

國立中央大學九十學年度碩士班研究生入學試題卷

所別: 天文研究所 不分組 科目: 近代物理 共 一 頁 第 一 頁

(1) (25 points)

- (5 points) What is the value of c , the speed of light? Describe the two postulates of special theory of relativity.
- (5 points) What is quantum tunneling? Describe three examples of this phenomenon.
- (5 points) What is space quantization? Describe Stern-Gerlach experiment.
- (5 points) How many transitions are possible when an atom interacts with radiation? Describe the principle of laser.
- (5 points) How many fundamental forces of nature have been observed? Describe their characteristics.

(2) (25 points)

- (5 points) What is the relation between energy, momentum and mass of an electron in special relativity? What are the energy and momentum of a photon of wavelength λ ?
- (10 points) A photon (angular frequency ω) and a relativistic electron (velocity v) are traveling in the z -direction. At some point they collide. Suppose the photon is still moving in the z -direction after collision, compute the frequency change of the photon.
- (10 points) Now, if after collision, the photon moves in a direction at an angle θ away from the z -direction, compute the frequency change of the photon.

(3) (25 points)

- (10 points) Describe Bohr's model of hydrogen atom. Use Bohr's model to find the radius (a_0) and energy (E_1) of the ground state of an hydrogen atom. Estimate a_0 .
- (5 points) Describe the four quantum numbers of hydrogen atom wavefunction. What values can they have?
- (10 points) The ground state wavefunction of an hydrogen atom is $A \exp(-r/a_0)$. Find the normalization constant A . Find the most probable radius and the mean radius of the electron in the ground state.

(4) (25 points)

- (5 points) What is the meaning of indistinguishable particles? Describe the difference between bosons and fermions (in terms of spins, statistics, wavefunctions, etc.). Give an example of a boson and a fermion.
- (10 points) Derive the energies and the normalized wavefunctions of a particle in a one-dimensional infinite square well of length L (i.e., in a one-dimension box of length L).
- (10 points) Find the energies and the normalized wavefunctions of the ground state and the first excited state of two non-interacting bosons in a one-dimensional infinite well. Repeat the calculation for two non-interacting fermions.

