Date: 10h00, 21 Feb 2018 Mid-Semester Examination

PH4204: High Energy Physics

Duration: 90 minutes Weight: 20%

1. **Quark Model and baryons:** Assuming $SU(3)_{flavor}$ symmetry for three flavor of quarks and $SU(2)$ symmetry for the spin (spin-$1/2$) of the quarks consider three quark bound state model for the baryon octet containing protons and neutrons. Further, imagine that these eight baryon in the octet are the only baryons (spin-1/2) in the nature and the spin-3/2 decuplet does not exist.

   (a) Under above scenario construct the spin-flavor wave-function of proton. 4

   (b) Repeate the above for the neutron wave-fucntion. 1

   (c) Calculate the magnetic moments for proton and neutron using above wave-functions. Also estimate the ratio μ_p/μ_n assuming $\mu_u = -2\mu_d$. 3

2. **Iso-spin symmetry of strong interaction:** We know that in nature the only bound state with two nucleons is dueteron, i.e. the bound state of one proton and one nuetron. Further, we know that dueteron is a spin-1 state. How would you use above two experimental fact to prove the hypothesis that iso-spin is a good symmetry of strong interaction. 5

3. **Graph theory and Feynman Diagrams:** Consider the following Lagrangian involving three real scalar fields ϕ, χ and ψ :

$$\mathcal{L} = \underbrace{\frac{1}{2}(\partial_\mu\phi)(\partial^\mu\phi) - \frac{m_1^2}{2}\phi^2}_{free\ \phi} + \underbrace{\frac{1}{2}(\partial_\mu\chi)(\partial^\mu\chi) - \frac{m_2^2}{2}\chi^2}_{free\ \chi} + \underbrace{\frac{1}{2}(\partial_\mu\psi)(\partial^\mu\psi) - \frac{m_1^2}{2}\psi^2}_{free\ \psi} - \underbrace{\frac{g_1}{2}\phi^2\psi - \frac{g_2}{2}\chi^2\psi}_{3\ point\ interaction}$$

   (a) For the two point Green's function $\langle\Omega|\mathcal{T}\{\phi_1\chi_2\}|\Omega\rangle$ we have $n_1 = 2$. For one component graphs with n_l loop find n_3 using the graph theoretic formula. 1

   (b) Show that all the Feynman diagrams constructible above would evaluate to zero for all n_l for the above given Lagrangian. 3

   (c) Propose a (single) three point vertex that would give non-zero Feyman diagram for $\langle\Omega|\mathcal{T}\{\phi_1\chi_2\}|\Omega\rangle$ for at least one value of n_l. 3

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