

**Selected Topics in Theoretical Physics:
Introduction to Multipartite Quantum Entanglement and Non-Locality**

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Lectures take place in the building of Institute of Physics PAN (details will be provided soon). In special circumstances, some lectures might be conducted online (via Zoom) and the appropriate technical details will be provided in a separate message.

Topics covered by the lecture:

Part I – Multipartite Quantum Entanglement

- Hilbert space formalism. Pure and mixed state (qudit). Schmidt decomposition. Purification.
- Tensor structure, partial operations and LOCC paradigm.
- Quantum measurement. Two-body quantum entanglement. Bell states.
- Multipartite quantum entanglement, genuine multipartite entanglement.
- Detection, monogamy and measures of entanglement.
- Special classes of highly entangled quantum states and bound entanglement.
- Graphs states, stabilizing formalism, Clifford algebras, Weyl-Heisenberg groups.

Part II – Introduction to Quantum Non-Locality

- Application of multipartite quantum entanglement in quantum computing (quantum algorithms).
- Bell Inequalities (CHSH Inequality). Sum-of-Squares decomposition.
- Certification of quantum states, measurements and randomness.
- Self-Testing quantum devices and robustness to noise.

Bibliography:

- John Watrous “*Lecture Notes*” <https://johnwatrous.com/lecture-notes/> (2025)
- Michael Nielsen and Isaac Chuang „*Quantum Computation and Quantum Information*” Cambridge University Press (2010)
- Valerio Scarani, „*Bell Nonlocality*” Cambridge University Press (2019)
- Teiko Heinosaari and Mário Ziman „*The Mathematical Language of Quantum Theory, From Uncertainty to Entanglement*” Cambridge University Press (2011)