Physics 302b-2010 Exam 1 Coverage

Coverage:

Townsend 1.1-3.4

Class meetings class 1 (1-19-10) through class 8 (2-16-10)

Assignments 1-4

For the exam, you should create an equation sheet with up to 15 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, 2-27-10, 12:30 pm

Critical concepts

Stern-Gerlach experiment

Qualitative argument for how the apparatus measures the component of **J** along a particular direction

Be ready to summarize the most important experimental observations, and their implications. For example, be ready to explain how the experiments show that we need probability amplitudes, rather than just probabilities.

Understand what the terms "SGx", "SGFy", etc. mean

Be ready to explain, using bra-ket notation, the experiment in which adding back in the $|-x\rangle$ beam cancels out the $|-z\rangle$ beam (see p. 3 of lecture summary for our first class).

Know $|+x\rangle, |-x\rangle, |+y\rangle,$ and $|-y\rangle$ in the *z*-basis for spin- ½ particles. We will use the uncorrected versions, i.e. the versions presented in Townsend, e.g. $|+x\rangle = \frac{1}{\sqrt{2}}\left(|+z\rangle + |-z\rangle\right)$.

Hilbert space and bra-ket notation

What a ket represents

Meaning of "complete basis"

Analogy between kets in Hilbert space and ordinary vectors in ordinary two-dimensional space

Analogy between basis states and unit vectors

Orthogonality of basis states, analogous to orthogonality of unit vectors

Expanding an arbitrary state in terms of basis vectors, analogy for ordinary vectors

Finding the coefficients in the above expansion using inner products, analogy for ordinary vectors

Meaning of the expansion coefficients

The identity operator $\sum |a_n\rangle\langle a_n|$

What an inner product such as $\langle a|b\rangle$ represents

Mechanics of quantum mechanics

How to compute an expectation value, using either known expansion coefficients or inner products

How to compute standard deviations

Expected scatter for an experiment on *N* particles

What it means for an operator to be Hermitian, connection with observables

What it means for an operator to be unitary

Meaning of the terms "eigenvalue", "eigenstate", and "eigenvalue equation"

Taking the adjoint of a product of two operators

Definition of the commutator, significance of a commutator that equals zero or that doesn't equal zero

Cyclic permutations

Inner products can be evaluated in whatever basis you like

Meaning of having an operator in an exponent, e.g. $e^{-i\hat{J}_z\phi/\hbar}$

Matrix notation

Representing a ket as a matrix

Be ready to explain why it is formally not appropriate to write $|+z\rangle = \begin{pmatrix} 1 \\ 0 \end{pmatrix}$

Converting a ket to a bra, using matrix notation

For a column vector, know what inner products are used to compute each entry

Converting column vectors from one basis to another using the $\mathbb{S}$-matrix method

Converting column vectors from one basis to another using inner products

Meaning of "adjoint"

Matrix representation of operators: know what inner products to use to compute the entries

Transforming operators from one basis to another using the $\mathbb{S}$-matrix method

Computing expectation values using matrix notation

Significance of whether or not an operator is diagonal, meaning of the diagonal entries

Polarization

Know the eigenstates of $\hat{J}_z$ for photons

Be able to convert between $|R\rangle, |L\rangle$ basis and $|x\rangle, |y\rangle$ basis

Know how to express a photon with linear polarization at angle ϕ relative to the *x*- and *y*-axes in terms of $|x\rangle$ and $|y\rangle$

Rotations and angular momentum

Action of the $\hat{R}(\theta \hat{\mathbf{n}})$ operator (where $\hat{\mathbf{n}}$ represents a generic unit vector)

Be ready to prove that $\hat{R}(\theta \hat{\mathbf{n}})$ is unitary

Two connections between $\hat{R}(?\hat{?})$ and $\hat{J}_?$ (fill in all three question marks yourself)

Physical significance of the $\hat{J}_z$ and $\hat{J}^2$ operators

Eigenvalues of $\hat{J}_z$ and $\hat{J}^2$ for the general case (not just spin ½)

Commutation relations between $\hat{J}_x$, $\hat{J}_y$, and $\hat{J}_z$

$|j,m\rangle$ notation

Raising and lowering operators

Action of the $\hat{J}_+$ and $\hat{J}_-$ operators

Connections between $\hat{J}_x$, $\hat{J}_y$, $\hat{J}_+$ and $\hat{J}_-$

Matrix elements for $\hat{J}_+$ and $\hat{J}_-$