

Übungen zu Physik an Hadron-Collidern SS 2013  
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Übungsblatt Nr. 6

Die Lösungen müssen bis 11 Uhr am Mittwoch, 12.6.2013 in die Briefkästen  
im Erdgeschoss des Gustav-Mie-Hauses eingeworfen werden!

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1. **Weak interactions**

- Show that the  $V - A$  expression for the “charged” weak current can be rewritten as a pure vectorial current involving the left-handed components of the involved fermions. That is, show the equivalence of the two expressions below (focusing in the notation on a  $W e \nu$  vertex) [**2 points**]:

$$\bar{\nu} \gamma_{\mu} \frac{1}{2} (1 - \gamma_5) u_e = \bar{\nu}_L \gamma_{\mu} e_L \quad (1)$$

- In a similar way, show that the expression for the weak neutral current can be rewritten as a current involving left handed fermion components plus a current involving right-handed fermion components. That is, show that [**2 points**]:

$$\bar{e} \gamma_{\mu} \frac{1}{2} (C_V - C_A \gamma_5) e = \bar{e}_L g_L \gamma_{\mu} e_L + \bar{e}_R g_R \gamma_{\mu} e_R \quad (2)$$

2. **Electroweak unification**

In the unified electroweak theory, the electroweak current can be written as:

$$-i g \vec{j}_{\mu} \cdot \vec{W}^{\mu} - i \frac{g'}{2} j_{\mu}^Y B^{\mu} \quad (3)$$

where  $\vec{j}_{\mu}$  is the weak isospin current,  $j_{\mu}^Y$  is the hypercharge current,  $\vec{W}^{\mu}$  and  $B^{\mu}$  are the gauge fields.

- Write down the expression for the 4 physical fields  $W^{\pm}$ ,  $A$ ,  $Z$  in terms of the quantities appearing on the expression above and the weak mixing angle  $\theta_W$  [**2 points**].
- Given the relationship between the electromagnetic current and  $\vec{j}_{\mu}, j_{\mu}^Y$ , what is the relation between the electric charge and  $g, g'$ ? [**2 points**]
- From the neutral current interaction term, derive an expression for the vectorial and axial couplings  $C_V, C_A$  to fermions in terms of the hypercharge and weak isospin of the fermions. [**2 points**]