Particle Physics - Exercise 3

3.1 Isospin is homework, 3.2 C and P invariance we discuss in the exercise!

3.1. Isospin Invariance

The vector addition of two angular momentum states $|j_1 m_1\rangle$ and $|j_2 m_2\rangle$ to a total angular momentum state $|JM\rangle$ is described by the Clebsch-Gordon coefficients $\langle j_1 m_1\, j_2 m_2\, |JM\rangle$:

$$|JM\rangle = \sum_{m_1+m_2} |j_1\, m_1\, j_2\, m_2\rangle \langle j_1 m_1\, j_2 m_2\, |JM\rangle \quad \text{where } |j_1-j_2| < J < j_1+j_2 \quad \text{and} \quad M = m_1+m_2.$$

1. Use the Clebsch-Gordon coefficients for the isospin states to calculate the ratios of the following strong interaction cross sections σ and decay widths Γ:

$$\sigma \sim \Gamma \sim \left| \langle \text{out}|S|\text{in}\rangle \langle j_1 m_1\, j_2 m_2\, |JM\rangle \right|^2$$

Reactions:

$\sigma(\pi^- p \rightarrow K^+ \Sigma^-) / \sigma(K^- p \rightarrow \pi^+ \Sigma^-)$ **[2]**

Decays:

$\Gamma(\Delta^+ \rightarrow p\, \pi^0) / \Gamma(\Delta^+ \rightarrow n\, \pi^+)$ **[2]**

2. Give all reasons forbidding the decay $\rho^0 \rightarrow \pi^0 \pi^0$! **[3]**

3.2. C and P Invariance

2. The quantum numbers spin J and P and C parity for the pseudoscalar mesons π^0 and η^0 are $J^{PC} = 0^{-+}$. The vector bosons γ and Z^0 and the vector mesons ρ^0, ω^0, Φ^0, Ψ^0, $\Psi^{0'}$ have $J^{PC} = 1^{--}$.

Are the following strong or electromagnetic decays allowed?
If not give the violated conservation law!

$\pi^0 \rightarrow \gamma\,\gamma$

$\pi^0 \rightarrow \gamma\,\gamma\,\gamma$

$\eta^0 \rightarrow \pi^0\,\pi^0$ **[1]**

$\omega^0 \rightarrow \pi^+\,\pi^-\,\pi^0$ **[1]**

$\omega^0 \rightarrow \pi^0\,\gamma$ **[1]**

$\Psi' \rightarrow \Psi\,\gamma$ **[1]**

3. The K^+ meson can decay to $(\pi^+\,\pi^0)$ and $(\pi^+\pi^+\pi^-)$.
What is the parity of the two final states? **[2]**
Why can a particle with defined parity decay to final states with different parity? **[1]**