

QUANTUM TECHNOLOGIES

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Physics Division, School of Science and Technology

Permanent staff: 19; Postdocs and PhDs: 16



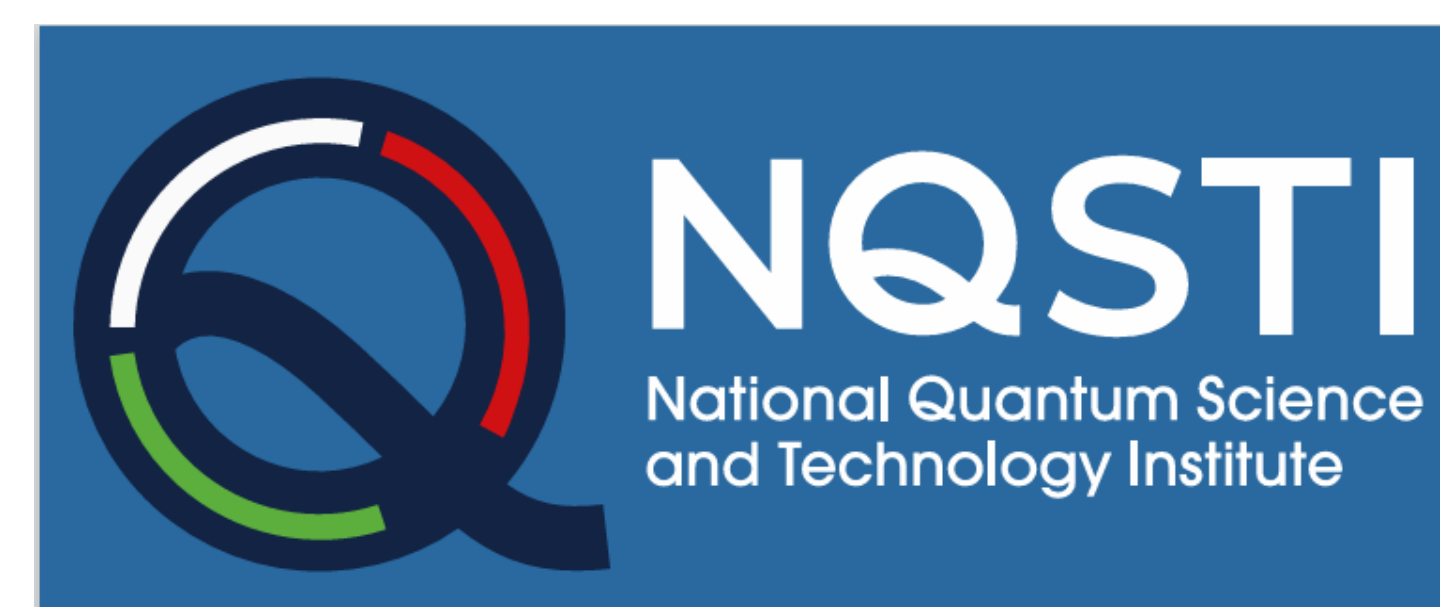
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Abstract

The UNICAM Physics Division has been working on quantum information and quantum technologies for almost 30 years. Involved in many European projects (six in the last ten years). The Master degree in Physics includes a curriculum in Quantum Technologies, and UNICAM is part of a national consortium awarding a PhD in Quantum Technology.

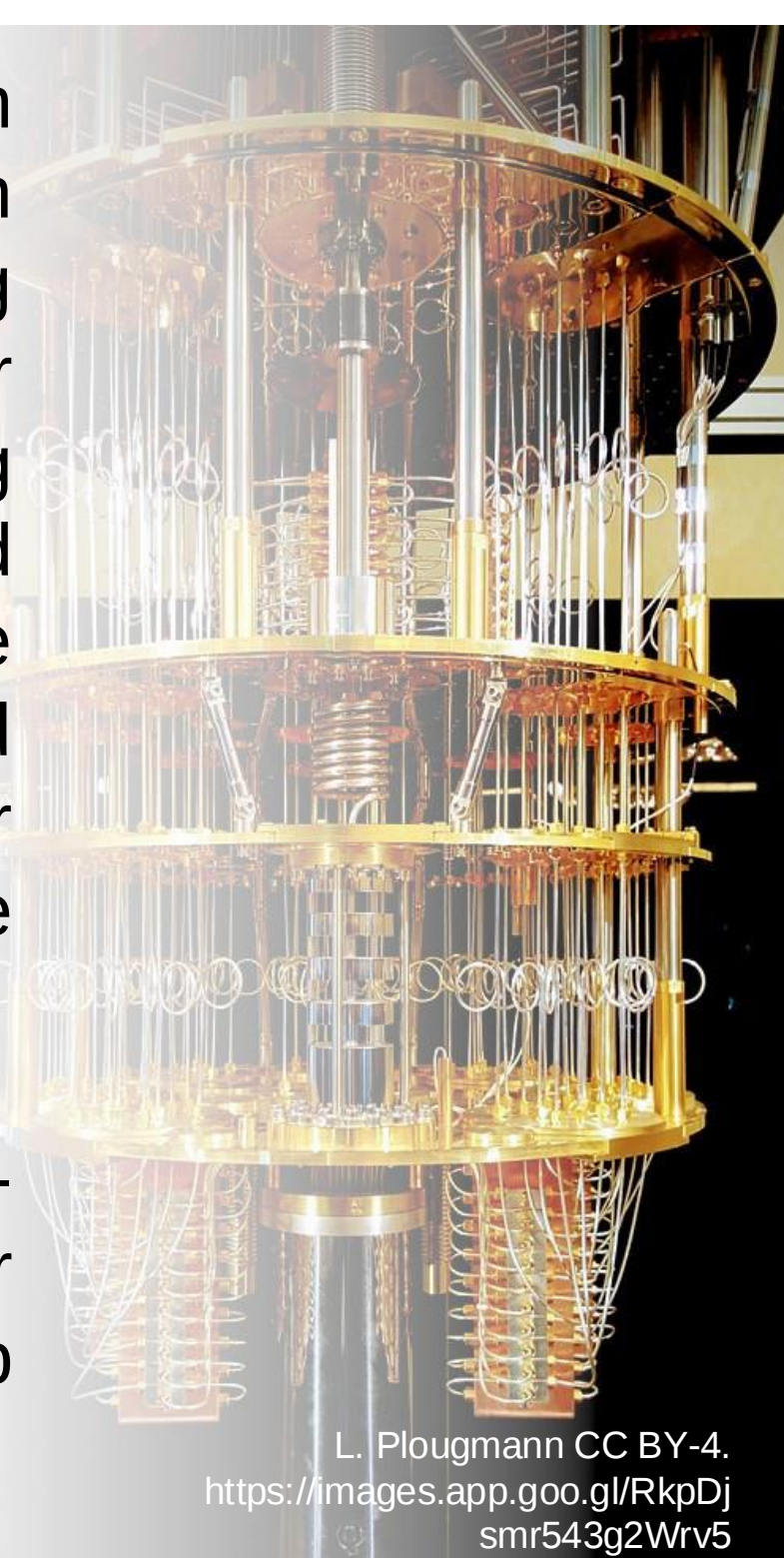
UNICAM has been the **proposing institution of the Extended partnership program “National Quantum Science and Technology Institute” (NQSTI)**, funded within the NextGenEU PNRR MUR program, and involving 18 research institutions and 2 major private companies. Linked with the **EU Quantum Flagship**.



Quantum flagship pillar 1 - Quantum computation

Quantum computers process quantum information and execute algorithms on quantum hardware (e.g., superconducting devices, photons, atoms) to outperform or accelerate classical computers in solving problems relevant to industry, science, and technology. Quantum advantage can take the form of faster problem-solving, improved accuracy, reduced energy consumption, lower operational costs, or combinations of these benefits.

UNICAM activity: improving noisy intermediate-scale quantum (NISQ) devices through error mitigation, hybrid approaches based on deep learning, and quantum error correction codes.

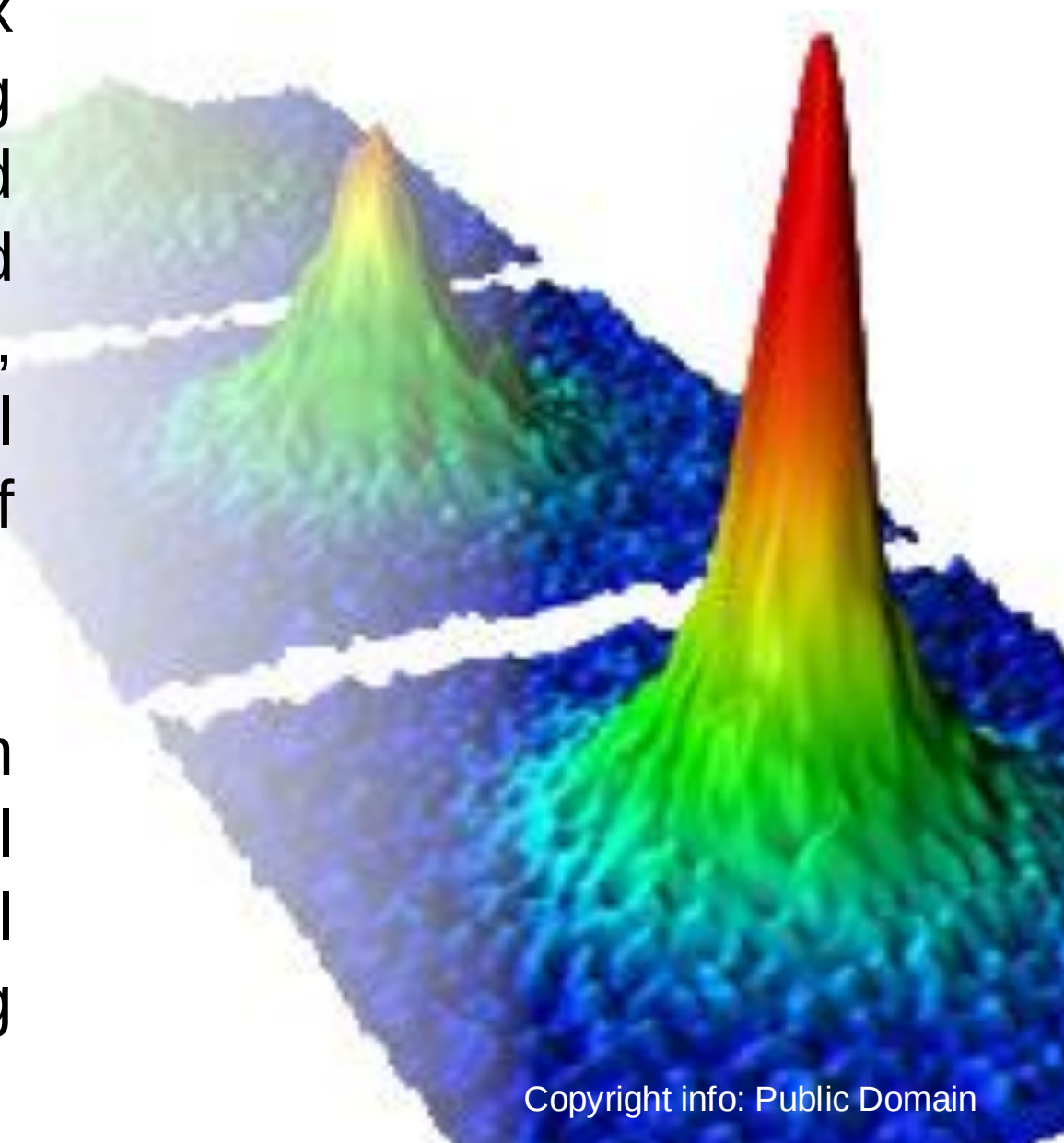


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Quantum flagship pillar 2 - Quantum simulation

Engineered quantum systems are used to model and study complex quantum phenomena addressing computational challenges beyond classical capabilities. It can find application into quantum chemistry, materials science, fundamental physics, and in the development of new technologies.

UNICAM activity: exploit quantum data for training classical neural network, tackling computational problems which are overwhelming for classical computers.

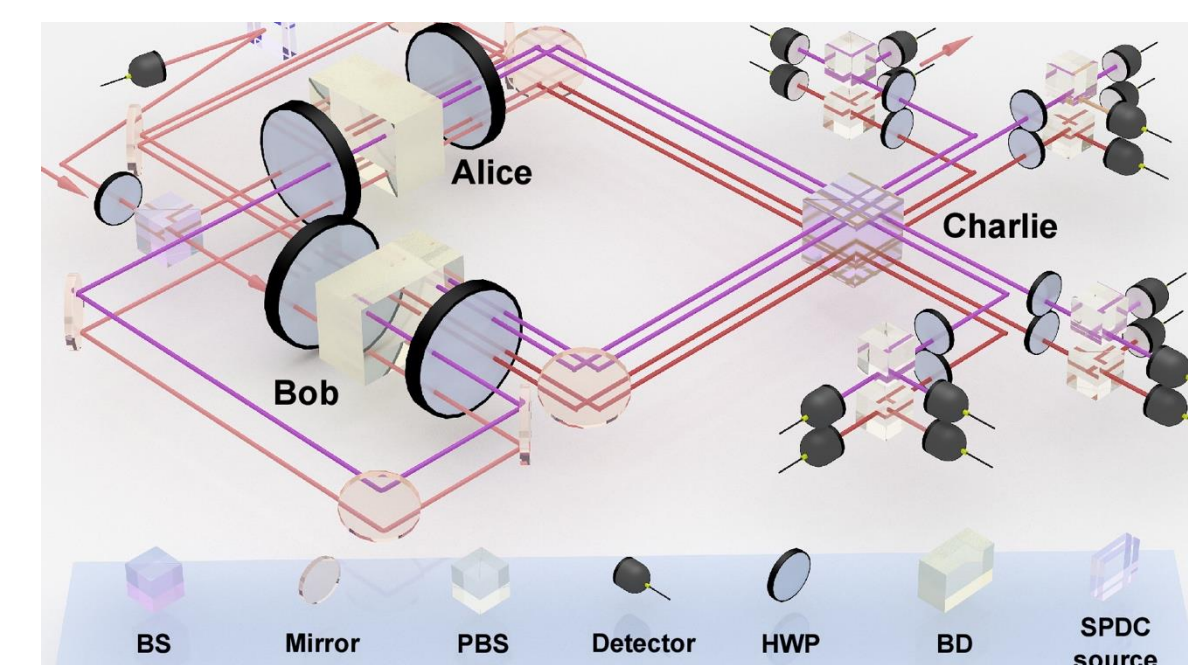


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Quantum flagship pillar 3 - Quantum communication

Designing hardware, tools, and protocols to exchange quantum information among distant users, paving the way for a Quantum Internet. Key goals: i) secure communication via quantum key distribution and cryptography, ii) long-distance entanglement distribution, iii) efficient quantum signal transduction at different wavelengths.

UNICAM activity: nanomechanically-mediated optical-microwave reversible quantum transduction, quantum cryptography protocols and channel characterization.

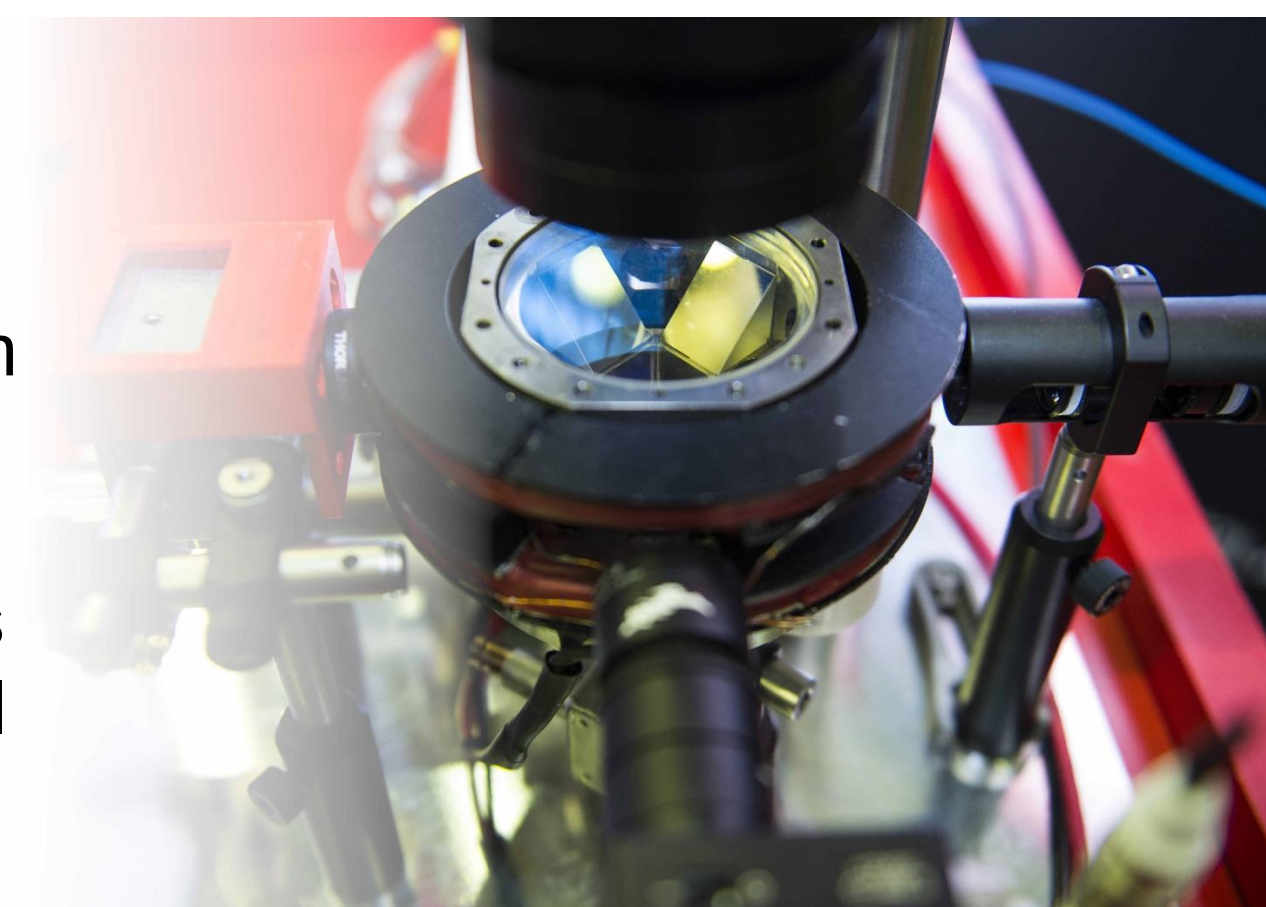


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Quantum flagship pillar 4 - Quantum sensing

Quantum sensors and imagers, use quantum systems and processes, including quantum engineered states (squeezed, multipartite entangled states), for enhanced accuracy and precision measurements, enabling sub-shot noise microscopy, or quantum-based super-resolution imaging. Applications include medical diagnostics and imaging, high-precision navigation, and Earth observation.

UNICAM activity: quantum-based target detection and ranging (Quantum radar); quantum-limited detection of weak forces and displacements for the detection of gravitational waves and testing quantum gravity.



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TRANSVERSAL ASPECTS - Quantum Resources and Societal Impact - UNICAM activity in:

Basic science: Broadening the boundaries of quantum mechanics for quantum technologies. Basic research for quantum information theory. Energy cost of quantum information processing.

Education and workforce development: Outreach and quantum awareness among the public, government, and industry; raising the interest of high-school students, novel approaches for improving early education of quantum physics; addressing teachers and other education professional to bring awareness of the emerging field of quantum technologies.

Sources of funding:

EU (EIC, MSCA, COST)

National (MUR Prin, INFN, CNR, Min Difesa)

International organizations (FQxi)

International collaborations:

University of Wien, Delft University of Technology, University of Hannover, Aalto University, EPFL Lausanne, University of Barcelona, IBM Zurich, University of Copenhagen, IST Austria, University of York, DTU Lingby, CNRS Institute d'Optique, Olomouc University, Université Sorbonne, Université Paris, Max Planck Institute Erlangen, Technical University of Munich, U. of Zurich

