

Nathan Shammah

Date of Birth: 12 April 1987

nathan@unitary.fund,
nathan.shammah@gmail.com

Place of Birth: Milan, Italy

Nationality: Italian

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 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 (QED).

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 *Berkeley, USA*
I lead the technical team performing in-house research projects and help support the open-source scientific ecosystem in quantum technology.
- 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

11 published papers, 7 as first or last author, with a total of >270 citations, h-index: 7 ([Google Scholar](#), 11/2021).

Submitted or in preparation:

Preprints:

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

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

<https://arxiv.org/abs/2105.09902>

[13] *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

<https://arxiv.org/abs/2104.15044>

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

Ryan LaRose, Andrea Mari, Peter Karalekas, Nathan Shammah, and William J. Zeng

<https://arxiv.org/abs/2009.04417>

Peer-reviewed publications:

[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>.

[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> *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>

[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>

[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:

- [Mitig](#): A Python toolkit for error mitigation on quantum computers.
- QuTiP, the Quantum Toolbox in Python, J. R. Johansson, P. Nation, A. Pitchford, N. Shammah, C. Granade, A. Grimsmo, S. Ahmed, Neill Lambert, E. Giguere, and F. Nori, <http://qutip.org>
- Permutational Invariant Quantum Solver (PIQS). Nathan Shammah and Shahnawaz Ahmed github.com/nathanshammah/piqs. Documentation: piqs.readthedocs.io
- *scikit-project*, <https://github.com/nathanshammah/scikit-project>
- Commits to: Qiskit, Cirq, PyEPR, Bokeh, Sphinx, Conda-Forge

Talks at International Meetings

2019 Dec 20 th	Invited talk at the 4th AQM Meeting <i>Milan, Italy</i>
2019 Sep 11 th	IQIS Conference <i>Milan, Italy</i>
2019 Sep 4 th	EuroScipy 2019 <i>Bilbao, Spain</i>
2019 Jan 26 th	Invited talk: RIKEN-Berkeley Quantum Information Science Workshop, <i>Berkeley, USA</i>
2018 Aug 31 st	EuroScipy 2018 – 11th European Conference on Python in Science <i>Trento, Italy</i>
2018 Jul 16 th	Current Trends in Open and Nonequilibrium Quantum Optical Systems, Max Planck Institute for the Science of Light <i>Erlangen, Germany</i>
2018 Jun 29 th	ImPACT JST Quantum Simulation Meeting <i>Wako-shi, Japan</i>
2018 Apr 18 th	C3QS – Coherent Control of Complex Quantum Systems, OIST <i>Okinawa, Japan</i>
2017 Feb 13 th	VSI Workshops – Quantum Steering and Time Correlations Workshop <i>Tokyo, Japan</i>
2015 Jul 12 th	PIERS Conference, Solid State Photonics Focus Session <i>Prague, Czech Republic</i>
2015 Mar 12 th	Advanced Polaritonics Workshop (the British Council funded my participation) <i>Suzdal, Russia</i>
2014 Jul 31 st	ICOOPMA14 – Intl. Conference on Optical, Optoelectronic and Photonic Materials <i>Leeds, UK</i>

Poster Presentations at International Meetings

- 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

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

Visits

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

Workshop Organization

- Oct 18-22 2021 *Open Quantum Hardware Workshop, International Conference on Quantum Computing and Engineering*
- 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 EPL Journal* at the Intl. School of Nanophot. and Photovoltaics.

Funding

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

Teaching and Mentoring

2018 – 2020 **Mentor** to two research interns, 4 PhD students, 2 MSc. students on my physics & code projects
 2019 – 2021 **Mentor** to Google Summer of Code students for the QuTiP project, NumFOCUS org.
 2017 – 2018 **Mentor** to Shahnawaz Ahmed, MSc student in Eng. and Physics, intern at RIKEN from BITS Pilani Goa, India
 2014 – 2015 **University of Southampton** *Southampton, United Kingdom*
Teaching Assistant, School of Physics and Astronomy
 Computational Techniques in Physics (PHYS 3008) and Atomic Physics (PHYS 6017)

Languages and IT Skills

Fluent: Italian (*Native*), English, French, Spanish. *Beginner:* Japanese.
 Programming: Python, C/C++, Mathematica, MATLAB. Libraries: QuTiP, Matplotlib, Cython, Scipy, Jupyter.

Service and Outreach

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

2020 – 2021 Ecosystem Task Force Member, SQMS Collaboration, <http://sqms.fnal.gov/>

2021 Nov 5th Talk at Primo Ventures
 2017 July - Now Writer, Newsletter on Quantum Technology medium.com/quantum-tech.
 2019 Nov 7th Talk at Machine Learning Tokyo Meetup *Tokyo, Japan*
 2019 Oct 28th Article for the online newspaper Linkiesta.
 2019 Jan 11th Article: *The rise of open source in quantum physics research*, Nature Blogs – with S. Ahmed
 2018 Sep 29th Talk 'Open-source for open science', European Research Day, Italian Inst. of Culture *Tokyo*
 2017 Jun 16th Talk on Quantum Technologies at Nerd Nite Tokyo *Tokyo, Japan*
 2017 May 27th Talk at Falling Walls Lab, The National Museum of Emerging Science and Innovation *Tokyo*
 2017 Mar 10th Talk at the European Innovation Day by EURAXESS, Accenture Digital Hub *Tokyo, Japan*
 Aug 2014 – 2016 *University Coordinator*, Pint of Science International Festival *Southampton, United Kingdom*
 2016 May 16th Talk at the Researchers' Café of the University of Southampton *Southampton, United Kingdom*
 2016 May 26th Article: *Que la lumière soit ! Mais une particule à la fois – The Conversation France*
 2013 May 15th Print and Online Article: *Five easy pieces on quantum information* – with S. De Liberato
IL magazine, Il Sole 24 Ore (the Italian business and finance newspaper)

References

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