University of Calgary
Fall semester 2015

PHYS 543: Quantum Mechanics II

Homework assignment 2

Due Tuesday, October 6, 2015

Problem 2.1. Linearly polarized photons with different polarization angles α pass through a quarter-wave plate with its optical axis oriented

a) horizontally,

b) at 45°.

Plot the locus of the resulting states on the Bloch sphere.
Hint: For (b), try ingenuity rather than brute force.

Problem 2.2. Find the matrix elements (a) $\langle 100|\,\hat{A}\,|200\rangle$, (b) $\langle 100|\,\hat{A}\,|210\rangle$, (c)$\langle 100|\,\hat{A}\,|211\rangle$ of observables $\hat{A} = \hat{x}, \hat{y}, \hat{z}$ in the hydrogen atom.

Problem 2.3. Consider the evolution of the spin state of a spin-1 particle under the action of a constant magnetic field $\vec{B}$ oriented along the x axis. The initial state is $|\psi(0)\rangle = |m_s = -1\rangle$.

a) Find the spin state $|\psi(t)\rangle$ as a function of time in the matrix form, in the eigenbasis of $\hat{S}_z$.

b) Find the mean values $\left\langle \hat{S}_x(t) \right\rangle, \left\langle \hat{S}_y(t) \right\rangle, \left\langle \hat{S}_z(t) \right\rangle$ and verify that they are consistent with what is expected classically.

c) State $|\psi(t)\rangle$ is measured using a Stern-Gerlach apparatus with the magnetic field along the y axis. Find the probability for the particle to land in each of the three spots. Are the values found at one-quarter and three-quarters of the Larmor period consistent with what you would expect from part (b)?

Hint: The relevant matrices of the components of the spin, as well as their eigenvectors and eigenvalues, can be found in the new version of the lecture notes.

Problem 2.4. Verify that $[\hat{L}_x, \hat{L}_y] = i\hbar\hat{L}_z$ for the angular momentum components expressed as differential operators

a) in Cartesian coordinates;

b) in spherical coordinates.