

Problem J

Consider electron-positron annihilation where the electron and positron are initially at rest, the electron is initially spin up, the positron is initially spin down, and the outgoing photons travel in the $\pm z$ directions.

- (a) Show that the 4-momenta are given by Eq. 7.136, and show that the general form of the spinors (Eqs. 7.46 and 7.47) reduce to Eqs. 7.151 and 7.152.
- (b) For the matrix element \mathcal{M}_1 in Eq. 7.133, show that

$$\not{p}_1 - \not{p}_3 + mc = mc(\mathbf{1} + \gamma^3)$$

where $\mathbf{1}$ is the 4×4 identity matrix.

- (c) Calculate \mathcal{M}_1 for the case where the two outgoing photons are left- and right-circularly polarized, with the polarization 4-vectors:

$$\epsilon_\mu^*(3) = \frac{1}{\sqrt{2}} (0 \ 1 \ i \ 0) \quad \epsilon_\mu^*(4) = \frac{1}{\sqrt{2}} (0 \ 1 \ -i \ 0)$$

[Answer: $-2g_e^2$.]

- (d) The total \mathcal{M} is double this result. Use this in the Golden Rule for Scattering to get the total cross section σ (see Eq. 7.168 and preceding discussion).