

Physics 302b-2010 Exam 2 Coverage

The exam will be cumulative, but with a focus on the material covered since exam 1:

Townsend 3.5-5.3

Class meetings class 9 (2-18-10) through the first part of class 16 (3-23-10)

Assignments 5-7

For the exam, you should create an equation sheet with up to 30 equations to refer to during the exam. Each “=” sign on your sheet counts as one equation, and you’re not allowed to use an alternate symbol or arrangement of text to get around this rule. No text or pictures allowed. The exam will include numerical values of all relevant constants. You may consult with other students on what they have included on their equation sheets, but only if none of the students involved in the consultation has yet taken the exam.

Due Saturday, 4-3-10, 12:30 pm

Critical concepts

Uncertainty principles

The generalized uncertainty principle (connection between product of uncertainties & commutator)

Uncertainty relation between x -, y -, and z -components of angular momentum

Energy-time uncertainty principle: interpretation in terms of time for energy to change and in terms of precision to which energy is known

Miscellaneous

Pauli spin matrices

Know the relation between the eigenvalues for the \hat{J}^2 and \hat{J}_z operators and the associated quantum numbers.

Understand the $|s, m\rangle$ notation.

Be especially familiar with the states for spin- $1/2$ and spin-1 particles, as well as linearly- and circularly-polarized photons.

The eigenvalue problem

Be ready to solve it, including normalization.

Time translation

Time translation operator, and its two connections to the Hamiltonian.

The time-dependent Schrodinger equation

Time dependence of energy eigenstates

How to translate an arbitrary state forward through time

Time dependence of the expectation value for an arbitrary state

Time dependence (or lack thereof) of expectation values for an energy eigenstate

Precession

Be ready to show the derivation of how applying a constant magnetic field causes the spin to precess about the field axis.

Know the Hamiltonian for a spin in an applied magnetic field.

Be ready to calculate the time progression of the state due to precession in a constant field.

Berry phase: be ready to describe an experiment that shows that you must rotate a spin- $1/2$ particle by 4π to get back to the original state.

Know the meaning of “g-factor”, be ready to deduce the g-factor from experimental data.

Topics continue on the next page

Magnetic resonance

Understand the combination of fields that are applied.

Understand the final result for $|\psi(t)\rangle$ for the case $\omega = \omega_0$, and how it is interpreted in terms of oscillations between the energy eigenstates of the unperturbed Hamiltonian (i.e. the Hamiltonian with only a DC magnetic field)

Be ready to explain how this result correlates with the idea that you can absorb a photon of energy $\hbar\omega_0$ to make a transition up in energy between the unperturbed energy eigenstates.

Be ready to explain how the above final result shows that stimulated emission occurs.

Rabi's formula: understand what it means, be ready to apply it.

Ammonia

Be ready to reproduce the argument for finding the energy eigenstates of any system with a double-well potential.

Given the above energy eigenstates, be ready to reproduce the argument for why, if the particle is initially localized in one of the wells, it will oscillate back and forth between the two wells.

Understand qualitatively the connections between the strength of coupling between two wells, the above oscillation frequency, and the difference in energy of the energy eigenstates.

Two spin-1/2 particles

Understand the basis states for this system.

Direct product

Be ready to use the direct product to create a two-particle operator from two one-particle operators.

Be ready to use the direct product to create a two-particle state from two one-particle states.

Understand how to compute inner products for two-particle states by breaking them down into the inner products of one-particle states.

Understand the terms "triplet state" and "singlet state", be ready to make and explain the semi-classical sketches of the angular momentum vectors for these states.

Know that, for a hydrogen atom, the three triplet states have a slightly higher energy than the singlet state, and be ready to explain what spins are involved in forming these states and why the interaction between them is so weak.

Given the matrix representations for the two-particle raising and lowering operators (e.g. \hat{S}_{2+}), be ready to show how they perform the functions they're supposed to.

Know how to predict the results of measurements on the two particles by taking appropriate inner products of the two-particle states.

General addition of angular momenta

Given the quantum numbers for the \hat{J}^2 operator for the two particles, be ready to list the possible quantum numbers for the total \hat{J}^2 operator, and the corresponding possible values of m .

Be ready to show that the number of states for the two particles considered separately (i.e. the eigenstates for the one-particle \hat{J}^2 operator and the one-particle \hat{J}_z operator) is the same as the number of simultaneous eigenstates of the total \hat{J}^2 operator and the total \hat{J}_z operator.