypen Lab, QuTech, TU Delft. Host: G. Zheng. <i>Delft, The Netherlands</i>
2019 Feb 1 st	IQIM Seminar, Caltech. Host: V. Albert. <i>Pasadena, USA</i>
2019 Jan 29 th	Seminar, Google Quantum A.I. Lab, Google. Host: H. Neven. <i>Los Angeles, USA</i>
2019 Jan 28 th	Seminar, NASA, Ames Research Center and USRA. Host: D. Venturelli. <i>Mountain View, USA</i>
2019 Jan 23 rd	Special Seminar, Appl. Physics Dept., Stanford University. Host: P. McMahon. <i>Palo Alto, USA</i>
2018 July 16 th	Seminar, Applied Quantum Mechanics Group, Univ. of Milan. Host: M. Genoni. <i>Milan, Italy</i>
2017 Aug 22 nd	Qulink – National Institute of Informatics. Host: K. Nemoto. <i>Tokyo, Japan</i>
2017 May 15 th	Laboratoire Pierre Aigrain – École Normale Supérieure Paris. Host: G. Hetet. <i>Paris, France</i>
2016 Oct 6 th	RIKEN Quantum Condensed Matter Research Group Meeting <i>Tokyo, Japan</i>
2015 Jun 3 rd	Bar-Ilan University. Host: E. Dalla Torre. <i>Tel Aviv, Israel</i>
2014 Jul 8 th	The Racah Institute of Physics, Hebrew Univ. of Jerusalem. Host: A. Retzker. <i>Jerusalem, Israel</i>
2014 Sep 19 th	Photonics Day, Zepler Institute and Optoelectronics Research Centre <i>Southampton, UK</i>
2012 Mar 21 st	QOLS Group, Imperial College London <i>London, UK</i>
2012 Nov 6 th	IQOQI. Host: A.V. Gorshkov. <i>Innsbruck, Austria</i>

Visits

Jul – Sep 2019	University of Milan Applied Quantum Mechanics Group. Host: Dr. Marco Genoni
Jun – Jul 2019	ICTP and International School for Advanced Studies (SISSA) Trieste, Italy. Hosts: Prof. Rosario Fazio and Dr. Marcello Dalmonte
Mar – Apr 2019	University of Antwerp Antwerp, Belgium. Host: Prof. M. Wouters
Jul – Sep 2018	University of Milan Applied Quantum Mechanics Group. Host: Dr. Marco Genoni
Jun – Jul 2015	RIKEN Wako-shi, Japan, Summer Research Intern, Quantum Condensed Matter Research Group

Workshop and Conference Organization

June 7-14 2022	<i>UnitaryHACK, online event</i>
Oct 18-22 2021	<i>Open Quantum Hardware Workshop, International Conference on Quantum Computing and Engineering, IEEE Quantum Week. Online Event. Organized with Travis Scholten</i>
May 14-30 2021	<i>UnitaryHACK, online event https://unitaryfund.github.io/unitaryhack/</i>
Feb 19-21 2019	1st QuTiP Developers Workshop RIKEN, Wako, Japan.

Awards

2016	University of Southampton Vice-Chancellor's Awards (Runner-up) Science Outreach
2015	Embassy of Italy in the UK 'Italy Made Me' Awards Certificate of Excellence in Research
2013	Best Poster Award Awarded by the <i>EPL Journal</i> at the Intl. School of Nanophot. and Photovoltaics.

Funding

2013 – 2016	EPSRC UK and University of Southampton <i>EPSRC DTA Studentship</i> (PhD Funding)
2015	RIKEN Intern at the Quantum Condensed Matter Research Group
2011 – 2012	European Union Placement at the Controlled Quantum Dynamics Group, Imperial College
2010 – 2011	European Union Erasmus Program at the Niels Bohr Institute, University of Copenhagen

Service, Teaching and Mentoring

2021 – Now	Ecosystem Task Force Member , SQMS Collaboration, NQI Center led by Fermilab http://sqms.fnal.gov/
2021 – Now	Board Member , Unitary Fund
2017 – Now	Board Member, Co-Founder, and Vice-President , The Association of Italian Researchers in Japan (AIRJ). is a registered non-profit that organizes cultural activities and supports researchers with networking events and professional development resources. airj.info
2022	Mentor to two undergraduate students from the Qubit by Qubit organization within the “Early Quantum Career Immersion Training and Internship Program”
2022	Mentor to three PhD and MSc students from Stanford University for their projects within the course ““Quantum Computing: Open-Source Project Experience” (CS59SI)”
2020 – Now	Mentor to over 20 projects funded by the Unitary Fund. https://unitary.fund/grants.html
2019 – Now	Mentor to 9 Google Summer of Code students for the QuTiP project, NumFOCUS org.
2018 – 2020	Mentor to two research interns, 4 PhD students, 2 MSc. students on my physics & code projects
2017 – 2018	Mentor to Shahnawaz Ahmed, MSc student, intern at RIKEN from BITS Pilani Goa, India
2014 – 2015	Teaching Assistant , School of Physics and Astronomy, University of Southampton, Southampton, United Kingdom Computational Techniques in Physics (PHYS 3008) and Atomic Physics (PHYS 6017)

Referee for: *Phys. Rev. Lett.* (3), *Phys. Rev. X Quantum* (2), *Phys Lett A* (2), *Pys. Rev. A* (1), *SciPost Physics* (1), *IOP Quant. Sci. Tech.* (1), *Scientific Reports* (1), *Optics Communications* (1), *Eur. Phys. Journal Plus* (1).

Technology transfer

In 2017 I co-founded **Quantika** (quantika.co), a consulting hub of academia-embedded deep-tech experts with hands-on experience in technology transfer. Quantika engages with international research centers to increase spinoff creation and provides startup sourcing and technical due-diligence services to venture investors.

Since 2018, I have been a technical advisor or early investor for tech and deep-tech startups, including Agricola Moderna (agritech, vertical farming), Aspire (fintech, YC W18), Lifepal (insurtech), Pasqal (quantum computing), and an Italian legal tech startup.

Scientific Outreach

2022 Dec 1st	Campania Tech Forum, <i>Naples, Italy</i>
2022 Nov 16th	Bank of Italy, data science team, <i>Rome, Italy</i> (online talk)
2022 Jan 31st	Wisdom of Uncertainty: Un dialogo tra arte e scienza – Villa Brivio, Nova Milanese
2021 Dec 15th	Wisdom of Uncertainty. Photographic Exhibition, supported by Fondazione Rossi
2021 Nov 5th	Invited Talk at Primo Ventures, deep-tech VC, on quantum technologies
2017 - 2020	Writer, Newsletter on Quantum Technology medium.com/quantum-tech .
2019 Nov 7th	Talk at Machine Learning Tokyo Meetup <i>Tokyo, Japan</i>
2019 Oct 28th	Article for the online newspaper Linkiesta: “ <i>La scienza è open source: i progetti del futuro si baseranno sulla condivisione dei dati</i> ”
2018 Sep 29th	Article: “ <i>The rise of open source in quantum physics research</i> ”, Nature Blogs – with S. Ahmed
2017 Jun 16th	Talk ‘Open-source for open science’, European Research Day, Italian Inst. of Culture <i>Tokyo</i>
2017 May 27th	Talk on Quantum Technologies at Nerd Nite Tokyo <i>Tokyo, Japan</i>
2017 Mar 10th	Talk at Falling Walls Lab, The National Museum of Emerging Science and Innovation <i>Tokyo</i>
Aug 2014 – 2016	Talk at the European Innovation Day by EURAXESS, Accenture Digital Hub <i>Tokyo, Japan</i>
2016 May 16th	<i>University Coordinator</i> , Pint of Science International Festival <i>Southampton, United Kingdom</i>
2016 May 26th	Talk at the Researchers’ Café of the University of Southampton <i>Southampton, United Kingdom</i>
2013 May 15th	Article: <i>Que la lumière soit ! Mais une particule à la fois – The Conversation France</i> Print and Online Article: <i>Five easy pieces on quantum information</i> – with S. De Liberato <i>IL magazine, Il Sole 24 Ore</i> (the Italian business and finance newspaper)

Academic References

Dr. William J. Zeng
 President, Unitary Fund
 Also head of the quantum research team at Goldman Sachs, NYC, USA
 Email: will@unitary.fund

Prof. Franco Nori
 Chief Scientist, RIKEN, Japan
 Leader of the Theoretical Quantum Physics Laboratory, Cluster for Pioneering Research, <http://dml.riken.jp/>.
 Also at the Physics Department, University of Michigan, Ann Arbor, MI 48109-1040, USA
 E-mail: fnori@riken.jp

Prof. Simone De Liberato
 Professor of Nanophotonics and Royal Society University Fellow, University of Southampton, UK.
 Leader of the Quantum Theory and Technology Group, <http://simonedeliberato.org/>.
 E-mail: S.De-Liberato@soton.ac.uk

Prof. Matteo G. A. Paris
 Professor of Physics, Physics Department, University of Milan, Italy
 Leader of the Applied Quantum Mechanics Group, <https://sites.unimi.it/aqm/>.
 E-mail: matteo.paris@fisica.unimi.it