

Massachusetts Institute of Technology

Department of Physics

8.276 Nuclear and Particle Physics

April 12, 2007

Reading Assignment for 4/19 and 4/24

Particles and Nuclei, Chapter 16

Problem Set #8 (due 4/24)

1. An excited baryon state Σ' has been found which decays into a Λ and π . It has a total energy of 1380 MeV with a full-width-at-half-maximum of about 30 MeV.

- a) What is the lifetime of the Σ' ?
- b) What is its strangeness?

2. a) Members of the baryon decuplet typically decay after 10^{-23} sec into a lighter baryon (from the baryon octet) and a meson (from the pseudoscalar meson octet). Thus, for example, $\Delta^{++} \rightarrow p + \pi^+$. List all decay modes of this form for the Δ^- , Σ^{*+} and Ξ^{*-} . Remember that these strong-interaction decays must conserve strangeness.

b) In any decay, the original particle must have sufficient mass to cover the masses of the decay products. Check each of the decays you proposed in part (a) to see which ones meet this criterion. The others are kinematically forbidden.

3. a) Analyze the possible decay modes of the Ω^- , just as you did in Problem 2 for the Δ^- , Σ^{*+} and Ξ^{*-} . On what basis did Gell-Mann predict that the Ω^- would be "metastable" (i.e., much longer lived than the other members of the decuplet)?

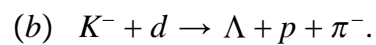
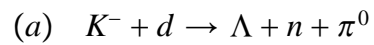
b) Using the bubble chamber photograph in the class handout, identify the the Ω^- track and measure its length, and use this information to estimate the lifetime of the Ω^- . (Of course, you do not know how fast it was going, but it is a safe bet that its speed was less than the velocity of light; assume it to be about $0.1c$. Also, you do not know if the reproduction has enlarged or shrunk the scale; ignore this possibility for the present.) Compare the lifetime you find with the 10^{-23} sec characteristic of all other members of the baryon decuplet. Estimate the uncertainties in your determination and comment on whether or not they are important.

c) What can you conclude about the interaction responsible for the decay of the Ω^- ? What quantities are conserved/not conserved in this decay?

4. The constituent up and down quarks in baryons are thought to have a mass of around $340 \text{ MeV}/c^2$. Use this information to predict the magnetic moments of the proton and the neutron and compare with the experimentally measured values.

5. *P&N*, 15-3

6. Use isospin to calculate the branching ratio $\sigma(a) : \sigma(b)$ of the reactions



The deuteron (d) has isospin zero.