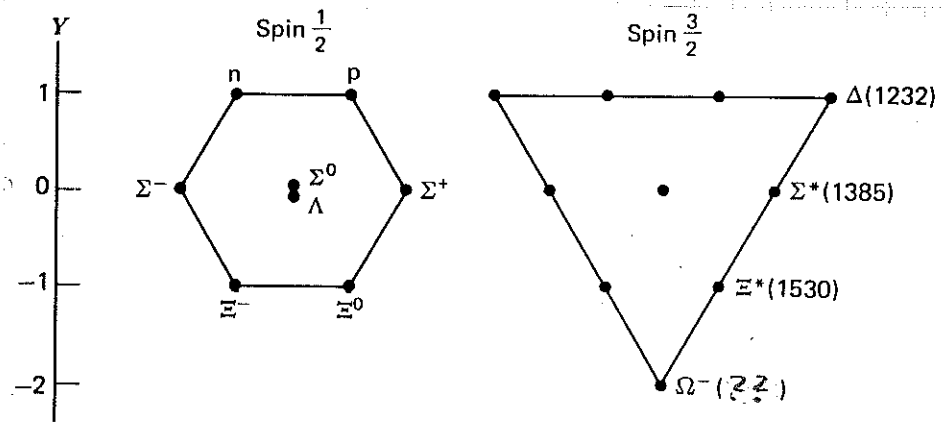
Ph 406 Problem Set 3

Due Friday, Feb 26, 1993

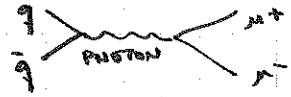
(1) Use the masses (in MeV) of the first three rows of the baryon decuplet to estimate the masses of the u, d, & s quarks, and then predict the mass of the Ω^- particle.



This was the only prediction of the quark model verified between conception in 1963 and the Nobel prize for it in 1969.

(2) The so-called Drell-Yan reactions $\pi^{\pm} p \to \mu^+ \mu^- X$ are thought to proceed via the elementary reaction

$q\bar{q} \to \mu^+\mu^-$



If so, predict $\dfrac{\sigma(\pi^+ p \to \mu^+\mu^- X)}{\sigma(\pi^- p \to \mu^+\mu^- X)}$ at high energies.

(3) Estimate the neutron lifetime, due to the decay $n \to p\, e\, \bar{\nu}$.

The art here is in a good choice of energy scale...

(4) The Equivalence Principle states that the ratio R of inertial to gravitational mass is the same for all substances. It has been tested by comparing the centrifugal force due to the earth's rotation on a body with the gravitational force of the earth (or sun). R is found to be the same for Al and Pt within 1 part in 10^{12}. These experiments also set a limit on the coupling, K_B of any long-range $(1/r^2)$ field coupling to baryon number. By considering nuclear binding energies and neutron/proton ratios, show that the difference in baryon number per unit mass in Al and Pt is 4×10^{-4}. Hence show that $K_B/K < 10^{-9}$, where K is the gravitational constant. (For further details, see, for example, Perkins (1984)).

(You may want to peek at Chap. 4 of Gottingham & Greenwood.)