

Curriculum Vitae

Dr Raffaele Santagati

Profile

I am a Quantum Computing Scientist at Boehringer Ingelheim, researching Quantum Computing applications for Pharma. My primary expertise is in quantum computing. My contributions to research, among the others, include conceiving and demonstrating new protocols for quantum simulation, implemented on integrated quantum photonic devices and the realisation of new methods exploiting machine learning and quantum computers for quantum system characterisation and quantum sensing.

Appointments (dd/mm/yyyy)

- 01/10/2020 Quantum Computing Scientist, Quantum Lab @ Boehringer Ingelheim, Vienna (AT) (Manager: C Utschig-Utschig)
- 01/07/2020 Tenure Track Staff Researcher, Quantum and Linear-Optical Computation group at Iberian International Nanotechnology Laboratory, Braga (PT) (PI: E. Galvao)
- 15/08/2017 Senior Research Associate, QETLabs, University of Bristol (UK) (PIs: A Laing) – team lead
- 01/11/2015 Research Associate, QETLabs, University of Bristol. (UK) (PI: MG Thompson)
- 16/04/2012 PhD student Research Assistant, Centre for Quantum Photonics, University of Bristol (Supervisors: JL O'Brien and M G Thompson)

Older selected Appointments (yyyy)

- 2011-2012 Researcher – EuroImaging, s.r.l. Roma – IT
Optical coherence tomography in turbid medium.
(PI/Manager: F. Prati)
- 2008-2010 Research student trainee, European Synchrotron Radiation Facility, Grenoble.
Designed first double analyser spectrometer for inelastic X-ray scattering. (PIs: GC Ruocco and G Monaco)
- 2006-2007 Research undergraduate student, Institute for Complex Systems – CNR, Sapienza, Roma - IT
First experimental study of collective animal behaviour with 3-dimensional data.
(PIs: G Parisi and A Cavagna)

Education (dd/mm/yyyy)

- 08/03/2016 PhD in Physics, School of Physics, University of Bristol
Advisors: Prof. Jeremy O'Brien and Prof. Mark G. Thompson
Thesis title: *Quantum information processing in silicon photonics*
- 30/03/2011 Master's Degree in physics (110/110), University of Rome La Sapienza
Advisor: Prof. Giancarlo Ruocco
Thesis title: *Double analyser spectrometer for inelastic X-ray scattering*

Publications (+ equally contributing, * corresponding author)

- Loipersberger, Malone, Welden, Parrish, Fox, Degroote, Kyoseva, Moll, Santagati, Streif
Interaction Energies on Noisy Intermediate-Scale Quantum Computers
arXiv preprint arXiv:2207.00218 (2022)
- Gebhart, Santagati, Gentile, Gauger, Craig, Ares, Banchi, Marquardt, Pezzè, Bonato
Learning Quantum Systems
arXiv preprint arXiv:2207.00298 (2022)
- Flynn, Gentile, Wiebe, Santagati*, Laing
Quantum model learning agent: characterisation of quantum systems through machine learning
New J. Phys. 24 053034 (2022)
- Xypakis, Gosti, Giordani, Santagati, Ruocco, Leonetti
Deep learning for blind structured illumination microscopy
Sci Rep 12, 8623 (2022)
- Malone, Parrish, Welden, Fox, Degroote, Kyoseva, Moll, Santagati, Streif
Towards the simulation of large scale protein–ligand interactions on NISQ-era quantum computers
Chem. Sci., 13, 3094-3108 (2022)
- O'Brien, Streif, Rubin, Santagati, Su, Huggins, Goings, Moll, Kyoseva, Degroote, Tautermann, Lee, Berry, Wiebe, Babbush
Efficient quantum computation of molecular forces and other energy gradients
arXiv preprint arXiv:2111.12437 (2021)
- Streif, Degroote, Kyoseva, Moll, Santagati, Tautermann, Utschig-Utschig
Quantum Applications - Fachbeitrag: Warum Moleküle Quantencomputer brauchen
Digitale Welt volume 5, pages16–20 (2021)
- Gentile, Flynn, Knauer, Wiebe, Paesani, Granade, Rarity, Santagati*+, Laing
Learning models of quantum systems from experiments
Nature Physics volume 17, pages 837–843 (2021)
- Paesani, Bulmer, Jones, Santagati, Laing
Scheme for universal high-dimensional quantum computation with linear optics
Phys. Rev. Lett. 126, 230504 (2021)

- Joas, Schmitt, Santagati, Gentile, Bonato, Laing, McGuinness, Jelezko
Online adaptive quantum characterization of a nuclear spin
npj Quantum Information volume 7, Article number: 56 (2021)
- Zhang, Gu, Jiang, Thompson, Cai, Paesani, Santagati, Laing, Zhang, Yung, Shi, Muhammad, Lo, Luo, Dong, Kwong, Kwek, Liu
An optical neural chip for implementing complex-valued neural network
Nature Communications volume 12, Article number: 457 (2021)
- Llewellyn, Ding, Faruque, Paesani, Bacco, Santagati, Qian, Li, Xiao, Huber, Malik, Sinclair, Zhou, Rottwitt, O'Brien, Rarity, Gong, Oxenlowe, Wang, Thompson
Chip-to-chip quantum teleportation and multi-photon entanglement in silicon
Nature Physics volume 16, pages148–153 (2020)
- Paesani, Ding, Santagati, Chakhmakhchyan, Vigliar, Rottwitt, Oxenløwe, Wang, Thompson, Laing
Generation and sampling of quantum states of light in a silicon chip
Nature Physics volume 15, pages925–929 (2019)
- Santagati+, Gentile+, Knauer+, Schmitt, Paesani, Granade, Wiebe, Osterkamp, McGuinness, Wang, Thompson, Rarity, Jelezko, Laing
Magnetic-field-learning using a single electronic spin in diamond with one-photon-readout at room temperature
Phys. Rev. X 9, 021019 (2019)
- Santagati*, Price, Rarity, Leonetti
Localisation-based two-photon wavefunction information encoding
Optics Express Vol. 27, Issue 15, pp. 20787-20799 (2019)
- Llewellyn, Ding, Faruque, Paesani, Bacco, Santagati, Qian, Li, Xiao, Huber, Malik, Sinclair, Zhou, Rottwitt, O'Brien, Rarity, Gong, Oxenløwe, Wang, Thompson
Optical Microresonator-enhanced Multiqubit Quantum Information Processing
Nature Photonics Accepted Manuscript (in press) - Preprint [Arxiv: 1911.07839](https://arxiv.org/abs/1911.07839) (2019)
- Adcock, Vigliar, Santagati, Silverstone, Thompson
Programmable four-photon graph states on a silicon chip
Nature Communication Accepted Manuscript. (in press) - Preprint [Arxiv: 1811.03023](https://arxiv.org/abs/1811.03023) (2018)
- Qiang, Zhou, Wang, Wilkes, Loke, O'Gara, Kling, Marshall, Santagati, Ralph, Wang, O'Brien, Thompson, Matthews
Large-scale silicon quantum photonics implementing arbitrary two-qubit processing
Nature Photonics 12, 534–539 (2018)
- Paesani, Ding, Santagati, Chakhmakhchyan, Vigliar, Rottwitt, Oxenløwe, Wang, Thompson, Laing
Generation and sampling of quantum states of light in a silicon chip.
Nature Physics 15, 925-929 (2019)
- Wang, Paesani, Ding, Santagati, Skrzypczyk, Salavrakos, Tura, Augusiak, Mančinska, Bacco, Bonneau, Silverstone, Gong, Acín, Rottwitt, Oxenløwe, O'Brien, Laing, Thompson
Multidimensional quantum entanglement with large-scale integrated optics
Science, 360, 6386, 285-291 (2018)

Santagati⁺, Wang⁺, Gentile⁺, Paesani, Wiebe, McClean, Short, Shadbolt, Bonneau, Silverstone, Tew, Zhou, O'Brien, Thompson
Witnessing eigenstates for quantum simulation of Hamiltonian spectra
Science Advances 4, 1, eaap9646 (2018)

Santagati⁺, Silverstone⁺, Sorel, Miki, Yamashita, Fujiwara, Sasaki, Terai, Tanner, Natarajan, Hadfield, O'Brien, Thompson
Silicon photonic processor of two-qubit entangling quantum logic
Journal of Optics 19, 11 (2017)

Wang⁺, Paesani⁺, Santagati⁺, Knauer, Gentile, Wiebe, Petruzzella, L O'Brien, G Rarity, Laing, Thompson
Experimental quantum Hamiltonian learning
Nature Physics 1, 149 (2017)

Paesani, Gentile, Santagati, Wang, Wiebe, Tew, O'Brien, Thompson
Experimental Bayesian Quantum Phase Estimation on a Silicon Photonic Chip
Physical Review Letters 118, 10 (2017)

Wilkes, Qiang, Wang, Santagati, Paesani, Zhou, Miller, Marshall, Thompson, O'Brien
60 dB high-extinction auto-configured Mach–Zehnder interferometer
Optics Letters 41, 22 (2016)

Wang, Bonneau, Villa, Silverstone, Santagati, Miki, Yamashita, Fujiwara, Sasaki, Terai, Tanner, Natarajan, Hadfield, O'Brien, Thompson
Chip-to-chip quantum photonic interconnect by path-polarization interconversion
Optica 3, 4, 407-413 (2016)

Mendoza, Santagati, Munns, Hemsley, Piekarek, Martín-López, Marshall, Bonneau, O'Brien, Thompson
Active temporal and spatial multiplexing of photons
Optica 3, 2, 127-132 (2016)

Silverstone⁺, Santagati⁺, Bonneau, Strain, Sorel, O'Brien and Thompson
Qubit entanglement between ring-resonator photon-pair sources on a silicon chip
Nature Communications 6, 7948 (2015)

Cavagna, Cimorelli, Giardina, Parisi, Santagati, Stefanini, Viale
Scale-free correlations in starling flocks
PNAS 107, 26, 11865-11870 (2010)

Cavagna, Cimorelli, Giardina, Parisi, Santagati, Stefanini, Tavarone
From empirical data to inter-individual interactions: unveiling the rules of collective animal behavior
Mathematical Models and Methods in Applied Sciences 20, 1491-1510 (2010)

Cavagna, Cimorelli, Giardina, Orlandi, Parisi, Procaccini, Santagati, Stefanini
New statistical tools for analyzing the structure of animal groups
Mathematical biosciences

Conference Presentations:

Presented >30 contributed talks plus 20 invited talks at leading conferences and research institutions. Authored >50 conference proceedings.

Selected Invited conference and university seminar talks:

Calculating Forces on quantum computers **QETLabs** group Talk, Bristol March 2022

Knowledge Hour on quantum computing **Boehringer Ingelheim** Nov 2021

Generating models of quantum systems from quantum optics **Photonics North** 2021

Silicon photonic quantum simulators **QCE IEEE Quantum Week** Oct 2020

Learning models of quantum systems **Iberian Nanotechnology Lab.** March 2020

Experimentally learning the properties of quantum systems with machine learning
Quandela Paris Saclay Feb 2020

Learning the physics of quantum systems using photonic quantum simulators.

The Institute of Photonic Sciences – ICFO – ICFO Colloquia

Castelldefels, Barcelona, Spain, 28th November 2019

Learning Physics with machines

Herriot-Watt Institute of Photonics and Quantum Sciences – School' Seminar talk

Edinburgh, UK , 18th June 2019

Learning Physics with machines and photonic quantum simulators

Machine Learning for Quantum Technology workshop. Max Planck Institute for the science of light.

Erlangen, Germany, 7th May 2019

Machine learning for characterising quantum technologies

Symposium on the science of light. Max Planck Institute for the science of light,

Erlangen, Germany, 28th March 2019

Statistical inference for the optimisation and study of quantum photonics and quantum optics experiments

F. Marquardt group talk. Max Planck Institute for the science of light,

Erlangen, Germany, 5th February 2019

Machine Learning for the characterisation and optimisation of quantum technologies

Asia Communication and Photonics ACP 2018 (OSA, IEEE)

Hangzhou, China, 29th September 2018

Hamiltonian Learning for nanoscale quantum sensors

IOP's Photon 2018

Birmingham (EN), UK, 5th September 2018

Quantum computers and their applications

The AI Summit - The Quantum Summit 2018

London (EN), UK, 13th June 2018

Towards quantum information processing in silicon quantum photonics
Blackett Physics laboratory, Imperial College
QOLS Group Seminar Prof. Myungshik Kim's quantum optics group talk
London (EN), UK, 12th April 2018

Silicon quantum photonics
University of Bath, School of Physics
Centre for Photonics and Photonic Materials group talk (Visiting Dr Peter Mosley)
Bath (EN), UK, 5th December 2017

Machine learning for engineering new generation quantum devices
Rank Prize Symposium on Solid State Nano-Photonics for Quantum Science and
Technology 2017
Windermere, UK, 27th September 2017

Quantum information processing and machine learning in silicon quantum photonics
Bristol Quantum Information Technology conference 2017
Bristol (EN), UK, 6th April 2017

Silicon quantum photonics
Frontiers in Optics 2016
Rochester (NY), USA, 20th October 2016

Quantum simulation in a silicon quantum photonic chip
Quantum Innovators 2016
Waterloo (ON), CANADA, 25th October 2016

From quantum simulation to machine learning applications in silicon waveguide
Harvard School of Chemistry, Harvard University – A. Aspuru-Guzik's group talk
Cambridge (MA), USA, 17th June 2016

Engineering integrated quantum photonics for quantum simulation
Massachusetts Institute of Technology Quantum Photonics Laboratory – group talk
Cambridge (MA), USA, 20th June 2016

Photonic quantum technologies
SPIE Optics + Photonics
San Diego (CA), USA, 11th August 2015

Entanglement generation in silicon waveguide
Physics Department Seminar, University of Rome La Sapienza
Rome (LA), Italy, 23rd September 2014

Reviewing

Manuscript reviewer for: Nature, Science, Nature Communications, Physical Review Letters, Physical Review X, Physical Review A, Physical Review Applied, Quantum Sciences and Technology, NPJ Quantum Information, NPJ Light Science and Applications, NPJ's Communication in Physics, Optica, Applied Physics Letters, New Journal of Physics, Optics Express, Optica, Applied Physics Express, Optics Letters, Journal of Visualized Experiments, and NPG's Scientific Reports.

Teaching experience

- 2019 Lectures on “Quantum Machine Learning” at the Centre for Doctoral Training in Quantum Engineering, University of Bristol, **Bristol** (UK)
- 2018 Lectures on “Photonic Quantum Computing” at the winter school on quantum computing of UCLQ. University College London CDT Cumberland lodge, **London** (UK)
- 2018 Lectures on “Quantum computers and their applications” at the summer school Quantum in the summer. School of Physics University of Bristol, **Bristol** (UK)
- 2018 Lecture/Tutorial on Machine Learning for quantum technologies. Department of Electrical and Electronic Engineering, Nanyang Technological University, **Singapore**
- 2018 Guest lecturer on Experimental Quantum Computation at the Quantum computing course by Dr Ashley Montanaro, School of Mathematics, University of Bristol, **Bristol** (UK)
- 2015/2016 Tutorials in Quantum Simulation, Centre for Doctoral Training in Quantum Engineering, University of Bristol, **Bristol** (UK)
- 2014/2015 2nd year undergraduate thermodynamics and electromagnetism, Teaching Assistant, University of Bristol, **Bristol** (UK)
- 2013/2014 3rd year undergraduate quantum mechanics, Teaching Assistant, University of Bristol, **Bristol** (UK)

Mentoring and supervision

I directly co-supervise tens of Master students at the University of Bristol, and at Minho University in Braga. I also supervised 5 PhD students in QETLabs, working on projects I conceived:

Ms Mafalda Francisco Ramoa

Adaptive approaches for variational quantum eigensolvers – INL and Uni Minho (PT)

Ms Alexandra Francisco Ramoa

Learning properties of open quantum systems – INL and Uni Minho (PT)

Mr Antonio Molero

Practical Characterisation of quantum systems – INL (PT)

Dr Andrea Antonio Gentile

Experimental quantum simulation in silicon quantum photonics – UOB (UK)

Dr Brian Flynn

Quantum model learning of open quantum systems – UOB (UK)

Dr Patrick Yard

Using machine learning to optimise quantum simulators in integrated photonics – UOB (UK)

Ms Katerina Koteva

Quantum simulation methodologies for calculation of excited states of particle physics Hamiltonians - UOB (UK)

I additionally provided day to day mentorship and co-supervision to other two former PhD students:

Dr **Stefano Paesani** – Boson sampling for quantum simulation – UOB (UK)

Dr **Jeremy Adcock** – Experimental generation of cluster states – UOB (UK)

Supervision of PhD students for Bristol's Centre for Doctoral Training in Quantum Engineering (CDT) summer projects:

2015 Dr Sam Morley-Short, *Digital quantum simulation of Bosons*

2015 Dr Alasdair Price, *Silicon quantum photonics quantum simulators*

2015 Dr Jeremy Adcock, *Post-selection of entangled multi-photon graph states*

2016 Dr Lawrence Rosenfeld, *Variational quantum simulators*

2017 Dr Brian Flynn, *Fast simulation of quantum simulators on classical computers*

Grant contributions:

EU FETFLAG-05-2020 Complementary Call on quantum computing, (2019) **Co-I, Co-Author**, Co-lead Bristol contribution (NOT AWARDED)

Quantum technology Hub phase 2, Work package in quantum simulation (2018) **Co-I, co-author**

EU Marie Curie Innovative Training Network 2018, Machine learning in photonics quantum information (QULEARN), **Co-I and co-author** (NOT AWARDED)

EU Quantum Flagship 2018, Photonic Quantum Computer Networks (Photon-Q), **Co-I and co-author** (NOT AWARDED)

EU FETPROACT-3-2014, Quantum simulation on a photonic Chip (QUCHIP) **Co-I and reporting** (AWARDED)

EPSRC Programme Grant 2014, Engineering Photonic Quantum Technologies (EPQT) **Co-I and Co-Leading WP on Applications**. (AWARDED)

USA's Army Research Office 2014, Photonic Quantum Characterization, Verification and Validation (QCVV) **Co-I and reporting** (AWARDED)

EU's FP7 2013, Breaking the Barrier on Optical Integration (BBOI) **Co-I and reporting** (AWARDED)

Outreach:

2015-2017 Bristol Quantum Information Technologies conference series *BQIT*, organiser

2014-2017 Centre for quantum Photonics outreach team, Member

2014 *Bristol Optical Student Society (BOSS)*, Founder and President

Vienna, 4 October 2022

