Q@TN COLLOQUIUM

Controlling the Quantum: A Mathematical viewpoint

SPEAKER

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28 April 2026 **14:00** **Aula A208** – Povo 1, Via Sommarive 5

ABSTRACT

The successful development of quantum technologies relies on the ability to precisely manipulate quantum states, whether for executing high-fidelity quantum gates, for preparing specific initial conditions, or for protecting the states from decoherence. In practice, this manipulation is achieved through the careful design of external fields, such as laser pulses or microwaves, or by suitably engineering the interaction between the system of interest and the environment or other auxiliary systems (ancillas).

Control Theory is a well-established discipline that has successfully addressed the systematic manipulation of dynamical systems across numerous fields of science and engineering. This seminar explores how this formal framework can be extended to the quantum domain, providing a rigorous methodology to account for the unique physical (and mathematical) peculiarities of quantum systems. We will treat a quantum system as a dynamical system driven by external control parameters.

The presentation will introduce two fundamental concepts in an intuitive manner:

- **Controllability:** Exploring the fundamental limits of our interventions, namely understanding whether a system can theoretically be steered from an initial state to a desired target state given the available interactions.
- **Optimal Control:** The formal frameworks used to find the most efficient strategies to achieve this transfer, such as minimizing operation time or maximizing gate fidelity in the presence of constraints.

By bridging quantum mechanics and mathematical control theory, this seminar aims to broaden the available theoretical toolkit, providing a systematic approach to the design and optimization of modern quantum hardware.

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With the financial support of