Physics 330 – Problem Set # 7

(due Wednesday, November 16)

1. Carry out all steps of the Feynman diagram calculation of the Compton scattering cross section, working from the diagrams at the beginning of P & S Section 5.5. In particular, include all steps in the derivation of eq. (5.87). Write the final result as a polarization-averaged cross section $d\sigma/d\cos\theta$ in the CM frame. Take the limit $m/E \to 0$.

2. Just as for Bhabha scattering, we can build up the cross section for Compton scattering as a sum of squares of helicity amplitudes. To do this calculation in the limit $m_e \to 0$, we need the polarization spinors

$$\begin{aligned} e^- \text{ with } \vec{p} \parallel \hat{3}\ : \qquad & u_R(p) = \sqrt{2E}\begin{pmatrix}0\\0\\1\\0\end{pmatrix} \quad u_L(p) = \sqrt{2E}\begin{pmatrix}0\\1\\0\\0\end{pmatrix} \\ e^- \text{ in } \theta \text{ direction}: \qquad & u_R(p) = \sqrt{2E}\begin{pmatrix}0\\0\\c_2\\s_2\end{pmatrix} \quad u_L(p) = \sqrt{2E}\begin{pmatrix}-s_2\\c_2\\0\\0\end{pmatrix} \end{aligned} \tag{1}$$

and the following polarization vectors for initial and final photons:

$$\begin{aligned} \gamma \text{ with } \vec{p} \parallel -\hat{3}\ : \qquad & \epsilon^\mu_R(p) = \frac{1}{\sqrt{2}}(0,-1,i,0)^\mu \qquad \epsilon^\mu_L(p) = \frac{1}{\sqrt{2}}(0,-1,-i,0)^\mu \\ \gamma \text{ opposite to } \theta: \qquad & \epsilon^\mu_R(p) = \frac{1}{\sqrt{2}}(0,-c,i,s)^\mu \qquad \epsilon^\mu_L(p) = \frac{1}{\sqrt{2}}(0,-c,-i,s)^\mu \end{aligned} \tag{2}$$

where $c = \cos\theta$, $s = \sin\theta$, and you should remember to use $\epsilon^*_\mu(p)$ for final-state photons.

   (a) Show that, for zero electron mass, only those helicity amplitudes are nonzero for which the e^- has the same helicity in the initial and final states. This reduces the number of nonzero helicity amplitudes to 8.

   (b) By explicit computation, show that 4 of these helicity amplitudes vanish and the other 4 are equal in pairs.

   (c) Show that the sum of the two different nonzero contributions reproduces the final result of Problem 1.

3. Peskin and Schroeder, problem 5.5.