SESSI 06/07/Quiz 3

10/10

ZCT 104/3E Modern Physics
Semester II, Sessi 2006/07
Open Book Quiz III
Duration: 20 min

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INSTRUCTION: Answer the following question. **[10 marks]**

Derive the Compton scattering formula between a photon and a free particle of mass m:

$$\Delta\lambda = \lambda' - \lambda = \lambda_c(1-\cos\theta)$$

where $\lambda_m = \dfrac{h}{mc}$ is the Compton wavelength of the target particle. Explain your steps clearly.

[10 mark]

Mom conservation in y : $p' \sin\theta = p_e \sin\phi$ ✓

Mom conservation in x : $p - p'\cos\theta = p_e \cos\phi$ ✓

} squaring and adding $p_e^2 = p^2 - 2pp'\cos\theta + p'^2$ -① ✓

Conservation of total relativistic energy :

$$cp + m_e c^2 = cp' + E_e \Rightarrow E + m_e c^2 = E' + E_e \quad -②$$ ✓

$(Py)^2 + (Px)^2$, substitute into $(RE)^2$ to eliminate ϕ, P_e and E_e (and using $E_e^2 = c^2 p_e^2 + m_e^2 c^4$):

~~squaring and adding → $p_e^2 = p^2 - 2pp'\cos\theta + p'^2$ -①~~

Gantiran ① dan ② dlm ③

$$E_e^2 = c^2 p_e^2 + m_e^2 c^4 \quad -③$$ ✓

~~$(E + m_e c^2)^2$~~

$$(E + m_e c^2 - E')^2 = c^2 (p^2 - 2pp'\cos\theta + p'^2) + m_e^2 c^4$$ ✓

left : $(E + m_e c^2 - E')^2 = E^2 + 2E m_e c^2 - 2EE' - 2E' m_e c^2 + m_e^2 c^4 + E'^2$

right : $c^2 (p^2 - 2pp'\cos\theta + p'^2) + m_e^2 c^4$

$= c^2 p^2 - 2c^2 pp'\cos\theta + c^2 p'^2 + m_e^2 c^4$

left = right

$$E^2 + 2E m_e c^2 - 2EE' - 2E' m_e c^2 + m_e^2 c^4 + E'^2 = c^2 p^2 - 2c^2 pp'\cos\theta + c^2 p'^2 + m_e^2 c^4$$

$$E^2 + 2E m_e c^2 - 2EE' - 2E' m_e c^2 + m_e^2 c^4 + E'^2 = E^2 - 2EE'\cos\theta + E'^2 + m_e^2 c^4$$

$$2E m_e c^2 - 2EE' - 2E' m_e c^2 = -2EE'\cos\theta$$ ✓

$$E m_e c^2 - E' m_e c^2 = -EE'\cos\theta + EE'$$

$$m_e c^2 (E - E') = EE'(1 - \cos\theta)$$

$$\frac{E - E'}{EE'} = \frac{(1-\cos\theta)}{m_e c^2}$$

$$\frac{1}{E'} - \frac{1}{E} = \frac{1}{m_e c^2}(1-\cos\theta)$$ ✓

$$\lambda e = \frac{h}{mec}$$

$$E = \frac{hc}{\lambda}$$

$$\frac{\lambda'}{hc} - \frac{\lambda}{hc} = \frac{1}{mec^2}(1-\cos\theta)$$

$$\frac{1}{hc}(\lambda'-\lambda) = \frac{1}{mec^2}(1-\cos\theta)$$

$$\lambda'-\lambda = \frac{hc}{mec^2}(1-\cos\theta)$$

$$\lambda'-\lambda = \frac{h}{mec}(1-\cos\theta)$$

$$\Delta\lambda = \lambda'-\lambda = \lambda e(1-\cos\theta) - \text{Torbarti}$$