PHYSICS 474: Introduction to Particle Physics

Homework 10 **Due:** noon Friday, April 13, 2018

Møller Scattering: In this problem, you will derive the differential scattering cross-section for the process $e^-e^- \to e^-e^-$.

(a) [20 points] Show that the spin-averaged total squared amplitude in the high-energy regime ($m_e \to 0$) is

$$\langle|\mathcal{M}|^2\rangle = \frac{2g_e^4}{(p_1\cdot p_3)^2(p_1\cdot p_4)^2}\left[(p_1\cdot p_2)^4 + (p_1\cdot p_3)^4 + (p_1\cdot p_4)^4\right], \tag{1}$$

where p_1, p_2 and p_3, p_4 are respectively the incoming and outgoing momenta.

(b) [10 points] Show that in the center-of-mass frame, Eq. (1) becomes

$$\langle|\mathcal{M}|^2\rangle = \left[2g_e^2\left(1 - \frac{4}{\sin^2\theta}\right)\right]^2, \tag{2}$$

where θ is the scattering angle.

(c) [10 points] Using Eq. (2) and the general formula for the differential cross section discussed in class, show that

$$\frac{d\sigma}{d\Omega} = \frac{1}{2}\left[\frac{\hbar c g_e^2}{8\pi E}\left(1 - \frac{4}{\sin^2\theta}\right)\right]^2, \tag{3}$$

where E is the initial energy of each electron in the CM frame.

(d) [10 points] Compare Eq. (3) with the corresponding result for the $e^-\mu^- \to e^-\mu^-$ scattering discussed in class (in the high-energy limit $m_e, m_\mu \to 0$). Does this agree with your expectation from classical electrodynamics?