Decay constants and mass spectrum of pseudoscalars mesons

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Abstract

Abstracts

From Quantum Field Theory (QFT) for non-perturbative systems, the Schiwnger-Dyson equations (SDE) are obtained, which are analogous to the Euler-Lagrange equations in QFT, since they are the equations of motion of the Green's functions . The SDEs are an infinite set of integral equations coupled to each other and it is only possible to solve them by means of a truncation scheme. The Bethe-Salpeter equations (BSE) have as a solution the wave function of the states bound to a system of two particles. The BSEs are obtained from a covariant relativistic formalism. We solve abelian models for quantum chromodynamics (QCD) at low energies, which rules allow us to obtain the spectrum of pseudoscalar mesons $J_p = 0^-$ and the decay constants.

Schwinger-Dyson equation

Schwinger-Dyson equation

In general the Green functions for a given number n of points, there are correlation functions of type

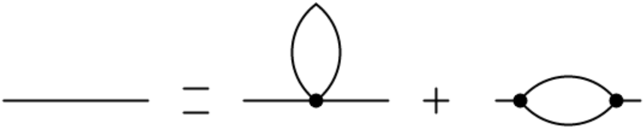
$$G(x_1 \cdots x_n) = \langle 0| \, T(\phi(x_1) \cdots \phi(x_n)) \, |0\rangle$$

Which are related to Feynmann diagrams, for $n = 2$, it is related to the propagator; it is likely that at n=3 (tree level) a-loops may appear, and this would generate an anomaly.

Self-energy

Self-energy

In QFT, the energy that a particle has as a result of changes that it causes in its environment defines self-energy Σ , and represents the contribution to the particle's energy, or effective mass, due to interactions between the particle and its environment.

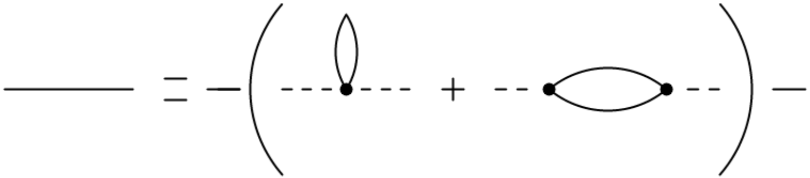


The term of interaction will be

$$\mathcal{L}_I = \frac{\lambda}{4!}\phi^4 + \frac{\mu}{3!}\phi^3$$

Self-energy

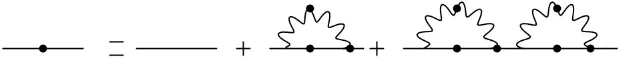
If we extract the external legs, amputating each of these, we obtain the diagrams



Dynamical mass generation

Dynamical mass generation

Using the definition of self-energy, the full fermion propagator is given by the summation; wheresum of all diagrams 1PI . The solid dots indicate the Green's functions are fully dressed.



This can equally well be written as

$$S_F(p) = S_F^0(p) + S_F^0(p)\Sigma S_F^0(p) + S_F^0(p)\Sigma S_F^0(p)\Sigma S_F^0(p) + \cdots$$

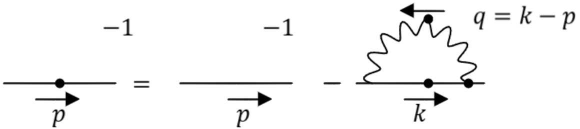
or also

$$S_F(p) = S_F^0(p) + S_F^0(p)\Sigma S_F(p)$$

Dynamical mass generation

So finally, we obtain the field equation for the inverse fermion propagator

$$S_F(p)^{-1} = S_F^0(p)^{-1} - \Sigma$$



whose integral equation has the form

$$S_F(p)^{-1} = S_F^0(p)^{-1} - \frac{\alpha}{4\pi}(3+\xi)\int \mathrm{d}^4k\gamma_\mu S_F(k)\Gamma_\nu(k,p)\Delta(q)$$

Dynamical mass generation

Where $S_F^0(p)^{-1} = p - m_0$ is the inverse bare propagator; the photon propagator in a covariant gauge $\Delta^{\mu\nu}(q) = \frac{1}{q^2}\left\{\mathcal{G}(q)\left(q^{\mu\nu} - \frac{q^\mu q^\nu}{q^2}\right) + \xi\frac{q^\mu q^\nu}{q^2}\right\}$ the complete structure of the fermion-boson interaction vertex $\Gamma_\nu(k,p)$ so that

$$S_F(p) = \frac{\mathcal{F}(p)}{p - \mathcal{M}(p)}$$

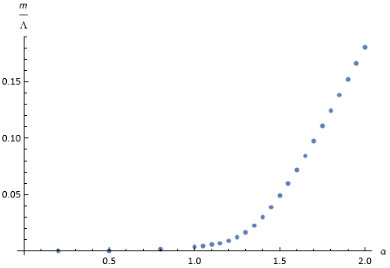
The special case where de bare propagator is $\mathcal{M}(p) = m_0$ y $\mathcal{F}(p) = 1$, we deduce one coupled fermion equations on tracing with the unit matrix p

$$\frac{\mathcal{M}(p)}{\mathcal{F}(p)} = m_0 + \frac{\alpha}{4\pi}(3+\xi)\int_0^{k^2} \mathrm{d}k^2 \frac{\mathcal{F}(k)\mathcal{M}(k)}{k^2 + \mathcal{M}(k)^2}\left[\theta_+\frac{k^2}{p^2} + \theta_-\right]$$

Results

Results

We initiate a change of variable $k^2 = \Lambda^2 x$, so $\mathrm{d}k^2 = \Lambda^2 \mathrm{d}x$. We will use the program *Wolfram Mathematica: Modern Technical computing* considering the conditions $\xi = 0$ and a $\alpha \gg m_0$ and $m_0 \to 0$ doing a quadrature Gaussinian weights and taking different values for $0.5 < \alpha < 2$.



$$\mathcal{M}(p) = m_0 + \frac{\alpha}{4\pi}(3)\int_0^{\Lambda^2 x} \mathrm{d}x \frac{\mathcal{M}(k)}{x + \left(\frac{\mathcal{M}(k)}{\Lambda}\right)^2}\left[\theta_+ \frac{k^2}{p^2} + \theta_-\right]$$