# FY3403 Particle physics

# Problemset 7 fall 2008

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**Problem 12. Isospin classification**

Write down the isospin classification $|II_3\rangle$ of the following elementary particles:
(i) $\Omega^-$, (ii) $\Sigma^+$, (iii) $\Xi^0$, (iv) $\Delta^0$, (v) $\rho^+$, (vi) $\eta$, (vii) $\bar{K}^0$.

**Problem 13. Isospin analysis of pion-nucleon scattering**

In this problem you should use the isospin symmetry of strong interactions to find relations between the cross-sections for the following processes

1. $\pi^+ + p \longrightarrow \pi^+ + p$
2. $\pi^0 + p \longrightarrow \pi^0 + p$
3. $\pi^- + p \longrightarrow \pi^- + p$
4. $\pi^+ + n \longrightarrow \pi^+ + n$
5. $\pi^0 + n \longrightarrow \pi^0 + n$
6. $\pi^- + n \longrightarrow \pi^- + n$
7. $\pi^+ + n \longrightarrow \pi^0 + p$
8. $\pi^0 + p \longrightarrow \pi^+ + n$
9. $\pi^0 + n \longrightarrow \pi^- + p$
10. $\pi^- + p \longrightarrow \pi^0 + n$

**a)** Write the isospin contents of the states involved (on the form $|I^{(1)} I_3^{(1)}\rangle\, |I^{(2)} I_3^{(2)}\rangle$), and decompose these into a sum over states with fixed isospin (on the form $|II_3\rangle$), for each of the cases above.

**b)** The assumption of isospin symmetry means that the scattering amplitude only depends on the total isospin,

$$\langle II_3|S|I'I_3'\rangle = \mathcal{M}^{(I)}\, \delta_{II'}\, \delta_{I_3 I_3'}, \tag{1}$$

where the amplitudes $\mathcal{M}^{(I)}$ generally are complex numbers. Express the altogether ten scattering amplitudes $\mathcal{M}_i$ for the above processes in terms of the amplitudes $\mathcal{M}^{(I)}$.

**c)** The scattering cross-sections $\sigma_i$ for the processes above has the form $\sigma_i = C\,|\mathcal{M}_i|^2$, where $C$ is the same for all processes. Find all possible relations (that can be derived from isospin symmetry) between these cross-sections.

**d)** When the center-of-mass energy $E$ is at the $\Delta$–resonance, $E \approx 1232$ MeV, the amplitude $\mathcal{M}^{(3/2)}$ becomes completely dominating. Which relations between cross-sections can be deduced in this case?