

八十四學年度 核二所 組碩士班研究生入學考試

科目 近代物理 科號 3308 共 2 頁第 1 頁 *請在試卷【答案卷】內作答

1. A star move relatively to the earth at $v = 0.5c$ and emits light at constant frequency of 10^{15} Hz. Derive the frequency ν observed on the earth by Doppler effect in the condition:
 - A) If the star move perpendicular to the earth.
 - B) If the star move receding from the earth.
 - C) Calculate the observed wave length λ of (B).

2. In the Compton scattering: a photon with energy 1 Mev is scattered by an electron at rest into angle $\theta = 60^\circ$:
 - A) Derive the Compton equation: $\Delta\lambda = \frac{h}{m_0 c} (1 - \cos\theta)$ and calculate the wave length λ' of scattered photon.
 - B) show that the recoil electron kinetic energy is:

$$K = h\nu \left(\frac{h\nu}{2m_0 c^2 + h\nu} \right)$$
 - C) Calculate the de Broglie wave length of the recoil electron.

3. The solution of Schroedinger equation for hydrogen atom yield: $\Psi_{n\ell m_\ell} \equiv |n, \ell, m_\ell\rangle = R_{n,\ell}(r) \cdot Y_\ell^{m_\ell}(\theta, \phi)$
 If $R_{2,1} = \frac{1}{\sqrt{24}} (e^{-r/2}) \cdot r$; $Y_1^1 = \sqrt{\frac{3}{8\pi}} \sin\theta \cdot e^{-i\phi}$.
 - A) For $n=2$, write all possible quantum states labeled by $|n, \ell, m_\ell\rangle$.

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B) Calculate the location at which the radial probability density of the state $|2, 1, 1\rangle$ is maximum.

C) Work out and plot the angular probability density distribution of the state $|2, 1, 1\rangle$.

4. The multi-electron atom Boron (${}_5\text{B}$) is in the ground state.

A) Write the electronic configurations and compute the total angular momentum J .

B) Work out the expectation values of the spin-orbital interaction $\langle S \cdot L \rangle$. (ψ is normalized)

C) If an external weak magnetic field B is applied, plotting the Zeeman effect splitting of the energy levels. (labeled)

use : $c = 3 \times 10^8 \text{ m/sec}$

$$m_e c^2 = 0.5 \text{ Mev}$$

$$h c = 1.24 \times 10^{-12} \text{ Mev-m}$$

Each : A) 10%

B) 10%

C) 5%