WINQ/Quantum

Wallenberg Initiative on Networks and Quantum information

Nordita Day of Open Doors

4th December 2025

What is WINQ?

WINQ | Wallenberg Initiative on Networks and Quantum information

NORDITA
The Nordic Institute for Theoretical Physics

Quantum Information

Thermodynamics

Quantum metrology

Measurements

Gaussian states

Qubits

Quantum optics

Complex Dynamical Networks

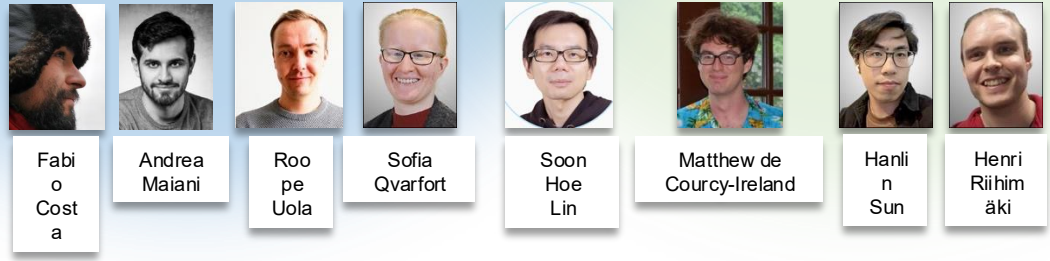
Networks

Stochastic processes

Graph theory

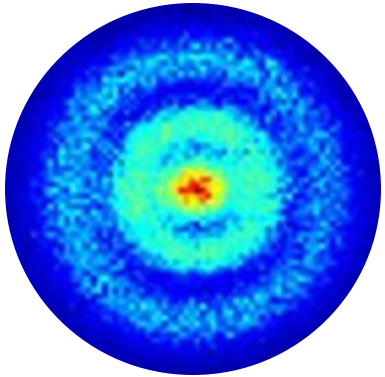
Percolation

Machine learning



Fabio Costa | Andrea Maiani | Roope Uola | Sofia Qvarfort | Soon Hoe Lin | Matthew de Courcy-Ireland | Hanlin Sun | Henri Riihimäki

Quantum information theory



The study of quantum systems from an information-theoretic point-of-view

Quantum Computing

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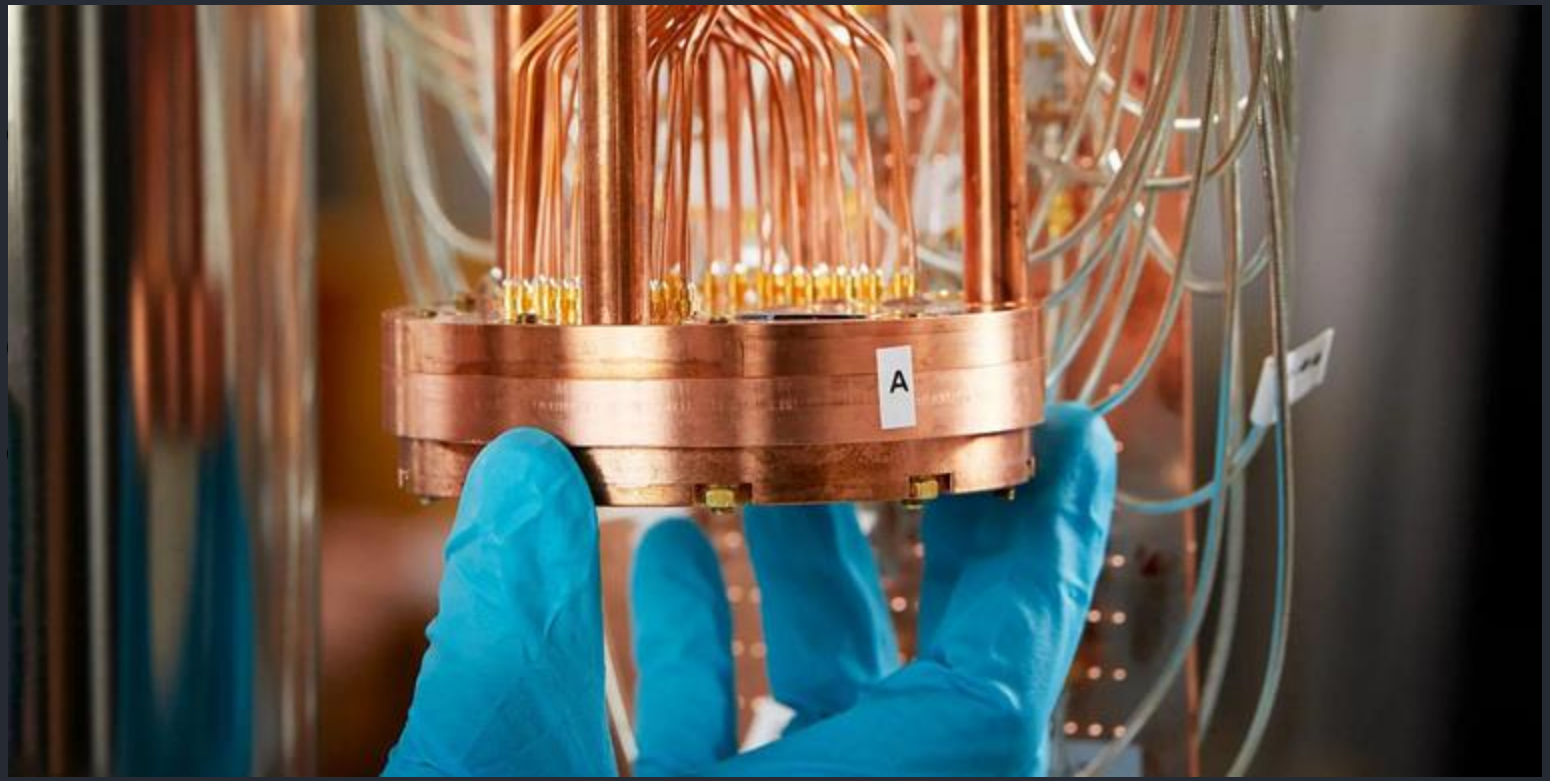
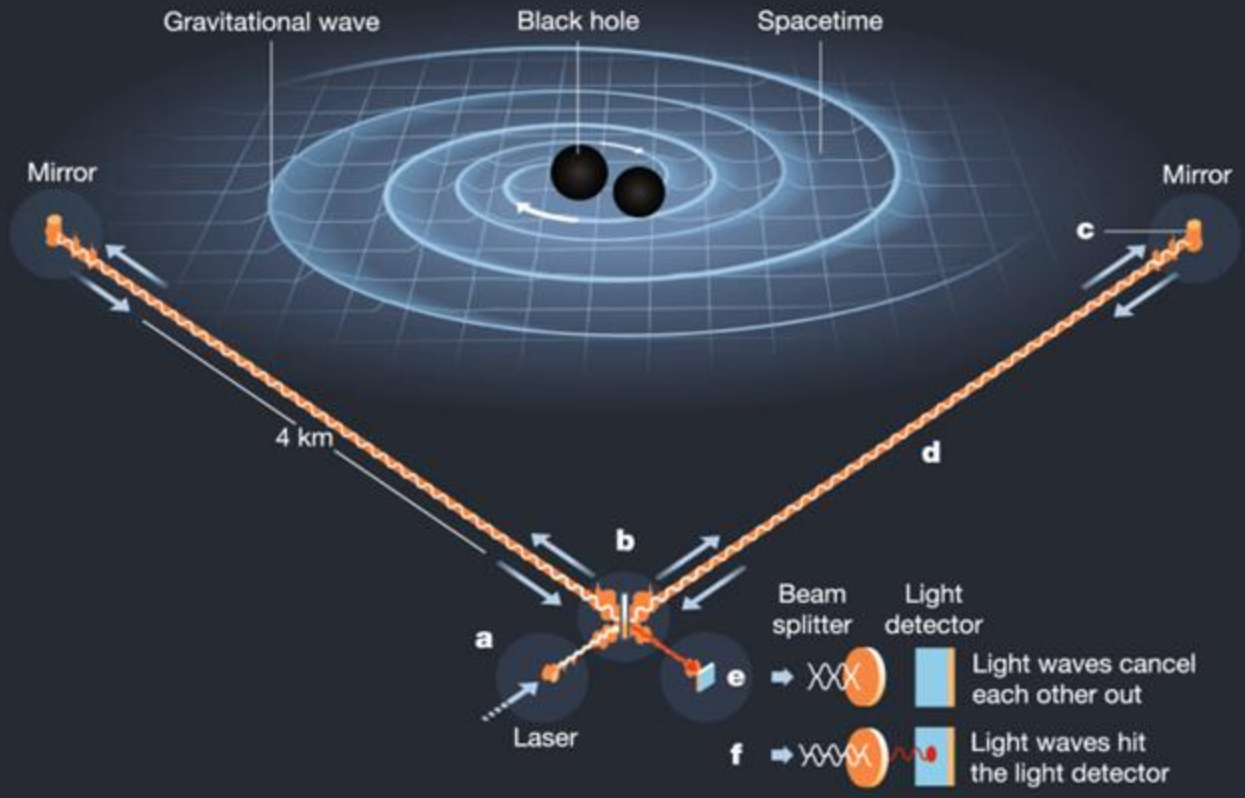


Credit: WACQT quantum computer

Quantum Sensing



Credit: LIGO collaboration

Quantum Communication

Credit: PhysicsWorld

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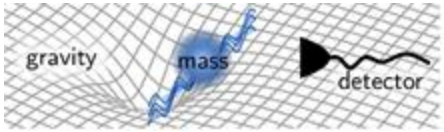
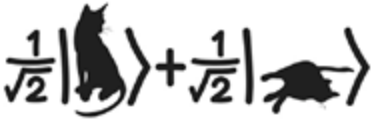


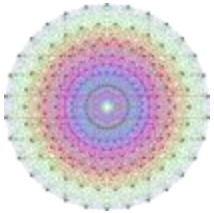
Topics: Quantum optics, quantum information, quantum metrology, quantum optomechanics

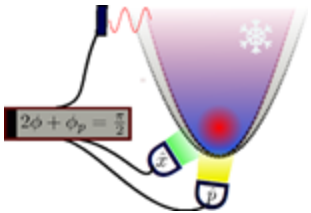
- *SQ, et al. "Gravimetry through non-linear optomechanics." Nat. Comms. 9.1 (2018): 3690.*M. Araújo, F. Costa, Č. Brukner, Phys. Rev. Lett. **113**, 250402 (2014)
- *Manikandan, Sreenath K., and SQ. "Optimal quantum parametric feedback cooling." PRA 107.2 (2023): 023516.*

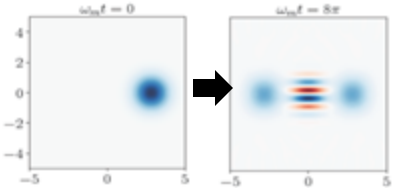


Available projects:

- Probing the Quantum Energy Landscape of a Superconducting Qubit: Josephson Potential Tomography via Dynamics
- How cold can you go? Cooling levitated nanoparticles in the presence of a stochastic force







Andrea Maiani
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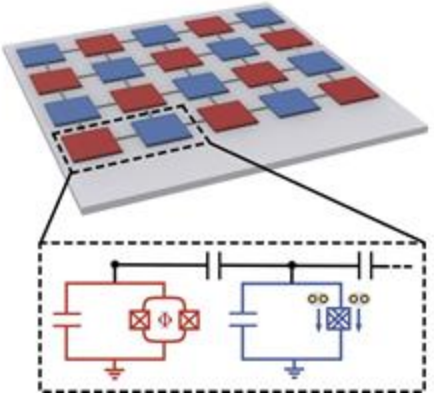
Topics: Quantum transport, complex heterostructures, superconducting qubits

Available projects:

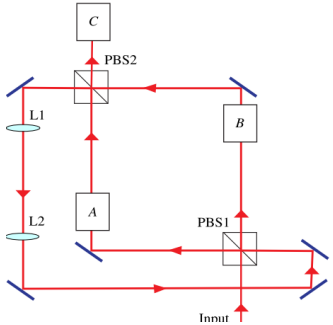
- Exploring quantum point contacts with neural networks
- Probing the Quantum Energy Landscape of a Superconducting Qubit: Josephson Potential Tomography Dynamics



Fabio Costa
fabio.costa@su.se

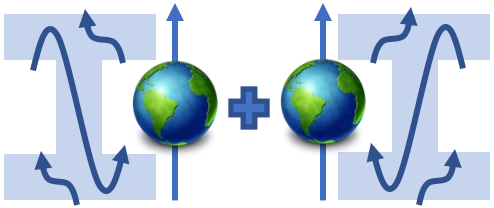
Topics: Quantum causal structures, new resources for quantum computing, memory in open quantum systems

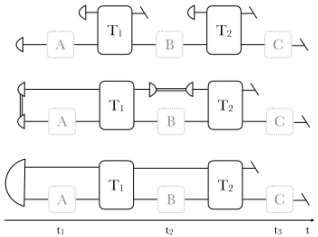
- *O. Oreshkov, F. Costa, Č. Brukner, Nat. Commun.* ***3****, 1092 (2012)*
- M. Araújo, F. Costa, Č. Brukner, Phys. Rev. Lett. **113**, 250402 (2014)
- *C. Giarmatzi, F. Costa, Quantum* ***5****, 440 (2021)*



Available projects:

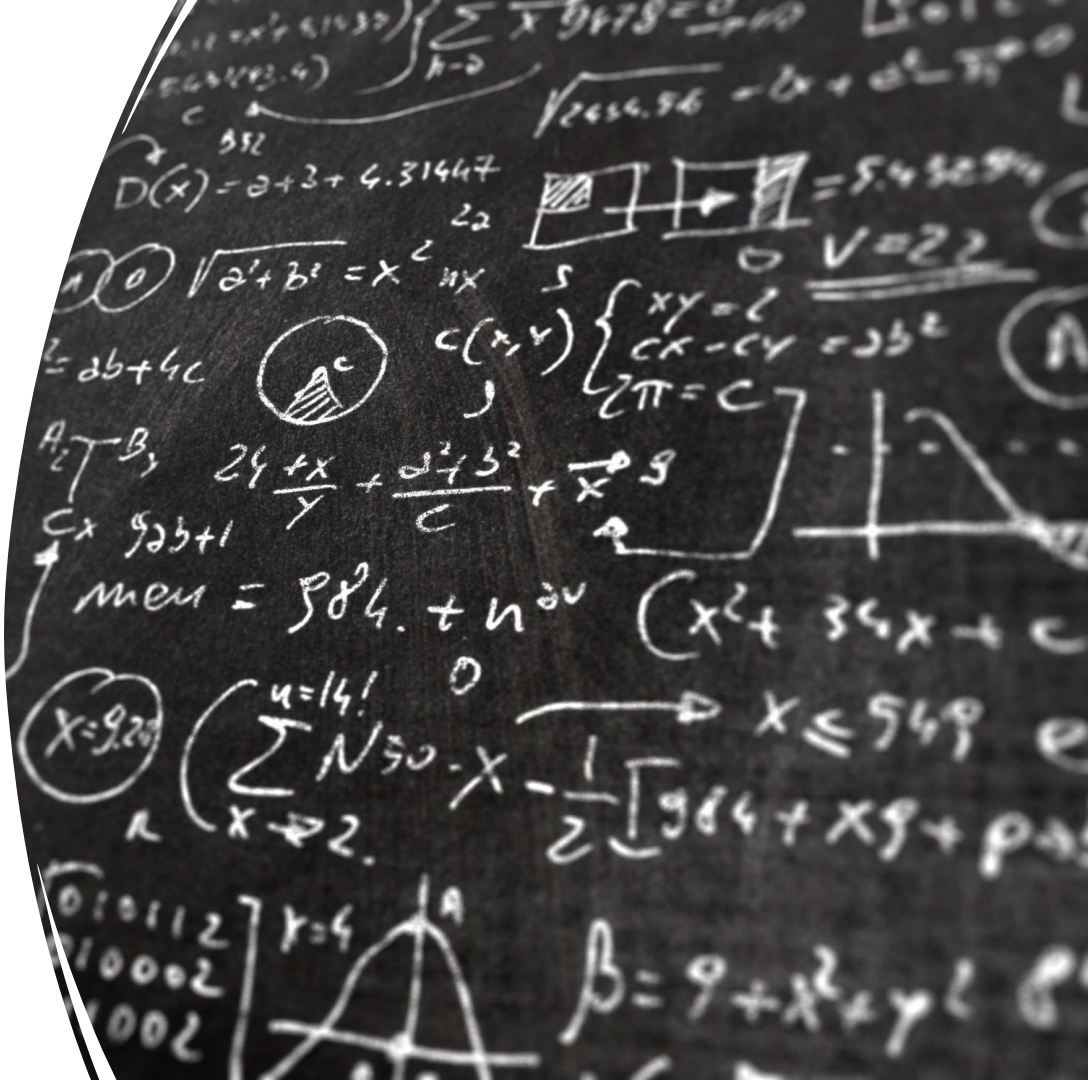
- Coarse graining and delocalised subsystems in quantum causal structures
- Information measures on quantum causal structure
- Characterisation of memory in multi-time quantum processes



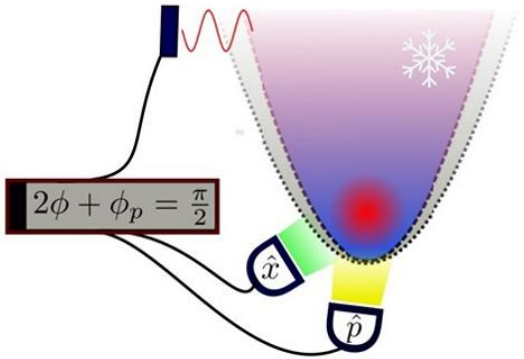


Possible projects

Offered by the WINQ quantum team. Contact the supervisors for more information.



How cold can you go? Cooling levitated nanoparticles in the presence of a stochastic force

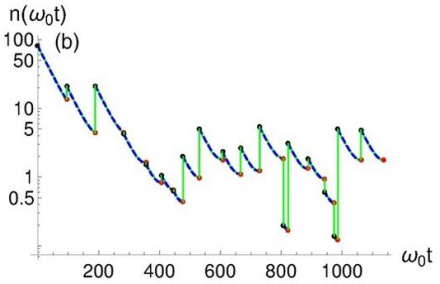


Supervisor: Sofia Qvarfort

Key goals:

1. Study a parametric feedback protocol for cooling levitated nano-particles to the quantum ground state
2. Solve the quantum dynamics for an additional stochastic force
3. Look at the resulting limitations in cooling

Strong analytical project (possibly experiment-facing)



Probing the Quantum Energy Landscape of a Superconducting Qubit

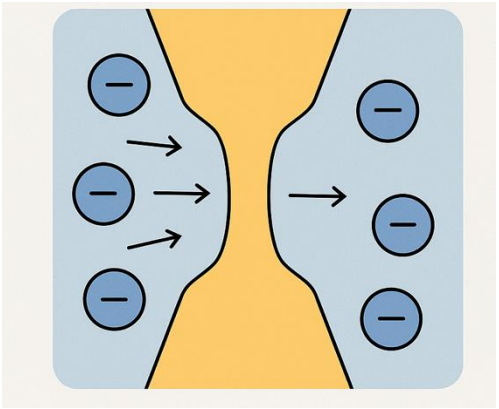
Supervisors: Sofia Qvarfort and **Andrea Maiani**

Key Goals:

1. Model the dynamics of a superconducting transmon qubit for two different Hamiltonians
2. Use quantum metrology tools to distinguish between the Hamiltonians
3. Compare with microwave spectroscopy
4. Implement hypothesis testing for Hamiltonian learning

Strong analytical and numerical project (possibly experiment-facing)

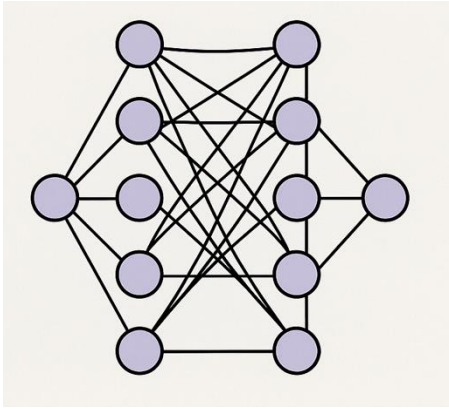
Exploring quantum point contacts with neural networks



Supervisor: Andrea Maiani

Key goals:

1. In this project we will study interacting QPCs using Neural Network Variational Monte Carlo, a modern approach that is reshaping many-body physics.
2. Diffusive superconductors are described by the Usadel equations, a powerful framework for modeling inhomogeneous superconducting devices with magnetism, disorder, and spin-orbit coupling.
3. This project focuses on extending pyUsadel code into a finite-element framework, enabling simulations of complex geometries and multicomponent superconductors.
4. Strongly computational project, with emphasis on scientific software development.



andrea.maiani@su.se, www.andreamaiani.com (find more details on the website!)

Coarse graining and delocalised subsystems in quantum causal structures

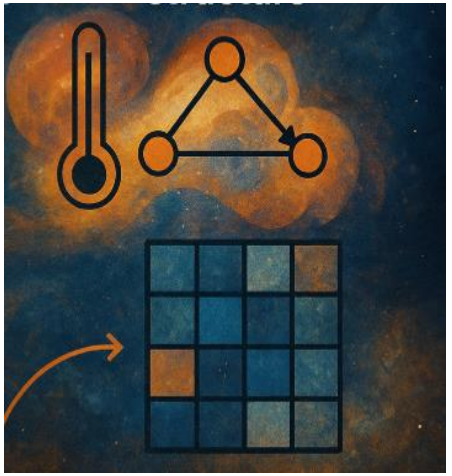
Supervisor: Fabio Costa

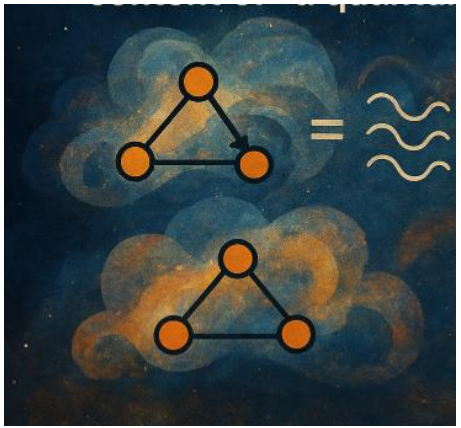
1. Instants of time as subsystems.
2. Quantum temporal subsystems: events with indefinite time.
3. Coarse-grained operations with definite and indefinite causal structure.

Information measures on quantum causal structure

Supervisor: Fabio Costa

1. Assign entropy to—quantify informational content of—a quantum causal structure.
2. “Thermodynamics” of quantum causal structure.
3. Partial tomography of quantum causal structures.

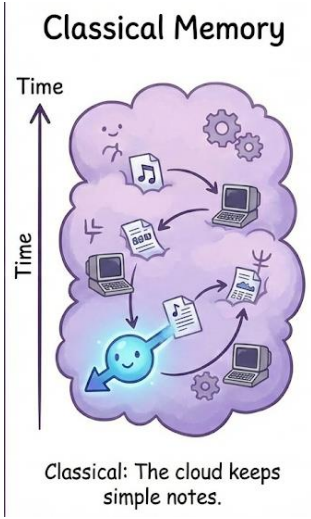


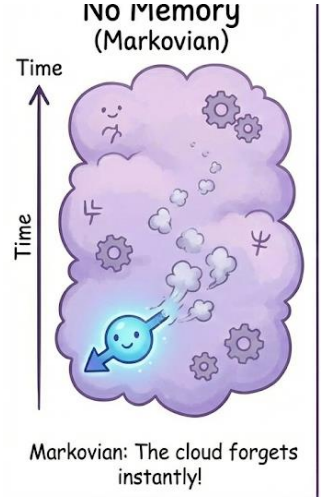


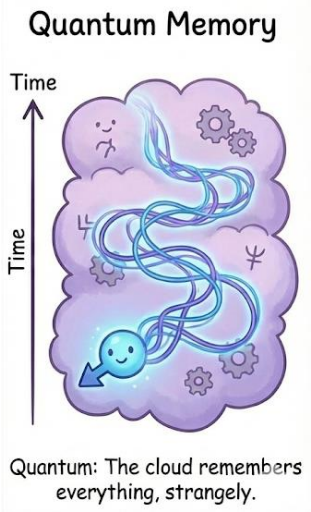
Characterisation of memory in multi-time quantum processes

Supervisor: Fabio Costa

- Characterise processes with quantum vs classical memory.
- Real-world multi-time processes, e.g. optomechanics (possible interaction with experiments)
- Multi-time tests of quantumness—tests of non-classicality of gravity.







Thank you!

Please come say hi in Hus 3!

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fabio.costa@su.se