3a) Strong interactions

QCD in the theory of strong interactions. It is obtained by gauging the color degree of freedom. Color is required to satisfy the spin-statistics theorem.

\( S = \text{up up up additional quantum number needed to have 3 particles in the same state. need 3 colors} \)

In QCD, the quark fields are taken to be mass eigenstates.

\( \mathbf{p} = \gamma \left( \delta \mathbf{p} + \mathbf{A} \right) \)

gauging \( \delta \mathbf{p} \rightarrow \delta \mathbf{p} = \delta \mathbf{p} + i g \mathbf{A} \mathbf{p} \)

\( \mathbf{p} \) transforms as \( \mathbf{p} \) under \( \text{strong gauge transformation} \)

\( \mathbf{p} \) in \( \mathbf{F}_{\mathbf{A}} \mathbf{F}^\mathbf{A} + i \Theta \mathbf{F}_{\mathbf{A}} \mathbf{F}^\mathbf{A} \)

\( \mathbf{p} \) changes as \( \mathbf{p} \) under \( \text{strong gauge transformation} \)

\( \mathbf{m} \to \mathbf{m} = \begin{pmatrix} m_1 + \mathbf{m} \\ m_2 + \mathbf{m} \\ m_3 + \mathbf{m} \end{pmatrix} \)

\( m_1 = 92 \) MeV

\( m_2 = 30 \) MeV

\( m_3 = 100 \) MeV

\( \eta_c = 1.2 \) GeV

\( \eta_c = 4.2 \) GeV

\( \eta_c = 174 \) GeV