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| **Course title** | **Introduction to theory of open quantum systems** |
| **School name and date** | Quantum Dynamics and Open Systems 14-25.08.2022 |
| **Teaching staff** | dr Krzysztof Szczygielski |
| **Forms of classes, the realization and number of hours**  |
| 1. **Forms of classes**
 | Online lectures and problem solving sessions. |
| 1. **The realization of activities**
 | online |
| 1. **Number of hours**
 | 30 (20 hrs of lectures and 10 hrs of problem solving sessions) |
| **Suggested prerequisite knowledge** |
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| **Brief description of the course** |
| During the course, students will have an opportunity of learning fundamental ideas and techniques utilized in a theory of open quantum systems. The course will start with a short mathematical introduction providing necessary theoretical background, followed by the main part devoted to most important, selected aspects of open quantum systems theory. In particular, students will learn the general model of open quantum system and a reduced density operator as its state, a concept of completely positive trace preserving map as a mathematical representation of system’s evolution and finally, the idea of Master Equation with special attention granted to the prominent Markovian approximation. Theoretical knowledge will be aided with a number of simple, computable examples and exercises. |
| **Course contents** |
| 1. Basic algebraic structures. Elements of a theory of ordinary differential equations.
2. Positive, *n*-positive and completely positive maps. Trace norm.
3. Characterization of complete positivity: Choi theorem, Kraus representation, Stinespring dilation theorem.
4. A concept of density operator, its properties and physical interpretation. Microscopic model of open quantum system.
5. Evolution od open quantum systems as a completely positive and trace preserving map. Master Equation and its general form.
6. Markovian approximation. Standard form of Markovian Master Equation. Quantum Dynamical Semigroup.
7. Weak Coupling Limit and Davies form of Markovian Master Equation.
8. Some generalizations: time-dependent generators, non-markovian evolution.
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| **Literature** |
| 1. R. Alicki, K. Lendi, *Quantum Dynamical Semigroups and Applications*, Springer-Verlag, Berlin Heidelberg 2007
2. H.-P. Breuer, F. Petruccione, *The Theory of Open Quantum Systems*, Oxford University Press, New York 2002
3. Á. Rivas, S. F. Huelga, *Open Quantum Systems. An Introduction*, Springer, Berlin Heidelberg 2012
4. I. Bengtsson, K. Życzkowski, *Geometry Of Quantum States*, Cambridge University Press, New York 2006
5. C. Chicone, *Ordinary Differential Equations with Applications*, Springer, New York 2006
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