

Phys 402 Midterm Exam, Feb 28, 930-1050am, Hebb 12

Manage your time wisely. Please write your name and student ID clearly on the cover page of exam booklet.

Total 100pts

Prob. I (50pts)

Consider a particle moving in a one-dimensional infinite square well; $V(x) = 0$ when $L > x > 0$ otherwise $V(x) = \infty$. A small perturbation of the following form is applied,

$$H' = A \cos \frac{2\pi x}{L} \quad (1)$$

where A is the amplitude of perturbation.

a)(30) Find the first and second order correction to the ground state energy.

b)(10) Find the first order correction to the ground state wavefunction.

c)(10) When A is very large, the perturbation is no longer valid. Can you speculate on what happens then?

Prob. II (50pts)

The spin-orbit coupling of an electron in an atom takes the following form

$$H_{SO} = A \mathbf{S} \cdot \mathbf{L} \quad (2)$$

where \mathbf{S} is the electron spin and \mathbf{L} is the angular momentum. An electron is initially in a product state $|S, S_z = -\frac{1}{2} \rangle \otimes |l = 1, l_z = 0 \rangle$ with spin pointing along the minus z direction.

a) (30) What are the probabilities of finding the electron with $S_z = \pm \frac{1}{2}$ at a later time $t = T$?

b) (10) Now a very strong magnetic field is further applied to the electron along the z -direction

$$H_B = \gamma(\mathbf{L} + 2\mathbf{S}) \cdot \mathbf{B}_{ext}, \mathbf{B}_{ext} = B_0 \mathbf{e}_z. \quad (3)$$

For an electron initially at a product state $|S, S_z = -\frac{1}{2} \rangle \otimes |l = 1, l_z = 0 \rangle$, discuss qualitatively what happens to the probability of finding $S_z = 1/2$ at a later time T . Whether it is enhanced or suppressed compared what you have found in a).

c) (10) Now assume an electron initially was prepared in a product state $|S, S_x = \frac{1}{2} \rangle \otimes |l = 1, l_z = 0 \rangle$ with spin pointing along the x direction. Repeat part b).