

Model Standard

Contesteu quatre de les preguntes següents

Cada pregunta correctament contestada val 2.5 punts

Temps: 4h

1.- In QCD the leading term in the interquark potential grows with r (the interquark separation). It is natural to expect that $V(r) = \sigma r - b \frac{\alpha_s}{r}$.

a) Take a look at the Particle Data Book for systems made of progressively heavier quarks ($u\bar{u}$, $s\bar{s}$, $c\bar{c}$, etc.) and examine the typical meson masses. How does the mass of the typical meson compare to $2m_q$? Where is the ‘excess’ energy stored?

b) Assume that $\sigma \sim \Lambda_{QCD}^2$ (take $\Lambda_{QCD}^2 \sim 200$ MeV). Could you estimate the average size of a typical hadron made of light quarks (‘confinement radius’). Compare this length scale to the Bohr radius (you can deduce it from the Coulombic part of the interquark potential) for systems of light quarks ($m_q \simeq 10$ MeV).

c) Let’s now move to systems made of heavier quarks (such as charmonium, bottonium or even toponium). Which would be the ‘confinement’ radius for these systems. Compare this length to the respective Bohr radii. What do you learn? Which piece of the interquark potential is at work?

d) Finally, look again in the PDB for states with $J^P = 0^-$ and compare their masses to the equivalent mesons with other quantum numbers (you should of course compare mesons with a similar quark contents). Which is the general pattern you observe?

2.- Discuss the transformations under CP of the different fields contained in the scalar sector of the Minimal Standard model, i.e. that containing a complex doublet of fields

$$\Phi = \frac{1}{\sqrt{2}} \begin{pmatrix} \phi_1 - i\phi_2 \\ v + \sigma + i\chi \end{pmatrix}$$

3.- Give an order of magnitude estimate of the amplitude corresponding to the following processes at tree level in the electroweak theory. It will be helpful if you draw the corresponding tree-level diagrams.

- $K^+ \rightarrow \pi^+ \pi^0$
- $\pi^+ \rightarrow e^+ \nu$
- $\pi^+ \rightarrow \pi^0 e^+ \nu$
- $K_S \rightarrow \gamma \gamma$
- $K_S \rightarrow \pi^+ \pi^-$

4.- Use the canonical commutation relations between fields and momenta to show that

$$[Q^a, \phi_k] = -T_{kl}^a \phi_l$$

5.- Discuss which is the dominant Feynman diagram for the decay of the Minimal Standard Model Higgs particle into two gluons. Give an order of magnitude estimate for the amplitude for such process without calculating anything. Hint: you must use gauge invariance. Write the simplest possible interaction term which may give rise to such decay and try to guess its coefficient.