Lecture 32

Field Quantization
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
Summary of the quantum postulates

- There is a (normalized) state vector
- Unitary evolution of the state vector is generated by a Hamiltonian
- Measurements are represented by Hermitian operators that place the system in a measurement eigenstate
- A composite state vector is represented in a basis that is an outer product of the basis sets of its component state vectors
This quarter in Schleich

- Review of QM and introduction to QM written in terms of the density matrix (C2)
- The thermal (blackbody) state of light (C2)
- Wigner functions (C3)
- Wigner representations of the states of light (C4)
- Quantization of the electromagnetic field (C10)
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
The Quantized EM Field

• EM energy in a cavity as an SHO
• Number states
• Photon counting
• Projection on to number states
• The Wigner representation of number states and densities of number states
Today’s Topics

• Conservation of charge in Maxwell’s equations
• Gauge invariance of Maxwell’s equations
• The equations of the Coulomb gauge
• The modes of a 3D box
• Modes of a box in a box and the Casimir effect
Charge Conservation

- Maxwell’s equations
- The divergence of a curl and the curl of a gradient
- M’s equations as 6+charge conservation
- Coupling of charges to M’s equations
- The coupling of fields to S equation via the Lorentz force law
Gauge Invariance

• The vector potential $A$
• The scalar potential $\phi$
• An extra scalar called $\chi$
• The Lorentz gauge
• The Coulomb gauge
Coulomb gauge equations

- Charges and potential
- Dynamic fields
- Boundary conditions from M’s equations
- Matter as boxes of springs
- Space and matter as springs coupling pieces of chewing gum
This Friday’s Topics

• Problem set 4
• Raising and lowering operators for a field in a cavity
• The Hamiltonian as sums of $a$ and $a^\dagger$
• Number states
• The coherent state as an eigenstate of $a$