Physics 247 HW 11

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Problem 1

Part a

According to $E^2 = (pc)^2 + (mc^2)^2$, the final energy of the electron only depends on its final momentum. From the equation derived in class,

$$\vec{P_e}^{\,2} = \vec{P_i}^{\,2} + \vec{P_f}^{\,2} - 2P_iP_f\cos\theta,$$

we can see that the final momentum of the electron only depends on the angle θ in $(-2P_iP_f\cos\theta)$. Therefore, in order to maximize P_e, we need to maximize $(-2P_iP_f\cos\theta)$.

$\cos\theta$ is equal to -1 when $\theta = \pm\pi$. Therefore, leaving just the positive part,

$$\theta = \pi.$$

Part b

Let us first find the final energy of the photon. Let λ_i and λ_f be the initial and the final wavelengths of the photon. Let E_{pi} and E_{pf} be the initial and the final energies of the photon. Using the equation derived in class:

$$(\lambda_f - \lambda_i) = \frac{h}{m_ec}(1-\cos\theta) = 2\frac{h}{m_ec};$$

$$\lambda_f = 2\frac{h}{m_ec} + \lambda_i = 2\frac{h}{m_ec} + \frac{hc}{E_{pi}};$$

$$E_{pf} = \frac{hc}{\lambda_f} = \frac{hc}{2\frac{h}{m_ec} + \frac{hc}{E_{pi}}} = \frac{E_{pi}\times m_ec^2}{2E_{pi} + m_ec^2} = \frac{0.1240\times 0.511}{2\times 0.1240 + 0.511} \approx 0.0835\,MeV.$$

Next, let us find the final energy of the electron using the law of conservation of energy:

$$E_{pi} + m_ec^2 = E_{pf} + E_e;$$

$$E_e = E_{pi} - E_{pf} + m_ec^2 = 0.1240 - 0.0835 + 0.511 = 0.5515\,MeV.$$