

The Vertex Function of Fundamental Scalar Charges in Landau QCD

Diploma Thesis

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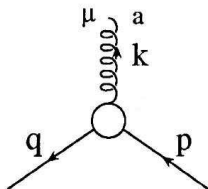
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Motivation

Quark-Gluon Vertex in QCD



General Structure

$$\Gamma_{\mu}^a(k, q, p) = -igt^a(2\pi)^4 \delta^4(k + q - p) \Gamma_{\mu}(q, p)$$

12 Tensor Structures

Relation to Quark Confinement see talk by Kai Schwenzer

Idea of Fundamental Scalar Charges

- Quarks \rightarrow Fundamental Scalar Charges
- Theory gets easier to handle
- reduce Number of Tensor Structures
- Confinement by the Vertex ?

Idea of Fundamental Scalar Charges

- Dyson-Schwinger Equations
- Infrared Analysis, IR Fixed Points
- Confinement ? (cf. Adjoint Charges)
- Numerical Solution of the Vertex
- Check with Lattice Calculations

Idea of Fundamental Scalar Charges

Lagrangian

$$\mathcal{L} = \frac{1}{4} F_{\mu\nu} F^{\mu\nu} + \bar{c}^a \partial_\mu D^{\mu,ab} c^b + \frac{1}{2} (D_{ij}^\mu \phi_j^*) (D_{\mu,ik} \phi_k) - \frac{1}{2} m^2 \phi_i^* \phi_i - \frac{\lambda}{4!} (\phi_i^* \phi_i)^2$$

$$\phi_i : i = 1, \dots, N \text{ (SU(N))}$$

$$D^{\mu,ab} = \partial^\mu \delta^{ab} - gf^{abc} A^{\mu,c}$$

$$D_{ij}^\mu = \partial^\mu \delta_{ij} - ig \left(\frac{t^a}{2} \right)_{ij} A^{\mu,a}$$

Formalism

Non-Perturbative Functional Method: *Dyson-Schwinger Equations*

$$\frac{\delta\Gamma[\phi]}{\delta\phi_i} - \frac{\delta S}{\delta\phi_i} \left[\phi + \frac{\delta^2 W}{\delta j \delta j} \frac{\delta}{\delta\phi} \right] = 0$$

Primitively Divergent Graphs:

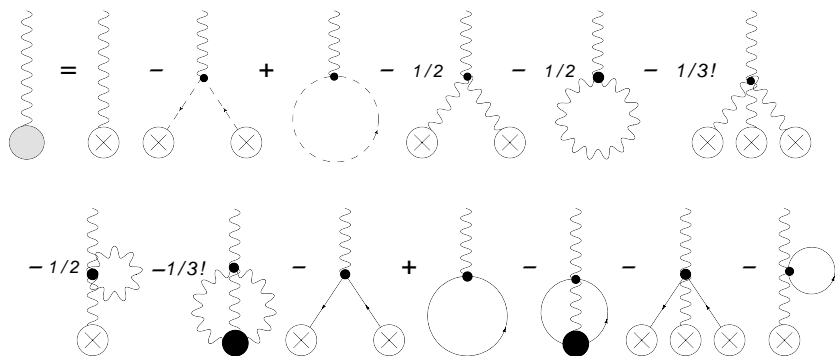
$$D_s, D_g, D_{gh}, \Gamma^{3g}, \Gamma^{4g}, \Gamma^{2s,g}, \Gamma^{2s,2g}, \Gamma^{4s}, \Gamma^{g,gh}$$

Dyson-Schwinger Equation for the Scalar Charge

The diagram illustrates the Dyson-Schwinger equation for the scalar charge vertex function. On the left, a tree-level vertex function is shown as a grey circle with a value of -1 . This is equal to the sum of several diagrams representing higher-order corrections:

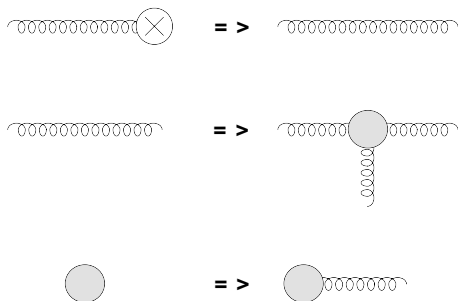
- A tree-level propagator (a horizontal line with an arrow pointing right).
- A diagram with a self-energy loop on the propagator, labeled $-1/2$.
- A diagram with a ghost loop on the propagator, labeled $-1/2$.
- A diagram with a ghost loop on the vertex, labeled $-1/2$.
- A diagram with a ghost loop on the vertex and a ghost loop on the propagator, labeled $-1/2$.
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Dyson-Schwinger Equation for the Gluon



Dyson-Schwinger Equation for the Scalar Particle-Gluon Vertex

graphical method:



Outlook

Solve coupled DSE:

- Infrared Behaviour: Qualitative Behaviour in the Infrared, IR-Exponents of the most singular Dressing Functions
- Infrared Fixed Points
- Numerical Solution