

Quantum Technology group at Queen's University Belfast





QTeQ's crew

Alessandro Ferraro

Alessio Belenchia

Gabriele De Chiara



Mauro Paternostro



Sandro Donadi (MSCA Fellow, 2023)

Kenza Hammam

Giorgio Zicari

1 more Postdoc

Matteo Carlesso



Hannah McAleese

J Barr

P McConnell

H Leitch

J Brown

P Sgroi

S Blair

I Palmisano

Q Wu



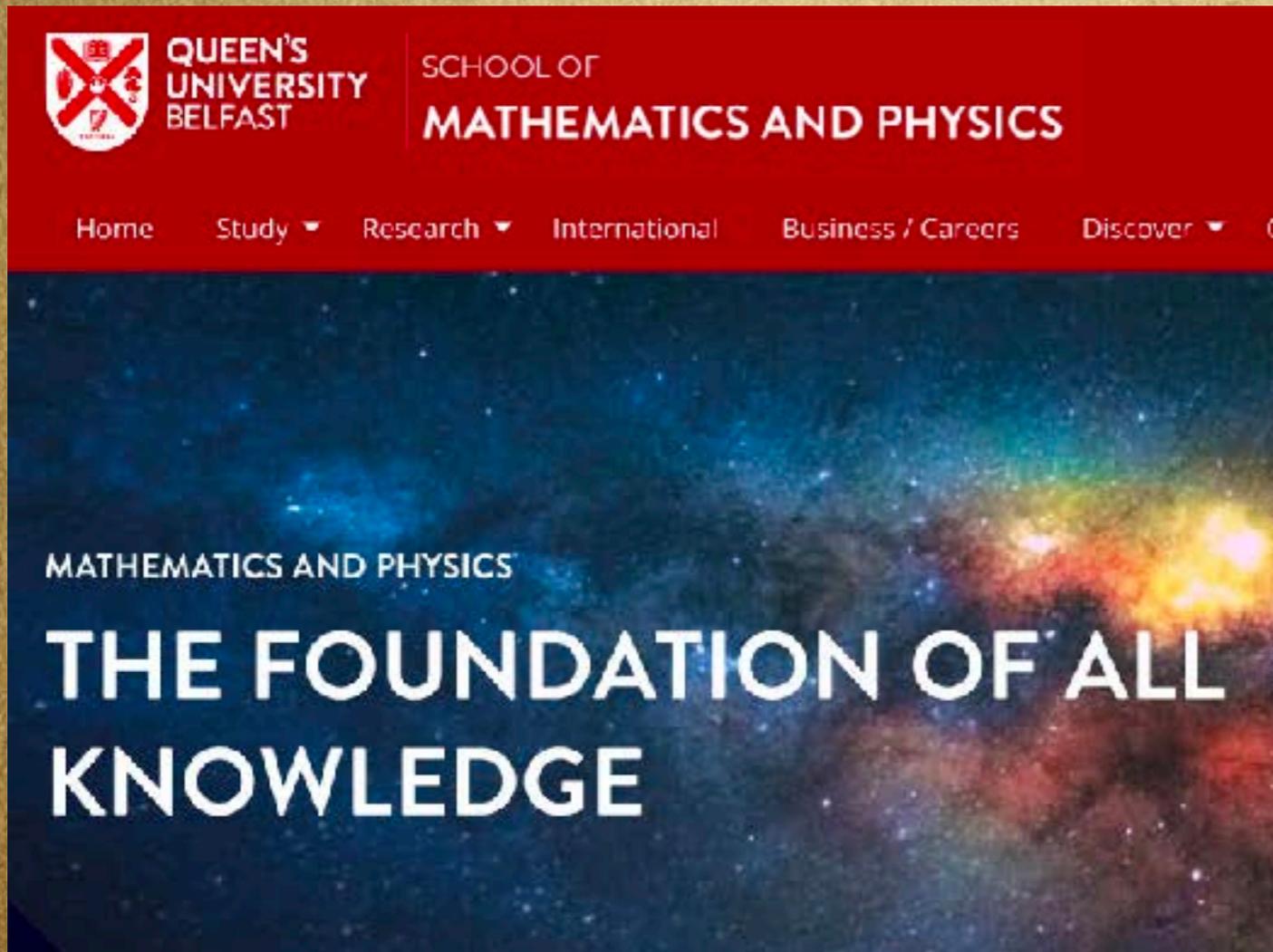
+ E Ryan, C Buchanan & 3 more PhD students starting in 2022



Where we operate



School of Mathematics and Physics

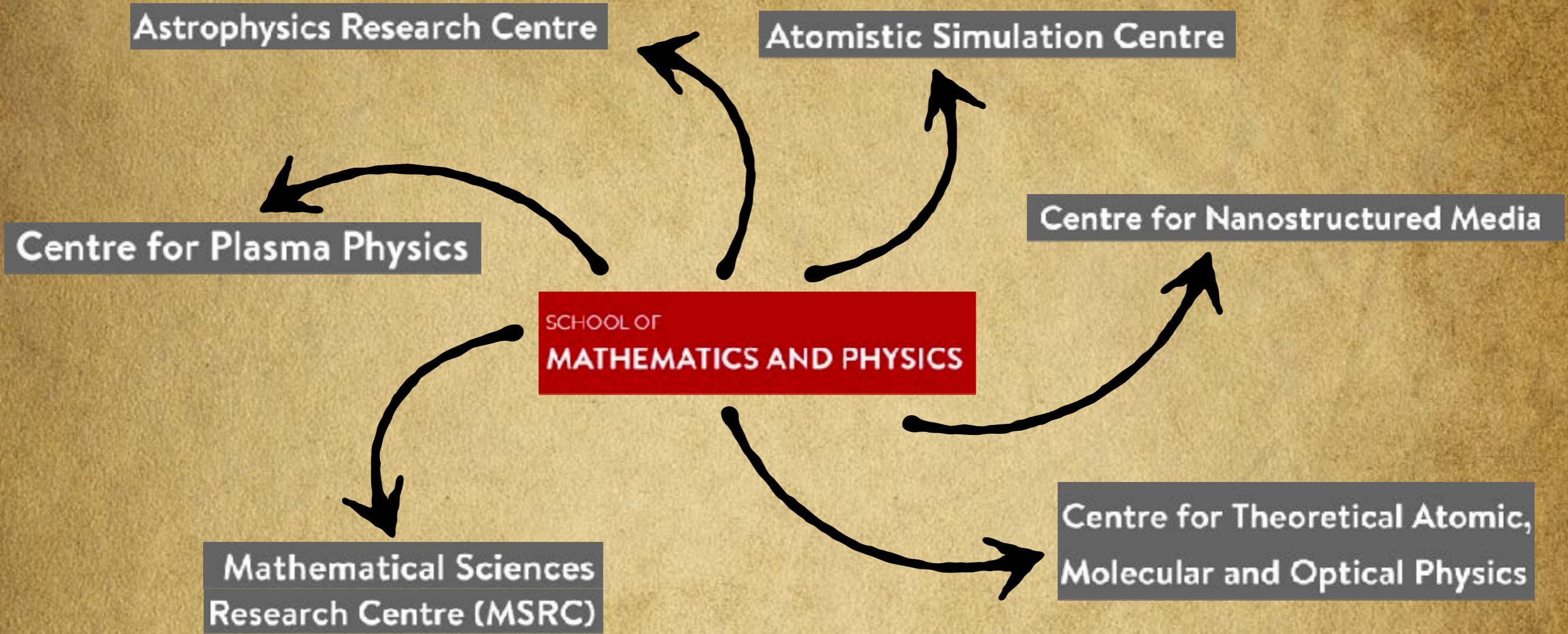


One of the largest Schools at QUB:

- 67 Academic staff members**
- 50+ Research staff**
- 6 Technical staff members**
- 10 Clerical staff members**
- 158 PGR students**
- 60+ PGT students**
- ~700 UG students**



Where we will operate



Where we will operate

Astrophysics Research Centre

Atomistic Simulation Centre

Centre for Plasma Physics

SCHOOL OF
MATHEMATICS AND PHYSICS

Mathematical Sciences
Research Centre (MSRC)



Exciting new endeavours

Physics of Nanomagnetism

- Synthetic antiferromagnets
- All optical magnetic switching
- Single molecule magnets
- Ambitions towards Quantum Sensing

Functional Imaging of Materials

- Transmission Electron Microscopy
- Scanning Electron Microscopy
- Novel Scanning Probe Microscopy

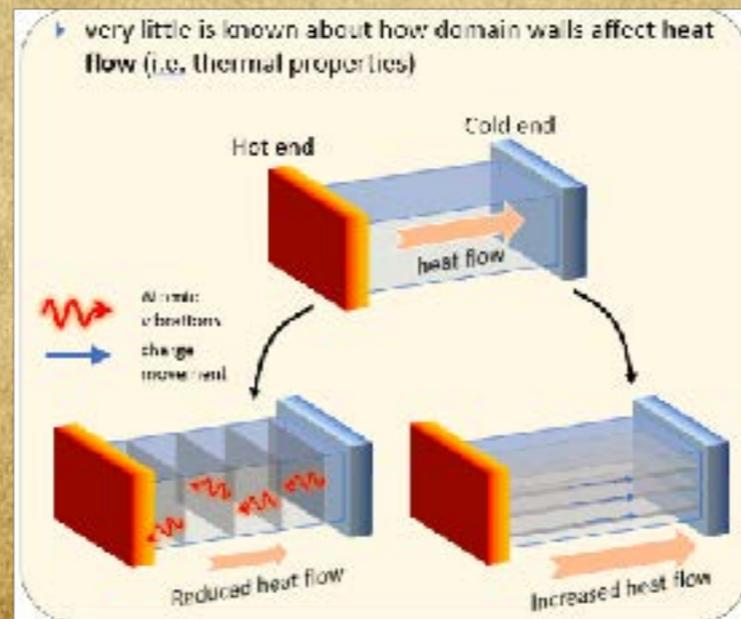


Physics of Ferroelectrics and Domain walls

- Domain Wall Functionality
- Stress Mediated Functionality
- DW mediated Thermal response
- Domain switching phenomena
- Proof-of-concept Device Implications

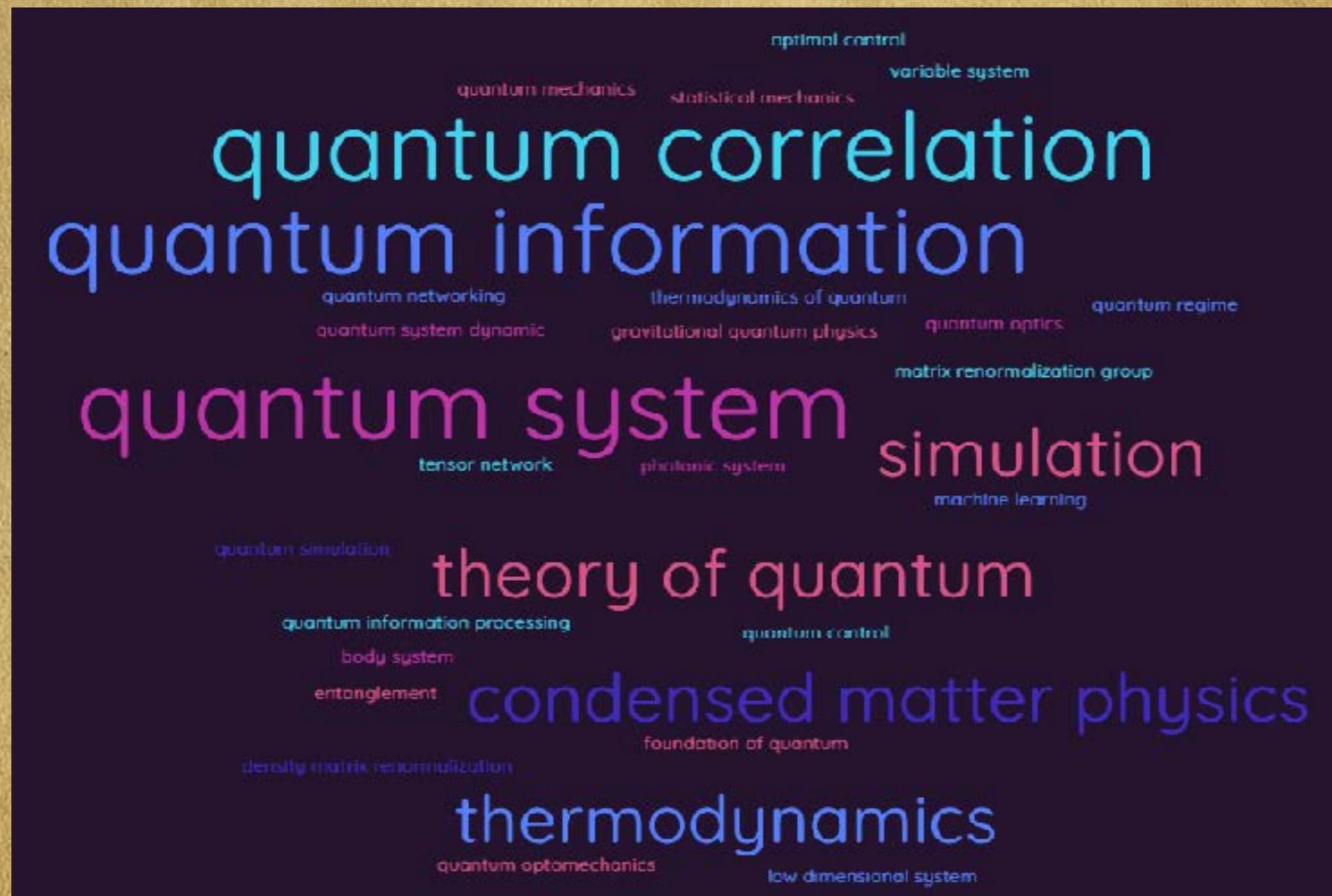
Plasmonics and 2D Materials

- Heat Assisted Magnetic Recording
- Plasmonic sensing
- 2D Material mediated Plasmonics



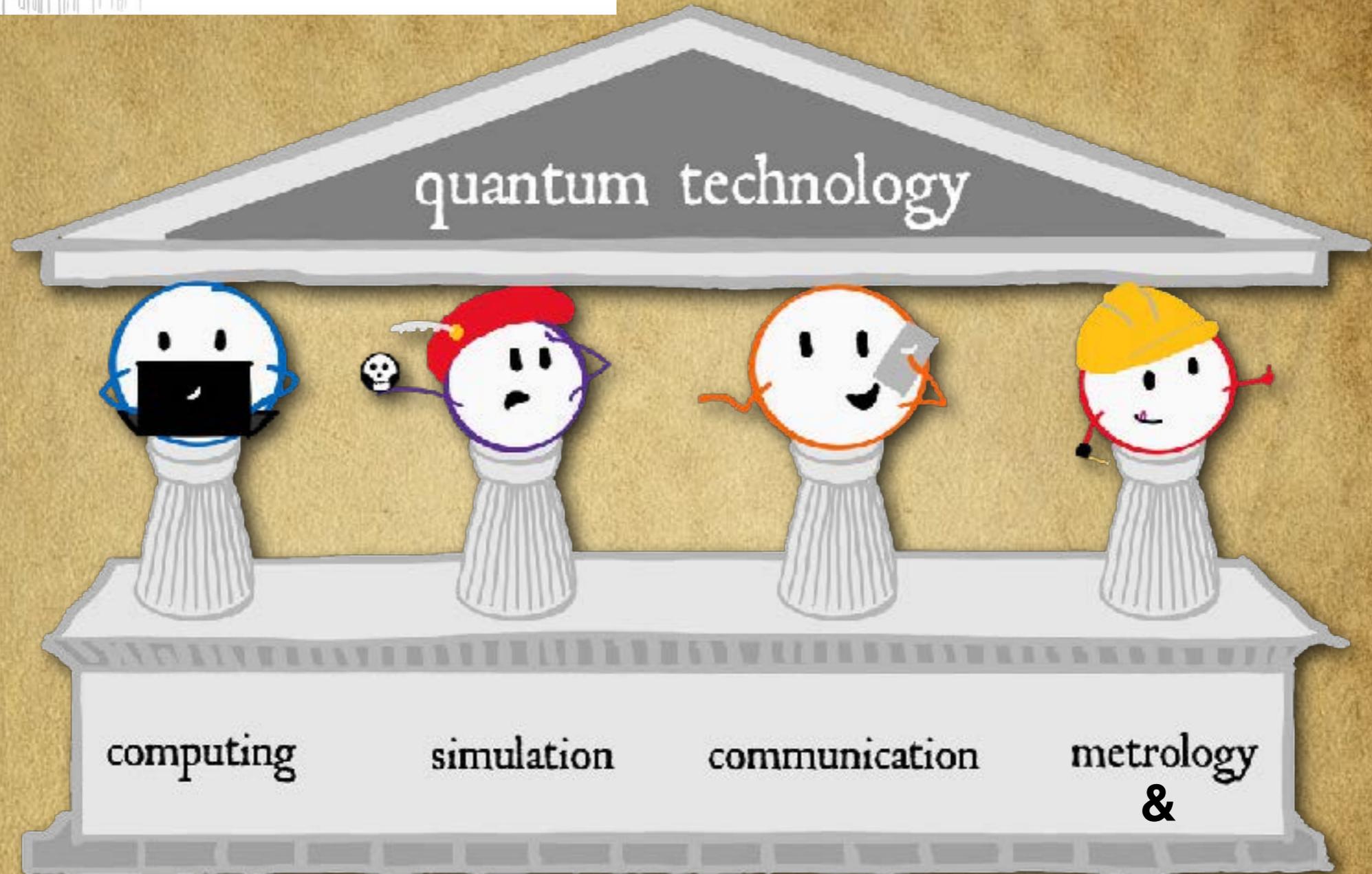


Current interests & strengths





Current interests & strengths



QUANTUM INFORMATION SCIENCE

FOUNDATIONS

TECHNOLOGIES

Quantum sensing & metrology

Photons, trapped ions, ultra-cold atoms, artificial systems (quantum dots, defect centres), optomechanical systems, superconducting nano-circuits



REVIEW ARTICLE
<https://doi.org/10.1038/s41567-021-01489-5>

[Check for updates](#)

Present status and future challenges of non-interferometric tests of collapse models

Matteo Carlesso¹, Sandro Donadi², Luca Ferialdi^{2,3}, Mauro Paternostro¹, Hendrik Ulbricht⁴ and Angelo Bassi^{2,3} 

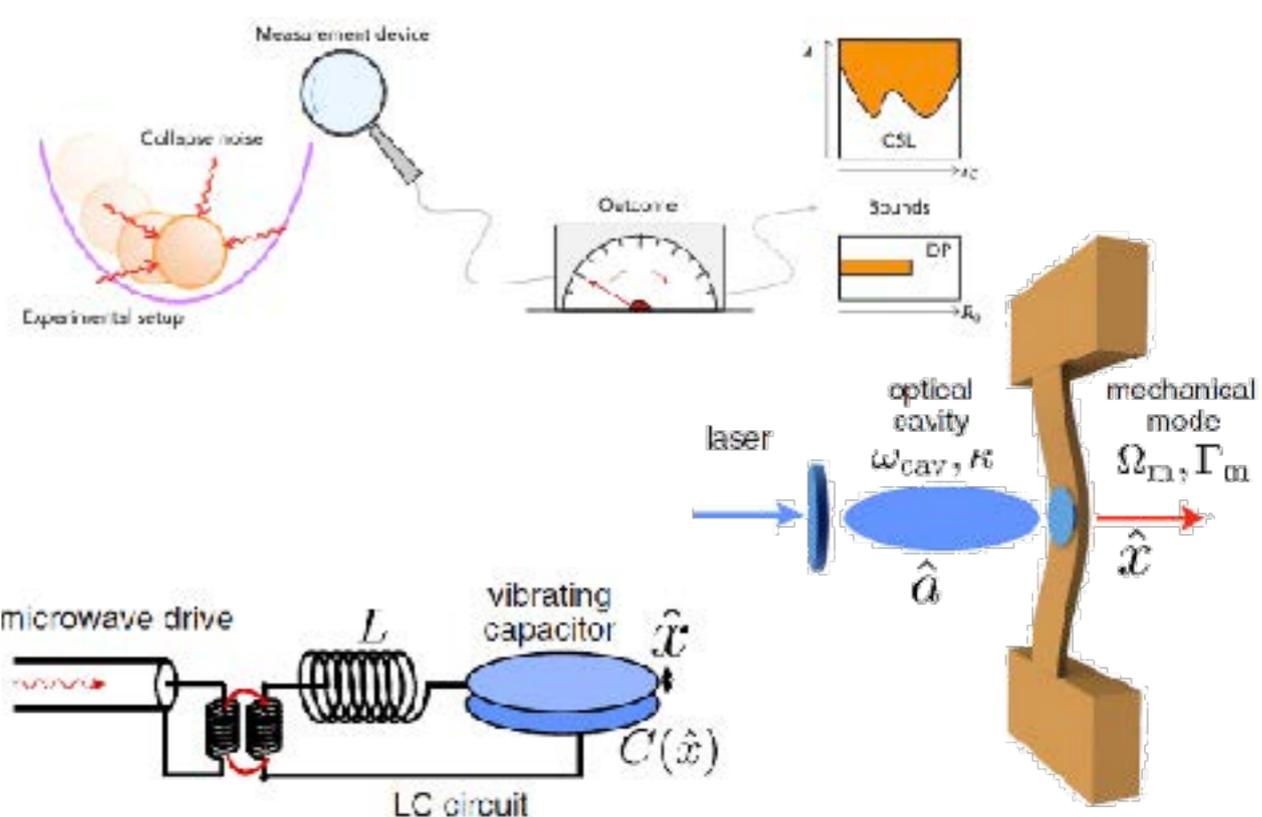


REVIEW ARTICLE
<https://doi.org/10.1038/s41567-021-01402-0>

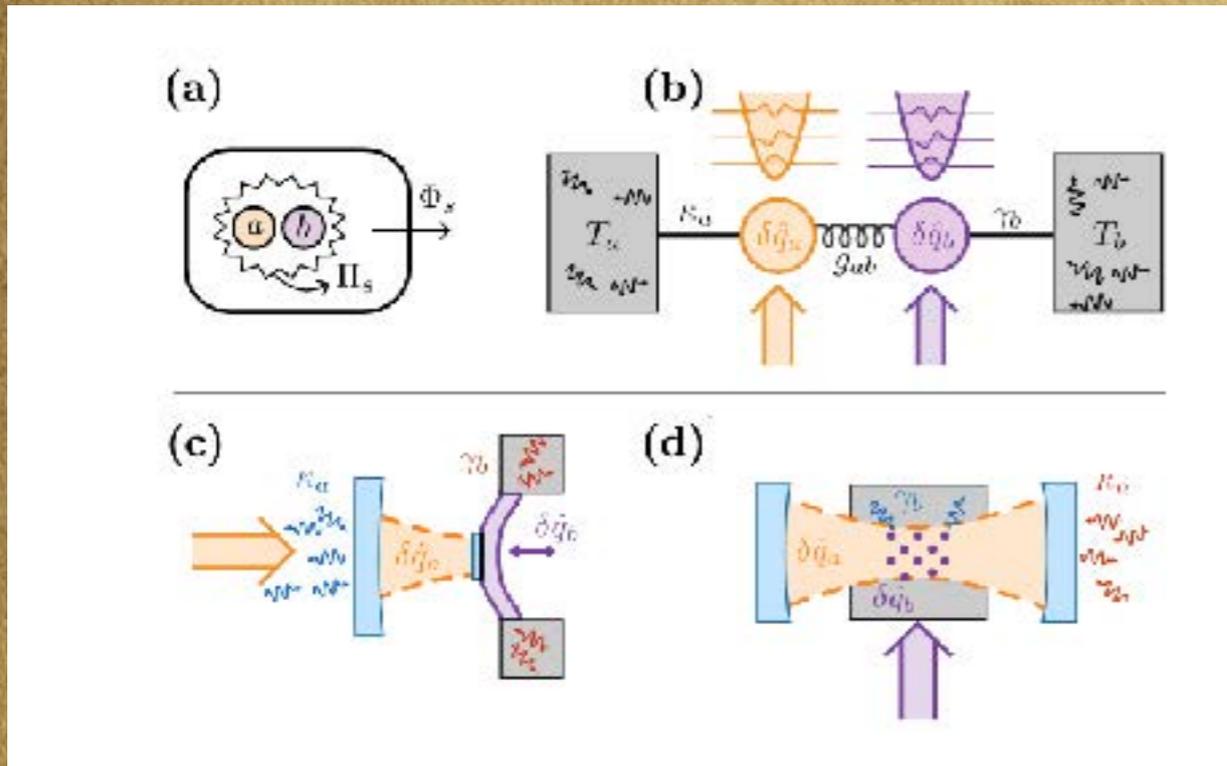
[Check for updates](#)

Optomechanics for quantum technologies

Shabir Barzanjeh^{1,2}, André Xuereb^{2,3}, Simon Gröblacher³, Mauro Paternostro⁴, Cindy A. Regal^{5,6} and Eva M. Weig^{7,8,9}



Current interests & strengths



PHYSICAL REVIEW LETTERS

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Featured in Physics Editors' Suggestion

Experimental Determination of Irreversible Entropy Production in out-of-Equilibrium Mesoscopic Quantum Systems

M. Brunelli, L. Fusco, R. Landig, W. Wieczorek, J. Hoelscher-Obermaier, G. Landi, F.L. Semião, A. Ferraro, M. Kiesel, T. Donner, G. De Chiara, and M. Paternostro
 Phys. Rev. Lett. **121**, 160604 – Published 17 October 2018

REVIEWS OF MODERN PHYSICS

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Irreversible entropy production: From classical to quantum

Gabriel T. Landi and Mauro Paternostro
 Rev. Mod. Phys. **93**, 035008 – Published 24 September 2021

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Featured in Physics Editors' Suggestion

Irreversibility and the Arrow of Time in a Quenched Quantum System

T. B. Batalhão, A. M. Souza, R. S. Sarthour, I. S. Oliveira, M. Paternostro, E. Lutz, and R. M. Serra
 Phys. Rev. Lett. **115**, 190601 – Published 2 November 2015

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Editors' Suggestion

Experimental Reconstruction of Work Distribution and Study of Fluctuation Relations in a Closed Quantum System

Tiago B. Batalhão, Alexandre M. Souza, Laura Mazzola, Ruben Auccaise, Roberto S. Sarthour, Ivan S. Oliveira, John Goolid, Gabriele De Chiara, Mauro Paternostro, and Roberto M. Serra
 Phys. Rev. Lett. **113**, 140601 – Published 3 October 2014

PHYSICAL REVIEW LETTERS

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Editors' Suggestion

Experimental Assessment of Entropy Production in a Continuously Measured Mechanical Resonator

Massimiliano Rossi, Luca Mancina, Gabriel T. Landi, Mauro Paternostro, Albert Schliesser, and Alessia Belenchia
 Phys. Rev. Lett. **125**, 080601 – Published 19 August 2020

Reconciliation of quantum local master equations with thermodynamics

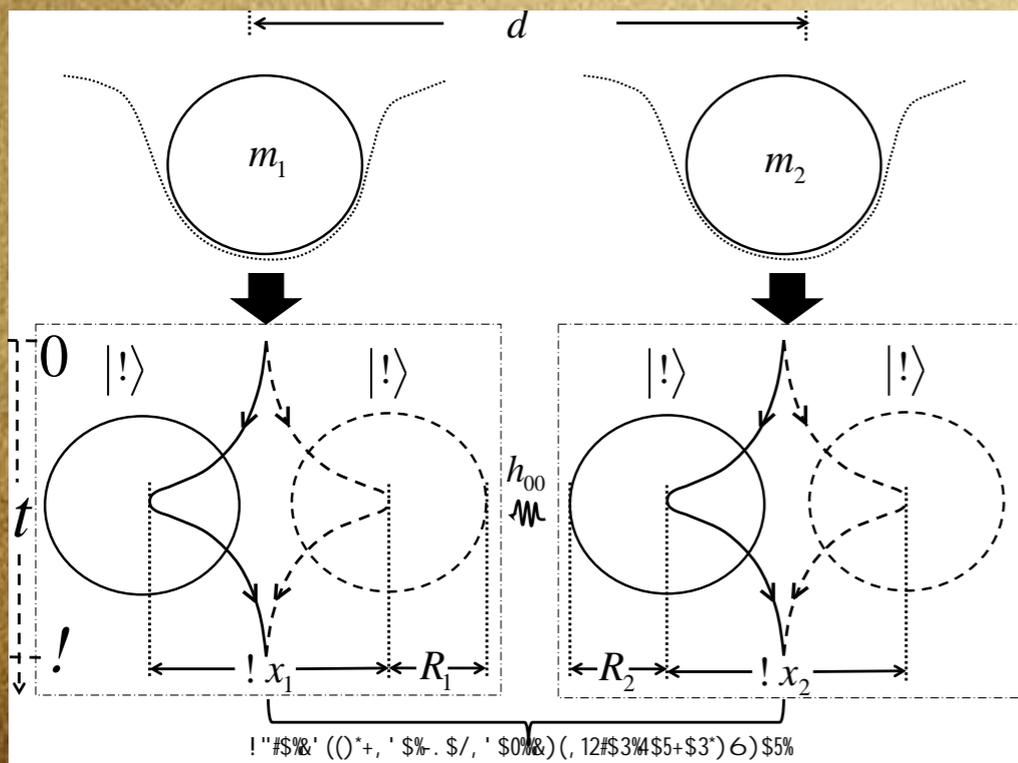
Gabriele De Chiara^{1,2}, Gabriel Landi³, Adam Hewgill¹, Brendan Reid¹, Alessandro Ferraro¹, Augusto J Roncaglia⁴ and Mauro Antezza^{2,5,6}

Published 16 November 2018 · © 2018 The Author(s). Published by IOP Publishing Ltd on behalf of the Institute of Physics and Deutsche Physikalische Gesellschaft

[New Journal of Physics](#), Volume 20, November 2018

Citation Gabriele De Chiara *et al* 2019 *New J. Phys.* **20** 113024

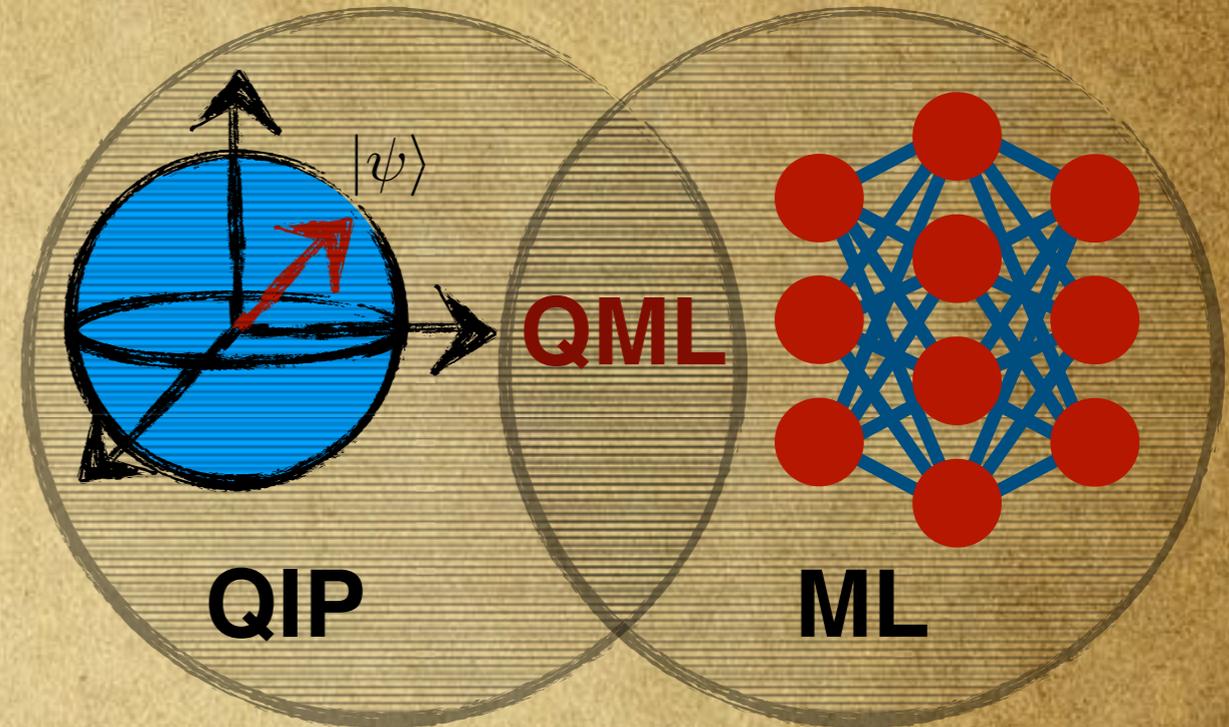
Current interests & strengths



S. Bose, et al., Phys. Rev. Lett. 119, 240401 (2017)

Current interests & strengths

- Fault-tolerant quantum computing
- Noise-Intermediate scale quantum devices (NISQ).
- Variational circuits: quantum chemistry (CCP-QC)
- Quantum algorithms
- Architecture, software and compilers
- Quantum machine learning (QML) (quantum data science)

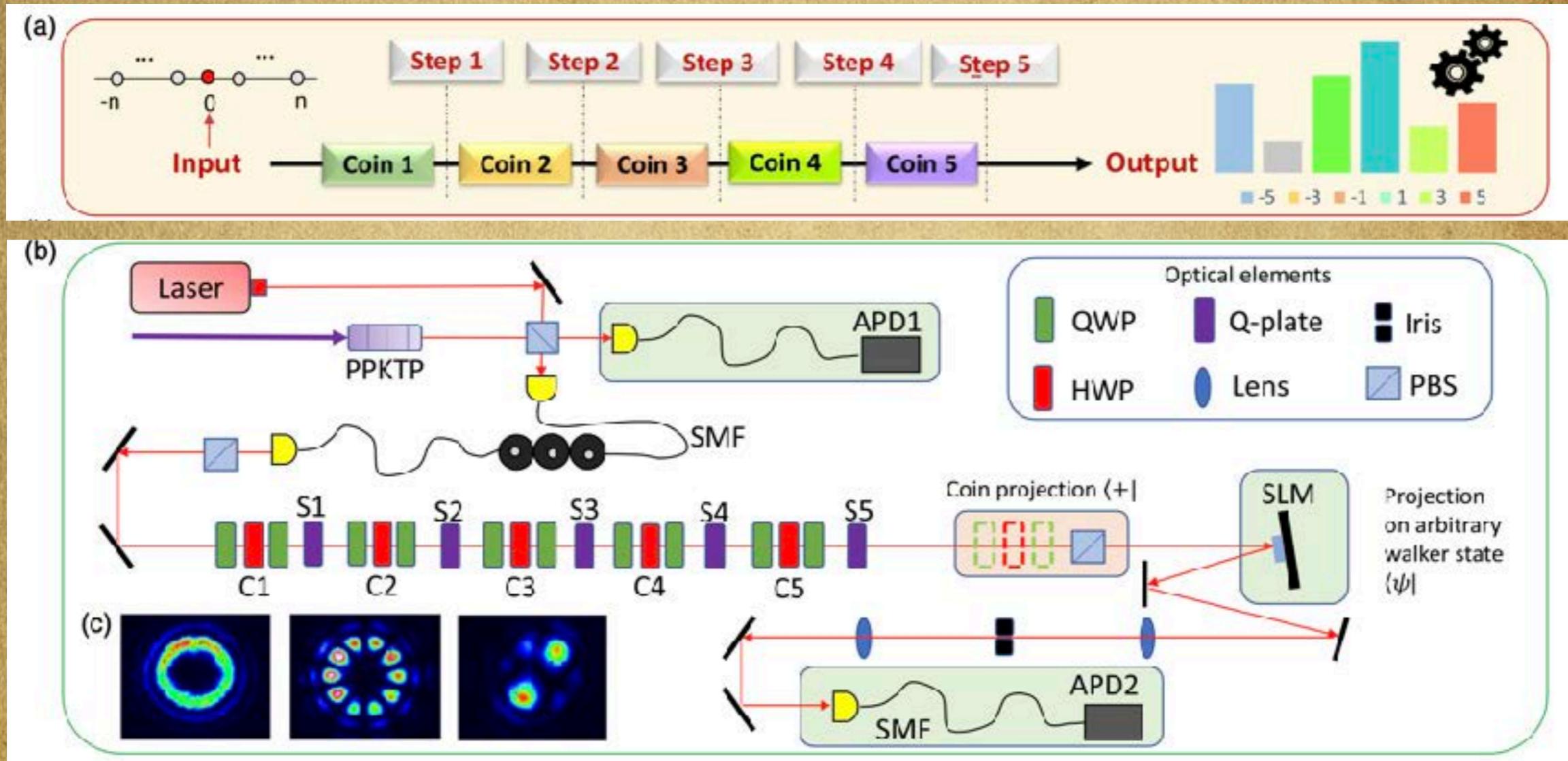


Classical-for-quantum



Use well-established ML methods to run quantum problems more efficiently

Exploiting ML methods for high-dimensional state preparation

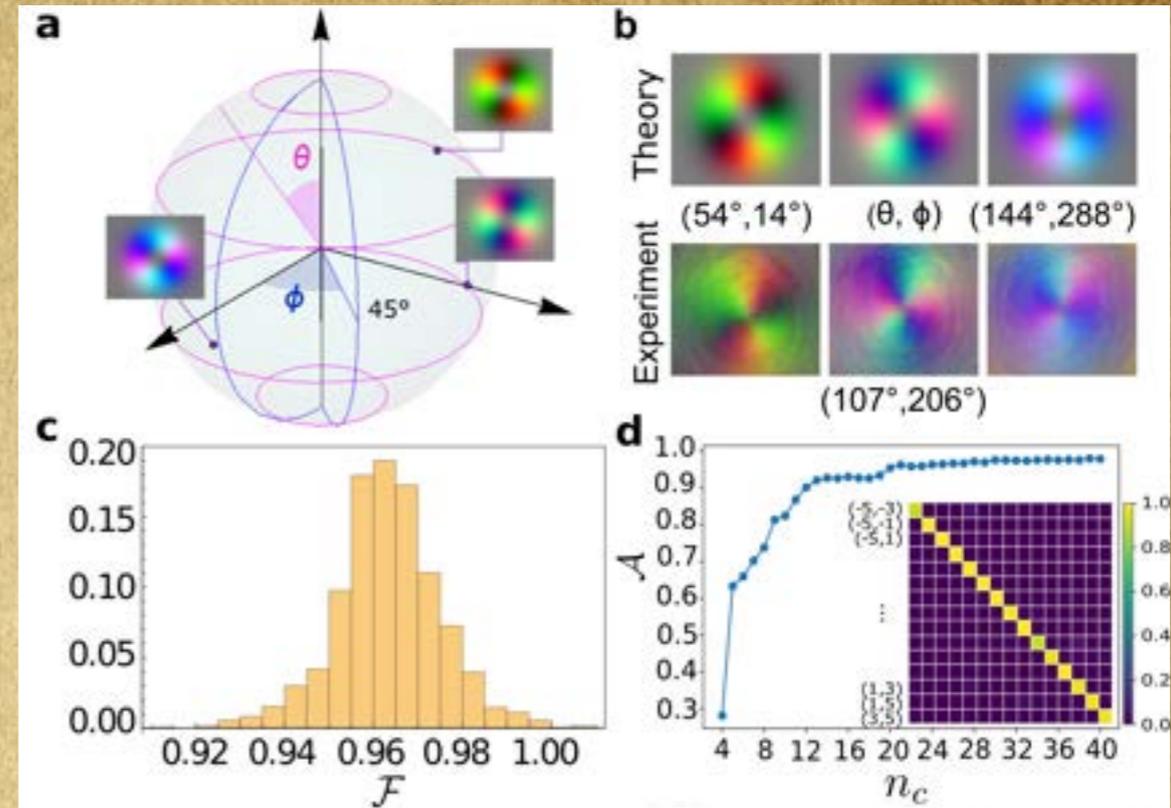
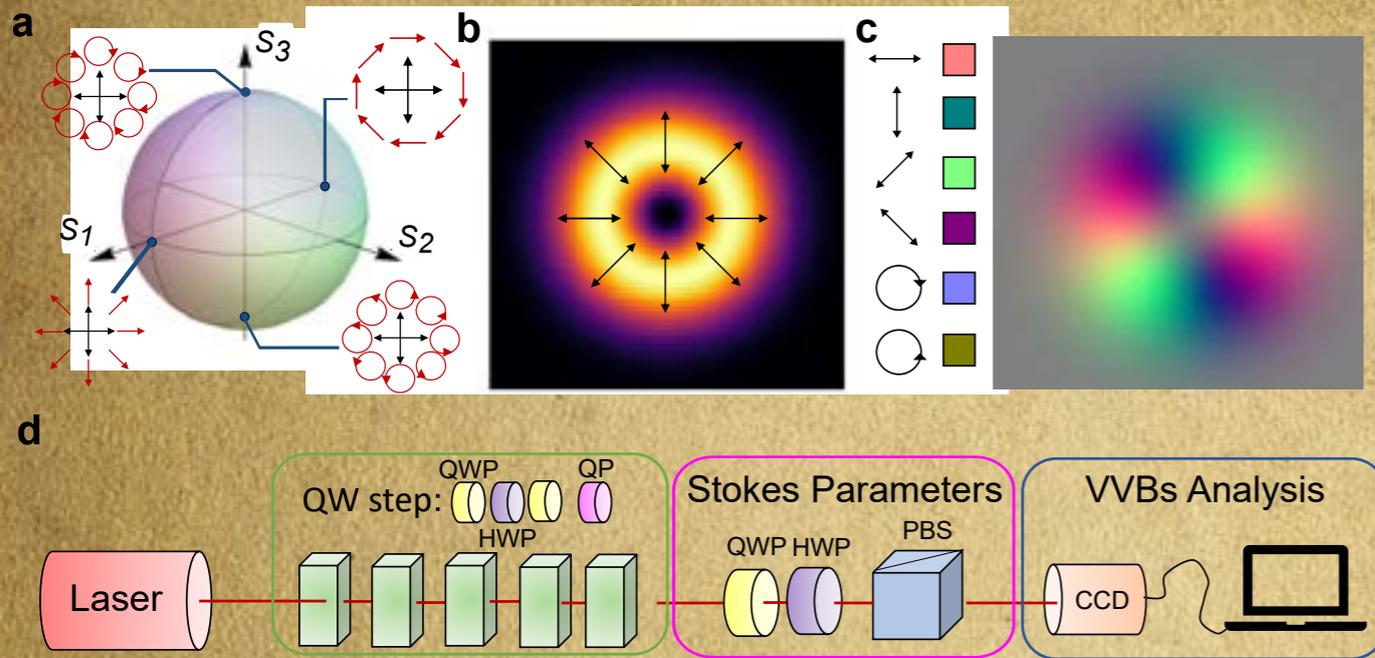


PHYSICAL REVIEW LETTERS 122, 020503 (2019)

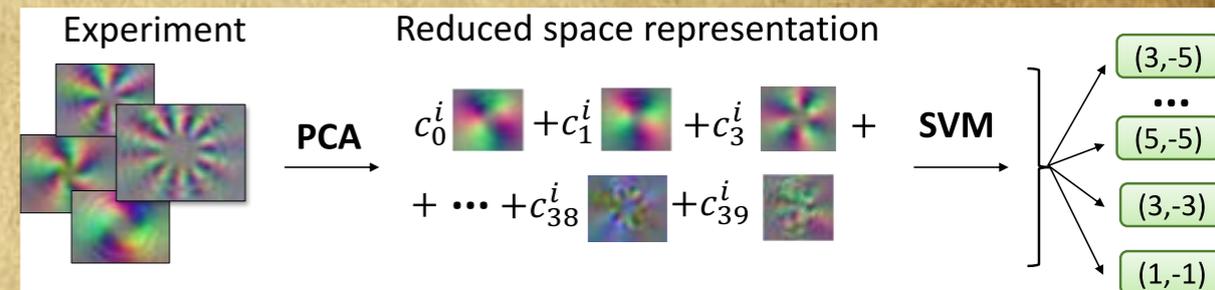
Experimental Engineering of Arbitrary Qudit States with Discrete-Time Quantum Walks

Taira Giordani,¹ Emanuele Polino,¹ Sabrina Emiliani,¹ Alessia Suprano,¹ Luca Innocenti,² Helena Majury,² Lorenzo Marrucci,³ Mauro Paternostro,² Alessandro Ferraro,² Nicolò Spagnolo,¹ and Fabio Sciarrino^{1,4}

Current interests & strengths



Dimensionality reduction & Principal component analysis for agile reconstruction of Vortex Vector Beam states

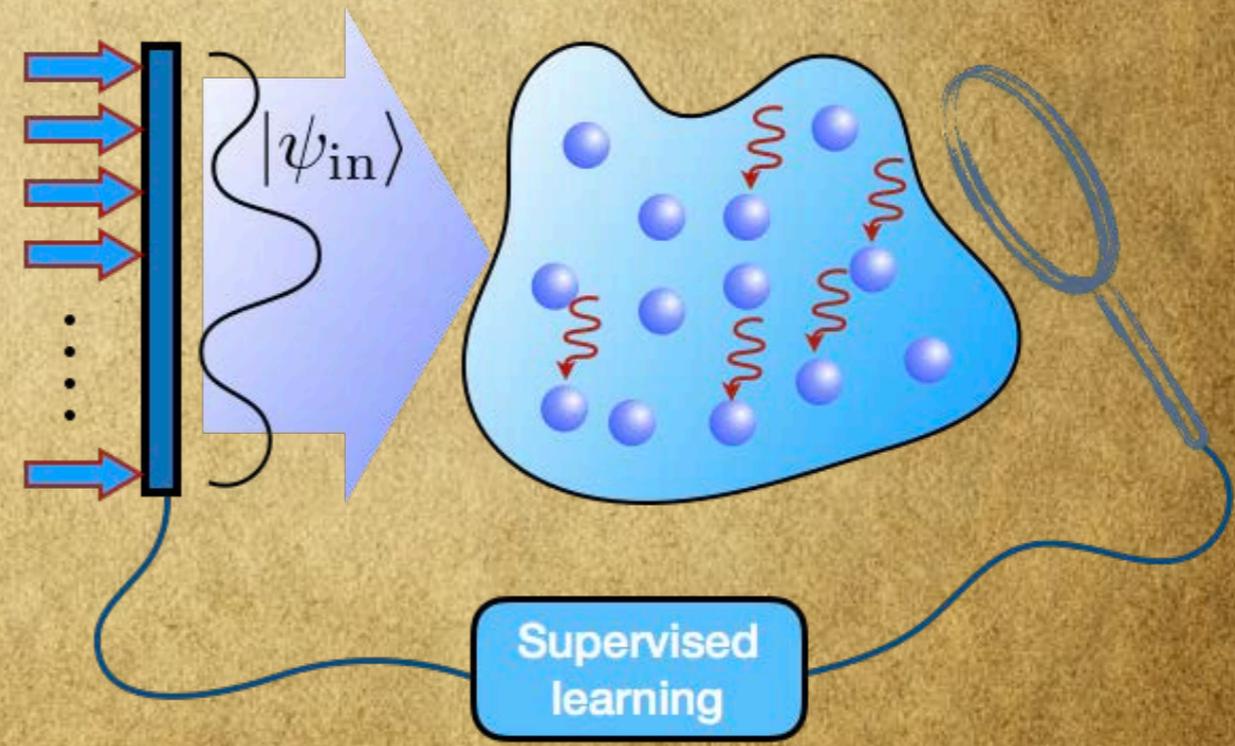
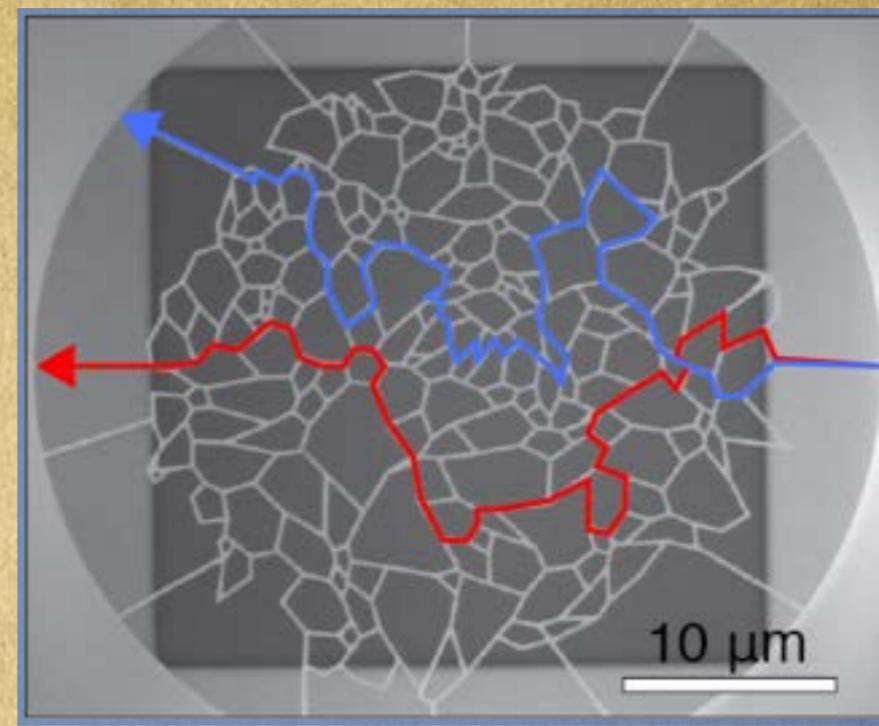
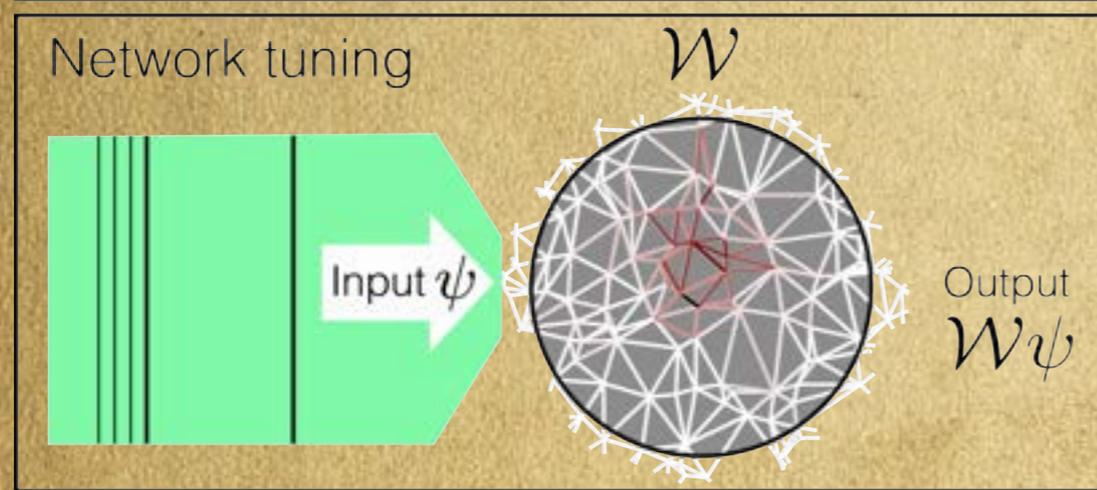
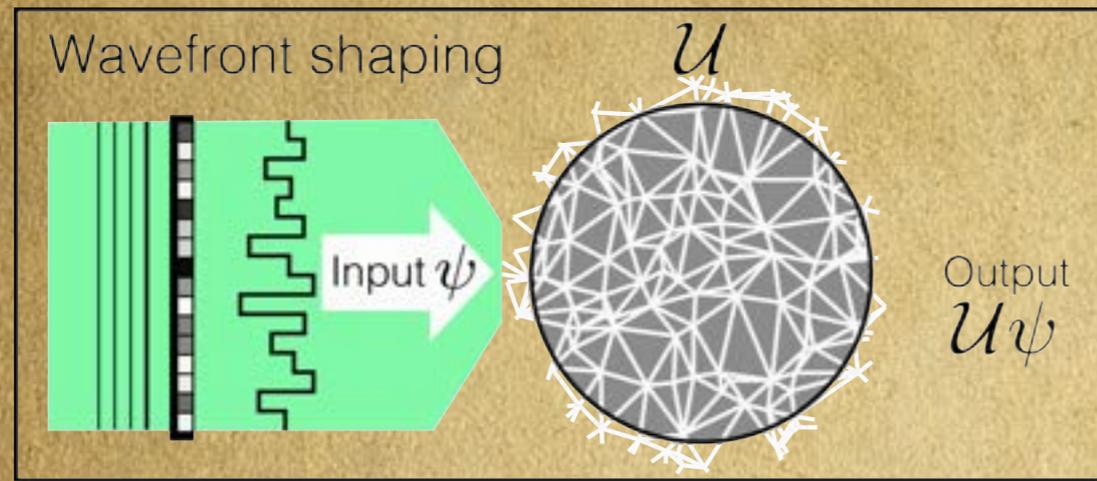


PHYSICAL REVIEW LETTERS **124**, 160401 (2020)

Machine Learning-Based Classification of Vector Vortex Beams

Taira Giordani,¹ Alessia Suprano,¹ Emanuele Polino,¹ Francesca Acanfora,¹ Luca Innocenti,² Alessandro Ferraro,² Mauro Paternostro,³ Nicolò Spagnolo,¹ and Fabio Sciarrino^{1,4}

Current interests & strengths



nature photonics

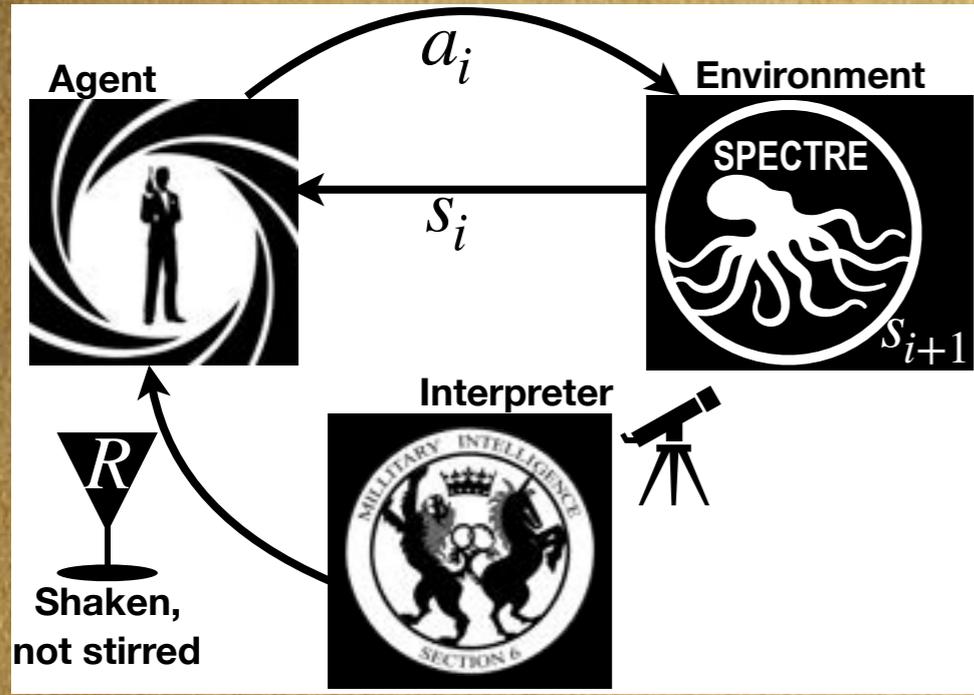
LETTERS

<https://doi.org/10.1038/s41566-019-0553-9>

Programmable linear quantum networks with a multimode fibre

Saroch Leedumrongwattanakun¹, Luca Innocenti², Hugo Defienne^{1,2}, Thomas Juffmann^{1,4,5}, Alessandro Ferraro², Mauro Paternostro² and Sylvain Gigan^{1*}

Current interests & strengths



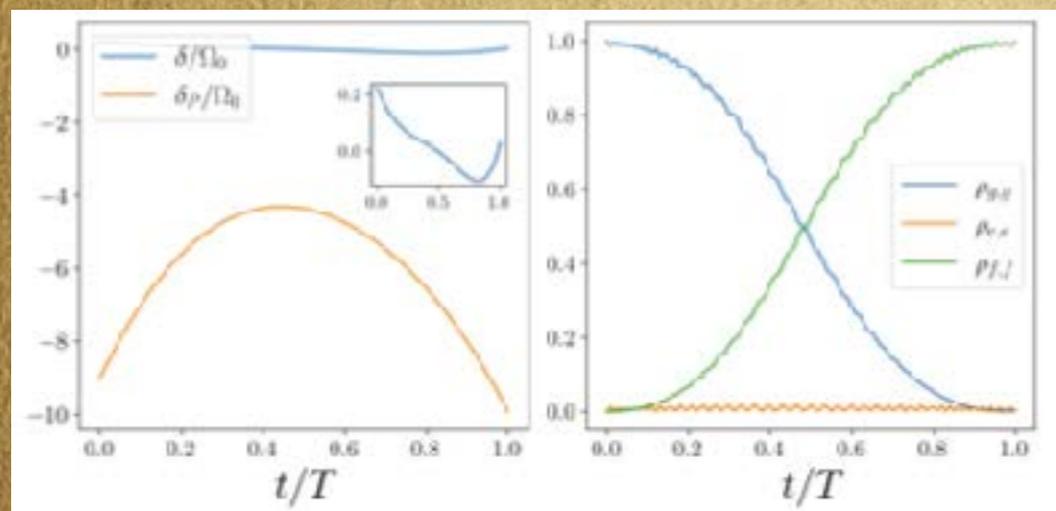
Reinforcement learning for the control of work extraction from non-equilibrium quantum system

PHYSICAL REVIEW LETTERS **126**, 020601 (2021)

Reinforcement Learning Approach to Nonequilibrium Quantum Thermodynamics

Pierpaolo Sgroi,^{1,2} G. Massimo Palma^{1,3} and Mauro Paternostro³

¹Dipartimento di Fisica e Chimica—Emilio Segrè, Università degli Studi di Palermo, via Archirafi 36, I-90123 Palermo, Italy
²Centre for Theoretical Atomic, Molecular and Optical Physics, School of Mathematics and Physics, Queen's University Belfast, Belfast BT7 1NN, United Kingdom
³NEST, Istituto Nanoscienze-CNR, Piazza S. Silvestro 12, 56127 Pisa, Italy

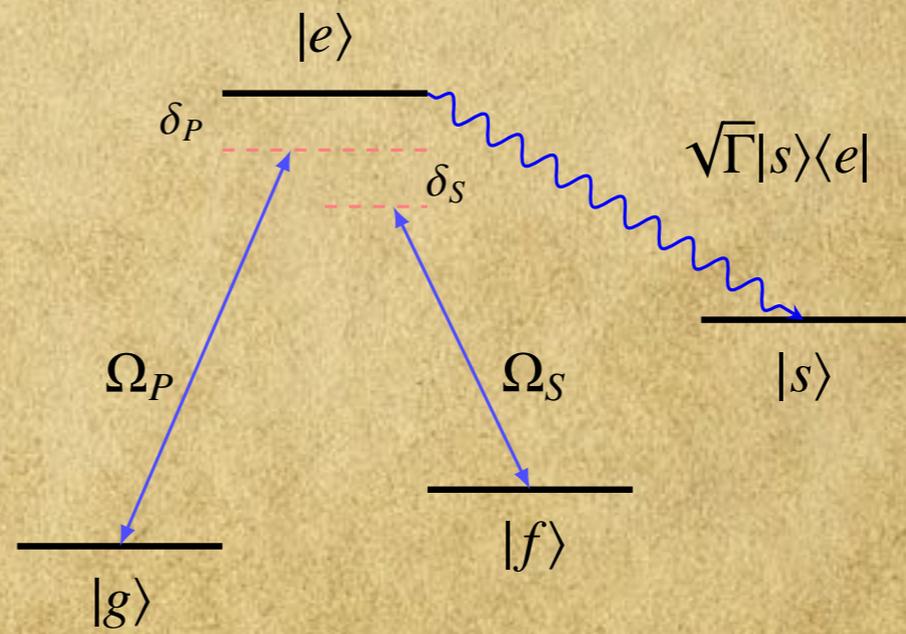


Reinforcement learning-enhanced protocols for coherent population-transfer in three-level quantum systems

Jonathan Brown^{2,5,1}, Pierpaolo Sgroi^{2,1}, Luigi Giannelli^{2,5}, Oheorghe Sorin Parvanu⁴, Elisabetta Paladino^{2,3,5}, Giuseppe Falci^{2,4,5}, Mauro Paternostro¹ and Alessandro Ferraro¹

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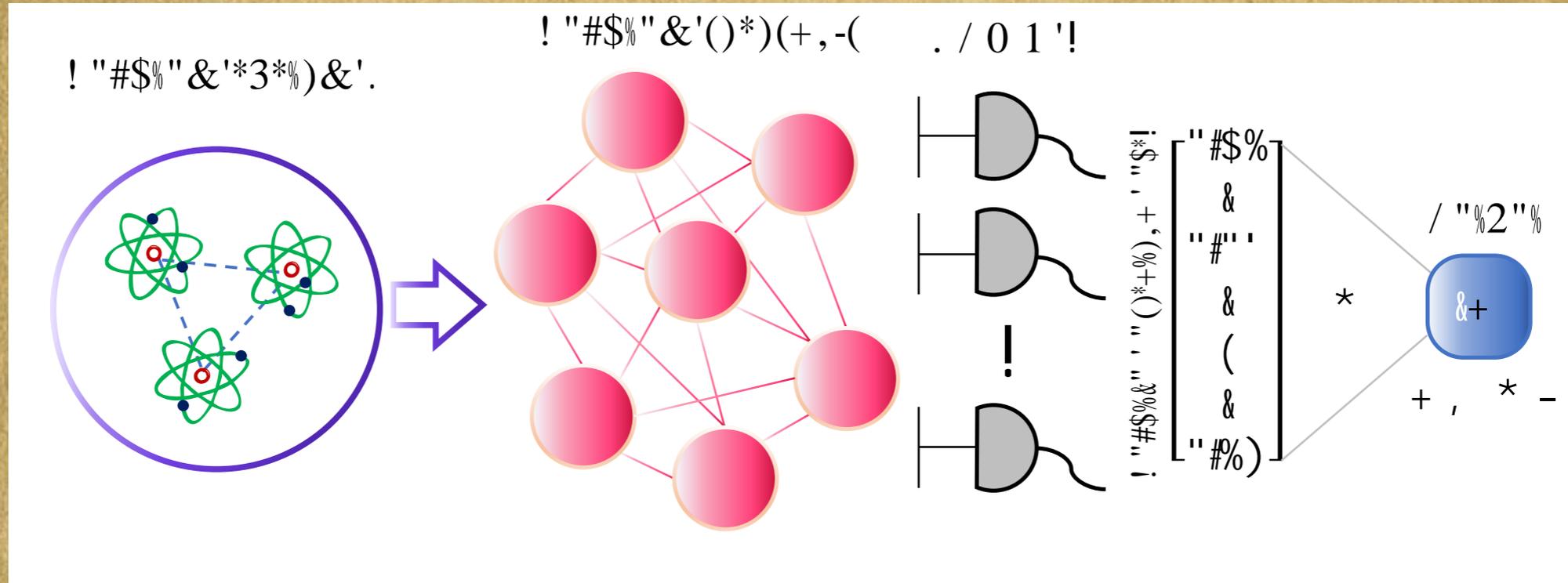
New Journal of Physics, Volume 23, September 2021



Optimising transport in nanostructure (Mauro)

Optimising efficiency of nano thermal machines (Gabriele)

Current interests & strengths





Funding portfolio



Many-body quantum engines
Non-equilibrium steady states of quantum many-body systems
+ International Network on Space Quantum Technologies & Levitation Network for Advanced Quantum Technologies

Convergent Quantum REsearch Alliance in TElecommunications (CoQREATE) & A Unified Framework for the Emulation of Classical and Quantum Physical Layer Networks



Royal Society Wolfson Research Fellowship (ExTraQT)
Bilateral research exchange grant with ICTP

Ultracold Quantum Engines (UltraQuTe)
& Interdisciplinary Network on Algorithmic Solutions



Complex Nano-photonics
for a quantum internet



Multi-time correlations in
open quantum systems



Testing large-scale limit
of quantum mechanics



Quantum control of gravity
with levitated mechanics



Funding portfolio



Overall current funding portfolio ~ 3M GBP



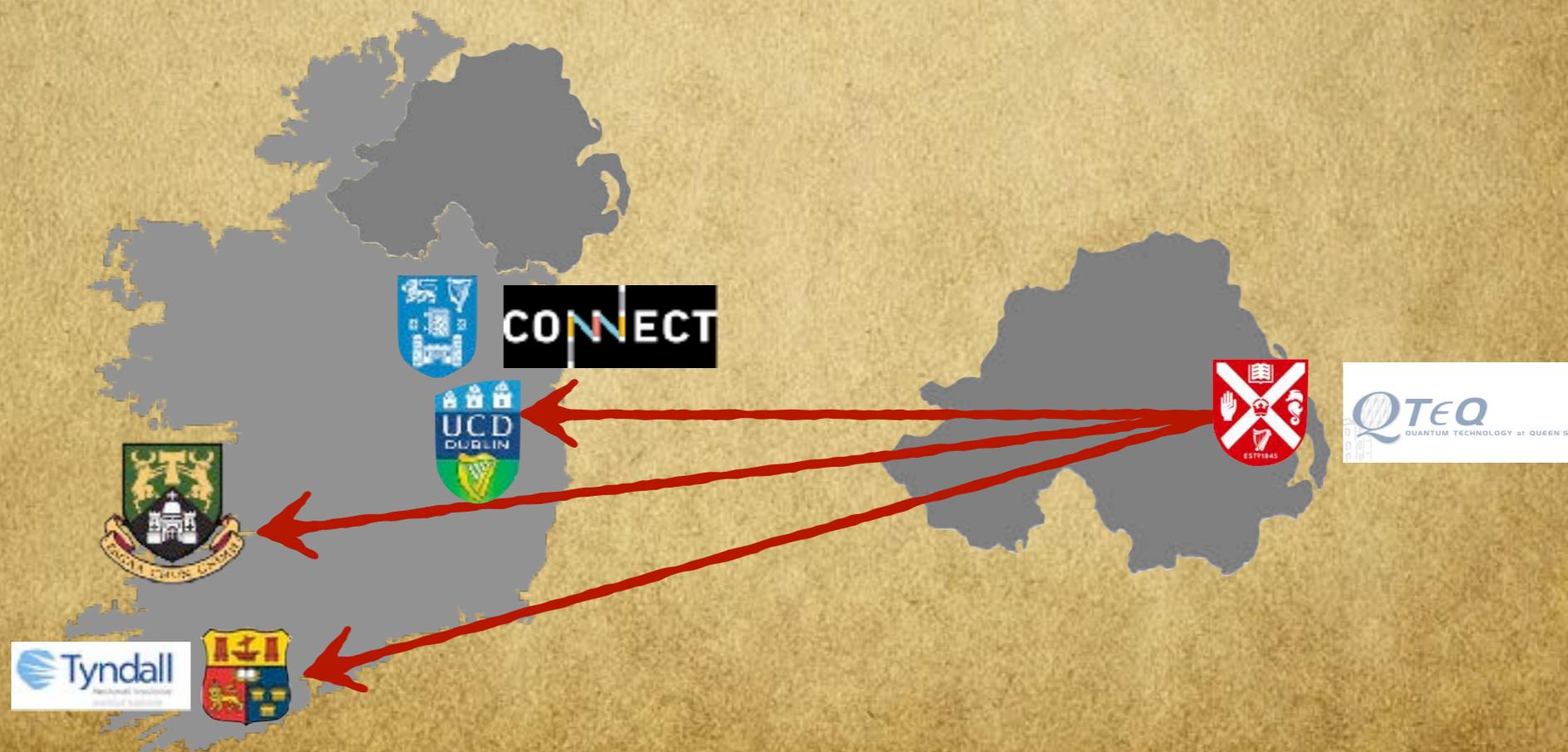
- CCPQ**
- INSQT**
- LeviNet**
- QTSPACE**
- UNIKORN**



Funding portfolio



Overall current funding portfolio ~ 3M GBP



THANK YOU