Lecture 31

Some Overview
And Some Project
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
This quarter in Schleich

- Wigner functions (C3)
- Wigner representations of the states of light (C4)
- The classical-quantum transition (C5,C6)
- Squeezed states as phase space interference (C7,C8)
- Quantization of the electromagnetic field (C10)
Some Facts

- The purpose of the course is the project
- The project is 25% of the grade
- The final covers the midterm plus chapter 2 and the Wigner representation of Schleich
- Chapters after chapter 2 in Schleich depend on chapter 2 and not much else
- Schleich covers the topics you need to do your project better than other texts
Where We Have Been

• Chapter 1 was a whirlwind overview
• Chapter 2 of Schleich is a review except for the density matrix and the thermal field
• Chapter 3 defines the Wigner function but includes many details not necessary for your project or homework
• Chapter 4 defines the states of the EM field in examples
Last Friday’s Topics

• The Quantized EM field
• The density operator and the Wigner density for photon counting
• The thermal distribution of number states
• The coherent state
• The squeezed state from the coherent state
What we will not cover

- WKB for solving unsolvable problems except for summary pages 164-165 (C5)
- Adiabatic and non adiabatic phase (C6)
- Phase space interference (C7,C8)
- Wave packet dynamics (C9)
The Rest of this Week (C10)

- Field quantization
- Raising and lowering operators for the field
- The Casimir effect
- Field Operators
- Number states of the field
This quarter in Schleich

- Wigner functions (C3)
- Wigner representations of the states of light (C4)
- The classical-quantum transition (C5,C6)
- Squeezed states as phase space interference (C7,C8)
- Quantization of the electromagnetic field (C10)
The Last Quarter of the Semester

- Field States (C11)
- Phase space functions (C12)
- Optical interferometers (C13)
- Atom-field coupling (C14)
- The JCP model (C15)
Some Project Details

• Project write up should include both some review and some original work be they calculations or revelations

• Format should be that of a research article

• Psets from here on out will be taken from topics about Q info as well as problems in Schleich related to Q info

• Project topic should be a Q info topic related to an area in Schleich

• Project is 25% of the course grade
Book References for Project

• George Johnson
• John Gribbon
• John Bell
• Nielson and Chuang
Articles for Project

- Gisin
- Bennett
- Nielson (Scientific American)
- Centre for Q computing tutorials
- Schleich on what is a photon
- Feynman on QM simulation
Previous Project Discussion

- Polarization and polarizers
- Quantum cryptography (non cloning theorem)
- Qubits, Poincare spheres and decoherence
- Entangled Qubits and Bell States
- Teleportation and Dense Coding
Today’s Topics: Quantum Computing with Gate Realizations

• Single qubit logic gates
• Two qubit logic gates
• A Q Computer
• A very simple adder
• Realizations of the simplest gates of the simplest adder
Single Qubit Quantum Logic

- X
- Z
- S
- Y
- H
- T
Two Qubit Quantum Logic

A \rightarrow \text{CNOT} \rightarrow A \ (XOR) \ B

A \rightarrow A

B \rightarrow A \ (XOR) \ B
A Model for a Q computer

Unitarily Evolve

Feedback
Examples using polarization as well as quadratures (CVQC)

• A modulo two adder
• A modulo 4 adder
• An adder
• A Q FFT on three bits
• A Q FFT
• Shor’s algorithm