Questions 18th April 2017

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QCD

1) What are the differences between a local and a global phase transformation and what is a *non-abelian* gauge group?

3) Write an expression for the quark current associated with a QCD quark-gluon vertex. 3i) Simply this expression to yield the Feynamn rule associated with the QCD vertex.

4) What is referred to as *colour confinement*?

5) What is *hadronisation*?

6) For electron-positron scattering, how does the cross section differ between a final state of $\mu^+\mu^-$ or $q\bar{q}$ i.e $e^+e^- \to q\bar{q}$?

6i) Expand for an inclusive final state.

7) The observed events in the process pp $\to$ two-jets at the LHC can be described in terms of the jet p_T and the jet rapidities y_3 and y_4. a) Assuming the jets are massless, $E^2 = p_T^2 + p_Z^2$, show that the four momenta of the final-state jets can be written as:

$$p_3 = (p_T cosh y_3, +p_T sin\phi, +p_T cos\phi, p_T sinh y_3) \tag{1}$$

$$p_4 = (p_T cosh y_4, -p_T sin\phi, -p_T cos\phi, p_T sinh y_4) \tag{2}$$

b) By writing the four-momenta of the colliding partons in a pp collision as

$$p_1 = \frac{\sqrt{s}}{2}(x_1, 0, 0, x_1) \tag{3}$$

and

$$p_2 = \frac{\sqrt{s}}{2}(x_2, 0, 0, -x_1) \tag{4}$$

show that the conservation of energy and momentum implies

$$x_1 = \frac{p_T}{\sqrt{s}}(e^{+y_3} + e^{+y_4}) \tag{5}$$

and

$$x_2 = \frac{p_T}{\sqrt{s}}(e^{-y_3} + e^{-y_4}) \tag{6}$$

c) Hence show that

$$Q^2 = p_T^2(1 + e^{y_4 - y_3}) \tag{7}$$