

Problem 2:

Problem 1:

$$|K^{*0}\rangle = |\bar{s}d\rangle = \left|\frac{1}{2} -\frac{1}{2}\right\rangle$$

$$|K^0\rangle = |\bar{s}d\rangle = \left|\frac{1}{2} -\frac{1}{2}\right\rangle$$

$$|\bar{\pi}^0\rangle = |10\rangle \quad |K^-\rangle = |s\bar{u}\rangle$$

$$|\pi^+\rangle = |11\rangle$$

$$|K^0\pi^0\rangle = \left|\frac{1}{2} -\frac{1}{2}\right\rangle |10\rangle = \sqrt{\frac{1}{3}} \left|\frac{1}{2} -\frac{1}{2}\right\rangle + \sqrt{\frac{2}{3}} \left|\frac{3}{2} -\frac{1}{2}\right\rangle$$

$$\Rightarrow \langle K^{*0} | K^0\pi^0 \rangle = \sqrt{\frac{1}{3}} \langle \frac{1}{2} | \frac{1}{2} \rangle$$

$$|K^-\pi^+\rangle = \left|\frac{1}{2} -\frac{1}{2}\right\rangle |11\rangle = \sqrt{\frac{2}{3}} \left|\frac{1}{2} +\frac{1}{2}\right\rangle + \sqrt{\frac{1}{3}} \left|\frac{3}{2} +\frac{1}{2}\right\rangle$$

$$\Rightarrow \langle K^{*0} | K^-\pi^+ \rangle = \sqrt{\frac{2}{3}} \langle \frac{1}{2} | \frac{1}{2} \rangle$$

$$\frac{\text{Br}(K^{*0} \rightarrow K^-\pi^+)}{\text{Br}(K^{*0} \rightarrow K^0\pi^0)} = \frac{\frac{2}{3}}{\frac{1}{3}} = 2$$

## Problem 2:

Parity of Charged pion

$\pi^- d \rightarrow n n$  is a strong interaction process  $\Rightarrow$  parity is conserved.

Initial state angular momentum:  $J = 1$

Final state:  $J = L + S = 1$

Let's look at the  $|nn\rangle$  state under interchange.

deuteron has  $S = 1$   
 $\bar{n}$  has  $S = 0$   
 Capture takes place in  $L = 0$

Quantum numbers			Spin	space	total	allowed
J	L	S				
1	2	1	+	+	+	NO
1	1	1	+	-	-	yes
1	1	0	-	-	+	NO
1	0	1	+	+	+	NO

only possibility  $\Rightarrow$

$$\text{Parity of final state} = (-1)^L (-1)^2 = (-1)^L = -1$$

$$\text{Parity of initial state} = P_{\pi^-} \cdot (-1)^L \cdot P_d = P_{\pi^-} \cdot 1 \cdot 1 = P_{\pi^-}$$

$$\Rightarrow \boxed{P_{\pi^-} = -1}$$

Problem 3:

$$(a) |\pi^0\rangle = |I, I_3\rangle = |10\rangle$$

$$|\pi^0\pi^0\rangle = |10\rangle|10\rangle = \sqrt{\frac{2}{3}}|20\rangle - \sqrt{\frac{1}{3}}|00\rangle$$

$$\Rightarrow \boxed{I=2, 0 \text{ are allowed}}$$

(b) Wave function total must be symmetric because of bosons.

$I=0, 2$  are both symmetric

$\Rightarrow L$  must be even

(c)  $J^{\pi^0} = 1$   $g^0 \rightarrow \pi^0\pi^0$  is thus forbidden

because  $S_{\pi^0} = 0 \Rightarrow L = 1$  However 1 is odd thus not allowed as explained in (b).

Hw 3: p.

Problem 4:

$$(a) |\pi^+ \pi^- \pi^0\rangle = |111\rangle |1-1\rangle |110\rangle$$

$$|111\rangle |1-1\rangle = \frac{1}{\sqrt{6}} |20\rangle + \frac{1}{\sqrt{2}} |110\rangle + \frac{1}{\sqrt{3}} |00\rangle$$

$$|20\rangle |110\rangle = \sqrt{\frac{3}{5}} |3,0\rangle - \sqrt{\frac{2}{5}} |110\rangle$$

$$|110\rangle |110\rangle = \sqrt{\frac{2}{3}} |20\rangle - \sqrt{\frac{1}{3}} |00\rangle$$

$$|00\rangle |110\rangle = |110\rangle$$

$$\Rightarrow \boxed{\bar{I} = 0, 1, 2, 3}$$

$$(b) |\pi^0 \pi^0 \pi^0\rangle = |110\rangle |110\rangle |110\rangle$$

$$|110\rangle |110\rangle = \sqrt{\frac{2}{3}} |20\rangle - \sqrt{\frac{1}{3}} |00\rangle$$

$$|110\rangle |00\rangle = |110\rangle$$

$$|20\rangle |110\rangle = \sqrt{\frac{3}{5}} |3,0\rangle - \sqrt{\frac{2}{5}} |110\rangle$$

$$\boxed{\bar{I} = 1, 3}$$

Problem 5.9

Greiner QM2 Symmetries  
lost part of Example 5.9

$$\sqrt{2} \langle n\pi^0 | S | p\pi^- \rangle + \langle p\pi^- | S | p\pi^- \rangle = \langle p\pi^+ | S | p\pi^+ \rangle$$

This forms a triangle in the complex plane.

$$|n\pi^0\rangle = \left| \frac{1}{2} \frac{-1}{2} \right\rangle |10\rangle = \sqrt{\frac{2}{3}} \left| \frac{3}{2} \frac{-1}{2} \right\rangle + \sqrt{\frac{1}{3}} \left| \frac{1}{2} \frac{-1}{2} \right\rangle$$

$$|p\pi^- \rangle = \left| \frac{1}{2} \frac{1}{2} \right\rangle |1-1\rangle = \sqrt{\frac{1}{3}} \left| \frac{3}{2} \frac{-1}{2} \right\rangle - \sqrt{\frac{2}{3}} \left| \frac{1}{2} \frac{-1}{2} \right\rangle$$

$$\langle n\pi^0 | p\pi^- \rangle = \frac{\sqrt{2}}{3} \langle \frac{3}{2} | \frac{3}{2} \rangle - \frac{\sqrt{2}}{3} \langle \frac{1}{2} | \frac{1}{2} \rangle$$

$$\langle p\pi^- | p\pi^- \rangle = \frac{1}{3} \langle \frac{3}{2} | \frac{3}{2} \rangle + \frac{2}{3} \langle \frac{1}{2} | \frac{1}{2} \rangle$$

$$\sqrt{2} \langle n\pi^0 | p\pi^- \rangle + \langle p\pi^- | p\pi^- \rangle = \left( \frac{2}{3} + \frac{1}{3} \right) \langle \frac{3}{2} | \frac{3}{2} \rangle$$

$$= \langle \frac{3}{2} | \frac{3}{2} \rangle$$

$$|p\pi^+ \rangle = \left| \frac{1}{2} \frac{1}{2} \right\rangle |11\rangle = \left| \frac{3}{2} \frac{3}{2} \right\rangle$$

$$\langle p\pi^+ | p\pi^+ \rangle = \langle \frac{3}{2} | \frac{3}{2} \rangle \quad \text{good}$$

Problem 6:

This is example 5.7 in Greiner QM2 Symmetries

$$p+d = \begin{cases} \pi^0 \text{He}^3 \\ \pi^+ \text{H}^3 \end{cases}$$

initial state:  $|\frac{1}{2} \frac{1}{2}\rangle |00\rangle$

final states:

~~$$|11\rangle |\frac{1}{2} -\frac{1}{2}\rangle = |\pi^+ \text{H}^3\rangle$$~~

$$|10\rangle |\frac{1}{2} \frac{1}{2}\rangle = |\pi^0 \text{He}^3\rangle$$

$$R = \frac{\sigma(p+d \rightarrow \pi^+ \text{He}^3)}{\sigma(p+d \rightarrow \pi^0 \text{H}^3)} = \frac{|\langle 1 \frac{1}{2} \frac{1}{2} | 1 -\frac{1}{2} \frac{1}{2} \rangle|^2}{|\langle 1 \frac{1}{2} \frac{1}{2} | 0 \frac{1}{2} \frac{1}{2} \rangle|^2} = \frac{2/3}{1/3}$$

$$R = 2$$