

# Simulation - Exam

## Introduction to Particle Physics

21/05/2021

Consider a theory based on a **global** group  $SU(2) \times U(1)$ . The matter content is composed by two fermions ( $\psi_L \sim \mathbf{2}_1$  and  $\chi_R \sim \mathbf{3}_{-1}$ ) and by a complex scalar  $\phi \sim \mathbf{2}_2$ .

1. Write the most general Lagrangian (considering only operators of dimensions smaller or equal to 4) invariant under all the symmetries of the theory (Lorentz and gauge invariance) **[3 pts]**;
2. Compute the total cross section for the process  $\psi\bar{\chi} \rightarrow \psi\bar{\chi}$  (pay attention: are the fermions massive in our theory? And the scalar?) **[3pts]**
3. Suppose now that the scalar  $\phi$  acquires a non-vanishing vacuum expectation value  $v$ :
  - (a) What is the value of  $v$  when expressed in terms of the parameters of the scalar potential? **[1 pt]**
  - (b) What is the pattern of symmetry breaking? What is (if any) the generator of the unbroken subgroup? **[1 pt]**
  - (c) Do some fermions acquire a non-vanishing mass due to symmetry breaking? Justify your answer. **[1 pt]**
4. What are the charges under the unbroken group of the components of the fermion and scalar fields? **[3 pts]**