ANALYSIS OF FULL-QCD AND QUENCHED-QCD LATTICE PROPAGATORS

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Investigation

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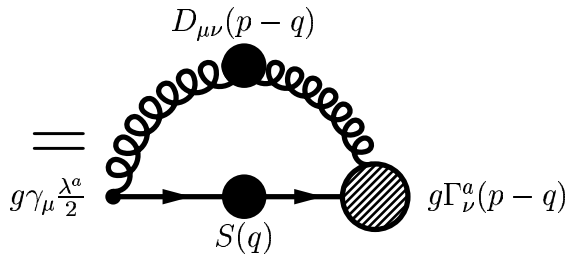
- *Motivation : Improved DSE phenomenology for hadron physics*
- **Self-energy** $\Sigma(\mathrm{p}, \Lambda) =$



- **Parametrize lattice gluon data**
- **Investigate nature of vertex dressing**
- **Calculate observables from DSE-lattice model** *(Future work)*

Gap equation

Gap equation

- **Gap equation**

$$\mathbf{S(p)^{-1} = Z_2(\zeta,\Lambda) i\gamma\cdot p + Z_4(\zeta,\Lambda) m(\zeta) + Z_1(\zeta,\Lambda)\Sigma(p,\Lambda)}$$

- **Solution gives the propagator**

$$\mathbf{S(p) = \frac{Z(p)}{i\gamma.p + M(p)}}$$

- **B.C.: For large spacelike ζ**

$$\mathbf{S^{-1}(p)|_{p^2=\zeta^2} = i\gamma.p + m(\zeta)}$$

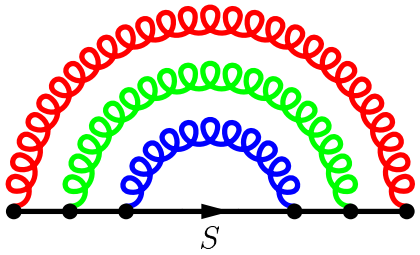
fixes Z_2 and Z_4

- **Landau gauge, Euclidean space**

Rainbow approximation

Rainbow approximation

- $\mathbf{g\Gamma_\mu \rightarrow g\gamma_\mu}$



- $\mathbf{g^2 D_{\mu\nu}(q) \rightarrow 4\pi\alpha_{eff}(q^2)\, D^{free}_{\mu\nu}(q)}$
- $\mathbf{Z_1 \Sigma(p) = \int_k^\Lambda 4\pi\alpha_{eff}((p-k)^2) D^{free}_{\mu\nu}(p-k) \frac{\lambda^a}{2} \gamma_\mu S(k) \gamma_\nu \frac{\lambda^a}{2}}$
- **We ensure for large $\mathbf{q^2}$,**

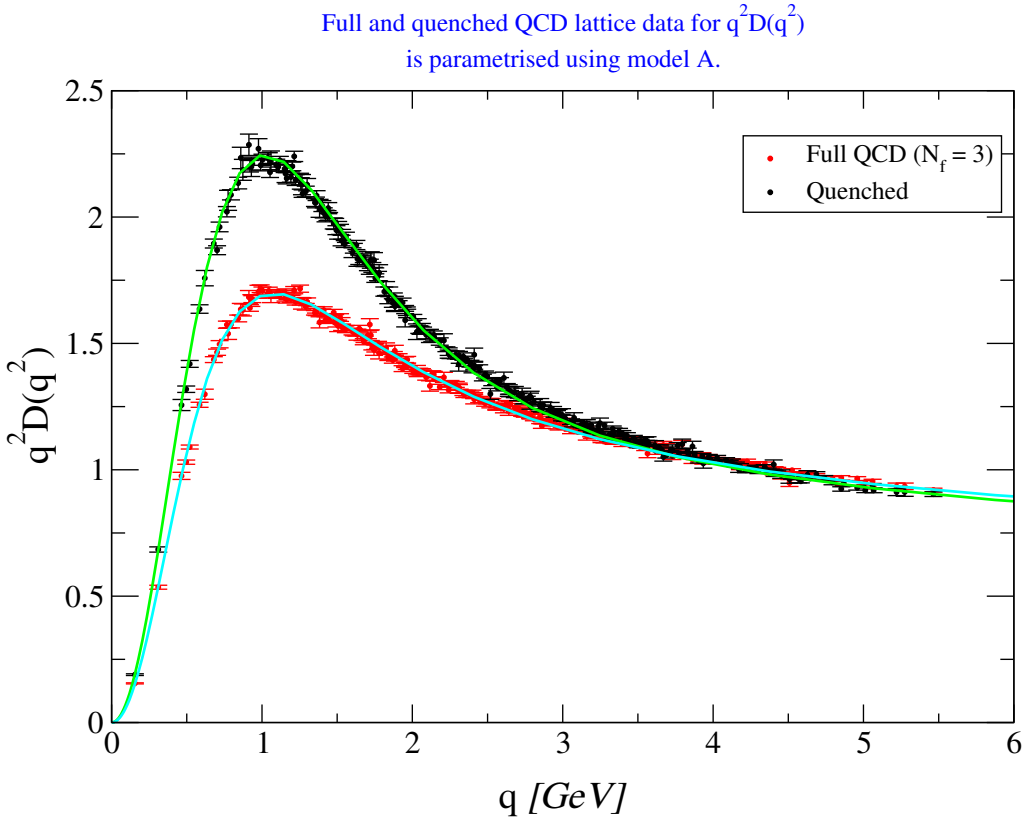
$$\mathbf{4\,\pi\,\alpha_{eff}(q^2)} \longrightarrow \frac{\mathbf{4\pi^2\gamma_m}}{\ln(\mathbf{q^2/\Lambda^2_{QCD}})}$$

$$\gamma_m = 12/(33 - 2N_f)$$

DSE-lattice model

DSE-lattice model

- **Parametrised form for lattice gluon**



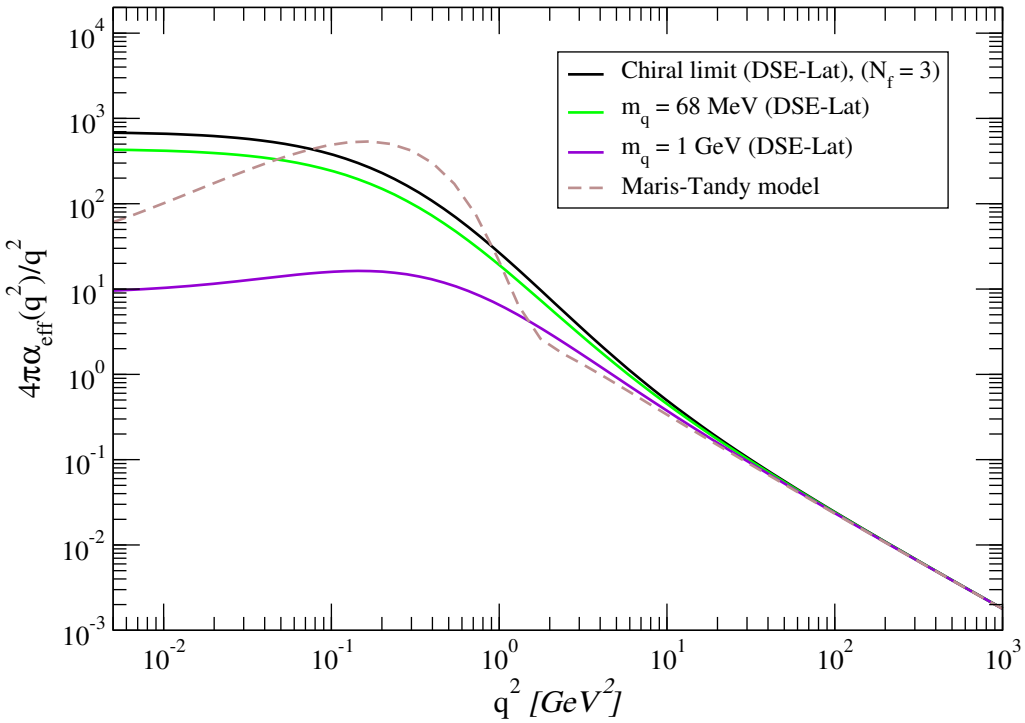
Leinweber, Skullerud, Williams, Parrinello **PRD60**

Bowman, Heller, Leinweber, Parapilly, Williams **hep-lat/0402032**

DSE-lattice model

- **Model:**

$$\frac{4\pi\alpha_{\rm eff}(\mathbf{q^2})}{\mathbf{q^2}} = \mathbf{D_{lat}(q^2)\,\Gamma(q^2)}$$



DSE fits and lattice data

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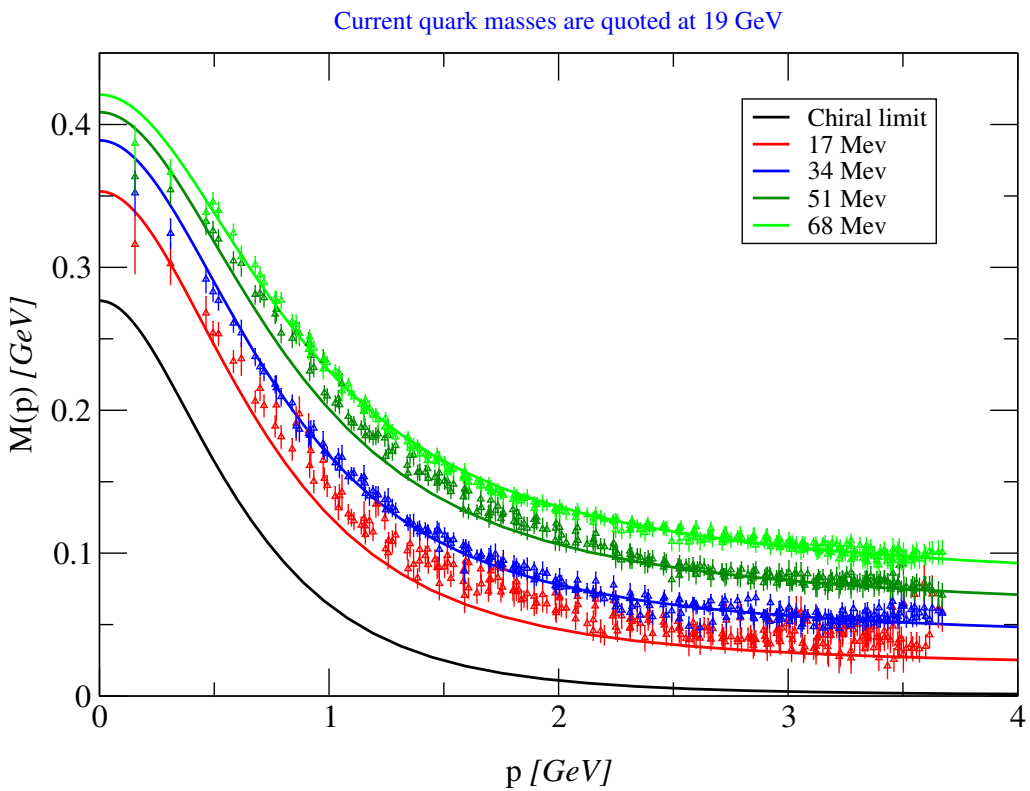
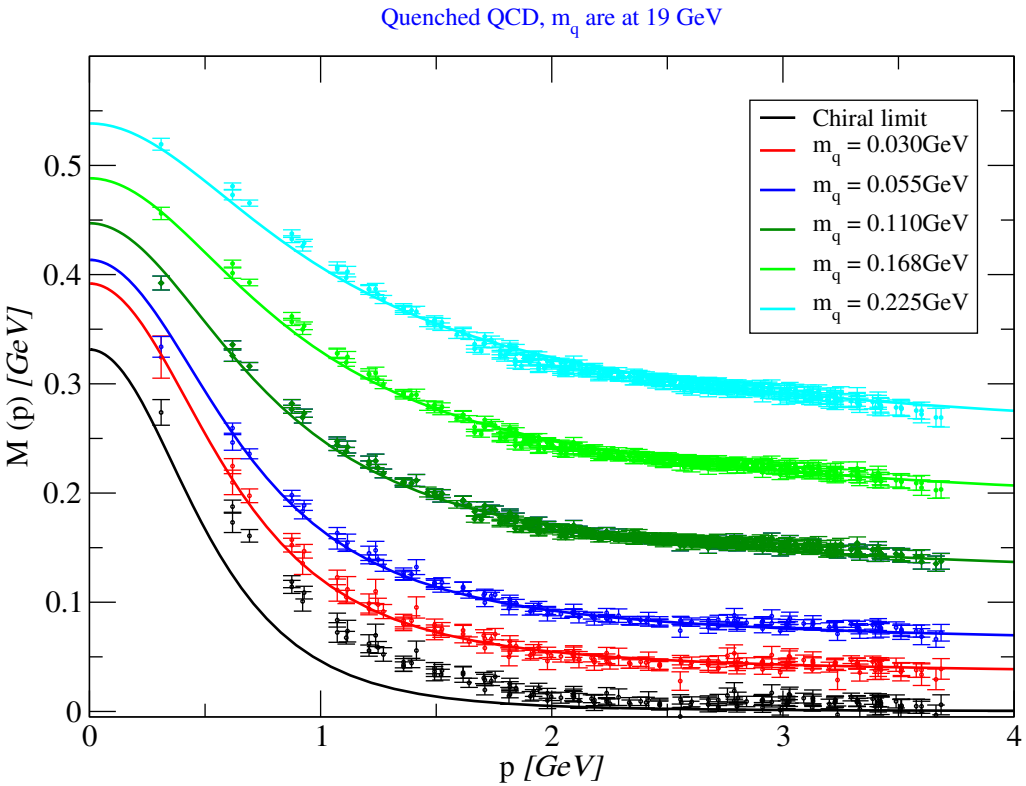
- $m_1 : m_2 : m_3 : m_4$ **fixed by lattice**



DSE fits and lattice data



MSB, Pichowsky, Roberts, Tandy PRC68

Spectral Properties

Spectral Properties

- $\mathbf{S(p) = -i\gamma.p\,\sigma_v(p^2) + \sigma_s(p^2)}$; $\mathbf{\Delta_S(T) = \int \frac{dp_4}{(2\pi)}\, e^{ip_4 T}\, \sigma_S(p^2)}$

- Eg: $\sigma_s(p^2) = \frac{m}{p^2+m^2}$; $\mathbf{\Delta_S(T) = \frac{1}{2}\, e^{-mT}}$, $+ve$ definite

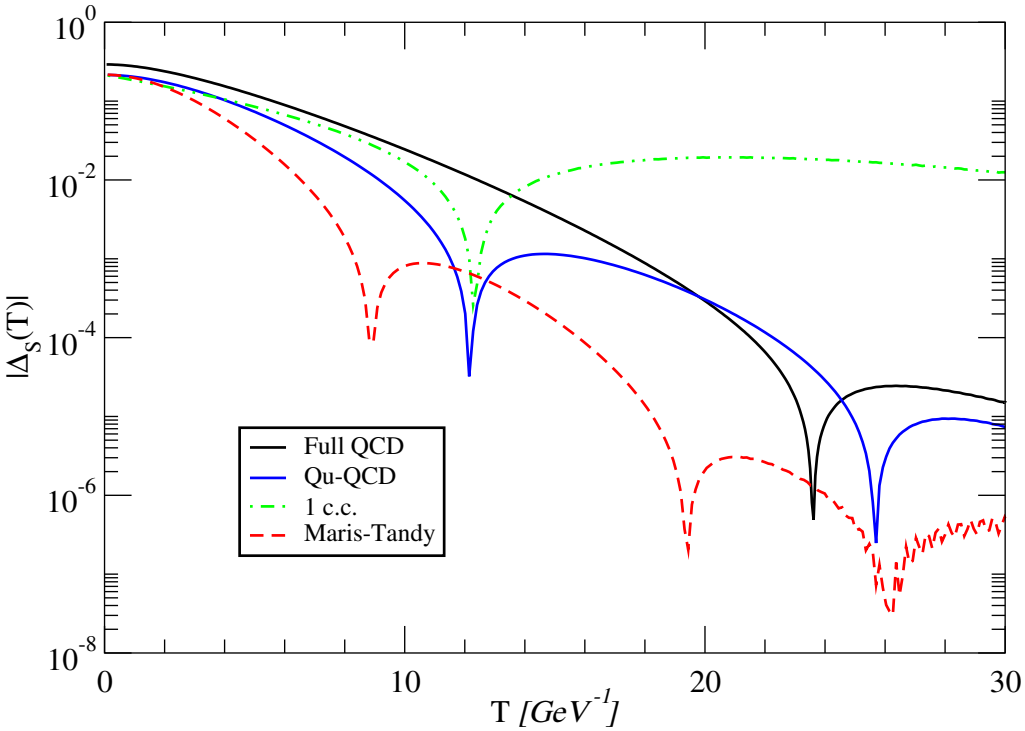
- **Eg:** $$\sigma_s(p^2) = \frac{m}{2}\left[\frac{1}{p^2+m^2-i\rho^2} + \frac{1}{p^2+m^2+i\rho^2}\right]$$

  $\mathbf{\Delta_S(T)}$ ***not*** $+ve$ **definite**

- $\Delta_S(T)$ **not +ve definite** $\Longrightarrow$ **No asymptotic state sufficient for confinement**

Spectral Properties

- $|\Delta_S(T)|$ **has cusps** $\Longrightarrow$ **No free quarks**



Chiral limit

Chiral limit

- **Quark condensate at the renormalization point ζ**

$$-\langle\bar{q}q\rangle^0_\zeta = \lim_{\Lambda\to\infty} Z_4(\zeta,\Lambda)\, N_c\, \mathrm{tr}\int_q^\Lambda S_0(q)$$

- **Condensate evolved to another scale ζ'**

$$\langle\bar{q}q\rangle^0_{\zeta'} = Z_m(\zeta',\zeta)\langle\bar{q}q\rangle^0_\zeta$$

$-\langle\bar{q}q\rangle^0_1$	Empirical	lattice ch.ex.	DSE – lattice
Full – QCD	$(0.24\mathrm{GeV})^3$	–	$(0.23\mathrm{GeV})^3$
Qu – QCD	–	$(0.27\mathrm{GeV})^3$	$(0.19\mathrm{GeV})^3$

Pion properties

Pion properties

- **Leptonic decay constant**

$$\mathbf{f_\pi\, \delta^{ij}\, 2\, P_\mu = Z_2\, \mathrm{tr} \int_q^\Lambda \tau^i \gamma_5 \gamma_\mu \chi_\pi^j(q;P)}$$

	Full-QCD	Qu-QCD
chiral f_π	0.072	0.063

Summary

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- **Information on infrared strength of vertex dressing**
- **Extracted vertex dependence on m_q**
- **DSE-BSE Kernel from full-QCD for meson physics**
- **More informed chiral extrapolation**
- **Beyond rainbow-ladder BSE for improved hadron physics** ***(Future work)***