Progress: $N \to N^*(1535)$ Transition Form Factors in a Contact Interaction

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Nucleon Resonances: From Photoproduction to High Photon Virtualities

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  Form factors for Meson and Diquark Transitions

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Introduction

Hadronic form factors are intimately related to their internal structure. Unraveling them from the basic building blocks of QCD, i.e., quarks and gluons, is a challenge.

Schwinger-Dyson equations are the fundamental equations of QCD and combine its UV and IR behavior.

Thus they provide a platform to study the form factors from small to large photon virtualities, measured at different hadron physics facilities.

An example of interest for us are the transition form factors $N \to N^*(1535)$ measured at Jlab (CLAS) and Mainz.

The form factors and their evolution along the axis of probing photon momentum help us understand the pattern of chiral symmetry breaking and confinement

Introduction

- Employing SDEs, we can study the structure of hadrons through first principles in the continuum.
- SDE for QCD have been extensively applied to meson spectra and interactions below the masses ~ 1 GeV.
- They have been employed to calculate:

the masses, charge radii and decays of mesons

P. Maris, C.D. Roberts, Phys. Rev. C56 3369 (1997).

P. Maris, P.C. Tandy, Phys. Rev. C62 055204 (2000).

D. Jarecke, P. Maris, P.C. Tandy, Phys. Rev. C67 035202 (2003).

M.A. Bedolla, J.J. Cobos Martínez, AB, Phys. Rev. D92 5 05403 (2015).

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P. Maris, P.C. Tandy, Phys. Rev. C62 055204 (2000).

L. Chang, I.C. Cloet, C.D. Roberts, S.M. Schmidt, P.C. Tandy, Phys. Rev. Lett. 111 14 141802 (2013).

K. Raya, L. Chang, AB, J. Cobos, L.X. Gutiérrez, C.D. Roberts, P.C. Tandy, arXiv:1510.02799 (2015).

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T. Nguyen, AB, C.D. Roberts, P.C. Tandy, Phys. Rev. C83062201 (2011).

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nucleon electromagnetic and transition form factors

G. Eichmann, et. al., Phys. Rev. C79 012202 (2009).
D. Wilson, L. Chang and C.D. Roberts, Phys. Rev. C85 025205 (2012).
J. Segovia, et. al. 1504.04386 (2015).

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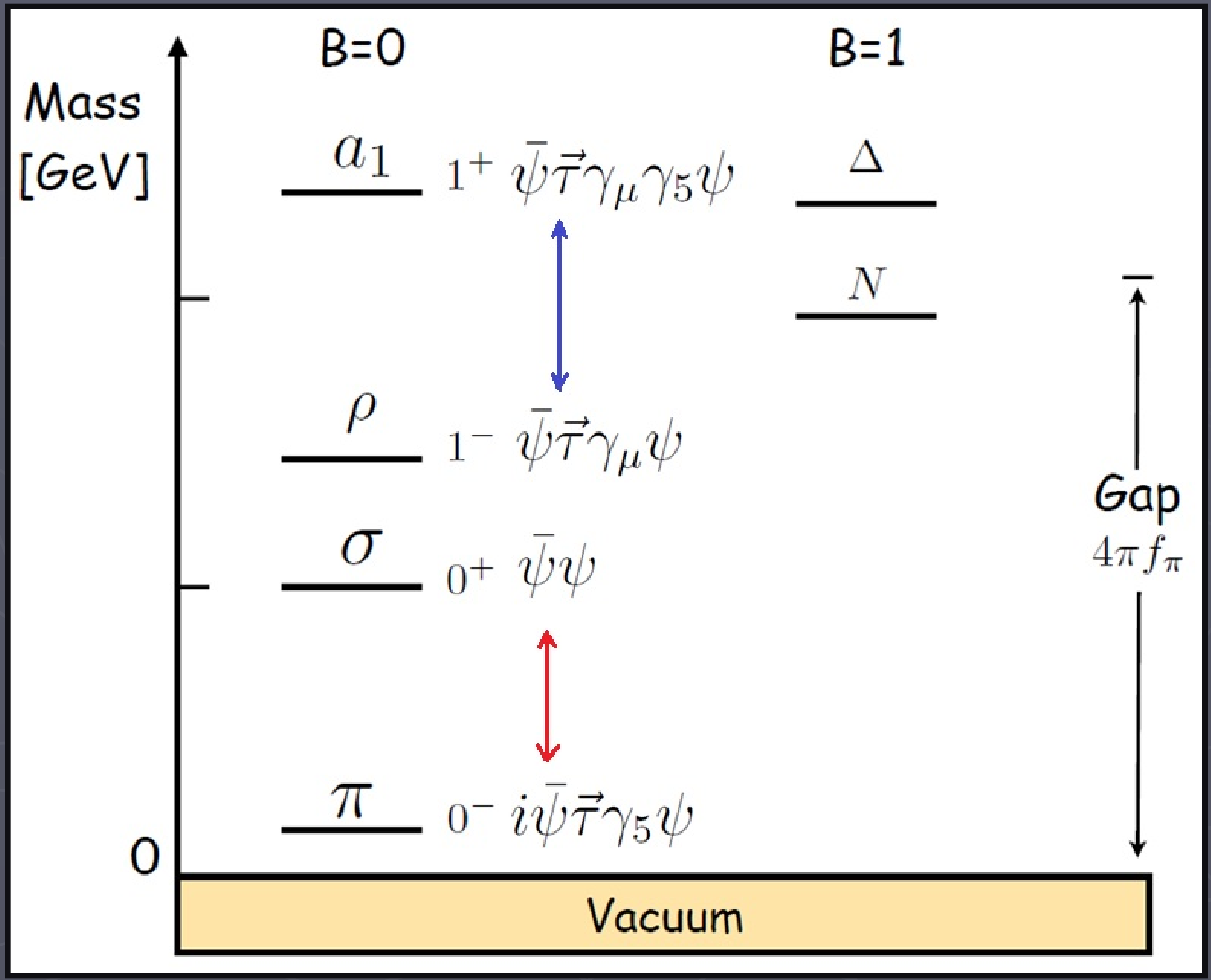
“Collective Perspective on advances in DSE QCD”,AB , L. Chang, I.C. Cloet, B. El Bennich, Y. Liu, C.D. Roberts, P.C. Tandy, Commun. Theor. Phys. 58 79 (2012)

Introduction

Parity Partners &

Chiral Symmetry Breaking



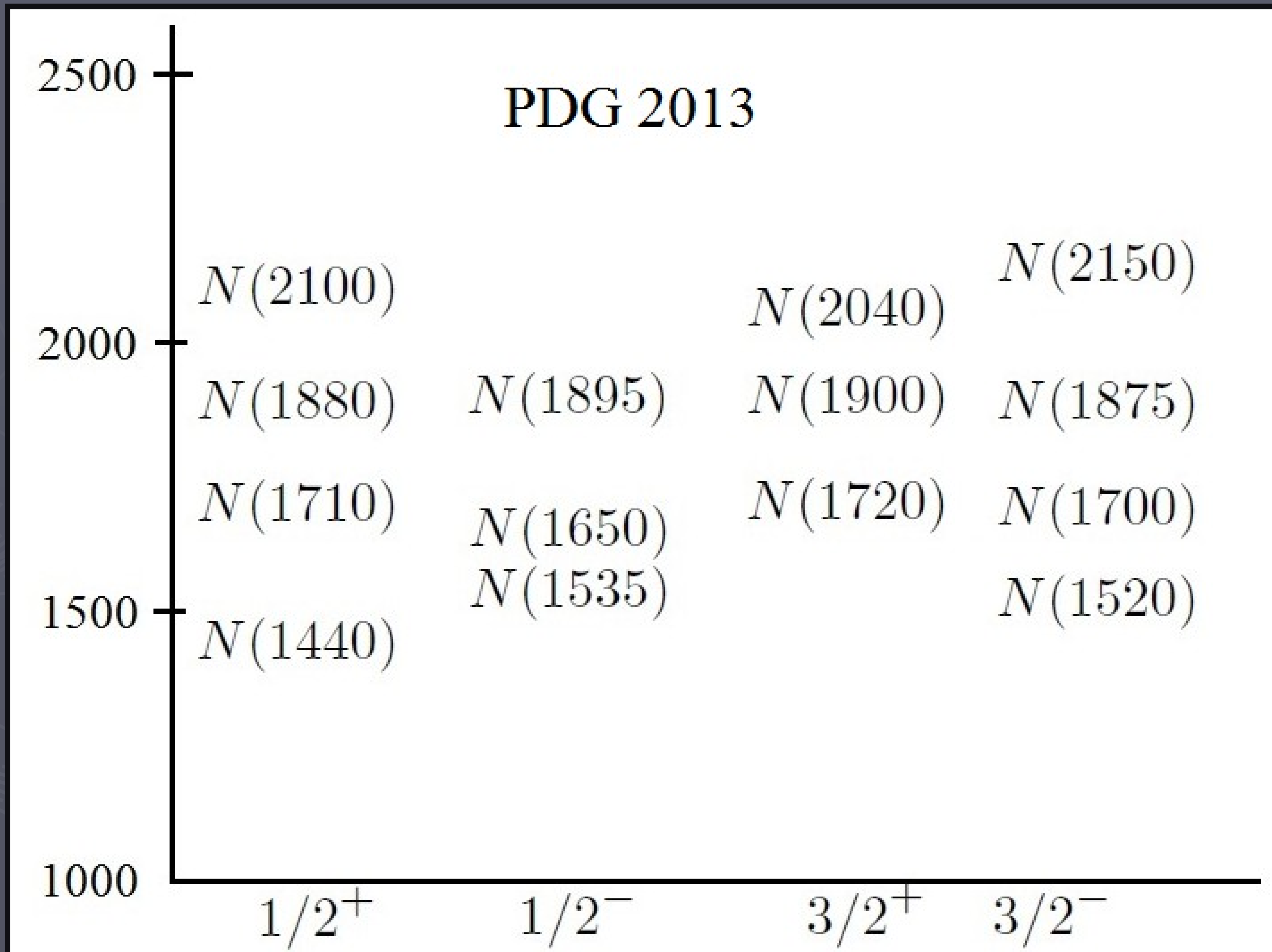
Introduction

Nucleon

And its

Parity

Partner



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Nucleon

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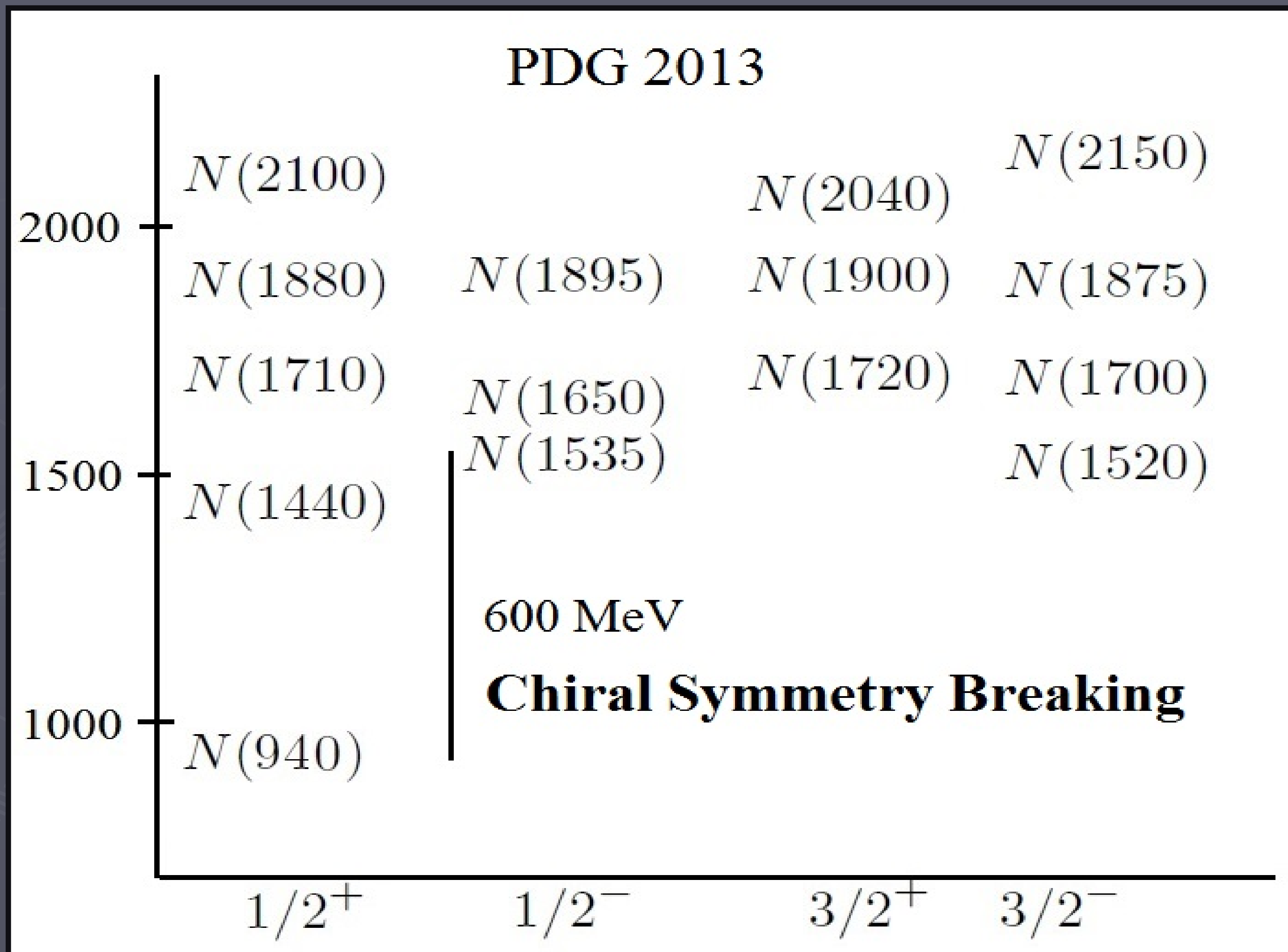
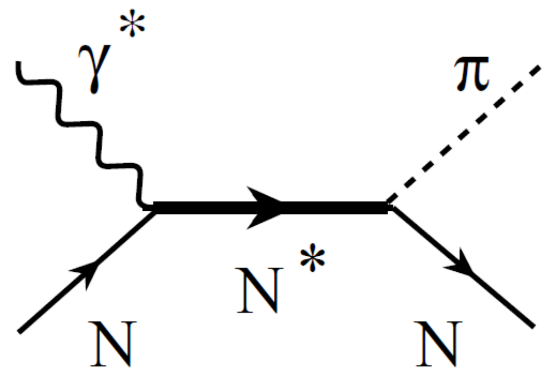


Introduction

- A photon causing a transition of N to N*:

The N^* contribution to $\gamma^* N \to N\pi$



- Matrix element of electromagnetic current j_μ^{em} between spin ½ states of opposite parity can be parameterized as:

$$\langle N^*(P')|j_\nu^{\rm em}|N(P)\rangle = \bar{u}_{N^*}(P')\gamma_5\Gamma_\nu u_N(P)$$

$$\Gamma_\nu = \frac{G_1(q^2)}{m_N^2}(\not{q}q_\nu - q^2\gamma_\nu) - i\frac{G_2(q^2)}{m_N}\sigma_{\nu\rho}q^\rho\,, \qquad q = P' - P$$

I.G. Aznauryan, V.D. Burkert, T.-S.H. Lee, arXiv:0810.0997 (2008).

V.M. Braun et. al., Phys. Rev. Lett. 103 072001 (2009).

Introduction

- The helicity amplitudes for the electro-production of N* can be written in terms of these form factors:

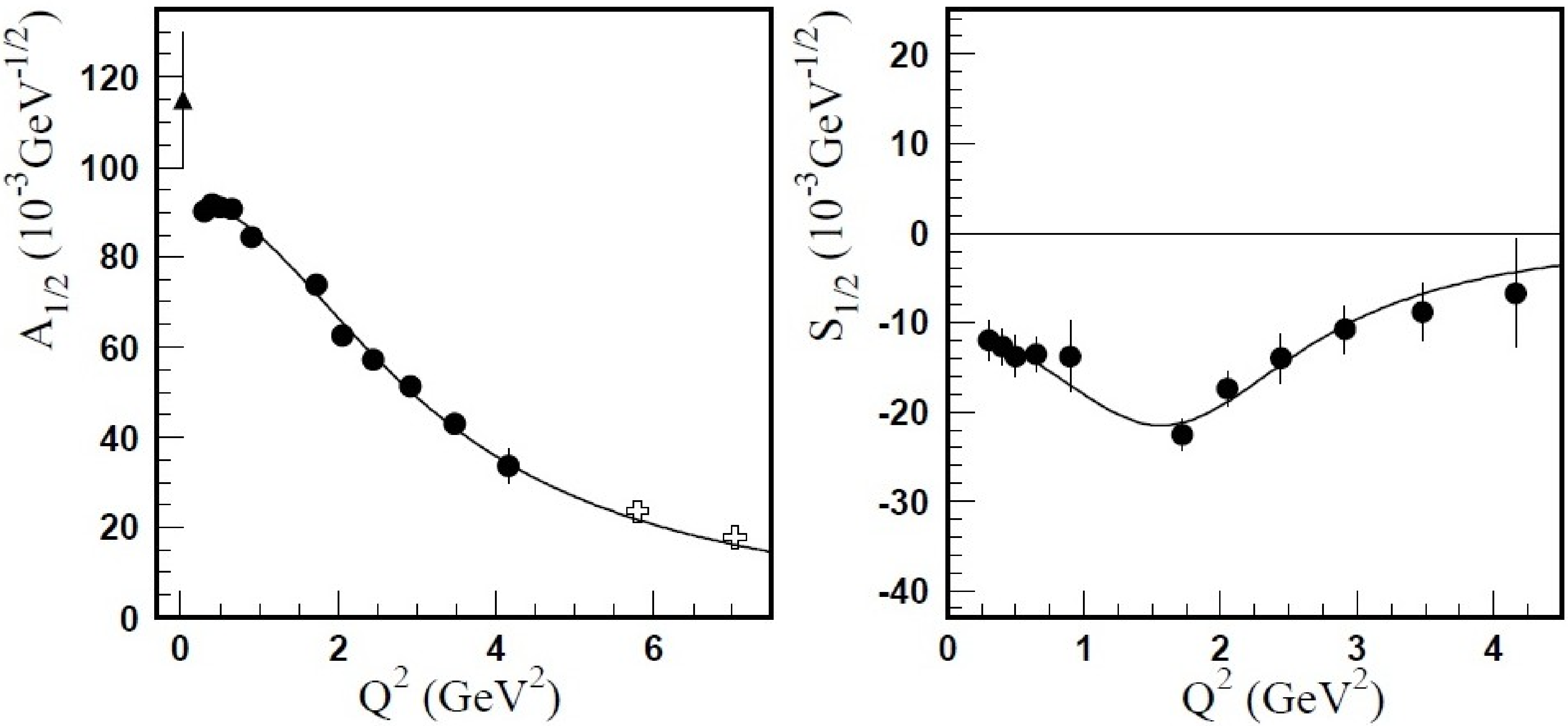
$$A_{1/2} = e\,B\left[Q^2 G_1(Q^2) + m_N(m_{N^*} - m_N)G_2(Q^2)\right]$$
$$S_{1/2} = \frac{e}{\sqrt{2}} B\,C\left[(m_N - m_{N^*})G_1(Q^2) + m_N G_2(Q^2)\right]$$

V.M. Braun et. al., Phys. Rev. Lett. 103 072001 (2009).

- where B and C are simple functions of m_N, m_{N^*} and Q^2:

$$B = \sqrt{\frac{Q^2 + (m_{N^*} + m_N)^2}{2m_N^5(m_{N^*}^2 - m_N^2)}}\,, \quad C = \sqrt{1 + \frac{(Q^2 - m_{N^*}^2 + m_N^2)^2}{4Q^2 m_{N^*}^2}}$$

Introduction



Transverse and scalar (longitudinal) helicity amplitudes for $\gamma p \rightarrow N(1535)1/2^-$ as extracted from the JLab/CLAS data in $n\pi^+$ production (full circles). The solid triangle is the PDG 2013 value at $Q^2 = 0$.

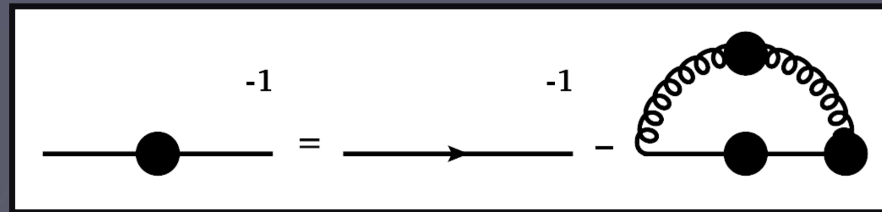
The Ingredients for

$N \rightarrow N^*(1535)$

Transition Form Factors

The Quark Propagator

Simplest SDE - quark propagator:



$$S_B^{-1}(p,\Lambda) = S_0^{-1}(p) + \int d^4q\, g_B^2(\Lambda) D_{\mu\nu}^B(p-q,\Lambda)\frac{\lambda^a}{2}\gamma_\mu S_B(q;\Lambda)\Gamma_{B\nu}^a(q,p;\Lambda)$$

$$\begin{aligned} g_B(\Lambda) &= \mathcal{Z}_g g(p-q,\mu) \\ D_{\mu\nu}^B(p-q,\Lambda) &= \mathcal{Z}_3 D_{\mu\nu}(p-q,\mu) \\ S_B(q;\Lambda) &= \mathcal{Z}_{2F} S(p,\mu) \\ \Gamma_{B\nu}^a(q,p;\Lambda) &= \mathcal{Z}_{1F}^{-1}\Gamma(p,q,\mu) \end{aligned}$$

$$\frac{\mathcal{Z}_1}{\mathcal{Z}_3} = \frac{\tilde{\mathcal{Z}}_1}{\tilde{\mathcal{Z}}_3} = \frac{\mathcal{Z}_5}{\mathcal{Z}_1} = \frac{\mathcal{Z}_{1Fj}}{\mathcal{Z}_{2Fj}}$$

$$S^{-1}(p,\mu) = \mathcal{Z}_{2F} i\gamma\cdot p + \mathcal{Z}_4 m(\mu) + \mathcal{Z}_{1F}\int \frac{d^4q}{(2\pi)^4} g^2 D_{\mu\nu}(p-q,\mu)\frac{\lambda^a}{2}\gamma_\mu S(p,\mu)\Gamma(p,q,\mu)$$

$$S^{-1}(p,\mu) = \mathcal{Z}_{2F} S_0^{-1}(p) + \frac{\tilde{\mathcal{Z}}_1 \mathcal{Z}_{2F}}{\tilde{\mathcal{Z}}_3}\int \frac{d^4q}{(2\pi)^4} g^2 D_{\mu\nu}(p-q,\mu)\frac{\lambda^a}{2}\gamma_\mu S(p,\mu)\Gamma(p,q,\mu)$$

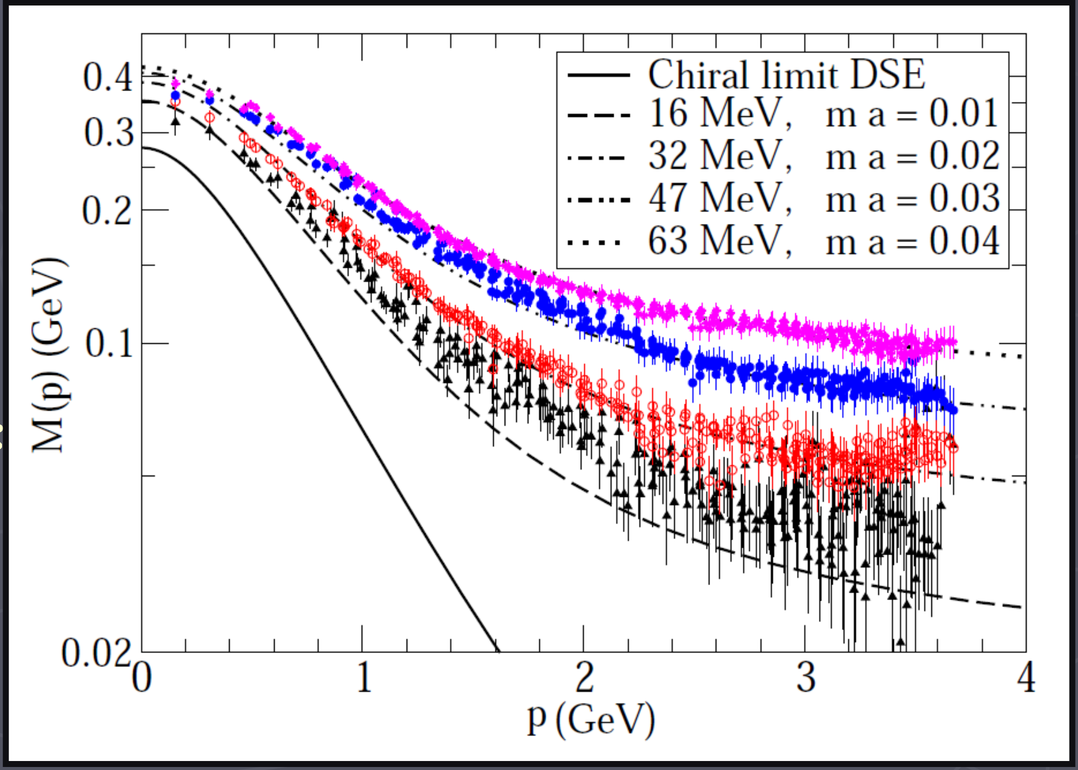
The Quark Propagator

The quark propagator:

$$S(p^2,\mu^2) = i\,\gamma\cdot p\,A(p^2,\mu^2) + B(p^2,\mu^2) = \frac{Z(p^2,\mu^2)}{i\,\gamma\cdot p + M(p^2)}$$

Quark mass is a function of momentum, dropping as $1/p^2$ in the ultraviolet.

Infrared enhancement of quark mass is a strictly non peturbative effect.

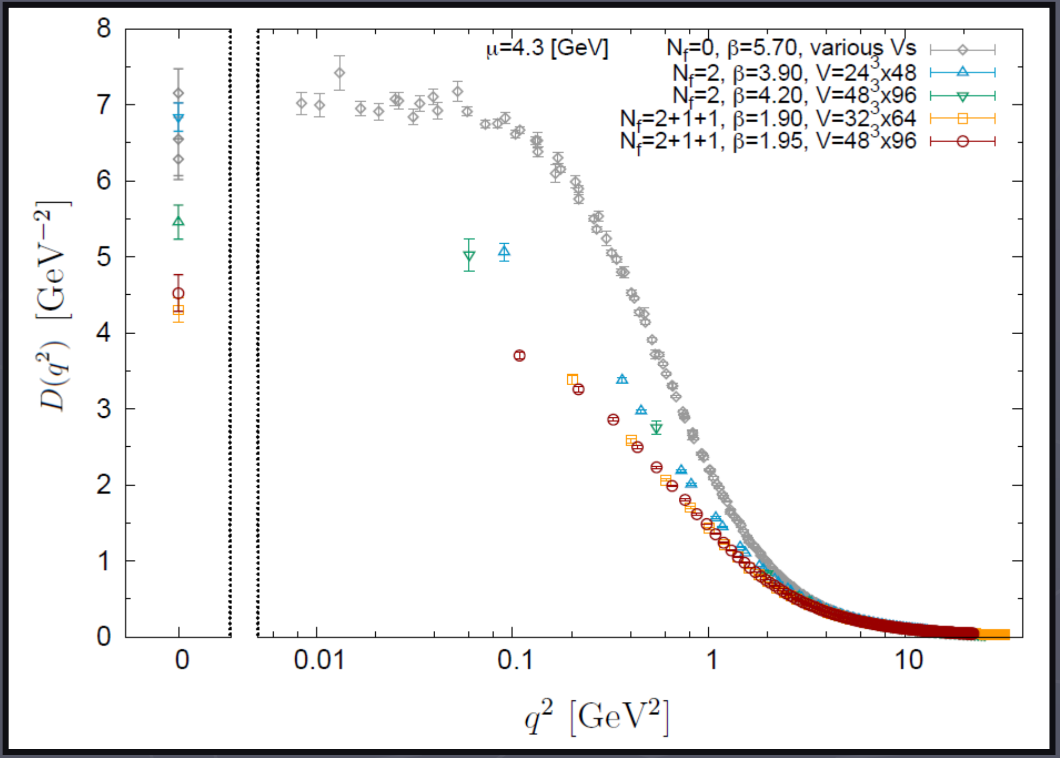


The Gluon Propagator

Gluon Propagator:

$$\Delta_{\mu\nu}^{ab}(q) = \delta^{ab} D(q^2) \left(\delta_{\mu\nu} - \frac{q_\mu q_\nu}{q^2} \right)$$

Modern SDE and lattice results support decoupling solution for the gluon propagator.



I.L. Bogolubsky, et. al. Phys. Lett. B676 69 (2009).

A. Ayala et. al. Phys. Rev. D86 074512 (2012).

AB, A. Raya, J. Rodrigues-Quintero, Phys. Rev. D88 054003 (2013).

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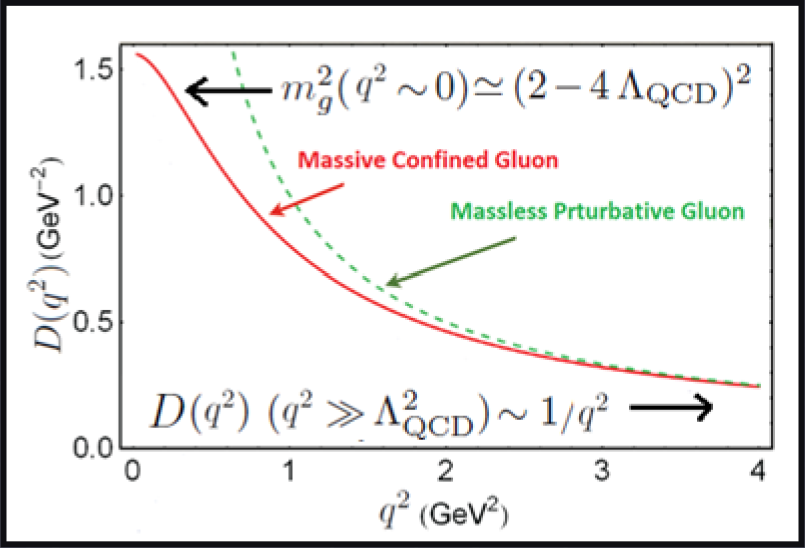

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AB, C. Lei, I. Cloet, B. El Bennich, Y. Liu, C. Roberts, P. Tandy, Comm. Theor. Phys. 58 79-134 (2012)

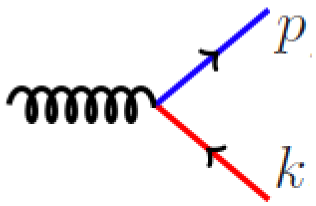
Momentum dependent gluon mass is reminiscent of the momentum dependent quark mass function.

It is in accord with the improved GZ-picture.

$$D^{\rm RGZ}(q^2) = \frac{q^2 + M^2}{q^4 + q^2(m^2+M^2) + 2g^2 N_c \gamma^2 + M^2 m^2}$$

The Quark-Gluon Vertex

- In addition to the the gluon propagator, quark-gluon vertex is another object which enters the quark SDE.



$$\gamma_\mu \quad k_\mu \quad p_\mu$$

$$1 \quad \gamma\cdot k \quad \gamma\cdot p \quad \gamma\cdot k\,\gamma\cdot p$$

- Quark gluon vertex consists of 12 linearly independent Dirac structures.

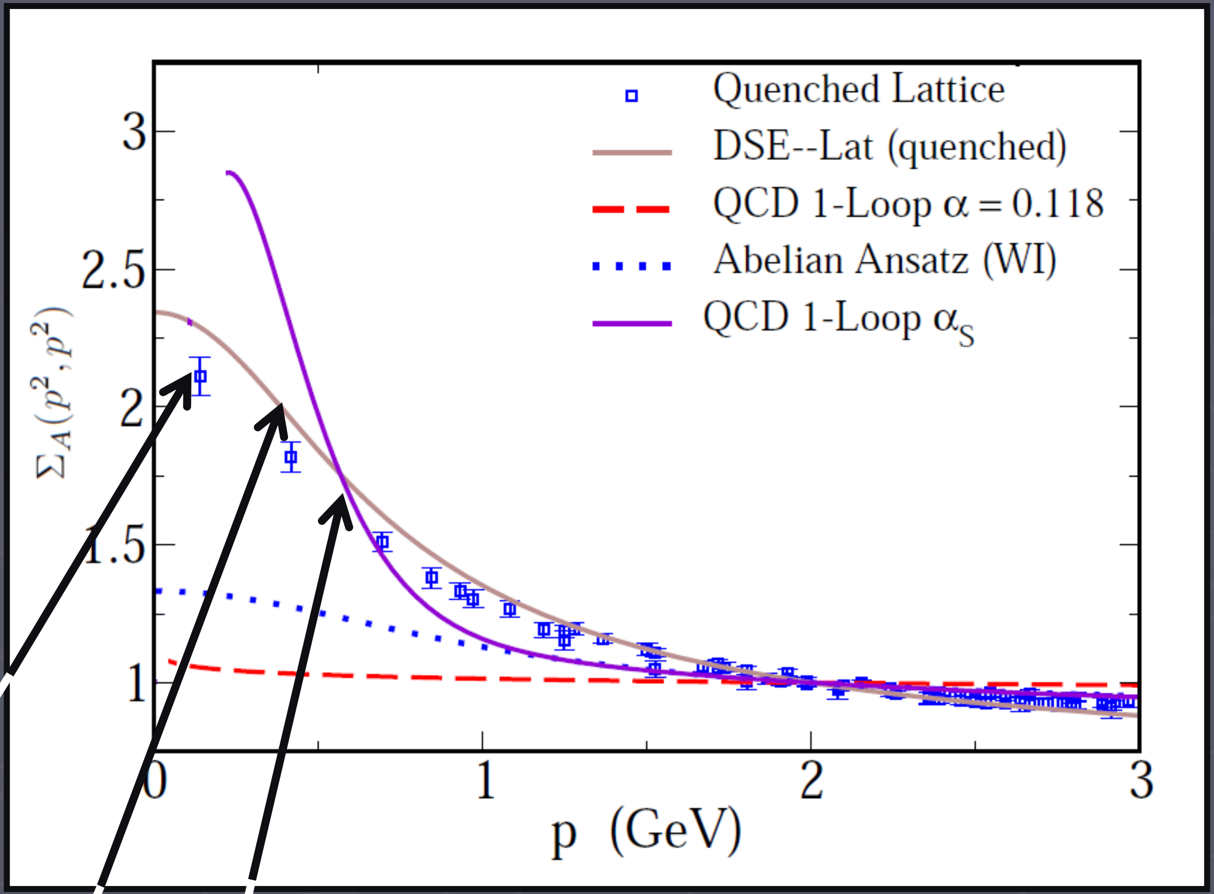
- 5 of these 12 structures are generated dynamically in the chiral limit.

- Thus DCSB manifests itself not only in the quark propagator but also the quark-gluon vertex.

The Quark-Gluon Vertex

The Quark-Gluon Vertex

One of the 12 form factors

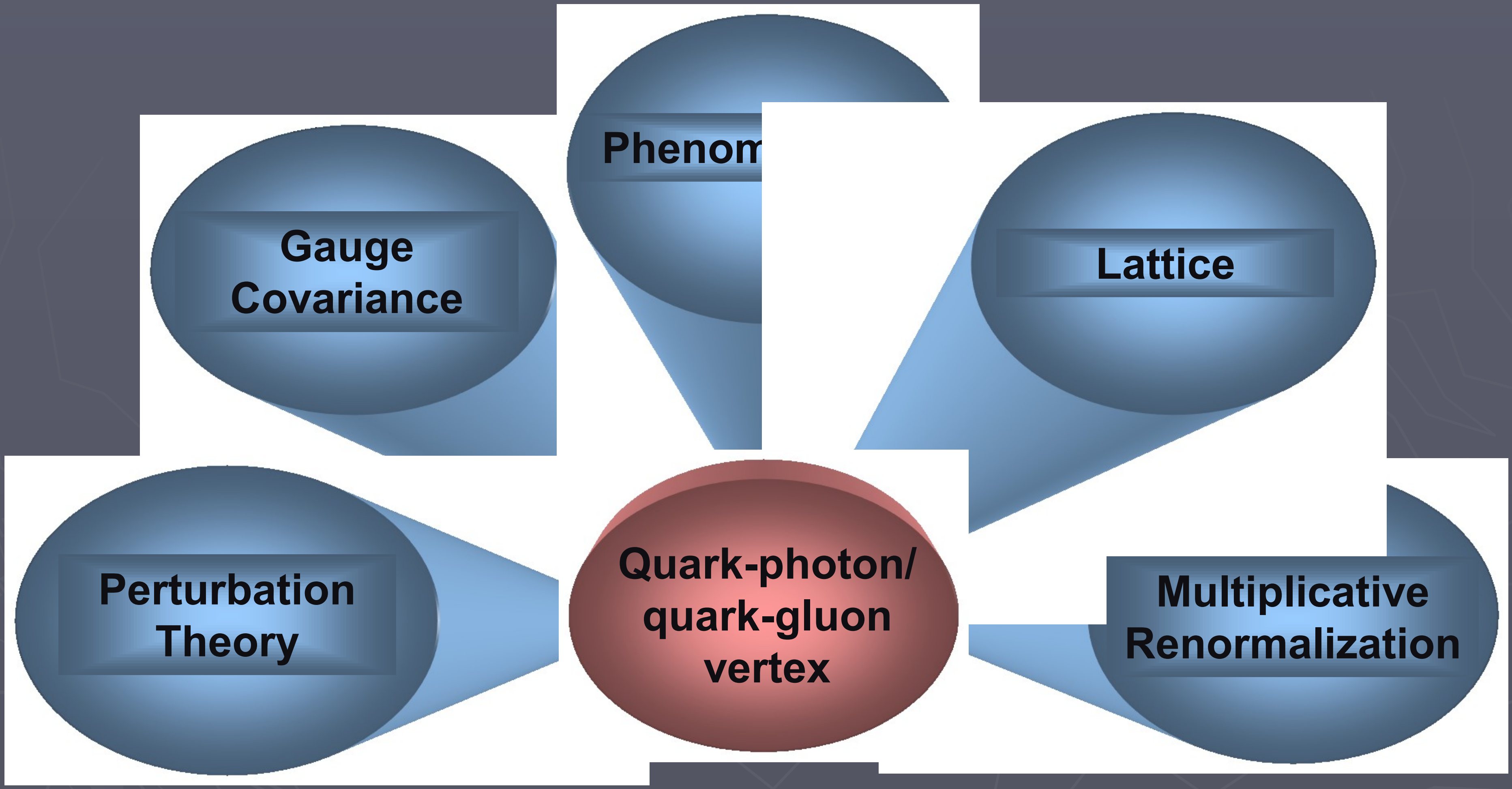


J. Skullerud, P. Bowman, A. Kizilersu, D. Leinweber, A. Williams, J. High Energy Phys. 04 047 (2003)

M. Bhagwat, M. Pichowsky, C. Roberts, P. Tandy, Phys. Rev. C68 015203 (2003).

AB, L. Gutiérrez, M. Tejeda, AIP Conf. Proc. 1026 262 (2008).

The Quark-Photon Vertex



Quark-photon Vertex

The Quark-Photon Vertex

D.C. Curtis and M.R. Pennington Phys. Rev. D42 4165 (1990)

AB, M.R. Pennington Phys. Rev. D50 7679 (1994)

A. Kizilersu and M.R. Pennington Phys. Rev. D79 125020 (2009)

L. Chang, C.D. Roberts, Phys. Rev. Lett. 103 081601 (2009)

AB, C. Calcaneo, L. Gutiérrez, M. Tejeda, Phys. Rev. D83 033003 (2011)

AB, R. Bermudez, L. Chang, C.D. Roberts, Phys. Rev. C85, 045205 (2012).

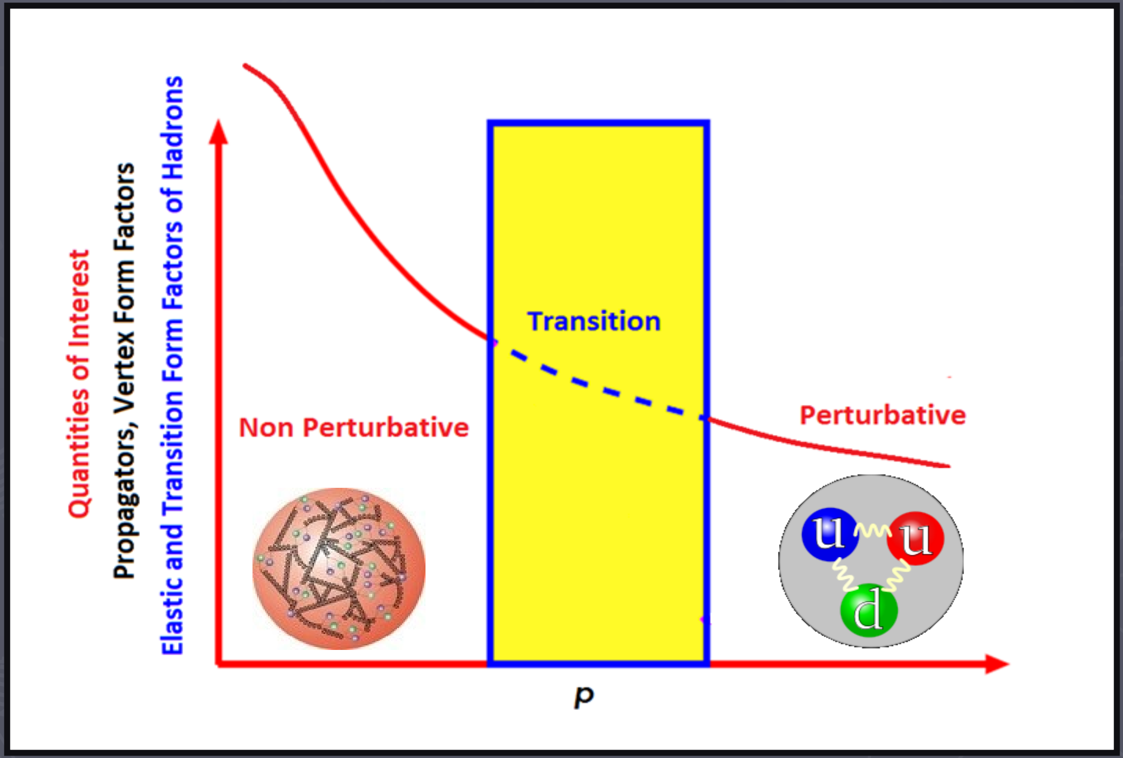
Significantly, this last ansatz contains nontrivial factors associated with those tensors whose appearance is solely driven by dynamical chiral symmetry breaking.

It yields gauge independent critical coupling in QED.

It also reproduces large anomalous magnetic moment for quarks in the infrared.

The Q^2 Evolution of Form Factors

Schwinger-Dyson equations are the fundamental equations of QCD and combine its UV and IR behaviour.

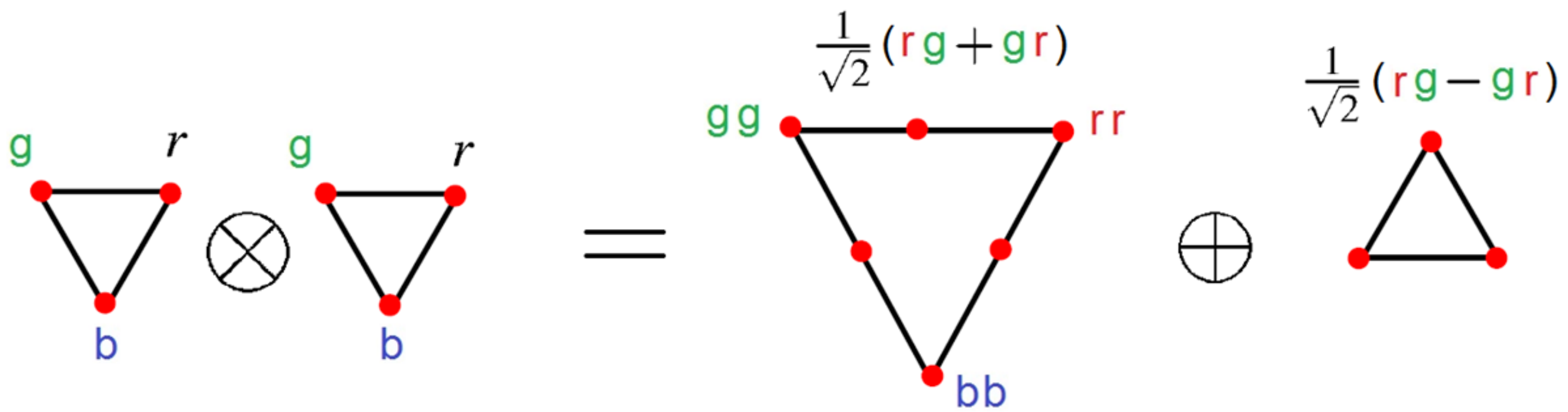


Observing the transition of the hadron from a sea of quarks and gluons to the one with valence quarks alone is an experimental and theoretical challenge.

Baryons
The Diquark Picture

Baryons – The Diquark Picture

Do the diquarks inside baryons have strong correlation?



$$3 \otimes 3 = 6 \oplus \bar{3}$$

Baryons can only have $\bar{3}$ diquarks becuse only they give a singlet when coupled to 3

$$\bar{3} \otimes 3 = 1 \oplus 8$$

- **Sign and strength** of the one-gluon exchange color potential for anti-triplet diquarks can be estimated.

Baryons – The Diquark Picture

- Color singlet meson.

$$\Psi_c^{q\bar{q}} = \frac{1}{\sqrt{3}} \left(r\bar{r} + g\bar{g} + b\bar{b}\right)$$

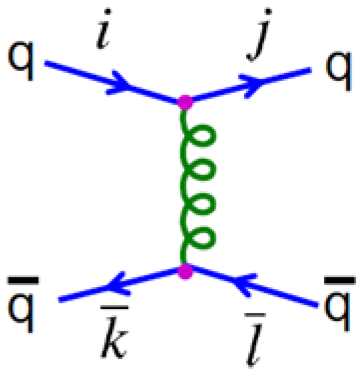
- The one gluon exchange potential can be calculated as:

$$\begin{aligned}\langle V_{q\bar{q}} \rangle &= \langle \Psi_c^{q\bar{q}} | V_{\mathrm{QCD}} | \Psi_c^{q\bar{q}} \rangle \\ &= \frac{1}{3}\Big(\langle r\bar{r} | V_{\mathrm{QCD}} | r\bar{r} \rangle + \langle g\bar{g} | V_{\mathrm{QCD}} | g\bar{g} \rangle + \langle b\bar{b} | V_{\mathrm{QCD}} | b\bar{b} \rangle \\ &\quad + \langle r\bar{r} | V_{\mathrm{QCD}} | b\bar{b} \rangle \cdots \Big)\end{aligned}$$

- Convention for color states:

$$r = c_1 = \begin{pmatrix}1\\0\\0\end{pmatrix} \quad g = c_2 = \begin{pmatrix}0\\1\\0\end{pmatrix} \quad b = c_3 = \begin{pmatrix}0\\0\\1\end{pmatrix}$$

Baryons – The Diquark Picture



$$C(i\bar{k} \rightarrow j\bar{l}) \equiv \frac{1}{4} \sum_{a=1}^{8} \lambda^a_{ji} \lambda^a_{kl}$$

$$C(r\bar{r} \rightarrow r\bar{r}) = \tfrac{1}{3}$$
$$C(r\bar{g} \rightarrow r\bar{g}) = -\tfrac{1}{6}$$
$$C(r\bar{r} \rightarrow g\bar{g}) = \tfrac{1}{2}$$

- **For color singlet mesons:**

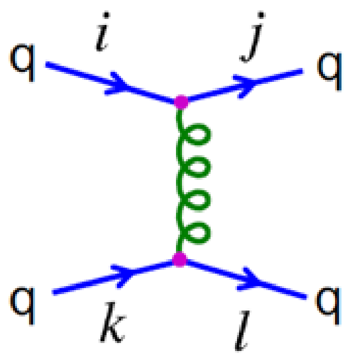
$$\Psi_c^{q\bar{q}} = \frac{1}{\sqrt{3}} \left(r\bar{r} + g\bar{g} + b\bar{b} \right)$$

$$\begin{aligned} \langle V_{q\bar{q}} \rangle &= -\frac{1}{3} \frac{\alpha_s}{r} \left[3 \times C(r\bar{r} \rightarrow r\bar{r}) + 6 \times C(r\bar{r} \rightarrow b\bar{b}) \right] \\ &= -\frac{1}{3} \frac{\alpha_s}{r} \left[3 \times \frac{1}{3} + 6 \times \frac{1}{2} \right] = -\frac{4}{3} \frac{\alpha_s}{r} \end{aligned}$$

Baryons – The Diquark Picture

- **Look at anti-triplet diquark:**

$$|\Psi_c{}^{rg}\rangle = \frac{1}{\sqrt{2}}[rg - gr]$$



$$C(ik \to jl) \equiv \frac{1}{4}\sum_{a=1}^{8} \lambda^a_{ji}\lambda^a_{lk}$$

$$C(rr \to rr) = \tfrac{1}{3}$$
$$C(rg \to rg) = -\tfrac{1}{6}$$
$$C(rg \to gr) = \tfrac{1}{2}$$

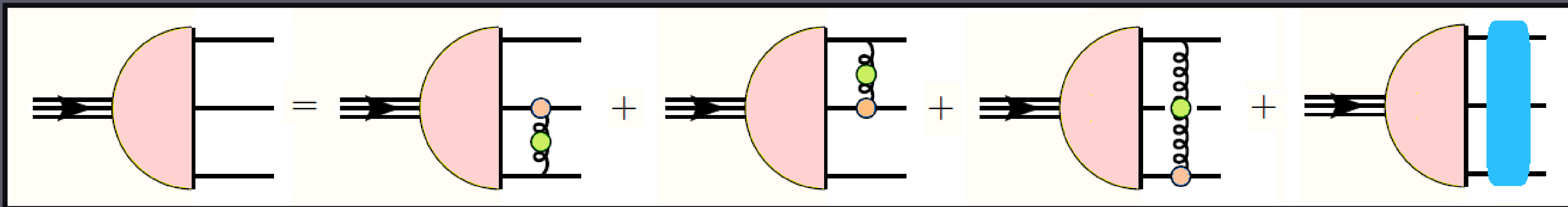
- **Thus the potential between quarks in a diquark is:**

$$\langle V_{rg}\rangle = \langle \Psi_c{}^{rg}|V_{\mathrm{QCD}}|\Psi_c{}^{rg}\rangle$$
$$= \frac{1}{2}\Big(\langle rg|V_{\mathrm{QCD}}|rg\rangle + \langle gr|V_{\mathrm{QCD}}|gr\rangle - \langle gr|V_{\mathrm{QCD}}|rg\rangle - \langle rg|V_{\mathrm{QCD}}|gr\rangle\Big)$$

- **Attractive Correlation:**

$$\langle V_{rg}\rangle = \frac{1}{2}\frac{\alpha_s}{r}\left(2(-1/6) - 2(1/2)\right) = -\frac{2}{3}\frac{\alpha_s}{r}$$

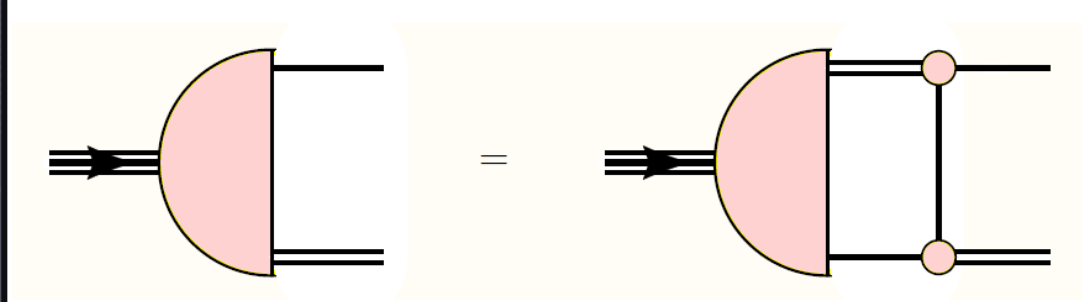
Baryons – The Diquark Picture



Faddeev equation for a baryon.

G. Eichmann, Phys. Rev. D84, 014014 (2011).

Faddeev equation in the quark diquark picture reproduces nucleon masses to within 5%.



Faddeev Equation in the Quark Diquark Picture

Baryons – The Diquark Picture

A nucleon primarily consists of scalar and axial vector diquarks because they have the same parity as the nucleon and adequate masses.

Its parity partner N*(1535) is likely to consist of pseudo-scalar and vector diquarks.

To calculate the nucleon electromagnetic & transition form factors, one needs to evaluate the diquark elastic and transition form factors.

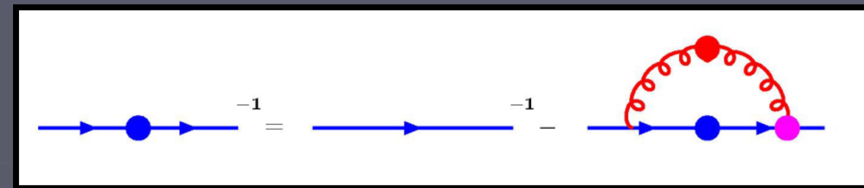
One option is to simplify the problem by replacing the refined interaction kernel by a simpler contact interaction and adapt it to capture as many aspects and symmetries of QCD as possible.

Contact Interaction

Contact interaction:

$$g^2 D_{\mu\nu}(p-q) = \delta_{\mu\nu}\frac{1}{m_G^2} = \delta_{\mu\nu}\frac{4\pi\alpha_{\rm IR}}{m_G^2}$$

$$\Gamma_\nu^a(p,q) \;=\; \frac{\lambda^a}{2}\gamma_\nu$$



$$m_G = 0.8\,\text{GeV}$$

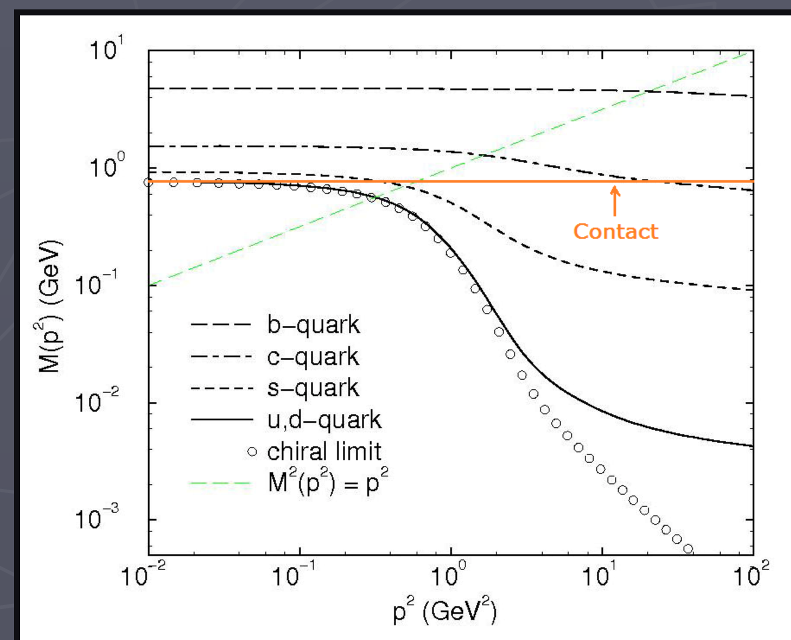
$$S(p) \;=\; \frac{Z(p^2)}{i\gamma\cdot p + M(p^2)}$$

$$Z(p^2) = 1$$

$$M \;=\; m + \frac{M}{3\pi^2 m_G^2}\int_0^{\Lambda^2} ds\,\frac{s}{s+M^2}$$

$$M = \frac{M}{3\pi^2 m_G^2}\left[\Lambda^2 - M^2 \text{Log}\left(1+\frac{\Lambda^2}{M^2}\right)\right]$$

$$S(p) \overset{\text{Contact}}{=} \frac{[Z(p^2)=1]}{i\gamma\cdot p + [M(p^2)=M]}$$



Contact Interaction

For the contact interaction:

Pseudo scalar component of the pion necessary to ensure GT-relations & pQCD.

$$\Gamma_\pi(P) = \gamma_5 \left[iE_\pi(P) + \frac{\gamma \cdot P}{M} F_\pi(P) \right]$$

Employing a proper time regularization scheme, one can ensure (i) confinement, (ii) axial vector Ward Takahashi identity is satisfied and (iii) the corresponding Goldberger-Triemann relations are obeyed:

$$P_\mu \Gamma_{5\mu}(q_+, q) = S^{-1}(q_+) i\gamma_5 + i\gamma_5 S^{-1}(q)$$

$$f_\pi \, E_\pi = M \qquad 2\,\frac{F_\pi}{E_\pi} + F_R = 1$$

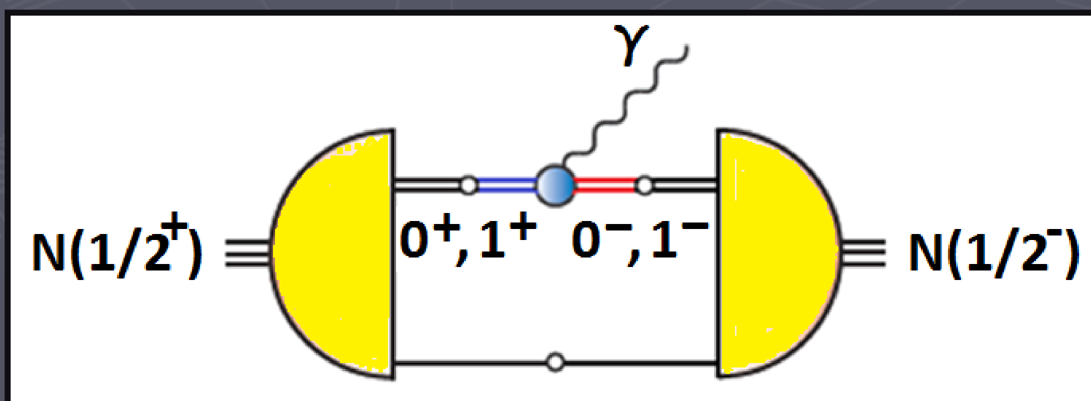
Transition $N(\frac{1}{2}^+) \longrightarrow N(\frac{1}{2}^-;1535)$

The nucleon primarily consists of scalar and axial vector diquarks and N*(1535) of its parity partners.

$$N(\tfrac{1}{2}^+) \longrightarrow N(\tfrac{1}{2}^-;1535)$$

scalar diquark	0^+	pseudo-scalar diquark	0^-
axial vector diquark	1^+	vector diquark	1^-

In the contact interaction model, the calculation of the transition form factors involves the diagram:



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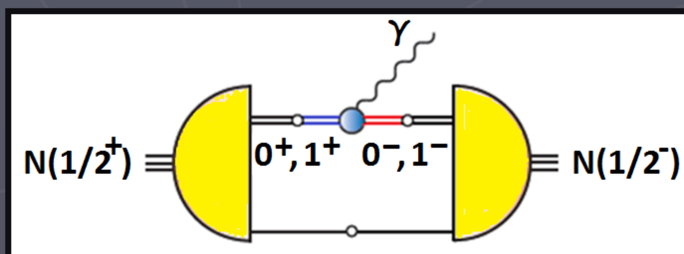


$$1^+\gamma 1^-,\quad 1^+\gamma 0^-,\quad 0^+\gamma 1^-,\quad 0^+\gamma 0^-$$

$$a_1 \to \rho\gamma,\ a_1 \to \pi\gamma,\ \rho \to \sigma\gamma,\ \sigma \to \pi\gamma$$

Elastic & Transition Form Factors: π,σ,ρ,a_1

The Bethe-Salpeter Amplitudes:

$$\Gamma_\sigma(P) = E_\sigma(P) I_D$$

$$\Gamma^{a_1}_\mu(P) = \gamma_5 \left[\gamma^T_\mu E_{a_1}(P) + \frac{1}{M} \sigma_{\mu\nu} P_\nu F_{a_1}(P) \right]$$

$$\Gamma_\pi(P) = \gamma_5 \left[i E_\pi(P) + \frac{\gamma \cdot P}{M} F_\pi(P) \right]$$

$$\Gamma^\rho_\mu(P) = \gamma^T_\mu E_\rho(P) + \frac{1}{M} \sigma_{\mu\nu} P_\nu F_\rho(P)$$

$$\gamma^T_\mu = \gamma_\mu + \frac{\gamma \cdot p}{p^2} p_\mu$$

$$C^\dagger = -C$$

$$[C, \gamma_5] = 0$$

$$C^\dagger \gamma^{\mathrm{T}}_\mu C = -\gamma_\mu$$

$$C^\dagger \sigma^{\mathrm{T}}_{\mu\nu} C = -\sigma_{\mu\nu}$$

$$C^\dagger \gamma^{\mathrm{T}}_5 C = \gamma_5$$

$$C^\dagger \gamma_5 \sigma^{\mathrm{T}}_{\mu\nu} C = -\gamma_5 \sigma_{\mu\nu}$$

$$C^\dagger (\gamma_5 \gamma_\mu)^{\mathrm{T}} C = \gamma_5 \gamma_\mu$$

Elastic & Transition Form Factors: π,σ,ρ,a_1

The Bethe-Salpeter Amplitudes:

All dimensioned quantities are listed in GeV

M	Λ_{IR}	Λ_{UV}	m_G
0.368	0.24	0.905	0.132

Meson	Mass	BS components
π	0.140	(E_π, F_π)=(3.639,0.481)
σ	1.290	$E_\sigma = 3.789$
ρ	0.929	$E_\rho = 1.531$
a_1	1.383	E_{a_1}=3.515

Elastic & Transition Form Factors: π,σ,ρ,a_1

- We can dress **quark-photon vertex**:

$$\Gamma_\mu(Q) = \gamma_\mu^T P_T(Q^2) + \gamma_\mu^L P_L(Q^2)$$

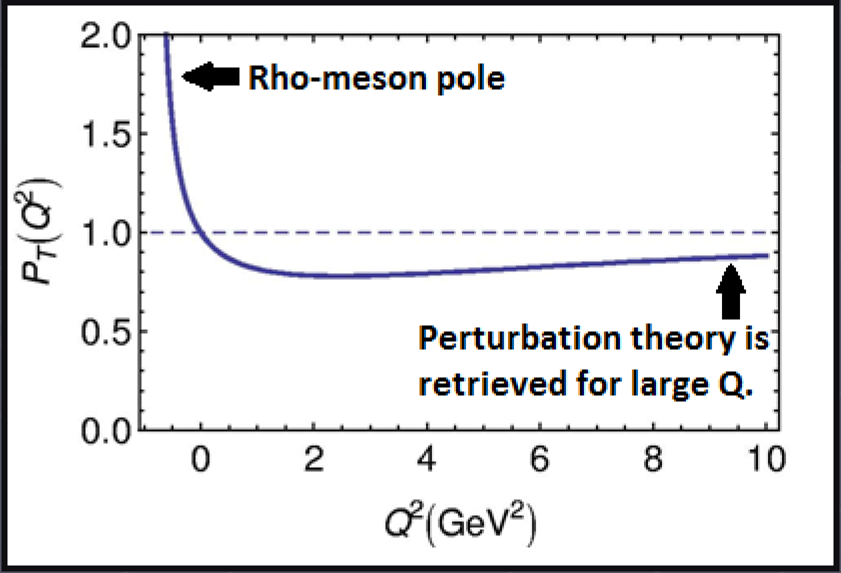
$$Q_\mu \gamma_\mu^T = 0 \text{ and } \gamma_\mu^T + \gamma_\mu^L = \gamma_\mu$$

- The corresponding IBS-equation thus yields:

$$\Gamma_\mu(Q) = \gamma_\mu - \frac{4}{3}\frac{1}{m_G^2}\int \frac{d^4q}{(2\pi)^4}\gamma_\alpha \chi_\mu(q_+, q)\gamma_\alpha$$

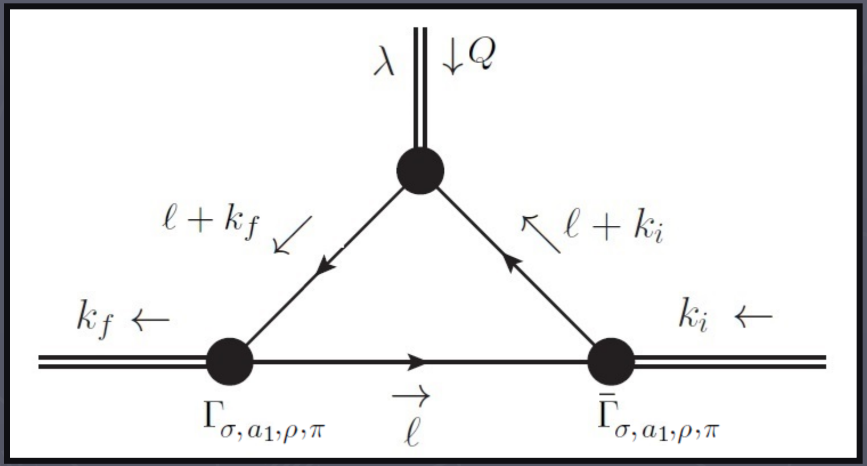
$$\chi_\mu(q_+, q) = S(q+P)\Gamma_\mu(Q)S(q)$$

$$P_L(Q^2) = 1$$



H.L.L. Robertes, C.D. Roberts, AB, L.X. Gutiérrez and P.C. Tandy, Phys. Rev. C82, (065202:1-11) 2010.

Elastic & Transition Form Factors: π, σ, ρ, a_1



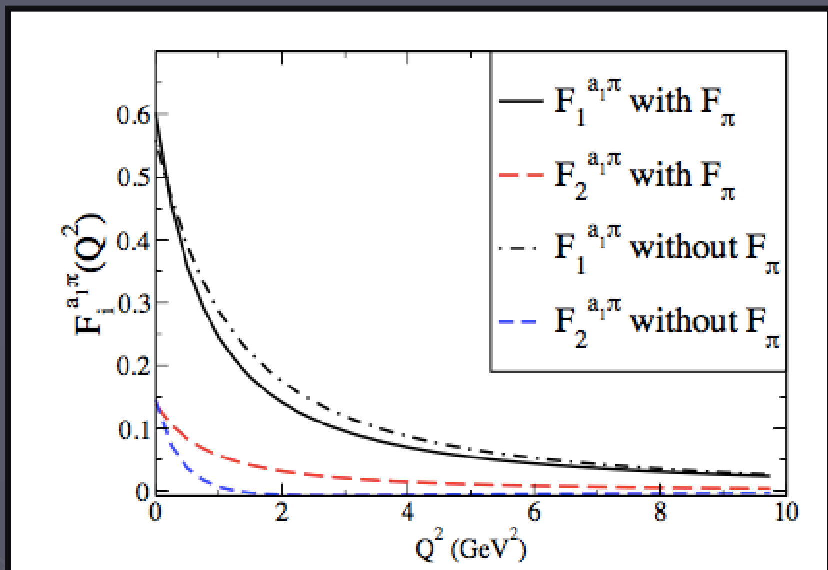
Transitions	Form factors
$\sigma\gamma\sigma$	1
$a_1\gamma a_1$	3
$a_1\gamma\sigma$	1
$a_1\,\gamma\pi$	2
$a_1\gamma\rho$	3

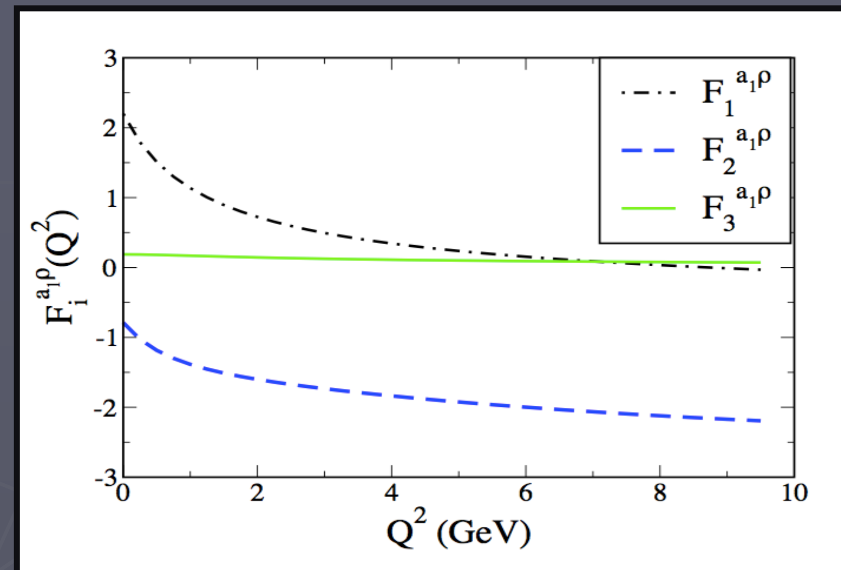
L.X. Gutiérrez, AB, I.C. Cloët, C.D. Roberts, Phys. Rev. C81 065202 (2010).

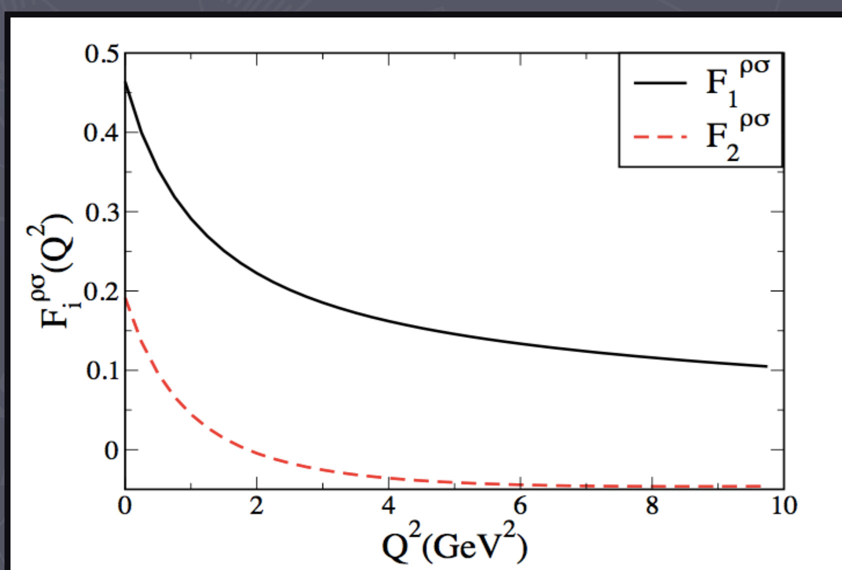
H.L.L. Roberts, AB, L.X. Gutiérrez, C.D. Roberts, Phys. Rev. C83, 065206 (2011).

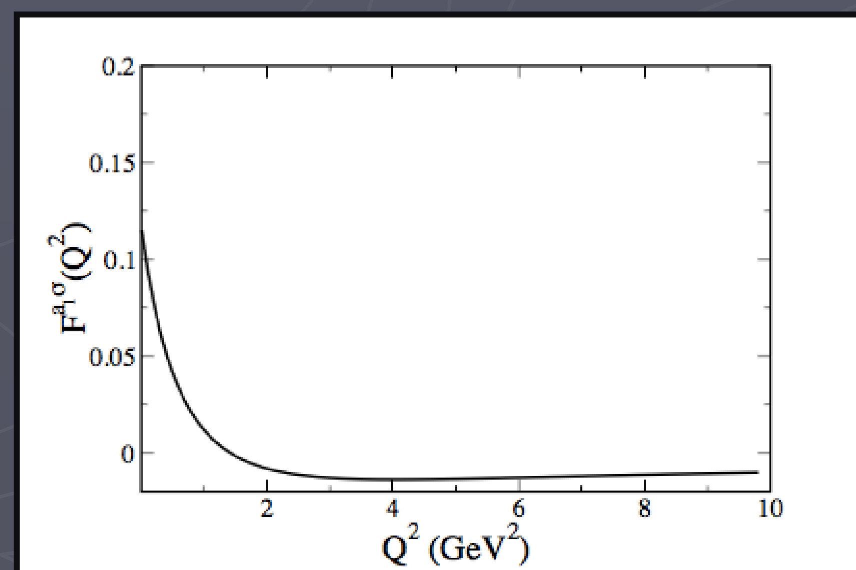
J.J. Dudek, R. Edwards, C.E. Thomas, Phys. Rev. D79 094504 (2009).

Elastic & Transition Form Factors: π, σ, ρ, a_1









Transition Form Factors and Couplings

The $\pi\gamma\rho$ transition and $g_{\pi\gamma\rho}$ coupling:

$$T^{\pi\gamma\rho}_{\mu\nu}(k_1,k_2) = \frac{g_{\pi\gamma\rho}}{m_\rho}\epsilon_{\mu\nu\alpha\beta}k_{1\alpha}k_{2\beta}G^{\pi\gamma\rho}(Q^2)$$

K.A. Olive et al. (Particle Data Group), Chin. Phys. C, 38, 090001 (2014).

$\Gamma_{\rho\gamma\pi}$ for $\rho^+ \to \pi^+\gamma$ is 68 ± 7 keV

$$\Gamma_{\rho\gamma\pi} = \alpha\frac{g^2_{\rho\pi\gamma}}{24}m_\rho\left(1-\frac{m_\pi^2}{m_\rho^2}\right)^3$$

Contact Interaction

$$g_{\pi\gamma\rho} = 0.63 m_\rho/GeV$$

$$g_{\pi\gamma\rho} = 0.74 \pm 0.05 m_\rho/GeV$$

Transition	Contact Interaction	Other Works
$\sigma\gamma\rho$	$g_{\sigma\gamma\rho} = 2.01$	$g_{\sigma\gamma\rho} = 2.71$ *
$a_1\gamma\pi$	$g_{a_1\gamma\pi} = 2.29$	$g_{a_1\gamma\pi} = 2.37$ **
$a_1\gamma\rho$	$g_{a_1\gamma\rho} = 0.55$	$g_{a_1\gamma\rho} = 0.79$ ***

* B. Friman and M. Soyeur, Nucl. Phys. A600 477 (1996).
** and *** M.F.M. Lutz, S. Leupold, Nucl.Phys. A813 96 (2008).

Conclusions

The large Q^2 evolution of the hadronic form factors, their experimental evaluation and theoretical predictions are likely to provide us with deep understanding of the pattern of DCSB and confinement.

A systematic framework based upon the QCD equations of motion (SDE) and its symmetries is important to chart out and comprehend the Q^2 evolution of these form factors, compare with experiment and make predictions.

Predictions based upon the contact interaction, can provide us with a starting point to compare and contrast the findings with experimental results and full QCD calculation.