PHYS 730: Theory of Open Quantum Systems

Spring 2020

Mondays, Wednesday, Fridays, 12:00pm-12:50pm,
KAP 138

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: Chris Sutherland, SHS 361, cjsuther@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. To model this interaction various formal methods and approximation techniques have been introduced, which will be reviewed. The goal of this course is to classify and describe these various methods and techniques, as well as implementing them to analyze various physical scenarios, with an eye towards quantum information processing. The course will finish with an end of semester project involving an evaluation of a research level problem in the field of open quantum systems, with the potential to develop a draft of an eventually publishable scientific paper on the topic.

RECOMMENDED LITERATURE:

- Lecture notes (will be distributed each class)
- The Theory of Open Quantum Systems, H.-P. Breuer and F. Petruccione, (Oxford)
- Density Matrix Theory and Applications, K. Blum, 2nd Edition (Plenum).
- Quantum Noise, C.W. Gardiner and P. Zoller, 2nd Edition (Springer).

CREDIT DISTRIBUTION:

• Homework (7 assignments): 2/3
• Final project: 1/3

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.

Week	**Start date**	**Chapter assignment and subject**
1	1/13	Review of Quantum Mechanics (depending on level of class)
2	1/20	Density Operators, **A1 due at end of week**
3	1/27	Composite Systems, Open System Dynamics, **A2 due**
4	2/3	Complete Positivity and Quantum Maps
5	2/10	Quantum Maps of a Qubit, **A3 due**
6	2/17	Quantum Maps from First Principles
7	2/24	Lindblad Equation Derivation I: Short Time Expansion, **A4 due**
8	3/2	Lindblad Equation Derivation II: Coarse Graining
9	3/9	Quantum Trajectories and Analytical Solution of General Lindblad Equation, **A5 due**
Spring Break March 15 – 22 **Potential Projects Ideas Given**		
10	3/23	Lindblad Equation Derivation III: Cumulant Expansion
11	3/30	Lindblad Equation Derivation IV: Born, Markov, and Rotating Wave, **A6 due**
12	4/6	Lindblad Equation Derivation V: Singular Coupling Limit
13	4/13	Nakajima-Zwanzig Equation, **Project topics and abstracts submitted, A7 due**
14	4/20	Time Convolutionless Master Equation
15	4/27	Post Markovian Master Equation
Final Projects Due: May 13th, 5pm		