

# CHEM 599: Theory of Open Quantum Systems

Unit value: 4 units  
Terms offered: Fall  
Grading: letter grade

## CATALOG DESCRIPTION:

The theory of open quantum systems, i.e., systems coupled to an environment, with applications to chemistry, physics, and quantum information processing.

INSTRUCTOR: Daniel Lidar (Chemistry & EE), SSC 609, x00198, [lidar@usc.edu](mailto:lidar@usc.edu)

GRADER: Alireza Shabani, SSC 602, [shabanib@usc.edu](mailto:shabanib@usc.edu)

## PREQUISITES:

A good knowledge of undergraduate quantum mechanics as taught in either Chemistry or Physics, and basic linear algebra. Graduate courses in quantum mechanics a plus.

## COURSE DESCRIPTION:

This course will provide a comprehensive introduction to the subject of open quantum systems. These are all real-life quantum systems, i.e., systems that interact with the surrounding environment. Typically the interaction leads to an effect known as decoherence, which means that a quantum system acquires some aspects of classical dynamics and states. To model this interaction various formal methods and approximation techniques have been introduced, which will be reviewed. This includes the operator sum representation, Markovian master equations, non-Markovian master equations, quantum trajectories, and more as time permits. Various applications will be discussed, with relevance to spectroscopy, condensed matter systems, and quantum information processing. The course will begin with a thorough review of the required mathematical background, which is mostly linear algebra. The introductory part will continue with a reformulation of quantum mechanics in terms of density matrices.

## RECOMMENDED LITERATURE:

- The Theory of Open Quantum Systems, H.-P. Breuer and F. Petruccione, (Oxford)
- Density Matrix Theory and Applications, K. Blum, 2<sup>nd</sup> Edition (Plenum).
- Quantum Noise, C.W. Gardiner and P. Zoller, 2<sup>nd</sup> Edition (Springer).

## CREDIT DISTRIBUTION:

- Homework: 30% (new assignment roughly every other week).
- Midterm exam: 20%
- Final project: 50%

## CLASS MEETING:

Tuesdays, 4-5, GFS 222  
Fridays, 4-6, SSL 150

AUDITING STUDENTS: Must submit homework assignments, exempt from exams.

**STATEMENT FOR STUDENTS WITH DISABILITIES:**

Any student requesting academic accommodations based on a disability is required to register with Disability services and programs (DSP) each semester. A letter of verification for approved accommodations can be obtained from DSP. Please be sure a letter is delivered to the instructor as early in the semester as possible. DSP is located in STU 301 and is open 8:30 a.m. – 5:00 p.m., Monday through Friday. The phone number for DSP is (213)740-0776.