Lecture 1

Formalities and Overview
Course Specifics

• **Title:** Quantum Mechanics for Engineers
• **Time:** MWF 9-9:50 am
• **Place:** ECCS 1B14
• **Website:**
What will be on the website?

- Course syllabus material as well as the syllabus itself
- Notes from the lectures
- Homework assignments and solutions
- Project assignments
- Occasional demonstration software
Instructor

- **Name**: Alan Mickelson
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- **Email**: alan.mickelson@colorado.edu
- **Official office hours**: 10-10:50 am MWF
Texts

- Robinett: Quantum Mechanics
- W. P. Schleich: Quantum Optics in Phase Space
Grading

• In class midterm: 25%
• In regular exam period final: 25%
• Homework: 25%
• Project: 25%
Homework details

- Biweekly (roughly) assignments to be discussed (to some extent) in class
- May be submitted electronically (pdf) whether handwritten (scanned) or processed
- Solutions will be posted and electronic comments submitted on each assignment handed in
Project details

- Will entail some aspect of quantum optical information transmission or processing
- There will be a due date (roughly) one week after the midterm for preliminaries and project proposal and a date the last day of class for the full project to be handed in
- There will be biweekly handouts (alternated with homework) describing the formalism and options
Some Course Overview

• Topical overview
• The why of these topics
• The what of these topics
• The why of the project
• A summary of the course plan in light of its purpose
Topical Overview

• Wave-particle duality
• Bound quantum mechanical states
• Quantum states of the electromagnetic field
• Interaction of quantized light and matter
Why These Topics?

- To investigate the solutions of 4 (of the ~ 5) “exactly” solvable problems in QM, solutions that are the same for QM particles and optical modes in paraxial waveguides.
- The QM states of the optical field identify how the information carried in the field can be transmitted, extracted,…
- One needs to use matter to manipulate the state of the optical field.
The What of These Topics

• The exactly solvable problems of coordinate representation wavefunctions (optical waveguide modes)

• The QM (energy representation) states of light

• Some dynamical problems of importance now and in the future
Exactly Solvable QM problems

• Free space propagation (diffraction and dispersion)
• Propagation in a periodic potential
• States of a square well
• States of a harmonic oscillator
• Hydrogen atom
Some QM states of light

- **Thermal**: tells the temperature and material composition of the radiating body and intervening space
- **Coherent**: the natural state of a laser that is used for optical communications, etc.
- **Squeezed**: the most easily generated quantum state (negative probabilities)
- **Qubit**: unit of quantum information
Generation of QM states of light

- Hot matter and thermal states—light bulbs and stars
- Classically pumped two level systems for coherent states—lasers
- Chi2 and chi3 for squeezing—measurement beyond the “quantum” limit (SQL)
- One two level for JCP generation of “cat” states—for quantum information processing
Quantum Information Processing (QIP)

- **What:** Use of the unique properties of quantum states to code, transmit and process information
- **Why:** Security, fidelity and processing power
- **When:** Quantum cryptography is in use over telephone lines already, although quantum computing is very much laboratory only
Summary

The course will cover basic concepts in (engineering) quantum mechanics with emphasis given to problems in optics in general and quantum optics in particular
How will optics be emphasized

- “The same equations have the same solutions” R. P. Feynman
- Diffraction, dispersion and waveguide modes will be discussed
- Schleich is a quantum optics text
- The project will cover some aspect of quantum information processing
The Game Plan for Next Time

• The form of the wave equation
• General solutions of the wave equation in terms of backward and forward going waves
• Waves in complex notation
• Wave packets and group velocity
• Fourier analysis
The Pieces of the Course

- Wave particle duality
- Bound states of quantum mechanical potentials
- Quantum mechanical states of optical radiation field
- Interaction of quantized light and matter
Assignment for Next Time

- Flip through Robinett to get a feeling for the text
- Look through homework assignment 1 that is due in two weeks
- Flip through chapter 1 w/wo too much comprehension
- Read some of chapter 2