PHYSICS 722/822 - Fall Semester 2018 - ODU

Nuclear Physics - Problem Set 7 – Due Tuesday, 11/6

Note: For the following problems, we should follow the nomenclature of Povh et al., where g_V and g_A include the Fermi constant and the Cabbibo factors (see Eqs. 16-49-16.50). Hence, the **dimensionless** axial coupling that appears in Problem 1 is really the ratio g_A/g_V . Note that $c_V = +1$. $c_A = -1$, but I will ignore any sign inconsistencies.

Problem 1)

a) Again starting with the wave function for a proton given in Povh et al., Eq. 16.4 page 262 or in Wong, Eq. 2-46 p. 48 or my HUGS writeup, calculate the the transition matrix element for the Gamov-Teller transition in neutron beta decay: $g_A/g_V = \langle p\uparrow|\Sigma_q \sigma_z(q) I^+(q)| n\uparrow\rangle$. ($I^+(q)$ turns a down quark into an up quark and yields zero if applied to an up quark.). Show that your answer agrees with the relationship $g_A/g_V = \Delta u(\text{proton}) - \Delta d(\text{proton})$ (quote the results from last weeks HW assignment). Ignore any difference in sign.

b) Check the Bjorken sum rule, i.e. show that your result for the difference $\Gamma_1^p - \Gamma_1^n$ from last week agrees with the prediction by Bjorken, $\Gamma_1^p - \Gamma_1^n = g_A/g_V /6$.

Problem 2)

Follow Chapter 16.6 ("Semileptonic Baryon Decays") in the book by Povh et al. to derive the life time τ_n of the neutron in terms of the parameters g_V and g_A. Note that E_0 refers to the total energy (mass) difference between the neutron and the proton, **not** that between a neutron and a hydrogen atom. You may begin with Eq. 16.59 (p. 278).

a) Determine $g_V = G_F \cos\theta_C$ and $g_A = g_A/g_V \cdot g_V$ using your result from Problem 1. With these constants, calculate the result for Eq. 16.59.

b) Compare your result with the measured lifetime. Repeat if you replace g_A/g_V with the "true" measured value for the axial coupling, $g_A/g_V = 1.26$.