Course Title:
Selected Topics in Theoretical Physics: Theory of Open Quantum Dynamics

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Fridays, 16:00-18:00, room A of the Institute of Physics PAS (IF PAN)
First lecture: 02 October 2026
Duration: 30 hours (15 x 2h).

Requirements: Basic knowledge of quantum mechanics, linear algebra and Hilbert spaces.

1. **Closed vs. Open Dynamics:** Unitary evolution, pure vs. mixed states, and environment interaction
2. **System-Environment Dynamics:** Born-Markov approximation and Lindblad Master equation
3. **Quantum Channels:** CPTP maps and Kraus operators
4. **Channel Representations:** Vectorization, Stinespring dilation and Choi-Jamiołkowski isomorphism
5. **Markovian Dynamics:** Dynamical semigroups and memoryless maps
6. **Divisibility:** CP-divisibility and non-Markovian dynamics
7. **Spectral Properties of Liouvillians:** Superoperator spectra and Jordan blocks
8. **Decay Timescales:** Spectral gaps and relaxation rates
9. **Asymptotic Behavior:** Steady states and decoherence-free subspaces
10. **Thermalization:** Thermodynamic equilibrium and KMS states
11. **Capacity of quantum channels:** Classical and quantum information against noise, asymptotic capacities

Literature:
D. Chruściński, *Dynamical maps beyond Markovian regime*, Physics Reports, **992** 1 (2022).
H.-P. Breuer and F. Petruccione, *The theory of open quantum systems*, Oxford, (2007).
M. M. Wolf, *Quantum Channels & Operations Guided Tour*, Online Lecture Notes (2012).