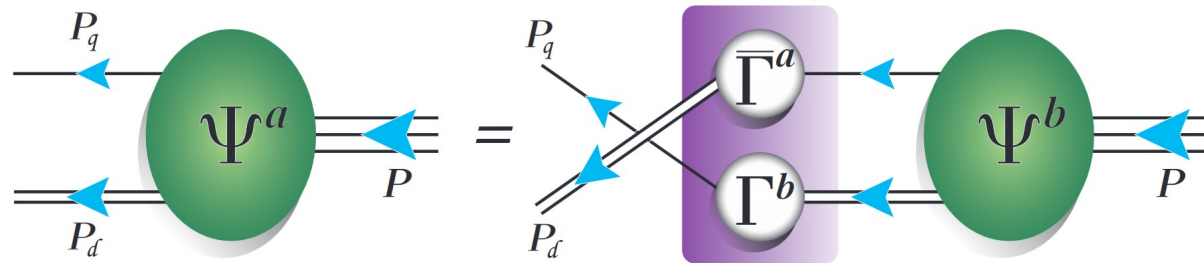


Nucleon Electromagnetic Transitions within Continuum Schwinger Methods

Khépani Raya Montaña

Albino, Bashir, Roberts, Segovia, etc..

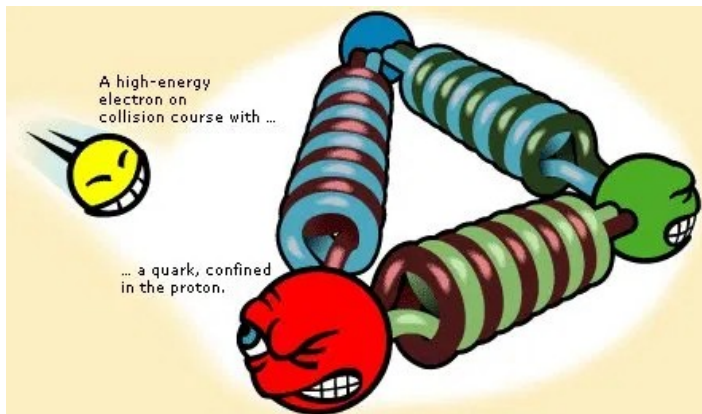


QCD: Basic Facts

- **QCD** is characterized by two **emergent** phenomena:
confinement and dynamical generation of mass (**DGM**).



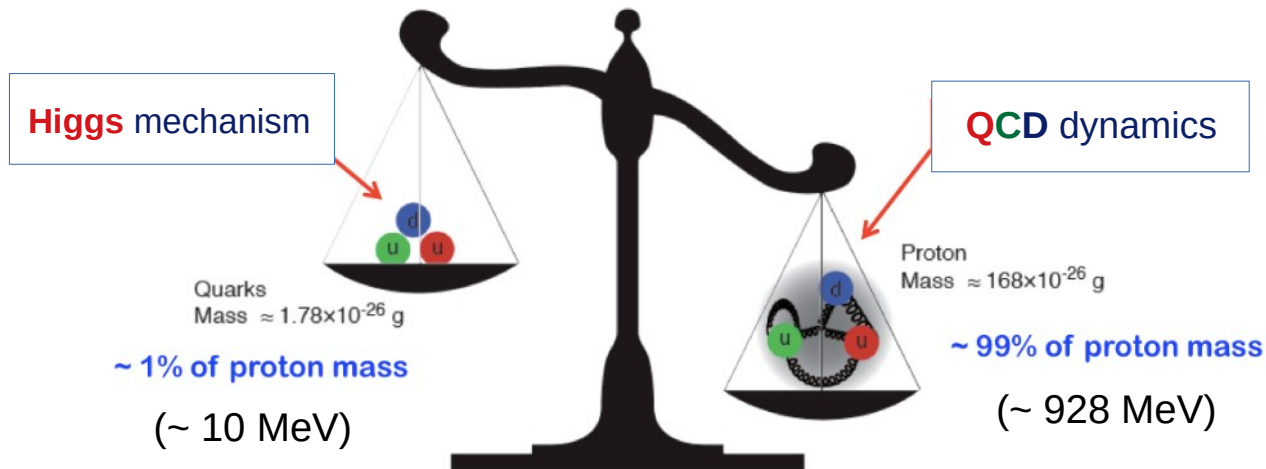
- ♦ Quarks and gluons not *isolated* in nature.
 - ➔ Formation of colorless bound states: “**Hadrons**”
 - ➔ **1-fm scale** size of hadrons?



$$\begin{aligned}\mathcal{L}_{\text{QCD}} &= \sum_{j=u,d,s,\dots} \bar{q}_j [\gamma_\mu D_\mu + m_j] q_j + \frac{1}{4} G_{\mu\nu}^a G_{\mu\nu}^a, \\ D_\mu &= \partial_\mu + ig \frac{1}{2} \lambda^a A_\mu^a, \\ G_{\mu\nu}^a &= \partial_\mu A_\nu^a - \partial_\nu A_\mu^a - gf^{abc} A_\mu^b A_\nu^c,\end{aligned}$$



- ♦ Emergence of hadron masses (**EHM**) from QCD **dynamics**

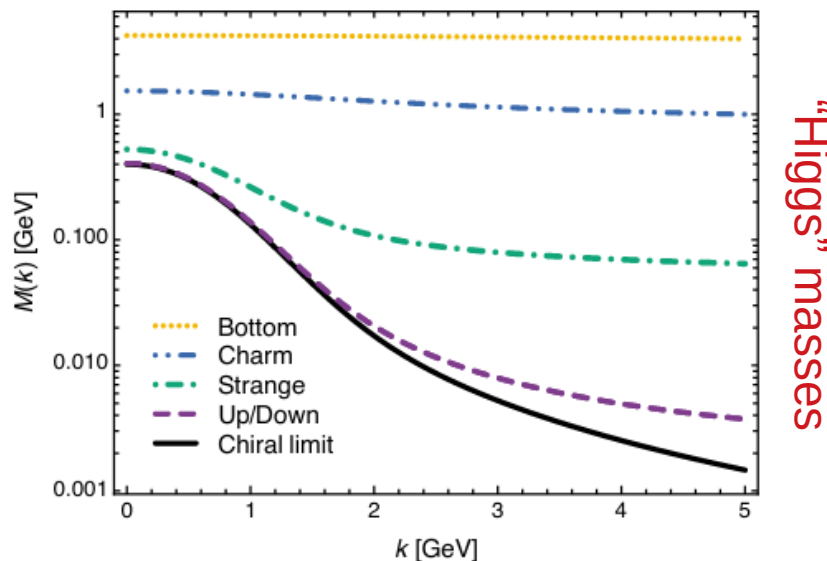


QCD: Basic Facts

- **QCD** is characterized by two **emergent** phenomena:
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Can we trace them down to fundamental d.o.f?

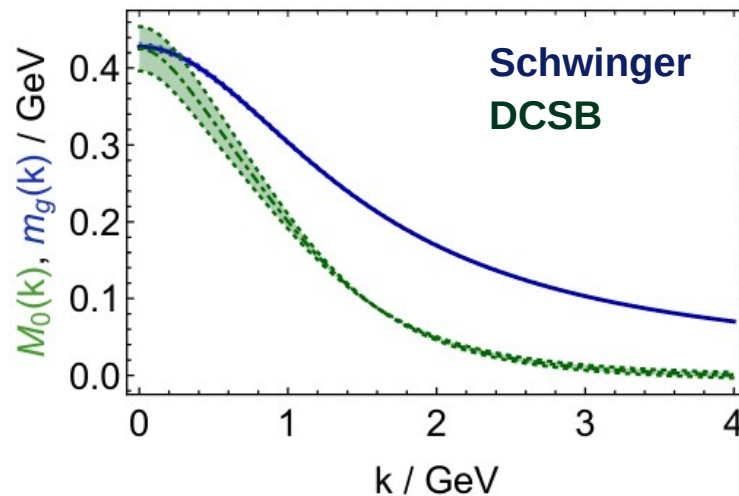
Dynamical masses
(Dynamical Chiral Symmetry Breaking)



$$S_f^{-1}(p) = Z_f^{-1}(p^2)(i\gamma \cdot p + \mathbf{M}_f(\mathbf{p}^2))$$

$$\begin{aligned}\mathcal{L}_{\text{QCD}} &= \sum_{j=u,d,s,\dots} \bar{q}_j [\gamma_\mu D_\mu + m_j] q_j + \frac{1}{4} G_{\mu\nu}^a G_{\mu\nu}^a, \\ D_\mu &= \partial_\mu + ig \frac{1}{2} \lambda^a A_\mu^a, \\ G_{\mu\nu}^a &= \partial_\mu A_\nu^a - \partial_\nu A_\mu^a - gf^{abc} A_\mu^b A_\nu^c,\end{aligned}$$

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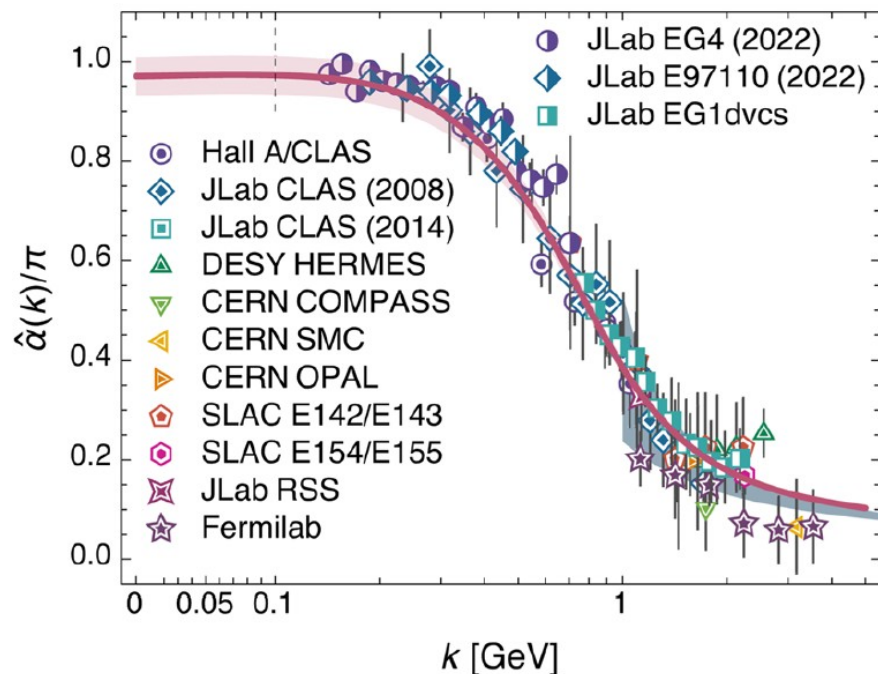


Gluon and quark *running masses*

QCD: Basic Facts

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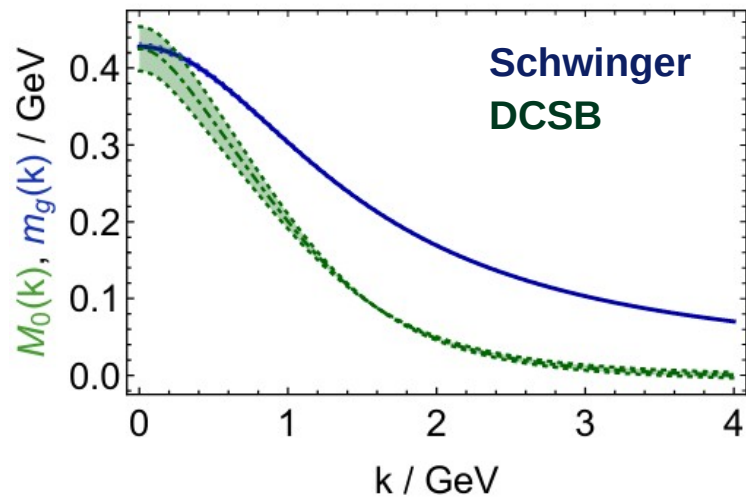


$$\mathcal{L}_{\text{QCD}} = \sum_{j=u,d,s,\dots} \bar{q}_j [\gamma_\mu D_\mu + m_j] q_j + \frac{1}{4} G_{\mu\nu}^a G_{\mu\nu}^a,$$

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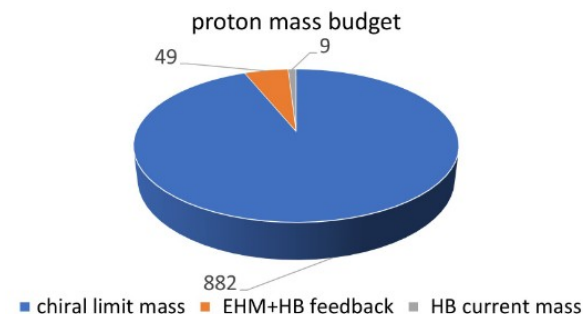
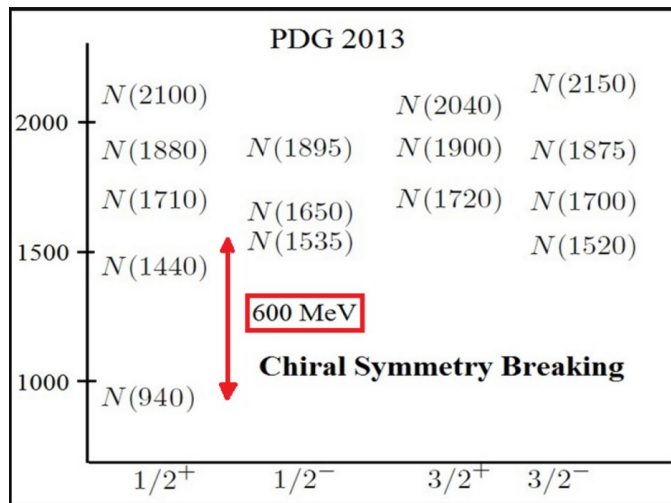
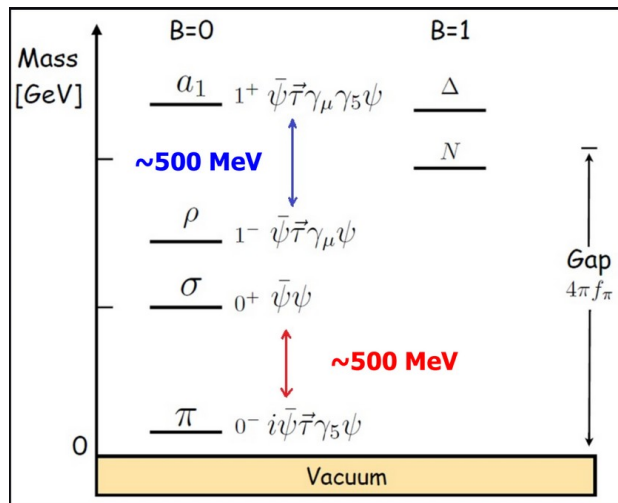
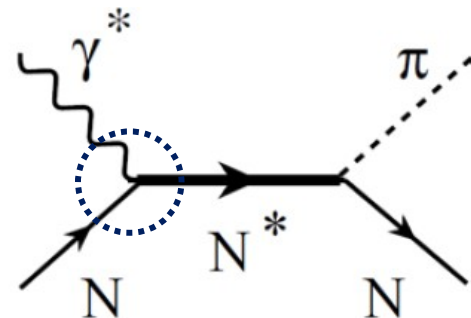


Gluon and quark *running masses*

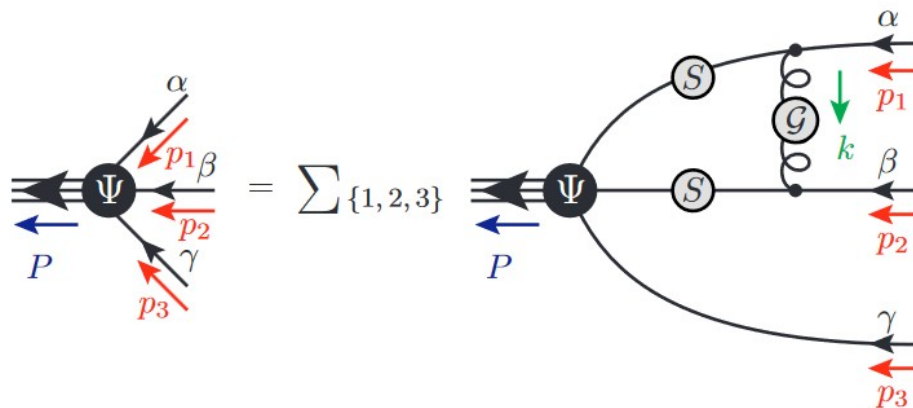
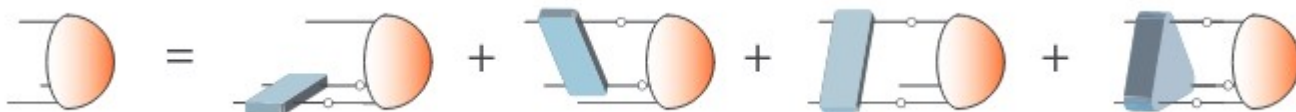
The proton: Understanding QCD

- Now, just as we learned from the **excited** states of the **hydrogen atom**, we should learn from the **excited** states of the **nucleon**.

- In particular, the role of **DCSB** could be well understood by analyzing **structural differences** of hadrons and their **parity partners**.



Baryon Faddeev equation



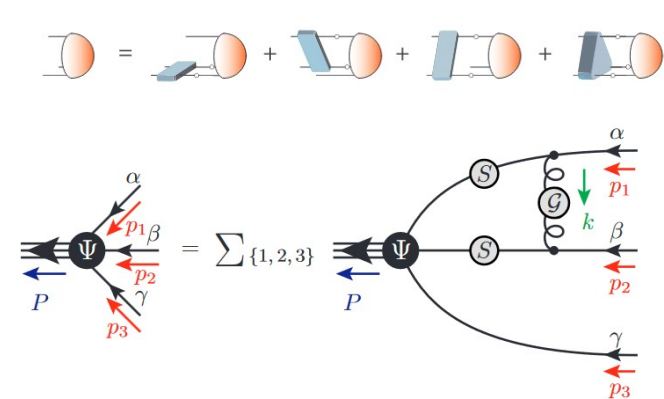
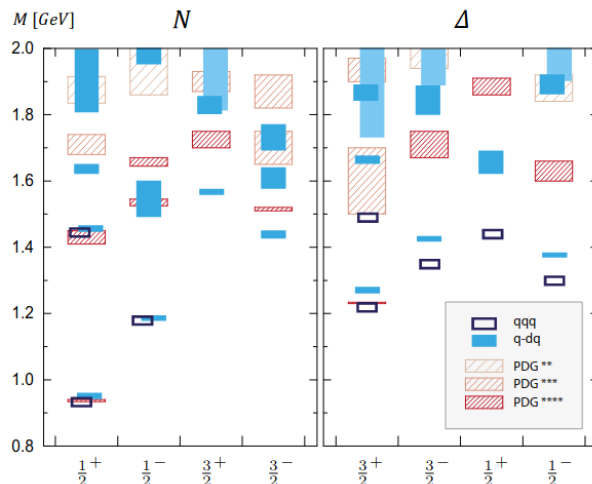
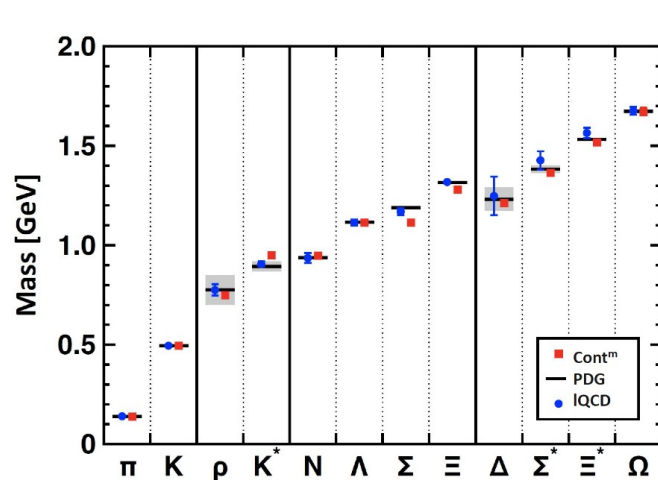
Eichmann:2016yit

Qin:2019hgk

Yao:2024uej

Baryons: Faddeev equation

- A Poincaré-covariant **Faddeev equation** encodes all possible interactions/exchanges that could take place between the three dressed valence-quarks.
- By employing the **symmetry-preserving rainbow-ladder** truncation, this equation can be solved.
(This implies, however, an outstanding challenge). Eichmann:2016yit Qin:2019hgk Yao:2024uej
- Exists now a plethora of results/predictions on the meson and baryon **mass spectrum**.
($J = 1/2+$ and $3/2+$ baryons, first excitations, parity partners...)



Baryons: Faddeev equation

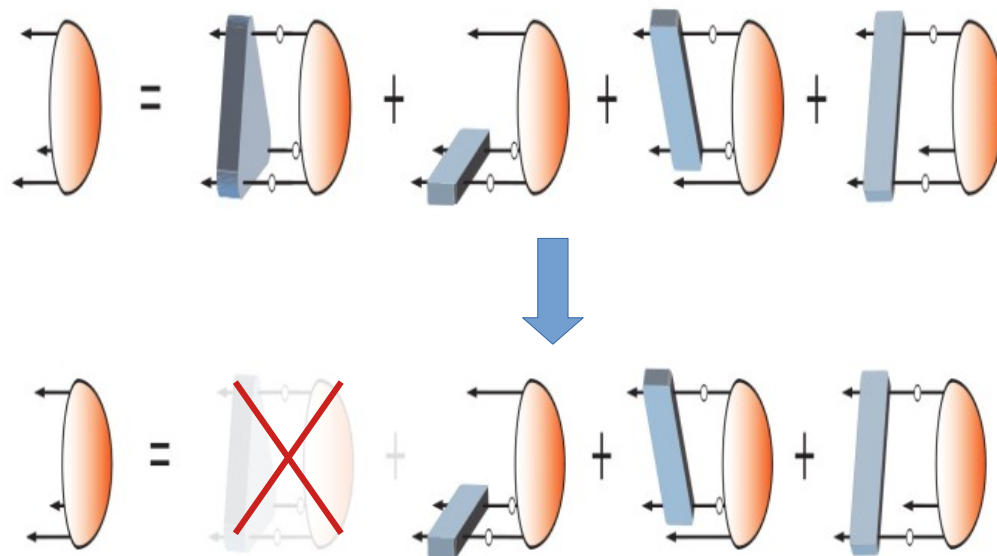
- Strong evidence anticipates the formation of **dynamical** quark-quark correlations (**diquarks**) within **baryons**, for instance:
 - The **primary three-body** force **binding** the quarks within the baryon vanishes when projected onto the color singlet channel.

Eichmann:2016yit

i.e. a 3-gluon vertex attached to each quark once (and only once)

- The dominant 3-gluon contribution is the one attaching twice to a quark
- This produces a strengthening of quark-quark interactions

Barabanov:2020jvn

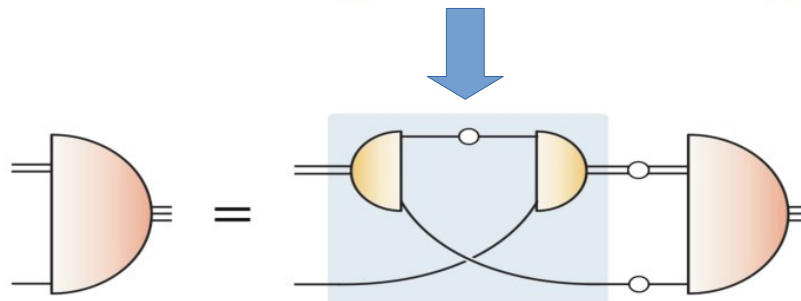
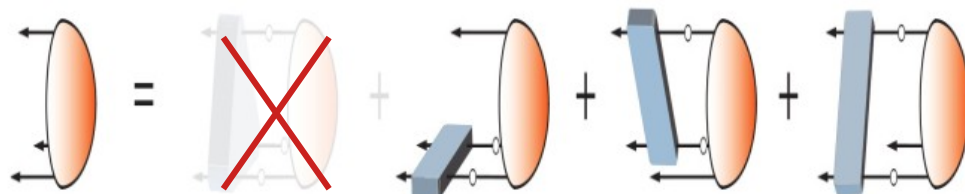


Baryons: Faddeev equation

- Strong evidence anticipates the formation of **dynamical** quark-quark correlations (**diquarks**) within **baryons**, for instance:

Barabanov:2020jvn

- The **primary three-body** force **binding** the quarks within the baryon vanishes when projected onto the color singlet channel.
- The **attractive** nature of **quark-antiquark** correlations in a color-singlet meson, is also **attractive** for $\bar{3}_c$ **quark-quark** correlations within a color singlet baryon.



Dynamical Quark-diquark picture

Non-pointlike **diquarks**:

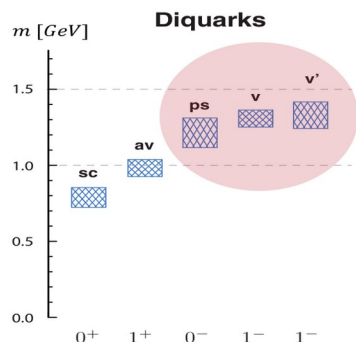
- Color anti-triplet
- Fully interacting
- Origins related to **EHM** phenomena

Baryons: Quark-diquark picture

Barabanov:2020jvn

→ The **attractive** nature of **quark-antiquark** correlations in a color-singlet meson, is also **attractive** for $\bar{3}_c$ **quark-quark** correlations within a color singlet baryon.

- Due to charge conjugation properties, a **J^P diquark** partners with an analogous **J^P meson**.
- We can thus establish a connection between the **meson** and **diquark** Bethe-Salpeter equations:



$$\Gamma_{q\bar{q}}(p; P) = - \int \frac{d^4 q}{(2\pi)^4} g^2 D_{\mu\nu}(p-q) \frac{\lambda^a}{2} \gamma_\mu S(q+P) \Gamma_{q\bar{q}}(q; P) S(q) \frac{\lambda^a}{2} \gamma_\nu$$

$$\Gamma_{qq}(p; P) C^\dagger = - \frac{1}{2} \int \frac{d^4 q}{(2\pi)^4} g^2 D_{\mu\nu}(p-q) \frac{\lambda^a}{2} \gamma_\mu S(q+P) \Gamma_{qq}(q; P) C^\dagger S(q) \frac{\lambda^a}{2} \gamma_\nu$$

Less tightly 'bound'

Non-pointlike diquarks:

- Color anti-triplet
- Fully interacting
- Origins related to **EHM** phenomena

- Computed '**masses**' should be interpreted as correlation **lengths**:

$$m_{[ud]_{0+}} = 0.7 - 0.8 \text{ GeV}, \quad m_{\{uu\}_{1+}} = 0.9 - 1.1 \text{ GeV}$$

- Stressing the fact that the **diquarks** have a **finite** size:

$$r_{[ud]_{0+}} \gtrsim r_\pi, \quad r_{\{uu\}_{1+}} \gtrsim r_\rho$$

Contact Interaction model:

Some highlights

Contact Interaction

- The quark **gap equation** in a symmetry-preserving **contact interaction** model (**SCI**):

$$S^{-1}(p) = i\gamma \cdot p + m + \frac{16\pi}{3} \frac{\alpha_{\text{IR}}}{m_G^2} \int \frac{d^4 q}{(2\pi)^4} \gamma_\mu S(q) \gamma_\mu$$

Infrared strength $\alpha_{\text{IR}} = 0.93\pi$.

Compatible with modern computations.

- **Recall** the quark **gap equation**:

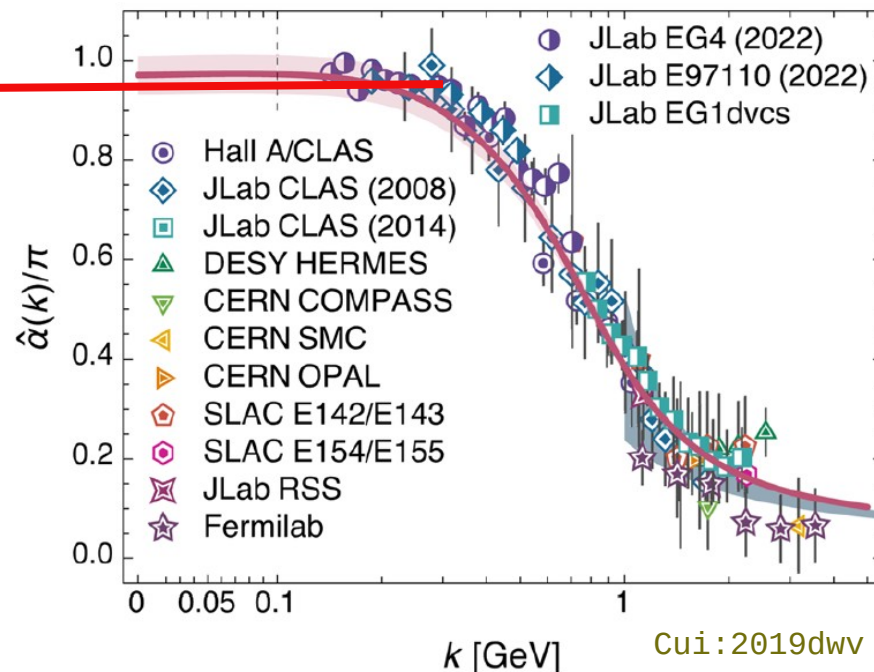
$$S_f^{-1}(p) = Z_2(i\gamma \cdot p + m_f^{\text{bm}}) + \Sigma_f(p),$$

$$\Sigma_f(p) = \frac{4}{3} Z_1 \int_{dq}^\Lambda g^2 D_{\mu\nu}(p-q) \gamma_\mu S_f(q) \Gamma_\nu^f(p, q)$$

- ➔ Namely, **SCI kernel** is essentially **RL** + **constant** gluon propagator

Roberts:2010rn

Gutierrez-Guerrero:2010waf



Contact Interaction

- The quark **gap equation** in a symmetry-preserving **contact interaction** model (**SCI**):

Roberts:2010rn

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$$S^{-1}(p) = i\gamma \cdot p + m + \frac{16\pi}{3} \frac{\alpha_{\text{IR}}}{m_G^2} \int \frac{d^4 q}{(2\pi)^4} \gamma_\mu S(q) \gamma_\mu$$

- Constant **gluon** propagator:

- Quark propagator, with **constant mass function**

- Non renormalizable

$$S_f(p) = Z_f(p^2)(i\gamma \cdot p + M_f(p^2))^{-1} \Rightarrow S(p)^{-1} = i\gamma \cdot p + M$$

- Needs regularization scheme:

$$\frac{1}{s + M_f^2} = \int_0^\infty d\tau e^{-\tau(s + M_f^2)} \rightarrow \int_{\tau_{uv}^2}^{\tau_{ir}^2} d\tau e^{-\tau(s + M_f^2)}$$

input: current masses				output: dressed masses			
m_0	m_u	m_s	m_s/m_u	M_0	M_u	M_s	M_s/M_u
0	0.007	0.17	24.3	0.36	0.37	0.53	1.43

$\tau_{ir} = 1/0.24 \text{ GeV}^{-1}$: Ensures the absence of quark production thresholds (**confinement**)

$\tau_{uv} = 1/0.905 \text{ GeV}^{-1}$: UV cutoff. Sets the **scale** of all dimensioned quantities.

Contact Interaction

- Let us now consider the quark gap equation in a symmetry-preserving **contact interaction** model (**SCI**)

$$S^{-1}(p) = i\gamma \cdot p + m + \frac{16\pi}{3} \frac{\alpha_{\text{IR}}}{m_G^2} \int \frac{d^4 q}{(2\pi)^4} \gamma_\mu S(q) \gamma_\mu \quad \longrightarrow$$

- The **meson** Bethe-Salpeter equation:

$$\Gamma(k; P) = -\frac{16\pi}{3} \frac{\alpha_{\text{IR}}}{m_G^2} \int \frac{d^4 q}{(2\pi)^4} \gamma_\mu \chi(q; P) \gamma_\mu \quad \longrightarrow$$

- The **diquark** Bethe-Salpeter equation:

$$\Gamma_{qq}(k; P) = -\frac{8\pi}{3} \frac{\alpha_{\text{IR}}}{m_G^2} \int \frac{d^4 q}{(2\pi)^4} \gamma_\mu \chi_{qq}(q; P) \gamma_\mu$$

- Recall a **J^P diquark** partners with an analogous **J^P meson**.

- Quark propagator, with **constant mass function**

$$S(p)^{-1} = i\gamma \cdot p + M$$

- The interaction produces **momentum independent** BSAs:

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

$$\Gamma_\sigma(P) = \mathbb{1} E_\sigma(P) ,$$

$$\Gamma_\rho(P) = \gamma^T E_\rho(P) ,$$

$$\Gamma_{a_1}(P) = \gamma_5 \gamma^T E_{a_1}(P) ,$$

- It is typical to reduce the RL strength in the scalar and axial-vector meson channels (and pseudoscalar and vector diquarks)

Contact Interaction

- The **quark-photon** vertex:

$$\Gamma_\mu^\gamma(Q) = \frac{Q_\mu Q_\nu}{Q^2} \gamma_\nu + \Gamma_\mu^T(Q)$$

Introduces a vector meson pole in the timelike axis.

$$\Gamma_\mu^T(Q) = P_T(Q^2) \mathcal{P}_{\mu\nu}(Q) \gamma_\nu + \frac{\zeta}{2M_u} \sigma_{\mu\nu} Q_\nu \exp\left(-\frac{Q^2}{4M_u^2}\right)$$

Quark anomalous magnetic moment (AMM) term

$\zeta \sim 1/3$ sets its strength

- Might be generated automatically in **beyond RL** approaches.

Xing:2021dwe

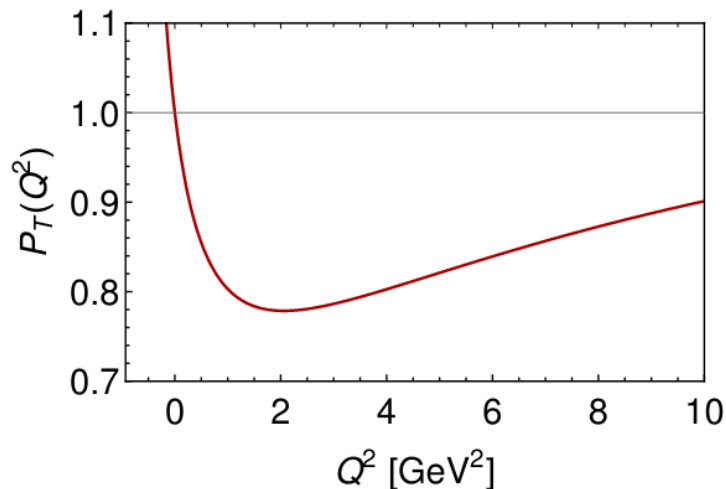
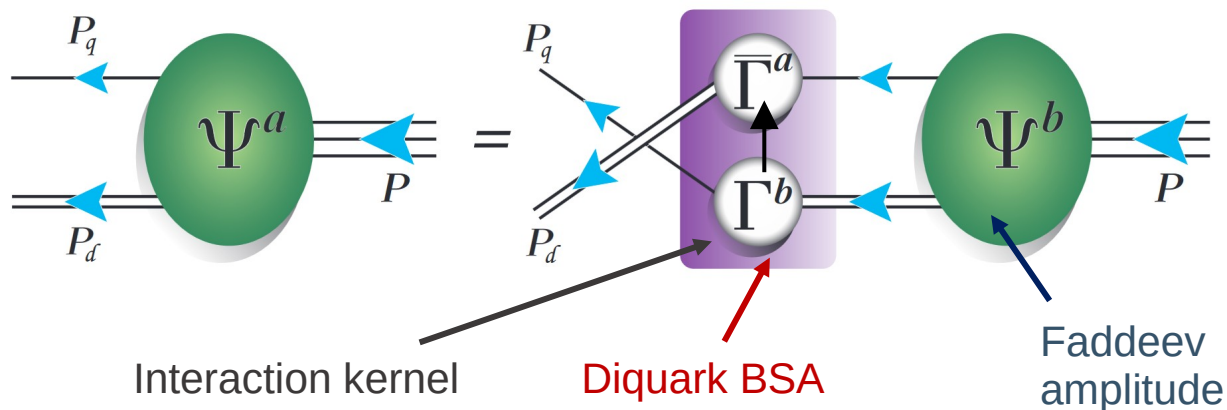


Fig. 9 Photon+quark vertex dressing function in Eq. (A.3). As in any symmetry preserving treatment of photon+quark interactions, $P_T(Q^2)$ exhibits a pole at $Q^2 = -m_\rho^2$. Moreover, $P_T(Q^2 = 0) = 1 = P_T(Q^2 \rightarrow \infty)$.

Contact Interaction

- The **Faddeev** equation, in the **SCI** dynamical **quark-diquark** picture:



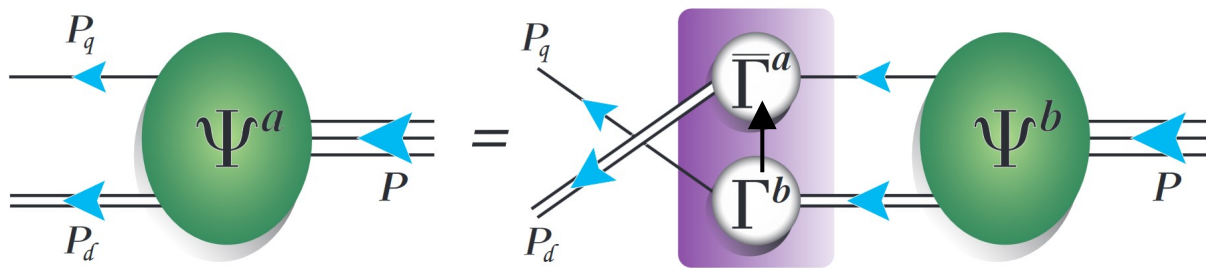
- Quarks inside baryons correlate into **non-point-like** diquarks.
- Breakup and reformation occurs via **quark exchange**.

- In the interaction kernel, the **exchanged quark** is represented in the **static approximation**:
- The kernel penalizes the contribution of diquarks whose parity is opposite to that of the baryon, using a multiplicative factor **gDB = 0.1-0.3**

$$S^T(k) \rightarrow \frac{g_B^2}{M_u}$$

Contact Interaction

- The **Faddeev** equation, in the dynamical **quark-diquark** picture:



- Quarks inside baryons correlate into **non-point-like** diquarks.
- Breakup and reformation occurs via **quark exchange**.

- Consider a **nucleon-like J=1/2** baryon:

$$\begin{aligned}
 \psi^\pm u(P) &= \Gamma_{0+}^1 \Delta^{0+}(K) \mathcal{S}^\pm(P) u(P) && \text{Scalar } (0^+) \\
 &+ \sum_{f=1,2} \Gamma_{1+\mu}^f \Delta_{\mu\nu}^{1+}(K) \mathcal{A}_\nu^{\pm f}(P) u(P) && \text{Axial vector } (1^+) \\
 &+ \Gamma_{0-}^1(K) \Delta^{0-}(K) \mathcal{P}^\pm(P) u(P) && \text{Pseudoscalar } (0^-) \\
 &+ \Gamma_{1-\mu}^1 \Delta_{\mu\nu}^{1-}(K) \mathcal{V}_\nu^\pm(P) u(P), && \text{Vector } (1^-)
 \end{aligned}$$

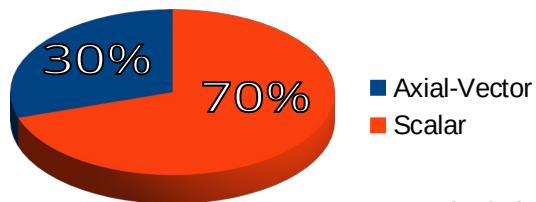
$$\begin{aligned}
 \mathcal{S}^\pm &= s^\pm \mathbf{I}_D \mathcal{G}^\pm, & i\mathcal{P}^\pm &= p^\pm \gamma_5 \mathcal{G}^\pm, \\
 i\mathcal{A}_\mu^{\pm f} &= (a_1^{\pm f} \gamma_5 \gamma_\mu - i a_2^{\pm f} \gamma_5 \hat{P}_\mu) \mathcal{G}^\pm, \\
 i\mathcal{V}_\mu^\pm &= (v_1^\pm \gamma_\mu - i v_2^\pm \mathbf{I}_D \hat{P}_\mu) \gamma_5 \mathcal{G}^\pm.
 \end{aligned}$$

- We then arrive at an eigenvalue equation for:

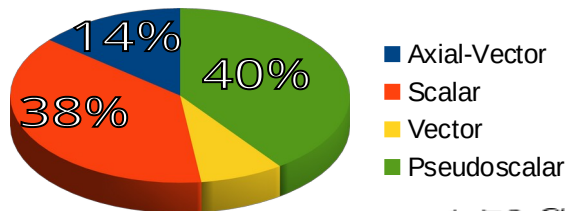
$$(s^\pm, a_1^{\pm f}, a_2^{\pm f}, p^\pm, v_1^\pm, v_2^\pm)$$

N(940) and N(1535)

- The produced masses and **diquark content**:



$m_N = 1.14 \text{ GeV}$



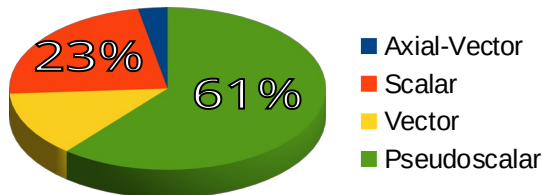
$m_{N^*} = 1.73 \text{ GeV}$

$g_{DB} = 0.2$

- As expected, the **nucleon** is mostly composed by **scalar** diquarks, while also exhibiting a sizeable **axial-vector** diquark component.
- With the preferred value of $g_{DB}=0.2$, the **nucleon parity partner** exhibits a similar contribution from $0^+/0^-$ diquarks.

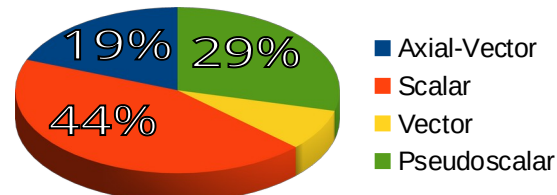
- The variation of $g_{DB} \rightarrow (1 \pm 0.5) g_{DB}$ produces:

$g_{DB} = 0.1$



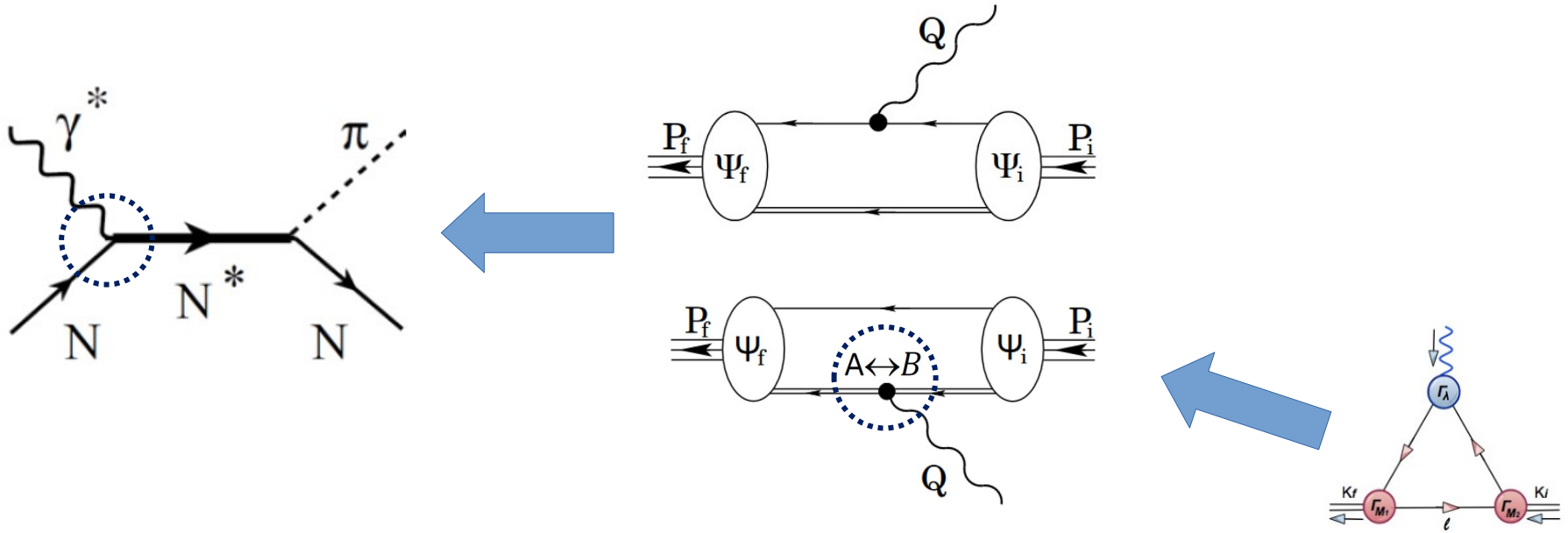
$m_{N^*} = 1.82 \text{ GeV}$

$g_{DB} = 0.3$



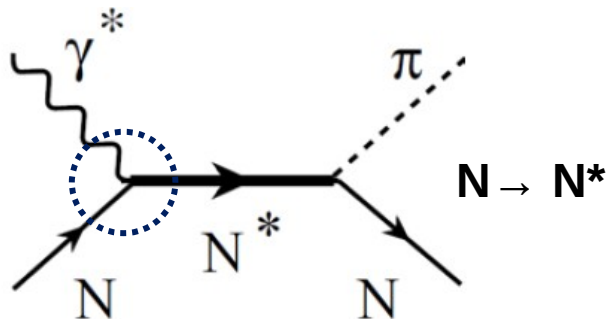
$m_{N^*} = 1.67 \text{ GeV}$

Nucleon TFFs: The approach



Nucleon transition form factors

- Let us consider the **electromagnetic transition**:



- In our approach, the **EM vertex** can be written:

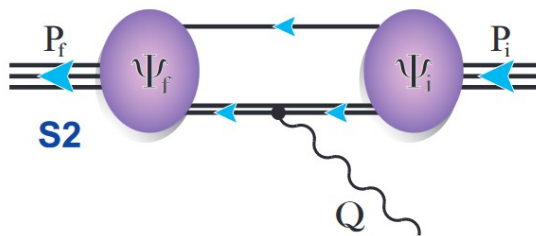
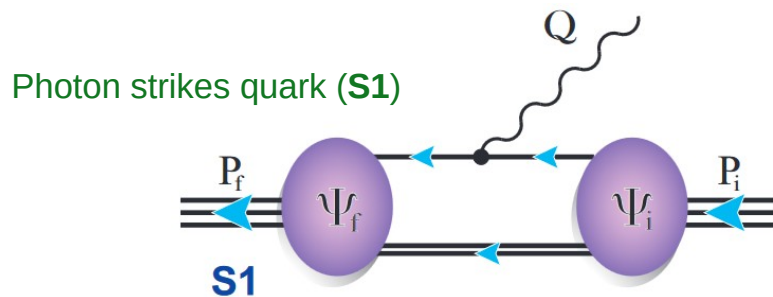
$$\Gamma_{\mu,\#}^{fi}(P_f, P_i) = \sum_{I=S1,S2,S3} \int_{\ell} \Lambda_{+,\#}^{P_f}(P_f) \mathcal{J}_{\mu,\#}^I(\ell; P_f, P_i) \Lambda_{+,\#}^{P_i}(P_i)$$

$$= \Lambda_{+,\#}^{P_f}(P_f) \left[\sum_r \mathcal{Q}_{\mu,\#}^{(j)}(\ell; P_f, P_i) + \sum_{s,t} \mathcal{D}_{\mu,\#}^{(s,t)}(\ell; P_f, P_i) \right] \Lambda_{+,\#}^{P_i}(P_i)$$

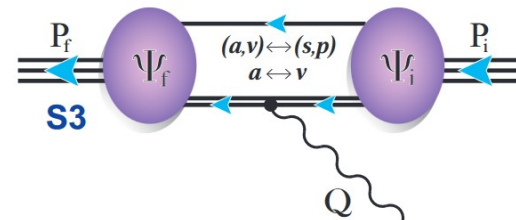
S1 diagrams

S2, S3 diagrams

- In the **quark-diquark picture**, within the **SCI model**, the electromagnetic vertex can be splitted into 3 categories:



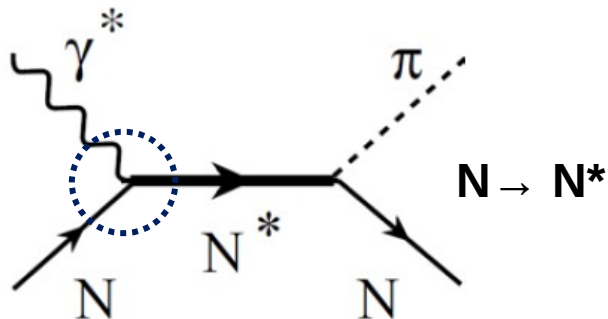
Photon strikes diquark, in an elastic scattering event (**S2**)



Photon strikes diquark, and a transition between different diquarks occurs (**S3**)

Nucleon transition form factors

- Let us consider the **electromagnetic transition**:

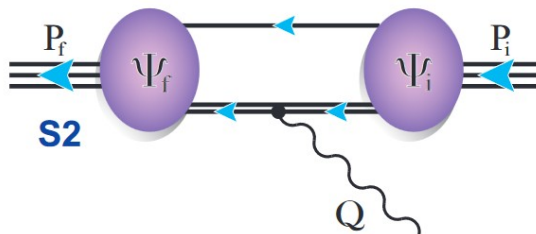
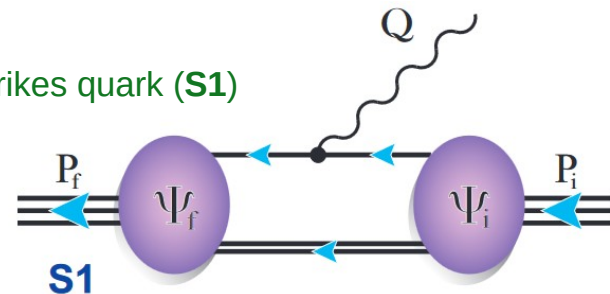


→ Therefore, to evaluate the full electromagnetic vertex, we need, *in principle* to calculate **20 intermediate** contributions:

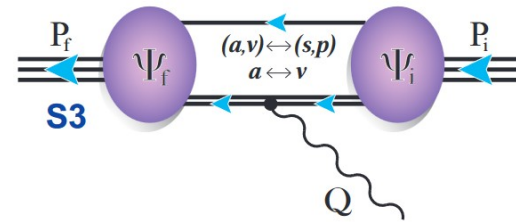
- 4** from the photon strikes **quark** case (1 for each spectator diquark)
- 4x4=16** from the photon strikes **diquark** cases.

- In the **quark-diquark picture**, within the **SCI model**, the electromagnetic vertex can be splitted into 3 categories:

Photon strikes quark (S1)



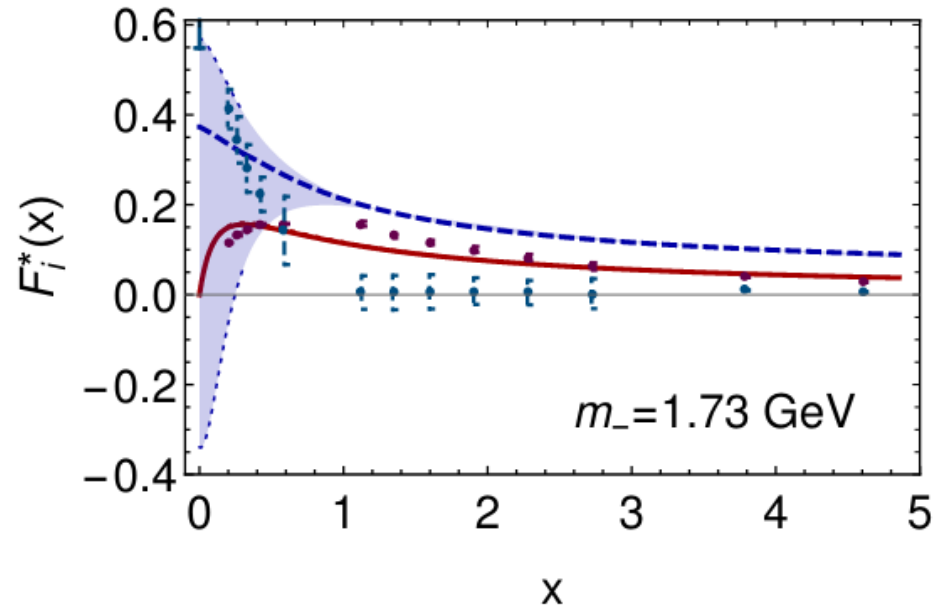
Photon strikes diquark, in an elastic scattering event (S2)



Photon strikes diquark, and a transition between different diquarks occurs (S3)

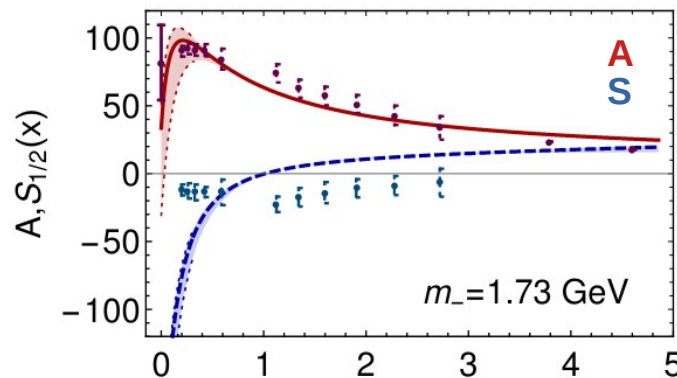
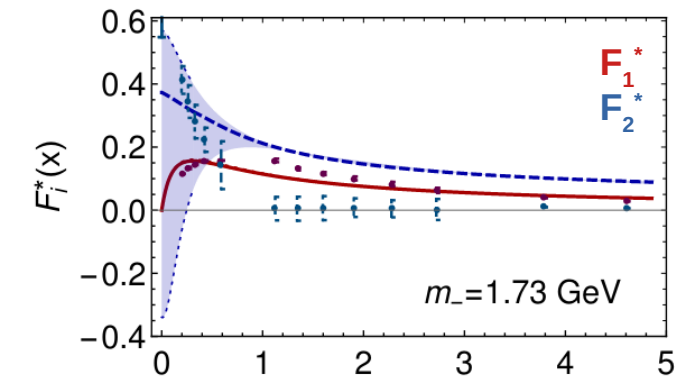
SCI Results:

$\gamma^{(*)} p \rightarrow N(1535) \frac{1}{2}^-$ transition



N → N(1535): Numerical results

- Transition form factors and **helicity amplitudes**:



Raya: 2021pyr

$x = Q^2/\bar{m}^2$, $\bar{m} = (m_+ + m_-)/2$:

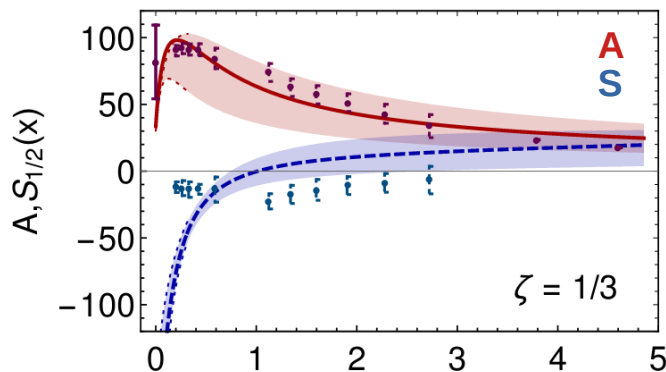
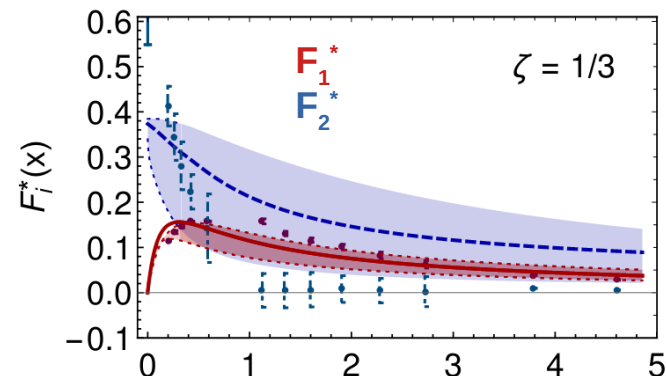
- The form factor F_1^* is **insensitive** to the quark **AMM**
→ Conversely, F_2^* is **rather sensitive** to it.
- F_1^* displays a **fair agreement** with CLAS data
- F_2^* becomes **too hard** as x increases, but it agrees in magnitude with data for $\zeta=1/3$
- The transverse helicity amplitude **A** is **sensitive** to the **AMM**, but still in **agreement** with the experiment.
→ The longitudinal one, **S**, is the **exact opposite**.

$$m_{N(940)} = 1.14, \quad m_{N(1535)} = 1.73, \quad \text{gDB} = 0.2$$

baryon	s	a_1^1	a_2^1	p	v_1	v_2
$N(940)\frac{1}{2}^+$	0.88	0.38	-0.06	0.02	0.02	0.00
$N(1535)\frac{1}{2}^-$	0.66	0.20	0.14	0.68	0.11	0.09

N → N(1535): Numerical results

- Transition form factors and **helicity amplitudes**:



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$$x = Q^2/\bar{m}^2, \bar{m} = (m_+ + m_-)/2$$

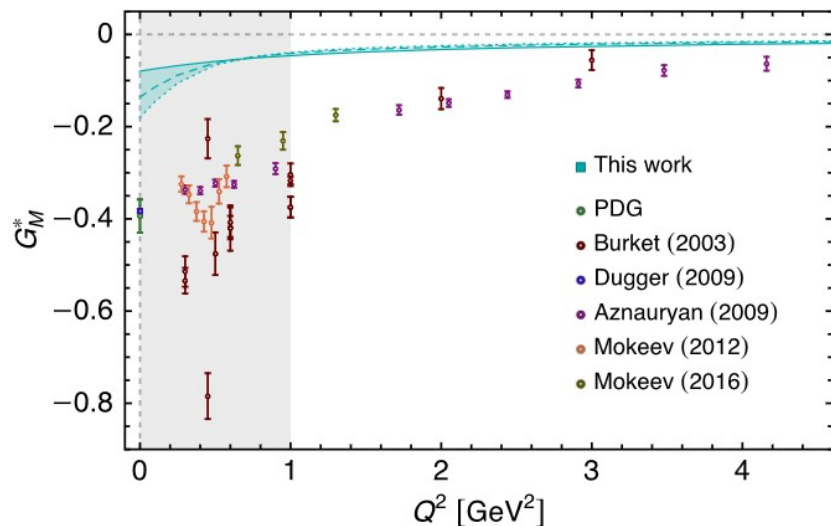
- Both form factors and helicity amplitudes are quite **sensitive** to the value **g_{DB}**, i.e., to both the **mass** and **diquark content** of the nucleon parity partner.
- In fact, **harder** form factors and helicity amplitudes are produced by the **heaviest N(1535)**.
 - This corresponds to the case in which the **0⁻ diquark overwhelms** the rest.
- The best agreement with data is obtained when the **0⁺ and 0⁻ diquark** content is **balanced**.

If one varies $g_{DB} \rightarrow g_{DB}(1 \pm 0.5)$, then $m_{N(1535)} = (1.67, 1.82)$ GeV and

$N(1535)\frac{1}{2}^-$	s	a_1^1	a_2^1	p	v_1	v_2
$g_{DB} 1.5$	0.76	0.27	0.18	0.49	0.12	0.08
$g_{DB} 1.0$	0.66	0.20	0.14	0.68	0.11	0.09
$g_{DB} 0.5$	0.35	0.04	0.00	0.92	-0.05	0.18

An update on

$$(I, J^P) = \left(\frac{1}{2}, \frac{3^-}{2} \right) \quad \& \quad \left(\frac{3}{2}, \frac{3^-}{2} \right)$$



Baryons:

$$\Delta(1700) \frac{3^-}{2} \quad N(1520) \frac{3^-}{2}$$

$\Delta(1700)$, $N(1520)$: Highlights

$$\Delta(1700) \frac{3}{2}^-$$

$$N(1520) \frac{3}{2}^-$$

- In a momentum-dependent interaction, the $\Delta(1700)$ state is described by **16 amplitudes**.

Liu:2022nku

$$\mathcal{V}_{\lambda\rho}^1(k; Q) = \delta_{\lambda\rho} \mathbb{I}_D, \quad (4a)$$

$$\mathcal{V}_{\lambda\rho}^2(k; Q) = \frac{i}{\sqrt{5}} [2\gamma_\lambda^\perp \hat{k}_\rho^\perp - 3\delta_{\lambda\rho} \gamma \cdot \hat{k}^\perp], \quad (4b)$$

$$\mathcal{V}_{\lambda\rho}^3(k; Q) = -i\gamma_\lambda^\perp \hat{k}_\rho^\perp, \quad (4c)$$

$$\mathcal{V}_{\lambda\rho}^4(k; Q) = \sqrt{3} \hat{Q}_\lambda \hat{k}_\rho^\perp, \quad (4d)$$

$$\mathcal{V}_{\lambda\rho}^5(k; Q) = 3\hat{k}_\lambda^\perp \hat{k}_\rho^\perp - \delta_{\lambda\rho} - \gamma_\lambda^\perp \hat{k}_\rho^\perp \gamma \cdot \hat{k}^\perp, \quad (4e)$$

$$\mathcal{V}_{\lambda\rho}^6(k; Q) = \gamma_\lambda^\perp \hat{k}_\rho^\perp \gamma \cdot \hat{k}^\perp, \quad (4f)$$

$$\mathcal{V}_{\lambda\rho}^7(k; Q) = -i\sqrt{3} \hat{Q}_\lambda \hat{k}_\rho^\perp \gamma \cdot \hat{k}^\perp, \quad (4g)$$

$$\mathcal{V}_{\lambda\rho}^8(k; Q) = \frac{i}{\sqrt{5}} [\delta_{\lambda\rho} \gamma \cdot \hat{k}^\perp + \gamma_\lambda^\perp \hat{k}_\rho^\perp - 5\hat{k}_\lambda^\perp \hat{k}_\rho^\perp \gamma \cdot \hat{k}^\perp].$$

- The $N(1520)$ case is even more complicated (**20 amplitudes**).

Liu:2022ndb

+

$$\begin{aligned} \chi_\rho^1(k; Q) &= i\sqrt{3} \hat{k}_\rho^\perp \gamma_5, \\ \chi_\rho^2(k; Q) &= i\gamma \cdot \hat{k}^\perp \chi_\rho^1(k; Q), \end{aligned}$$

$$(2 \times \text{green}) + (2 \times \text{red}) = 20$$

$\Delta(1700)$, $N(1520)$: Highlights

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$$(2 \times \text{green}) + (2 \times \text{red}) = 20$$

- But the **SCI kills them all**: Only survives one structure associated with the **$1^\pm$ correlations**.
- And then, the low masses of the $\Delta(1700)$ and $N(1520)$ states leave out the **1^-** .

$\Delta(1700)$, $N(1520)$: Highlights

- In a momentum-dependent interaction, the $\Delta(1700)$ state is described by **16 amplitudes**.

Liu:2022nku

$$\mathcal{V}_{\lambda\rho}^1(k; Q) = \delta_{\lambda\rho} \mathbb{I}_D, \quad (4a)$$

- The $N(1520)$ case is even more complicated (**20 amplitudes**).

Liu:2022ndb

$$\mathcal{X}_{\rho}^1(k; Q) = i\sqrt{3} \hat{k}_{\rho}^{\perp} \gamma_5,$$

- In realistic interactions, this is the precisely correlation that **contributes the most** to the normalization of the **wavefunction** and to the **mass**.

$\Delta(1700)$

mass %		amplitude %	
1^+	1^-	1^+	1^-
99.98	0.02	96.97	3.03

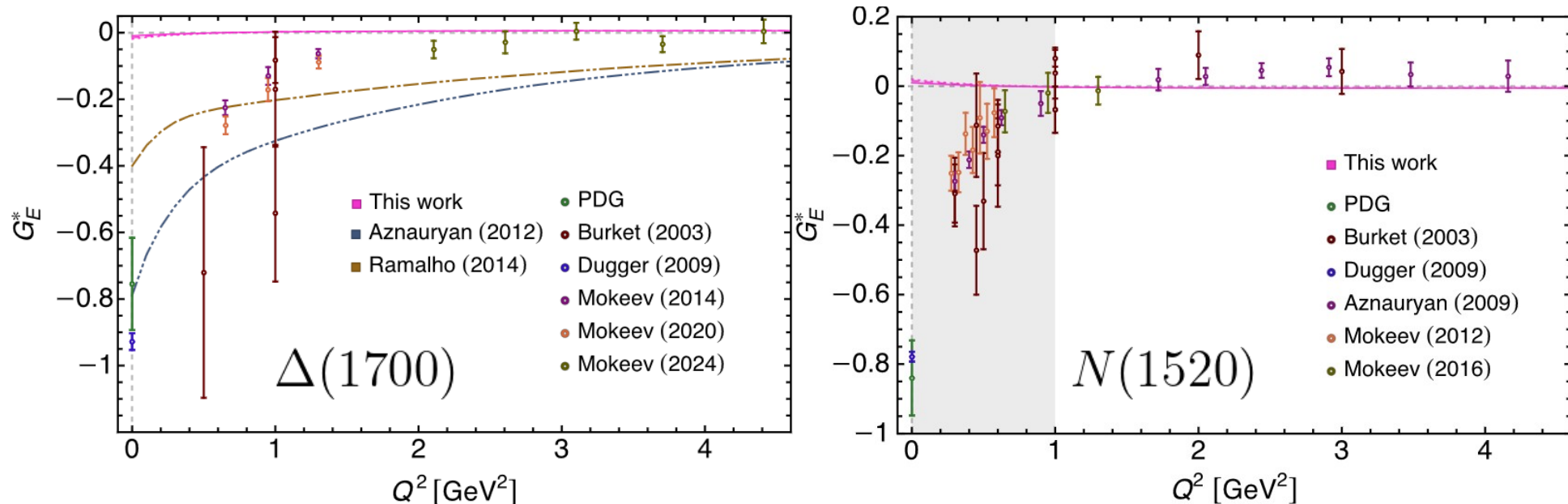
$N(1520)$

C. FA %	$N(1520)_{\frac{3}{2}^-}$	B. mass %	$N(1520)_{\frac{3}{2}^-}$
1^+	70.1	1^+	91.6
0^+	20.3	& 0^+	8.3
0^-	6.2	& 0^-	0.1
1^-	3.4	& 1^-	0.0

$p \rightarrow \Delta(1700), N(1520)$: TFFs

See next talk

- The G_E^* transition form factor:

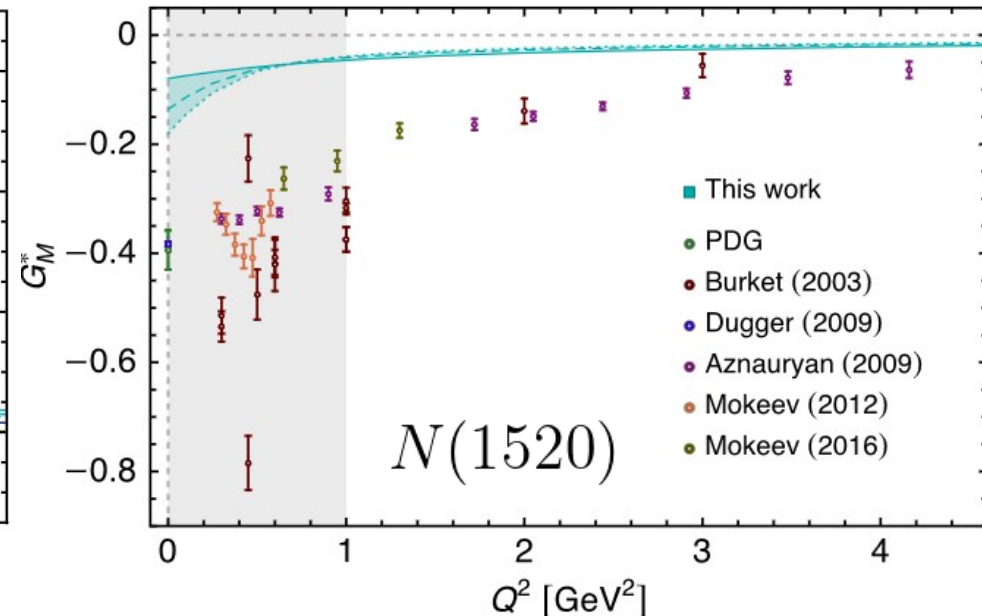
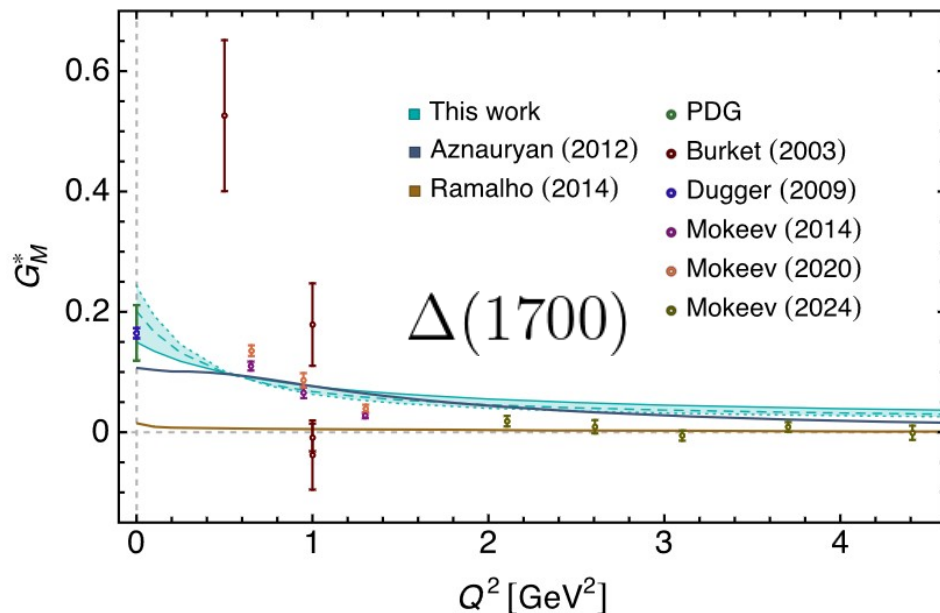


- At **large momenta**, our results are **compatible with 0**.
- At **small momenta**, where meson cloud effects are expected to manifest visible impact, we obtain the most **noticeable discrepancy**.

$p \rightarrow \Delta(1700), N(1520)$: TFFs

See next talk

- The G_M^* transition form factor:

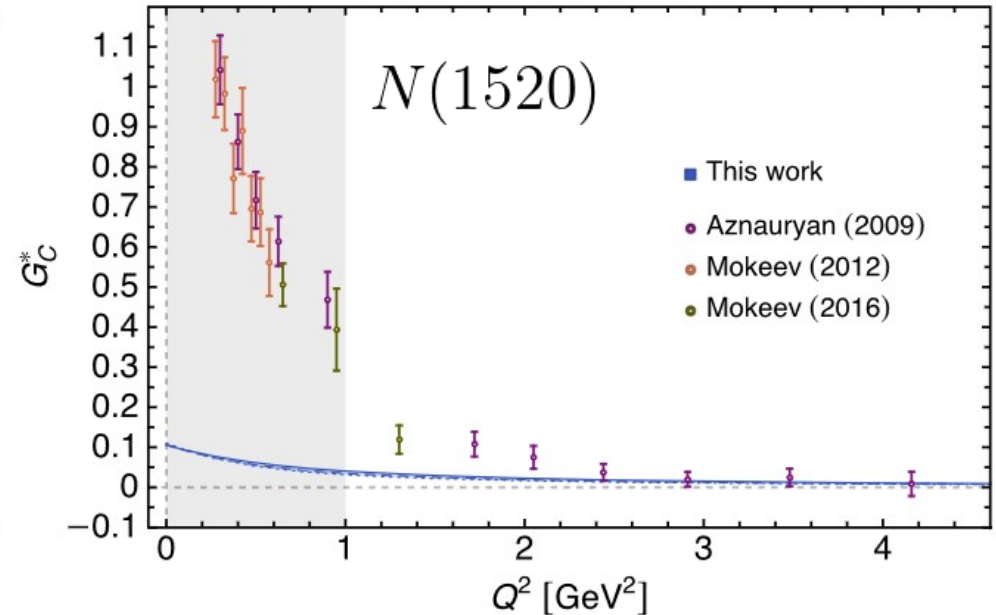
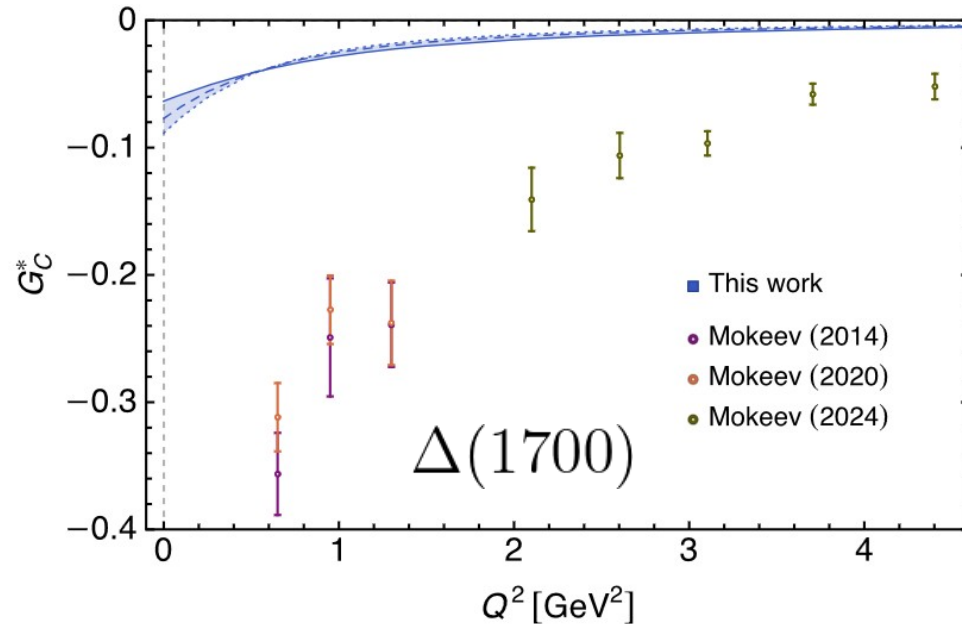


- The expected trends are **captured** at both **large** and **small** Q^2
- Nevertheless, the **magnitude** is still **not** properly **reproduced**.

$p \rightarrow \Delta(1700), N(1520)$: TFFs

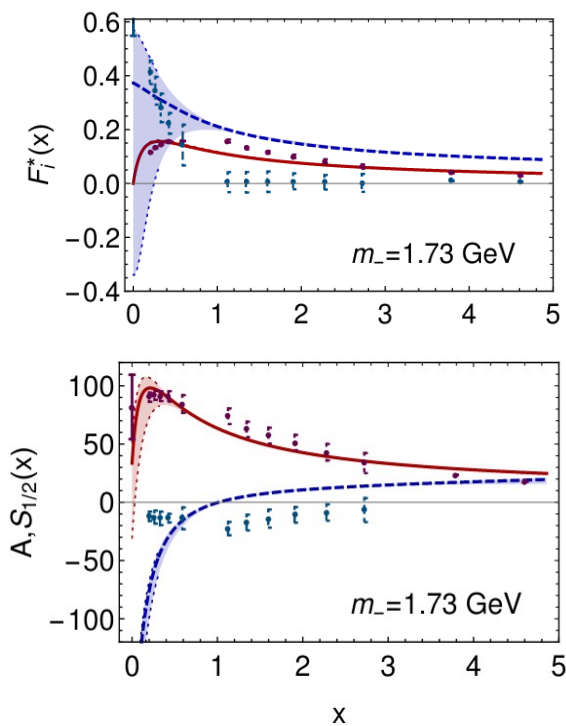
See next talk

- The G_C^* transition form factor:



- The expected trends are **captured** at both **large** and **small** Q^2
- Nevertheless, the **magnitude** is still **not** properly **reproduced**.

Summary

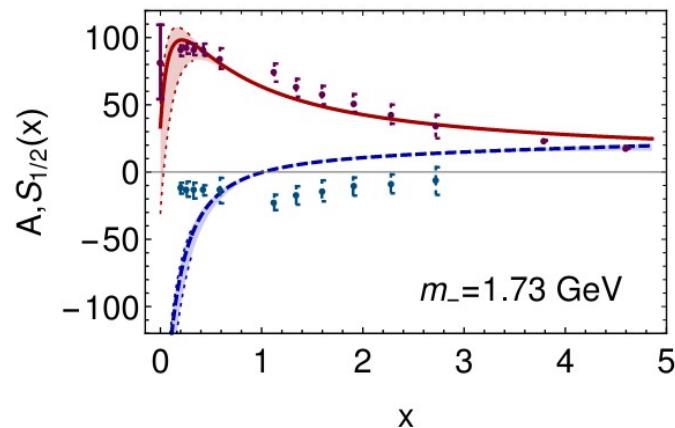


I just need
the main ideas



Summary

- **Theoretical** evidence suggests the existence of **dynamical diquark** correlations:
 - The **3-body Faddeev** equation kernel self-arranges in blocks with spin-flavor structure of diquarks.
 - The **2-body BSE** reveal strong correlations in quark-quark scattering channels.
 - ➔ Consequently, the existence of non-point-like **diquarks** within baryons should be **connected** with EHM phenomena.
- Some **experimental** observables could yield to **unambiguous signals** of the presence of dynamical diquark correlations:
 - ➔ Nucleon **transition form factors** and structure functions, spectroscopy of exotic hadrons, etc.
 - ➔ The electromagnetic transitions are highly **sensitive** to the **baryon wavefunction**, and a path to better understand **DCSB**.
- The **SCI** model provides a **practical** testing platform.

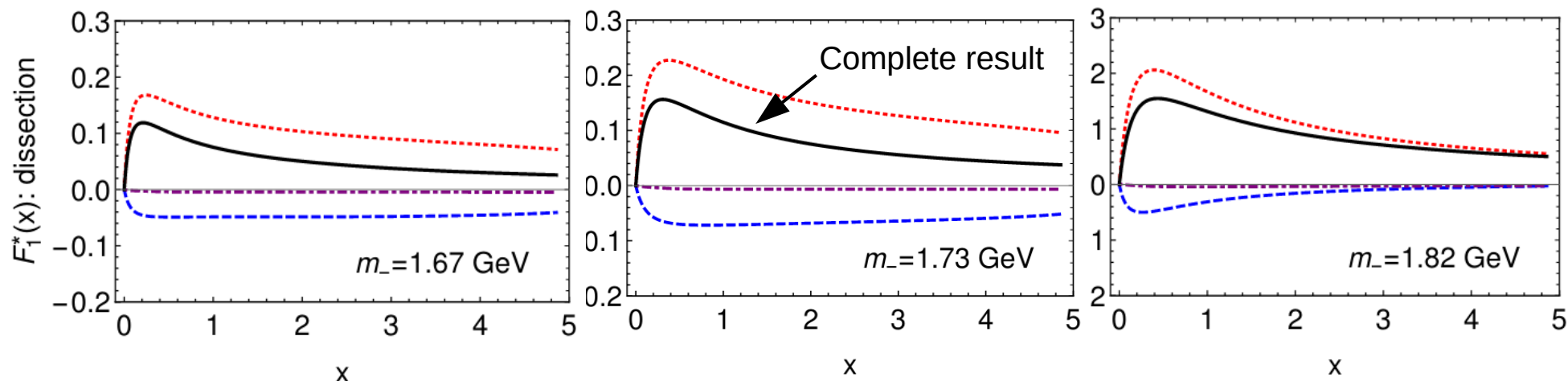


N → N(1535): Numerical results

- Dissection of the form factors: F_1^* .

Red: Photon strikes quark Q^+Q^+
 Blue: Photon strikes diquark, initial and final D^+D^+ one have same parity
 Purple: Photon strikes diquark, initial and final one have opposed parity D^-D^+

- The **parity-flip** contributions are practically **negligible**
- There is a **destructive interference** between the other two contributions, $Q^+Q^+ D^+D^+$
- In particular, the strength of Q^+Q^+ , seems to be modulated by D^+D^+

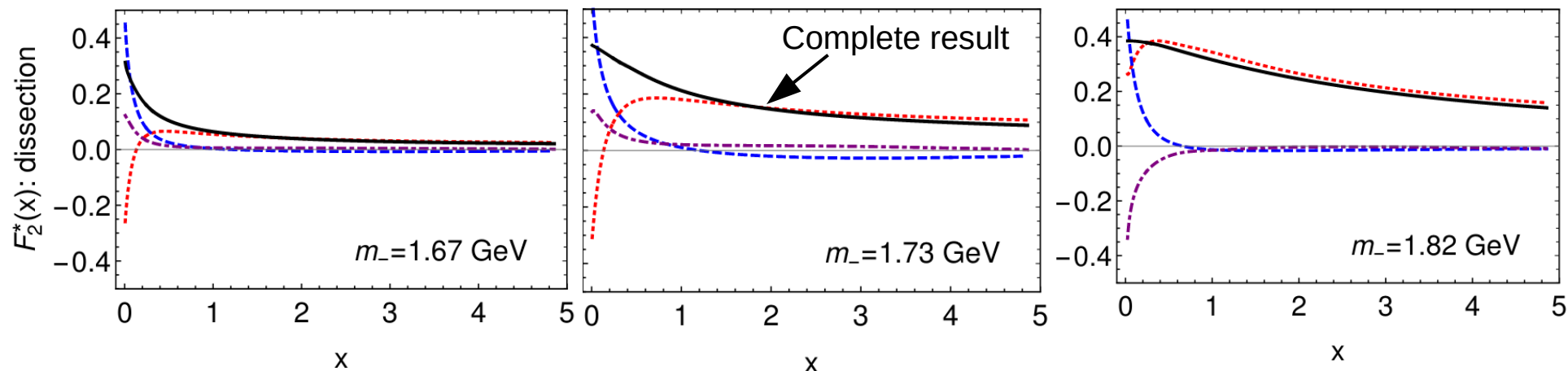


N → N(1535): Numerical results

- **Dissection** of the form factors: F_2^* .

Red: Photon strikes quark Q^+Q^+
 Blue: Photon strikes diquark, initial and final one have same parity D^+D^+
 Purple: Photon strikes diquark, initial and final one have opposed parity D^-D^+

- The photon **strikes diquark** contribution interfere **constructively** in the light cases, but **destructively** in the heaviest case.
- This form factor is more **sensitive** to the quark **AMM**, specially the photon **strikes quark** case.



N → N(1535): Numerical results

- Transition form factors and **helicity amplitudes**:

$$x = Q^2/\bar{m}^2, \bar{m} = (m_+ + m_-)/2:$$

