Final

Introduction to Particle Physics

09/07/2021

The solution must be sent back to me at the address bertuzzo@if.usp.br at most by 16/07/2021 at 13:00. If you want to sent it before there is no problem, but I will not accept solutions sent after the deadline.

Consider a gauge theory based on a local $SU(2)$ group. The particle content consist of

- one Dirac fermion $\psi \sim \mathbf{2}$;
- one real scalar $\phi \sim \mathbf{3}$.

Suppose the theory is also invariant under a **global** transformation

$$\psi(x) \to e^{i\alpha}\psi(x).$$

1. Write explicitly all the transformations (local and global) of the fields **[1.0]**;
2. What is the most general Lagrangian, considering operators up to $d = 4$? Write explicitly all the terms appearing **[2.0]**;
3. What are the Feynman rules for the interactions present in the model? **[1.0]**
4. Compute the total cross-section for the process

   $$\psi_k \bar{\psi}_k \to \psi_k \bar{\psi}_k,$$

   where ψ_k ($\bar{\psi}_k$) is any of the component of the fermion doublet (antidoublet); **[2.0]**
5. Suppose now that the scalar field acquires a non-vanishing vacuum expectation value v:
   (a) Compute v in terms of the parameters appearing in the scalar potential **[0.5]**;
   (b) What is the pattern of symmetry breaking? Compute the generator or generators of the unbroken symmetry **[1.5]**;
   (c) How many gauge bosons acquire a non-vanishing mass? Justify your answer **[0.5]**;
   (d) Compute the gauge bosons masses **[1.0]**;
   (e) How are the fermion masses modified by symmetry breaking **[0.5]**?
   (f) Determine the charges of the fermions and gauge bosons under the unbroken group **[1.5]**.