Physics 492 Homework XI, due Fri Apr 16

Reading: Chapters 10 and 12.1-2

Problems:

1. Within the simple quark model, calculate the value of the cross-section ratio $R = \sigma(e^+ + e^- \rightarrow \text{hadrons})/\sigma(e^+ + e^- \rightarrow \mu^+ + \mu^-)$, in $e^+ e^-$ collisions at $\sqrt{s} = 2.4$, 8 and 30 GeV. You can use the approximation $\beta = 1$ for the relevant quarks at different energies.

2. Williams, Problem 10.8. Check whether the quoted cross section agrees with the formula given in class and provided in the caption for Fig. 10.10. For calculating the rate, recall the definition of cross section. Consider either electrons or positrons as target particles. If you fail to find the rates, give at least the ratio of rates for hadron relative to muon production.

3. Williams, Problem 10.9. Sketch a Feynman diagram for positronium decay. How many α-factors in the decay rate are associated with the vertices in your diagram and how many must be associated with the positronium wavefunction? The rate behaves as a square of the amplitude and a coupling constant is associated with every vertex. For ψ decay, calculate first the partial width for decay into three gluons. What are the replacements in the positronium formula when going from QED to QCD (forget about factors of 4/3 or alike - we are interested in general magnitudes only)? Sketch a Feynman diagram for ψ decay into three gluons. When replacing one of the gluons with a photon, how many of the QCD α-factors get replaced by QED factors in the decay rate?

4. Williams, Problem 10.13.

5. In 1956 Sakata proposed a model with three fundamental quarks having the following quantum numbers:

	j	B	S	t	t_3
u	1/2	1	0	1/2	1/2
d	1/2	1	0	1/2	-1/2
s	1/2	1	-1	0	0

where j, B, S, and t, are the spin quantum number, baryon number, strangeness, and isotopic spin quantum number, respectively.
(a) Given the empirical relation for hadrons: $Q/e = t_3 + (B + S)/2$, what should be the charges of the three quarks? (b) Assign quark combinations to nucleons, pions, kaons, and Λ. (c) Why is the Sakata model not used?