Theories of particle physics Fall 1998, Exercise 10

1. Derive the differential cross section (8.1.6) for the process $e^+ + e^- \to \mu^+ + \mu^-$ (Feynman diagrams fig 8.2 at page 147. See also Okun p. 202, Halzen-Martin p.305). You can assume that the leptons are massless. Draw the additional graphs you would need to calculate if you would take the lepton masses into account. (Note misprint in page 146, in the formula for a the last parenthesis should be squared.)

2. Estimate the forward-backward asymmetry in the scattering $e^+e^- \to \mu^+\mu^-$

$$A_{\rm FB} \equiv \frac{\int_0^{\pi/2} \mathrm{d}\sigma - \int_{\pi/2}^{\pi} \mathrm{d}\sigma}{\int_0^{\pi} \mathrm{d}\sigma}\,.$$

   Hint: Solve the previous problem properly.

3. Consider a general Fierz transformation:

$$\overline{u}_3\Gamma_i u_2\overline{u}_1\Gamma_i u_4 = \sum_{j=1}^{5} \lambda_{ij}\overline{u}_1\Gamma_j u_2\overline{u}_3\Gamma_j u_4,$$

   where $\Gamma_i = 1, \gamma^\mu, \sigma^{\mu\nu}, \gamma^\mu\gamma^5, \gamma^5$. Find λ_{ij} and show especially that

$$\overline{u}_3\gamma_\mu(1-\gamma^5)u_2\overline{u}_1\gamma^\mu(1-\gamma^5)u_4 = \overline{u}_1\gamma_\mu(1-\gamma^5)u_2\overline{u}_3\gamma^\mu(1-\gamma^5)u_4.$$

   See e.g. Itzykson-Zuber p. 162, Bailin appendix, Peskin-Schoroeder p. 75. As application see the book p. 156 (8.2.15) and beyound:

$$(\overline{e}\gamma_{\mu L}\nu_e)(\overline{\nu}_e\gamma_L^\mu e) = (\overline{\nu}_e\gamma_{\mu L}\nu_e)(\overline{e}\gamma_L^\mu e).$$

Please find enclosed information on a memorial mass for Tomasz Kaszuba.

Return the solved problems to the downstairs box in Laurikainen building on Monday November 23rd at 15 o'clock at latest. There are two problems solving sessions: Tuesdays 16-18 in the Exercise room (harjoitussali) in the basement of the Laurikainen bldg [English] and Fridays 10-12 in Hall 5, Tallqvist bldg [Finnish].

The www-page of this course is: http://www.physics.helsinki.fi/%7Epuolamak/hitu/