PHYS 733: Elementary Particle Physics **Spring 2018**

Homework #3 **Due Date: 03/13/18**

---

1. a) Find the quark wave-function (flavor only) for the mixed-antisymmetric baryon octet representations (the mixed-symmetric wave-functions were all given in your handout). Show that the two Σ^0 and the two Λ^0 states (one MS and one MA each) are all orthogonal to each other.

b) From the quark wave-function for the Λ^0, show that

$$I^+\left|\Lambda^0\right\rangle = 0$$
$$V^+\left|\Lambda^0\right\rangle = \left|p\right\rangle$$

so that the Λ^0 has I=0 and is also a part of the baryon octet (J^P=1/2$^+$).

2. Use Young Tableaus to find the quantities A, B, and C in

a. $4 \otimes 4 \otimes 4 = A \oplus B \oplus B \oplus C$
b. $8 \otimes 8 \otimes 8 = A \oplus B \oplus B \oplus C$
c. $4 \otimes 4 = A \oplus B$
d. $4 \otimes \bar{4} = A \oplus B$

3. In addition to the u,d,s quarks, there is a fourth quark c which makes the upper member of a (c,s) doublet (but note that I=0 for both c and s). Find all of the ground state baryons containing one and only one c quark and their quark wave-functions, with

a. $J^P = \frac{3}{2}^+$
b. $J^P = \frac{1}{2}^+$ (use only the MS octet representation)

Give the quantum numbers I, I_3, S, and Q for each of these states.

4. From the quark wave-function for the mesons, prove that

a. $I^{+}|\eta^{8}\rangle = 0$ and $V^{+}|\eta^{8}\rangle = |K^{+}\rangle$

so that the η^8 has I=0 and belongs to the meson octet, and

b. $I^{+}|\eta^{1}\rangle = 0$ and $V^{+}|\eta^{1}\rangle = 0$

so that the η^1 has I=0 and does <u>not</u> belongs to the meson octet.

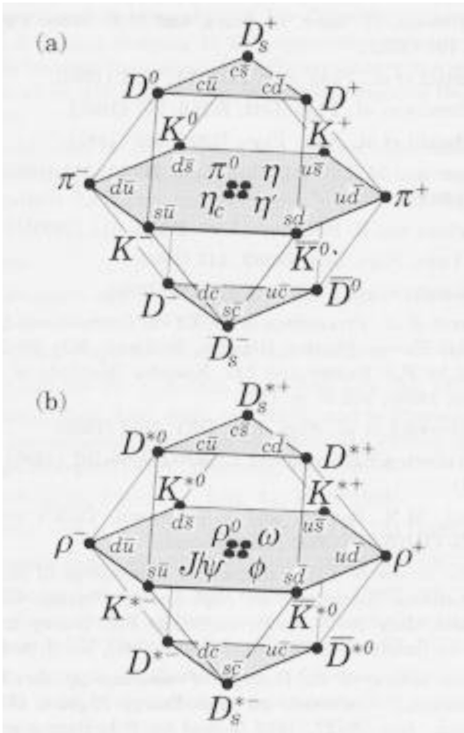
5. Find all of the ground state mesons containing one and only one c quark and their quark wave-functions, with

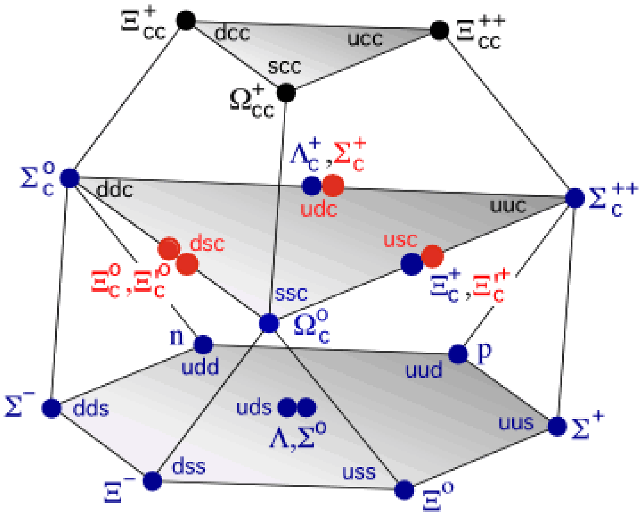
a. $J^{P} = 0^{-}$
b. $J^{P} = 1^{-}$

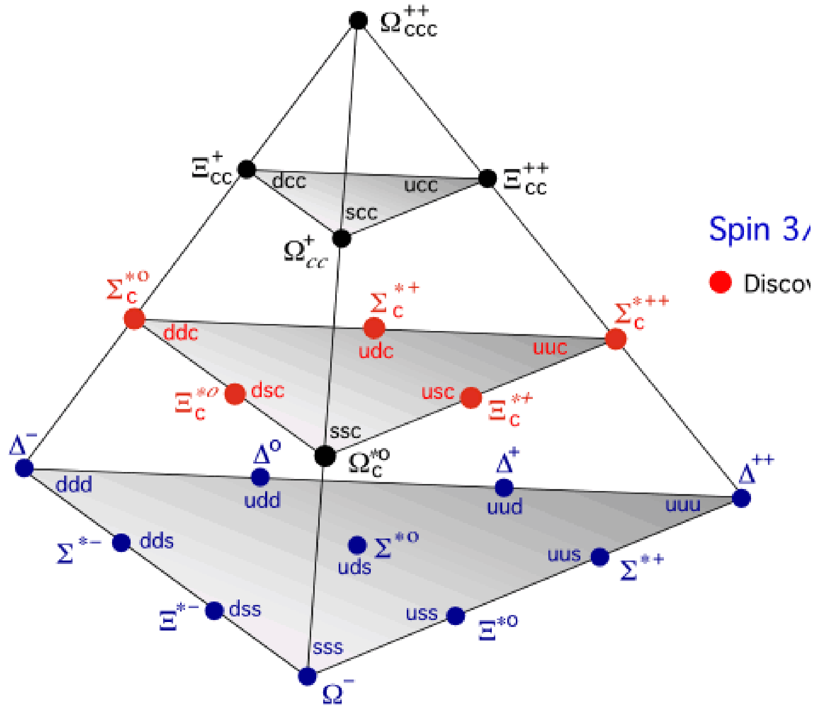
Start from the properly symmetrized wave-functions

$$|\pi^{+}\rangle = \frac{1}{\sqrt{2}}(u\bar{d} + \bar{d}u) \text{ and } |\rho^{+}\rangle = \frac{1}{\sqrt{2}}(u\bar{d} - \bar{d}u).$$

Give the quantum numbers I, I_3, S, and Q for each of these states.


(a)
D_s^+
D^0
D^+
K^0
K^+
π^-
π^0
η
η_c
η'
π^+
K^-
$\bar{K}^0$
D^-
$\bar{D}^0$
D_s^-
(b)
D_s^{*+}
D^{*0}
D^{*+}
K^{*0}
K^{*+}
ρ^-
ρ^0
ω
J/ψ
ϕ
ρ^+
K^{*-}
$\bar{K}^{*0}$
D^{*-}
$\bar{D}^{*0}$
D_s^{*-}


Ξ_{cc}^+
dcc
ucc
Ξ_{cc}^{++}
scc
Ω_{cc}^+
Λ_c^+, Σ_c^+
Σ_c^0
ddc
udc
uuc
Σ_c^{++}
dsc
usc
$\Xi_c^0, \Xi_c'^0$
$\Xi_c^+, \Xi_c'^+$
ssc
Ω_c^0
n
udd
uud
p
Σ^-
dds
uds
Λ, Σ^0
uus
Σ^+
Ξ^-
dss
uss
Ξ^0


Ω_{ccc}^{++}
Ξ_{cc}^+
dcc
ucc
Ξ_{cc}^{++}
scc
Ω_{cc}^+
Σ_c^{*0}
Σ_c^{*+}
Σ_c^{*++}
ddc
udc
uuc
Ξ_c^{*0}
dsc
usc
Ξ_c^{*+}
ssc
Ω_c^{*0}
Δ^-
Δ^0
Δ^+
Δ^{++}
ddd
udd
uud
uuu
Σ^{*-}
dds
Σ^{*0}
uds
uus
Σ^{*+}
Ξ^{*-}
dss
uss
Ξ^{*0}
sss
Ω^-