Modern quantum optics:
from single atoms to many interacting spins, photons, or qubits

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Office Hours	Wed 12-2p or by appointment. may change to suit student schedules	**Classroom**	Keck 101, 10:50AM - 12:05PM TR

Topics:

Quantum states: spins and light. Interferometry and spectroscopy in the quantum limit. Light-matter interaction. Open quantum systems: dissipation & decoherence. Quantum phase space distributions.

Use of these ideas in quantum technology from single to many particles: quantum information, quantum simulation. Experimental settings: atoms, cavities, circuits, optomechanics, defects in solids, plasmonic nanostructures, …

Learning outcomes:

Can mathematically represent states of *open quantum systems*: quantum systems that are a subsystem of a larger quantum system or which have some classical uncertainty about them. Can derive evolution equations for a quantum system coupled to a bath. Can write down equations for atoms coupling to light in the continuum and optical cavities. Understand the time dynamics of canonical examples of atoms interacting with light.

Course credit: 3 semester hours

Text:

There will be reading assignments out of Scully and Zubairy and Misha Lukin's lecture notes, which are available online at http://lukin.physics.harvard.edu/wp-uploads/Papers/285b_notes_2005-1.Lily.pdf. However, you will find similar material in most quantum optics books. As such, there is no strictly required text.

Resources for the majority of the course:

Scully & Zubairy, *Quantum Optics*

Misha Lukin's notes (linked above)

Meystre & Sargent, *Elements of Quantum Optics*

Walls & Milburn, *Quantum Optics*

The new book by Gardiner and Zoller, *The Quantum World of Ultra-Cold Atoms and Light Book 1: Foundation of Quantum Optics* looks useful as well, though I haven't yet had a chance to go through it.

I intend to provide an exact schedule of topics by class date by the end of the first week of class.

Supplementary resources:

We will also touch on topics covered in Wiseman & Milburn, *Quantum Measurement and Control*, Nielsen & Chuang, *Quantum Computation and Quantum Information,* and Pethick and Smith, *Bose-Einstein Condensation in Dilute Atomic Gases.*

Homework and evaluation:

I will generally assign a homework each week on Thursday, due the following Thursday. Problem sets will be available both online and distributed in class. Students are encouraged to work together in approaching the problems, but should understand and write up their own solutions. A list of other students who they discussed with should be written at the end of the assignment.

Additionally, there will be a "teaser question" due at the start of each class, assigned during the previous class. These are simple, frequently conceptual, questions to guide reading and create discussion for the following class. They may be open ended. Full credit is given for thoughtful completion without regard to the correctness of the answer. No more than 5-10 minutes needs to be spent on them.

Grades, to zero'th order, are weighted with HW as 50%, teaser questions as 10%, the midterm as 15% and the final as 25%. Perturbative corrections come from my interactions with you during class and office hours, and can only improve your grade.

The Rice Honor Code applies to all of these assignments.

Videos:

We are equipped for the course to be digitally filmed. If this is done, the lectures could be provided on a private web page (e.g., owlspace) accessible only to the class. I expect this would be a useful resource. First, if you have to miss a class, you will be able to catch up. Second, it provides a way to review material (later in the course or after the course). You would also be "paying it forward," as this would be a useful resource for future classes, and for me to improve my teaching.

We will discuss this the first day and decide whether we want to utilize this resource.

Disability and accommodations:

Any student with a disability requiring accommodations in this class is encouraged to contact the instructor after class. Additionally, students should contact the Disabled Student Services office in the Ley Student Center.