UNIVERSITÀ DI PAVIA

Dipartimento di Fisica

# Dottorato di Ricerca in Fisica

Academic Year 2024/2025

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| **Title:** | ***Advanced topics in quantum information theory*** |
| **Lecturers:** | P. Perinotti, A. Bisio, A. Rotundo, D. Poderini |
| **Duration:** | 24 - 28 hours |
| **CFU:** | 4 |
| **Period:** | March - May 2025 |

**Content:** The course will cover various aspects of the theory of quantum networks. In the first part we will introduce the general theory of networks of quantum processes and their applications, and higher-order processing involving indefinite causal order. In the second part we will review the formalism of quantum causal models for causal discovery and their application to the derivation of generalized Bell-like inequalities. In the final part we will introduce the formalism of tensor networks with special focus on matrix product states, with consequent techniques for simulation of many-body systems.

Module I (2 lectures) The theory of networks of quantum processes.

Module II (2 lectures) Higher-order quantum theory and indefinite causal order.

Module III (3 lectures) Quantum causal models.

Module IV (5 lectures) Tensor networks, matrix product states, applications to quantum simulation.

**Notes** The evaluation will be based on the presentation of a topic treated during the course, or a small project developed with the tools learned during the course.