

## Open Quantum Systems

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**Subject area:** Physics

**University:** CTU  
**Level:** BA4, MA all years, PhD  
**Teaching mode:** completely online, at specific time  
**Instructor(s):** Jaroslav Novotný

### Short description

Any quantum system is inevitably in contact with its environment. This is responsible for decoherence, dephasing, thermalization, synchronization, and other natural processes. Within the course we provide a theoretical framework for possible state changes and show its different representations. We develop theory of quantum dynamical semigroups, derive their master equations and theory for their asymptotics.

### Full description

In the course students will be introduced to quantum description of composite systems and their subsystems, pure and mixed states, quantum correlations, quantum entanglement, its key properties and applications in open quantum systems. Afterwards introduction to theory of generalized quantum measurement will be given. It includes positive operator-valued measure, physical realizations and application to quantum state discrimination. Further we will develop superoperator theoretical framework and based on that quantum operations as the most general description of state changes are introduced. Its main representations will be presented together with explicit examples of quantum operations. Finally concepts of quantum dynamical semigroups and quantum Markov evolutionary families will be introduced, master equation for these continuous quantum Markov processes will be derived and simple models for description of decoherence and thermalization will be shown.

### Learning outcomes

Ability to use superoperator formalism and consequently understand and efficiently work with open quantum systems.

### Recommended in particular for students of the following study programmes

Quantum technologies, mathematical physics, quantum electronics

## General information

<b>Contact hours per week:</b>	2
<b>Total workload:</b>	50 (in student hours for the whole course)
<b>ECTS credits:</b>	2
<b>Language:</b>	English
<b>Course start date:</b>	20 February 2023
<b>Course end date:</b>	28 May 2023
<b>Add. info about start date:</b>	Start date course refers to the date of start of the semester at CTU.
<b>Weekly teaching day/time:</b>	
<b>Time zone:</b>	CET (Denmark, Germany, France, Netherlands, Switzerland, Czech Republic)
<b>Further information:</b>	Lectures may be recorded on request, notes from lectures can be downloaded.
<b>Prerequisites:</b>	Knowledge of quantum mechanics.
<b>Activities and methods:</b>	Lectures
<b>Presence on campus:</b>	

## Final examination

<b>Form:</b>	written and oral exam
<b>Date:</b>	
<b>Location/format:</b>	online
<b>Re-sit possibility:</b>	yes
<b>Transcript available:</b>	end of semester
<b>Add. info/requirements:</b>	

## Registration

To register for this course, follow the registration requirements of your **home university** as specified here: [www.euroteq.eu/courses-registration](http://www.euroteq.eu/courses-registration).

## Administration

<b>Number of places:</b>	30
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**Minimum participants:** 1  
**Internal course code:** 02OKS  
**Contact:** jaroslav.novotny@fjfi.cvut.cz

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