

Coupling Constant of the $D_2^*(2460)^0 \rightarrow D^+ \pi^-$ Transition via QCD Sum Rules

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QCD@Work, International Workshop on QCD, Theory and
Experiment
16-19 June 2014, Bari, Italy

Outline

Introduction

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- ▶ The first observation of the orbitally excited charmed meson was made in 1986 [1] and the observation of them has continued in the following past few decades.
- ▶ This period has also been accompanied by several theoretical studies on the masses, strong and electromagnetic transitions of these mesons via various methods.
- ▶ In the literature one may find little theoretical works on the properties of tensor mesons compared to the other types of mesons.
- ▶ One can attain valuable information about the internal structures and the natures of these mesons via the study of the parameters of these mesons and comparison of their results with the existing experimental findings.

- ▶ Through these studies one may also test the assumptions of some theoretical calculations and comprehend the experimental results which provides a better understanding of the strong interaction.
- ▶ This type of work may also be helpful to gain useful information related to the study of B meson since charmed tensor mesons appear as an intermediate state in B meson decays. Additionally, the possibility for a search on the transition of D_2^* meson at LHC provides motivation on the study of these mesons.
- ▶ $D_2^*(2460)$ having the quantum number $I(J^P) = \frac{1}{2}(2^+)$ is among these orbitally excited mesons and was reported twenty years ago.
- ▶ In this work we present the analysis for the transition $D_2^*(2460)^0 \rightarrow D^+ \pi^-$

QCD sum rules calculation for the coupling constant

The method: QCD Sum Rules

The starting point: Three-point correlation function

$$\Pi_{\mu\nu}(p, p', q) = i^2 \int d^4x d^4y e^{-ip \cdot x} e^{ip' \cdot y} \langle 0 | \mathcal{T} \left(J^D(y) J^\pi(0) J_{\mu\nu}^{D_2^*}{}^\dagger(x) \right) | 0 \rangle. \quad (1)$$

$$\begin{aligned} J^D(y) &= i\bar{d}(y)\gamma_5 c(y), \\ J^\pi(0) &= i\bar{u}(0)\gamma_5 d(0), \\ J_{\mu\nu}^{D_2^*}(x) &= \frac{i}{2} \left[\bar{u}(x)\gamma_\mu \overset{\leftrightarrow}{D}_\nu(x)c(x) + \bar{u}(x)\gamma_\nu \overset{\leftrightarrow}{D}_\mu(x)c(x) \right], \end{aligned} \quad (2)$$

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└ QCD sum rules calculation for the coupling constant

Two-side covariant derivative is defined as;

$$\overleftrightarrow{\mathcal{D}}_\mu(x) = \frac{1}{2} \left[\overrightarrow{\mathcal{D}}_\mu(x) - \overleftarrow{\mathcal{D}}_\mu(x) \right], \quad (3)$$

and

$$\begin{aligned} \overrightarrow{\mathcal{D}}_\mu(x) &= \overrightarrow{\partial}_\mu(x) - i \frac{g}{2} \lambda^a A_\mu^a(x), \\ \overleftarrow{\mathcal{D}}_\mu(x) &= \overleftarrow{\partial}_\mu(x) + i \frac{g}{2} \lambda^a A_\mu^a(x). \end{aligned} \quad (4)$$

Fock-Schwinger gauge, $x^\mu A_\mu^a(x) = 0$

$$A_\mu^a(x) = \int_0^1 d\alpha \alpha x_\beta G_{\beta\mu}^a(\alpha x) = \frac{1}{2} x_\beta G_{\beta\mu}^a(0) + \frac{1}{3} x_\eta x_\beta \mathcal{D}_\eta G_{\beta\mu}^a(0) + \dots .$$

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Correlation functions:

$$\begin{aligned}\Pi_{\mu\nu}^{Phys}(p, p', q) &= \frac{\langle 0 | J^\pi | \pi(q) \rangle \langle 0 | J^D | D(p') \rangle \langle D_2^*(p, \epsilon) | J_{\mu\nu}^{D_2^*} | 0 \rangle}{(p^2 - m_{D_2^*}^2)(p'^2 - m_D^2)(q^2 - m_\pi^2)} \\ &\times \langle \pi(q) D(p') | D_2^*(p, \epsilon) \rangle + \dots ,\end{aligned}\quad (6)$$

$$\langle 0 | J^\pi | \pi(q) \rangle = i \frac{m_\pi^2 f_\pi}{m_d + m_u}, \quad (7)$$

$$\langle 0 | J^D | D(p') \rangle = i \frac{m_D^2 f_D}{m_d + m_c}, \quad (8)$$

$$\langle D_2^*(p, \epsilon) | J_{\mu\nu}^{D_2^*} | 0 \rangle = m_{D_2^*}^3 f_{D_2^*} \epsilon_{\mu\nu}^{*(\lambda)}, \quad (9)$$

$$\langle \pi(q) D(p') | D_2^*(p, \epsilon) \rangle = g_{D_2^* D \pi} \epsilon_{\eta\theta}^{(\lambda)} p'_\eta p'_\theta \quad (10)$$

Coupling Constant of the $D_2^*(2460)^0 \rightarrow D^+ \pi^-$ Transition via QCD Sum Rules

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$$\begin{aligned}
 \Pi_{\mu\nu}^{Phys}(p, p', q) &= \frac{g_{D_2^* D\pi} m_D^2 m_\pi^2 f_D f_\pi f_{D_2^*}}{(m_c + m_d)(m_u + m_d)(p^2 - m_{D_2^*}^2)(p'^2 - m_D^2)(q^2 - m_\pi^2)} \\
 &\times \left[m_{D_2^*} p \cdot p' p'_\mu p_\nu - \frac{2(p \cdot p')^2 + m_{D_2^*}^2 p'^2}{3 m_{D_2^*}} p_\mu p_\nu - m_{D_2^*}^3 p'_\mu p'_\nu \right. \\
 &+ \left. m_{D_2^*} (p \cdot p') p_\mu p'_\nu + \frac{m_{D_2^*} (m_{D_2^*}^2 p'^2 - (p \cdot p')^2)}{3} g_{\mu\nu} \right] + \dots,
 \end{aligned} \tag{11}$$

Summation over the polarization tensor

$$\sum_{\lambda} \varepsilon_{\mu\nu}^{(\lambda)} \varepsilon_{\alpha\beta}^{*(\lambda)} = \frac{1}{2} T_{\mu\alpha} T_{\nu\beta} + \frac{1}{2} T_{\mu\beta} T_{\nu\alpha} - \frac{1}{3} T_{\mu\nu} T_{\alpha\beta}, \tag{12}$$

$$T_{\mu\nu} = -g_{\mu\nu} + \frac{p_\mu p_\nu}{m_{D_2^*}^2}. \tag{13}$$

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$$\begin{aligned}\widehat{\mathbf{B}}\Pi_{\mu\nu}^{Phys}(q) &= g_{D_2^* D\pi} \frac{f_D f_{D_2^*} f_\pi m_D^2 m_\pi^2}{(m_c + m_d)(m_u + m_d)(m_\pi^2 - q^2)} e^{-\frac{m_{D_2^*}^2}{M^2}} e^{-\frac{m_D^2}{M'^2}} \\ &\left\{ \begin{array}{l} \frac{1}{12} m_{D_2^*} \left(m_D^4 + (m_{D_2^*}^2 - q^2)^2 - 2m_D^2(m_{D_2^*}^2 + q^2) \right) g_{\mu\nu} \\ + \frac{1}{6m_{D_2^*}^2} \left[m_D^4 + m_D^2(4m_{D_2^*}^2 - 2q^2) + (m_{D_2^*}^2 - q^2)^2 \right] p_\mu p_\nu \\ - \frac{1}{2} m_{D_2^*} (m_D^2 + m_{D_2^*}^2 - q^2) p_\nu p'_\mu + m_{D_2^*}^3 p'_\mu p'_\nu \\ - \frac{1}{2} m_{D_2^*} (m_D^2 + m_{D_2^*}^2 - q^2) p_\mu p'_\nu \end{array} \right\} + \dots . \quad (14)\end{aligned}$$

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└ QCD sum rules calculation for the coupling constant

The QCD side of the calculation is made in deep Euclidean region where $p^2 \rightarrow -\infty$ and $p'^2 \rightarrow -\infty$.

$$\begin{aligned} \Pi_{\mu\nu}^{QCD}(p, p', q) &= \frac{i^5}{2} \int d^4x \int d^4y e^{-ip \cdot x} e^{ip' \cdot y} \\ &\times \left\{ Tr \left[\gamma_5 S_d^{ij}(-y) \gamma_5 S_c^{i\ell}(y-x) \gamma_\mu \overset{\leftrightarrow}{D}_\nu(x) S_u^{\ell j}(x) \right] + [\mu \leftrightarrow \nu] \right\} \end{aligned} \quad (15)$$

$$\begin{aligned} S_c^{i\ell}(x) &= \frac{i}{(2\pi)^4} \int d^4k e^{-ik \cdot x} \left\{ \frac{\delta_{i\ell}}{k - m_c} - \frac{g_s G_{i\ell}^{\alpha\beta}}{4} \frac{\sigma_{\alpha\beta}(k + m_c) + (k + m_c)\sigma_{\alpha\beta}}{(k^2 - m_c^2)^2} \right. \\ &\quad \left. + \frac{\pi^2}{3} \langle \frac{\alpha_s GG}{\pi} \rangle \delta_{i\ell} m_c \frac{k^2 + m_c k}{(k^2 - m_c^2)^4} + \dots \right\} \end{aligned} \quad (16)$$

$$\begin{aligned} S_q^{ij}(x) &= i \frac{x}{2\pi^2 x^4} \delta_{ij} - \frac{m_q}{4\pi^2 x^2} \delta_{ij} - \frac{\langle \bar{q}q \rangle}{12} \left(1 - i \frac{m_q}{4} x \right) \delta_{ij} - \frac{x^2}{192} m_0^2 \langle \bar{q}q \rangle \left(1 - i \frac{m_q}{6} x \right) \delta_{ij} \\ &- \frac{ig_s G_{\theta\eta}^{ij}}{32\pi^2 x^2} [x \sigma^{\theta\eta} + \sigma^{\theta\eta} x] + \dots \end{aligned} \quad (17)$$

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└ QCD sum rules calculation for the coupling constant

To perform the four- x and four- y integrals

$$\begin{aligned}\frac{1}{[(y-x)^2]^n} &= \int \frac{d^D t}{(2\pi)^4} e^{-it(y-x)} i (-1)^{n+1} 2^{D-2n} \pi^{D/2} \frac{\Gamma(D/2-n)}{\Gamma(n)} \left(-\frac{1}{t^2}\right)^{D/2-n}, \\ \frac{1}{[(y)^2]^m} &= \int \frac{d^D s}{(2\pi)^4} e^{-isy} i (-1)^{m+1} 2^{D-2m} \pi^{D/2} \frac{\Gamma(D/2-m)}{\Gamma(m)} \left(-\frac{1}{s^2}\right)^{D/2-m}\end{aligned}\quad (18)$$

are used to transform the terms containing $\frac{1}{((y-x)^2)^n (y^2)^m}$ to the momentum space with $D = 4$.

$x_\mu \rightarrow i \frac{\partial}{\partial p_\mu}$ and $y_\mu \rightarrow -i \frac{\partial}{\partial p'_\mu}$.

$$\int d^4 t \frac{(t^2)^\beta}{(t^2 + L)^\alpha} = \frac{i\pi^2 (-1)^{\beta-\alpha} \Gamma(\beta+2) \Gamma(\alpha-\beta-2)}{\Gamma(2) \Gamma(\alpha) [-L]^{\alpha-\beta-2}}. \quad (19)$$

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└ QCD sum rules calculation for the coupling constant

$$\begin{aligned}\Pi_{\mu\nu}^{QCD}(p, p', q) = & \Pi_1(q^2)p_\mu p_\nu + \Pi_2(q^2)p_\nu p'_\mu + \Pi_3(q^2)p_\mu p'_\nu \\ & + \Pi_4(q^2)p'_\mu p'_\nu + \Pi_5(q^2)g_{\mu\nu}\end{aligned}\quad (20)$$

$$\Pi_i(q^2) = \int ds \int ds' \frac{\rho_i^{pert}(s, s', q^2)}{(s - p^2)(s' - p'^2)} + \Pi_i^{nonpert}(q^2), \quad (21)$$

where $i=1,2,3,4,5$ and the spectral density $\rho_i(s, s', q^2)$ is given by the imaginary part of the Π_i functions, i.e.,
 $\rho_i(s, s', q^2) = \frac{1}{\pi} Im[\Pi_i].$

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└ QCD sum rules calculation for the coupling constant

The $\rho_1(s, s', q^2)$ and $\Pi_1^{nonpert}(q^2)$ corresponding to Dirac structure, $p_\mu p_\nu$:

$$\begin{aligned} \rho_1^{pert}(s, s', q^2) &= \int_0^1 dx \int_0^{1-x} dy \frac{3(1 + 8x^2 - 7y + 8y^2 - 7x + 16xy)}{8\pi^2} \\ &\times \Theta[L(s, s', q^2)], \end{aligned} \quad (22)$$

and

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$$\begin{aligned}\Pi_1^{nonpert}(q^2) = & \int_0^1 dx \int_0^{1-x} dy \left\{ \left\langle \frac{\alpha_s G^2}{\pi} \right\rangle \right\} \left\{ \frac{1}{8L^4} m_c x^3 (1 - 2x - 2y) [m_c m_d m_u (1 - x - y) \right. \\ & + m_c (p^2 x + q^2(y-1)) (x+y-1)(x+y) + m_c p'^2 x (x+y-xy-y^2-1) \\ & + (m_u(x+y-1) - m_d(x+y)) (p^2(x-1)(x+y-1) + y(p'^2(1-x) \\ & + q^2(x+y-1)) \Big] + \frac{1}{24L^3} [(x-1)^2 x^2 (2x-1) (p^2 - q^2 + p^2(3x-2)) \\ & + xy(x-1) (q^2(x-1)(4-13x+6x^2) + p^2(x-1)(2-17x+24x^2) \\ & + p'^2(3-11x+15x^2-6x^3)) + q^2 y^2 (3-32x+81x^2-75x^3+24x^4) \\ & + xy^2 (p^2(57x-90x^2+42x^3-10) + p'^2(11-40x+50x^2-18x^3)) \\ & + q^2 y^3 (x-1)(15-62x+42x^2) + xy^3 (p^2(x-1)(42x-19) + 48xp'^2 \\ & - 24x^2 p'^2 - 19p'^2) + xy^4 (p'^2(17-18x) - p^2(17-24x)) \\ & + q^2 y^4 (27-73x+42x^2) + 6xy^5 (p^2 - p'^2) + 3y^5 q^2 (8x-7) \\ & + 6y^6 q^2 - m_c^2 x^3 (1+8x^2-7y+8y^2-7x+16xy)\end{aligned}$$

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$$\begin{aligned} & - m_c m_u x (x + y - 1) (8x^3 - 3x^2 - 2x - 5y + 10xy + 8x^2y + 8y^2) \\ & + m_c m_u x (8x^4 - 11x^3 + 8x^2 - 3x - 3y + 14xy - 19x^2y + 16x^3y + 7y^2 - 12xy^2 \\ & + 8x^2y^2 - 4y^3) \Big] + \frac{1}{48L^2} \left[24x^4 + x^3(72y - 55) + 3x^2(13 - 48y + 32y^2) \right. \\ & \left. + (y^2 - y)(8 - 31y + 24y^2) - 8x + 75xy - 144xy^2 + 72xy^3 \right] \Big\} \\ & + \frac{m_0^2 \langle \bar{d}d \rangle m_u}{24q^2(m_c^2 - p'^2)^4} \left(9m_c^4 - 8m_c^3 m_d - 12m_c^2 p'^2 + 2m_c m_d p'^2 + 3p'^4 \right) \\ & + \frac{m_0^2 \langle \bar{u}u \rangle m_d}{24q^2(m_c^2 - p^2)^4} \left(9m_c^4 + 8m_c^3 m_u - 12m_c^2 p'^2 - 2m_c m_u p^2 + 3p^4 \right) \Big\}, \quad (23) \end{aligned}$$

where

$$L(s, s', q^2) = -m_c^2 x + sx - sx^2 + q^2 y - q^2 xy - sxy + s'xy - q^2 y^2 \quad (24)$$

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└ QCD sum rules calculation for the coupling constant

After double Borel transformation the final form of the QCD side of the correlation function:

$$\begin{aligned}\hat{\mathbf{B}}\Pi_{\mu\nu}^{QCD}(q^2) &= \left\{ \int ds \int ds' e^{-\frac{s}{M^2}} e^{-\frac{s'}{M'^2}} \rho_1^{pert}(s, s', q^2) \right. \\ &\quad \left. + \hat{\mathbf{B}}\Pi_1^{nonpert}(q^2) \right\} p_\mu p_\nu + \dots ,\end{aligned}\tag{25}$$

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where

$$\begin{aligned}
 \widehat{\mathbf{B}}\Pi_1^{nonpert}(q^2) &= \int_1^0 dx \exp \left[\frac{m_c^2 M'^4 x + m_c^2 M^4 x + M^2 M'^2 (-q^2(x-1)r + 2m_c^2 x)}{M^2 M'^2 (M^2 + M'^2)x(x-1)} \right] \left(\frac{\alpha_s G^2}{\pi} \right) \\
 &\times \frac{1}{48} \sqrt{\frac{1}{(x-1)^2}} \left\{ \frac{M'^{12} (x-1)^6 (M^2 + M'^2 x)}{x^3 u^6 (M^2 + M'^2)^{10}} \left[x m_c^2 (M'^4 + M^4) - M'^2 M^2 \right. \right. \\
 &\times (q^2(x-1)^2 - 2m_c^2 x) \Big] + \frac{M'^{12} (x-1)^6 (M^2 + M'^2 x)}{x^3 u^5 (M^2 + M'^2)^9} \left(M^2 q^2 (x-1) \right. \\
 &+ 4M^4 x + M'^2 (q^2 + 2M^2 x - q^2 x) \Big) + \frac{M'^8 (x-1)^4}{x^2 u^4 M^2 (M^2 + M'^2)^7} \left[m_c m_d M^6 \right. \\
 &+ M'^6 x \left(M^2 (x-1) + m_c m_d x \right) + M^4 M'^2 \left(4M^2 (1-x) + m_c m_d (1+2x) \right) \\
 &+ M^2 M'^4 \left(m_c m_d x (2+x) + M^2 (7x - 5x^2 - 2) \right) \Big] - \frac{M'^8 (M^2 + M'^2 x)}{x^2 u^3 M^2 (M^2 + M'^2)^6} \\
 &\times (x-1)^4 \Big\} \Theta \left[\frac{M^2 - M^2 x}{M'^2 + M^2} \right], \tag{26}
 \end{aligned}$$

$$u = -1 + x + \frac{M^2 - M^2 x}{M^2 + M'^2}. \tag{27}$$

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└ QCD sum rules calculation for the coupling constant

The final form of the sum rules for the coupling form factor:

$$\begin{aligned}
g_{D_2^* D \pi} &= e^{\frac{m_{D_2^*}^2}{M^2}} e^{\frac{m_D^2}{M'^2}} \frac{6(m_c + m_d)(m_d + m_{u[s]})(m_\pi^2 - q^2)m_{D_2^*}}{f_{D_2^*} f_D f_\pi m_D^2 m_\pi^2} \\
&\times \frac{1}{\left[m_D^4 + m_D^2(4m_{D_2^*}^2 - 2q^2) + (m_{D_2^*}^2 - q^2)^2 \right]} \\
&\times \left\{ \int_{(m_c+m_u)^2}^{s_0} ds \int_{(m_c+m_d)^2}^{s'_0} ds' e^{-\frac{s}{M^2}} e^{-\frac{s'}{M'^2}} \rho_1^{pert}(s, s', q^2) \right. \\
&+ \left. \widehat{\mathbf{B}} \Pi_1^{non-pert}(q^2) \right\}, \tag{28}
\end{aligned}$$

Numerical Results and Conclusion

Parameters	Values
m_c	$(1.275 \pm 0.025) \text{ GeV}$ [19]
m_d	$4.8^{+0.5}_{-0.3} \text{ MeV}$ [19]
m_u	$2.3^{+0.7}_{-0.5} \text{ MeV}$ [19]
$m_{D_2^*(2460)}$	$(2462.6 \pm 0.6) \text{ MeV}$ [19]
m_D	$(1869.62 \pm 0.15) \text{ MeV}$ [19]
m_π	$(139.57018 \pm 0.00035) \text{ MeV}$ [19]
$f_{D_2^*(2460)}$	0.0228 ± 0.0068 [20]
f_D	$206.7 \pm 8.9 \text{ MeV}$ [19]
f_π	$130.41 \pm 0.03 \pm 0.20 \text{ MeV}$ [19]
$\langle \frac{\alpha_s G^2}{\pi} \rangle$	$(0.012 \pm 0.004) \text{ GeV}^4$

Table : Input parameters used in calculations

Four auxiliary parameters

- ▶ Continuum thresholds s_0 and s'_0
 $7.6 \text{ GeV}^2 \leq s_0 \leq 8.8 \text{ GeV}^2$
and
 $4.7 \text{ GeV}^2 \leq s'_0 \leq 5.6 \text{ GeV}^2$
- ▶ Borel mass parameters M^2 and M'^2
 $8 \text{ GeV}^2 \leq M^2 \leq 16 \text{ GeV}^2$
and
 $4 \text{ GeV}^2 \leq M'^2 \leq 10 \text{ GeV}^2$

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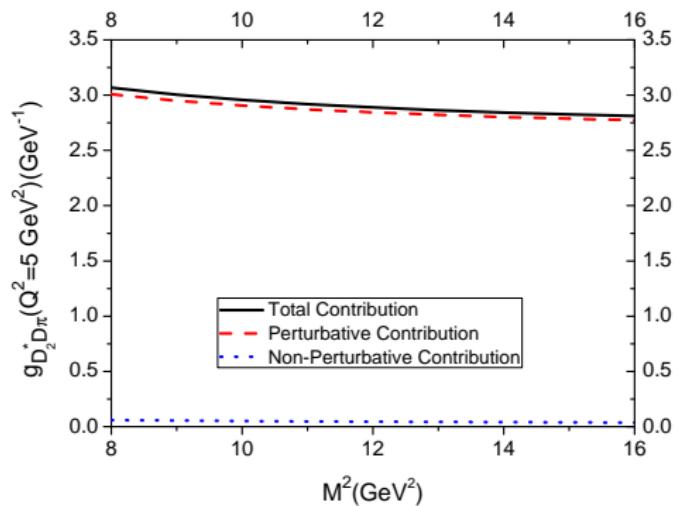


Figure : $g_{D_2^* D\pi}(Q^2 = 5 \text{ GeV}^2)(\text{GeV}^{-1})$ as a function of the Borel mass M^2 at $M'^2 = 5 \text{ GeV}^2$.

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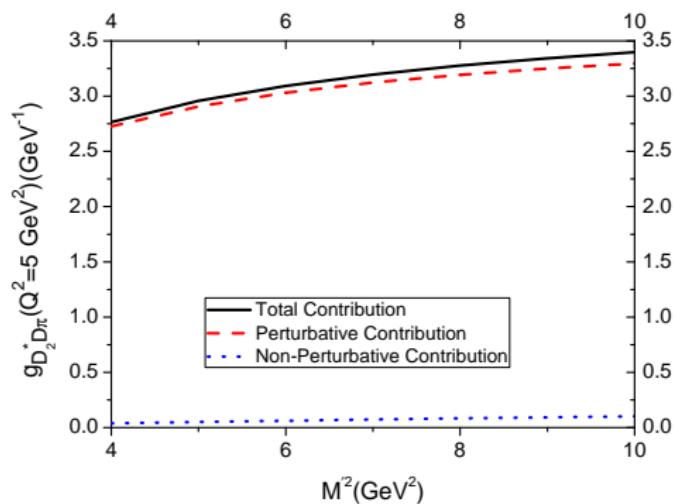


Figure : $g_{D_2^* D\pi}(Q^2 = 5 \text{ GeV}^2)(\text{GeV}^{-1})$ as a function of the Borel mass M^2 at $M^2 = 10 \text{ GeV}^2$.

The value of $Q^2 = -m_\pi^2$ is outside of the reliable region of our sum rules calculations. The fit function:

$$g_{D_2^* D\pi}(Q^2) = c_1 \exp \left[-\frac{Q^2}{c_2} \right] + c_3 \quad (29)$$

where $Q^2 = -q^2$. With the value of $M^2 = 10 \text{ GeV}^2$ and $M'^2 = 5 \text{ GeV}^2$ the obtained fit parameters

	$c_1(\text{GeV}^{-1})$	$c_2(\text{GeV}^2)$	$c_3(\text{GeV}^{-1})$
$g_{D_2^* D\pi}(Q^2)$	5.17 ± 1.50	13.21 ± 3.84	$-(0.54 \pm 0.16)$

Table : Parameters appearing in the fit function of the coupling constants.

The coupling constant at $Q^2 = -m_\pi^2$ is obtained as

$$g_{D_2^* D\pi} = 4.63 \pm 1.39 \text{ GeV}^{-1}. \quad (30)$$

The decay width for $D_2^* D\pi$ transition

$$\Gamma = \frac{|M(\mathbf{p}')|^2}{24\pi m_{D_2^*}} |\mathbf{p}'| \quad (31)$$

where

$$\begin{aligned} |M(\mathbf{p}')|^2 &= g_{D_2^* D\pi}^2 \left[\frac{2}{3m_{D_2^*}^4} \left(m_{D_2^*} \sqrt{\mathbf{p}'^2 + m_D^2} \right)^4 \right. \\ &\quad \left. - \frac{4m_D^2}{3m_{D_2^*}^2} \left(m_{D_2^*} \sqrt{\mathbf{p}'^2 + m_D^2} \right)^2 + \frac{2m_D^4}{3} \right] \end{aligned} \quad (32)$$

and

$$|\mathbf{p}'| = \frac{1}{2m_{D_2^*}} \sqrt{m_{D_2^*}^4 + m_D^4 + m_\pi^4 - 2m_{D_2^*}^2 m_\pi^2 - 2m_D^2 m_\pi^2 - 2m_{D_2^*}^2 m_D^2}. \quad (33)$$

Using the total decay width ($\Gamma_{D_2^*(2460)^0} = (49.0 \pm 1.3) \text{ MeV}$ [19]) the branching ratio of this transition is also attained from the outcomes of the decay width.

	$\Gamma(\text{GeV})$	BR
$D_2^*(2460)^0 \rightarrow D^+ \pi^-$	$(1.05 \pm 0.32) \times 10^{-3}$	$(2.13 \pm 0.67) \times 10^{-2}$

Table : Numerical results of decay widths and branching ratios.

To sum up, in this work we calculate the coupling constant for the transitions $D_2^*D\pi$ whose values is obtained as

$g_{D_2^*D\pi} = (4.63 \pm 1.39) \text{ GeV}^{-1}$ using the QCD sum rules. The results of the coupling constant is also used to determine the decay widths and the branching ratios of the mentioned transition.

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└ Numerical Results and Conclusion

THANK YOU...

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