



# Um resumo sobre a aplicação das RSQCD ao estudo de vértices estranhos mas charmosos

Bruno Osório,  
Mirian Bracco e Marcelo Chiapparini

Retinha XXV

07 de fevereiro de 2014



## Vértices desta apresentação

$$J/\psi D_s D_s$$

$$J/\psi D_s^* D_s$$

$$J/\psi D_s^* D_s^*$$

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$$J/\psi D_s D_s$$

$$J/\psi D_s^* D_s$$

$$J/\psi D_s^* D_s^*$$

## Vértices já calculados anteriormente

$$J/\psi DD$$

$$J/\psi D^* D$$

$$J/\psi D^* D^*$$

$$\rho DD$$

$$\rho D^* D$$

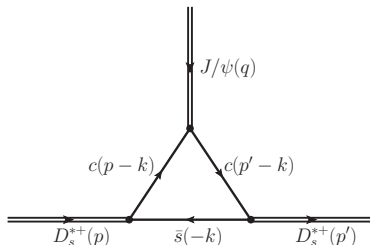
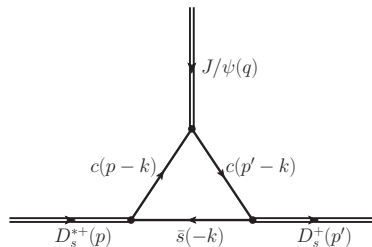
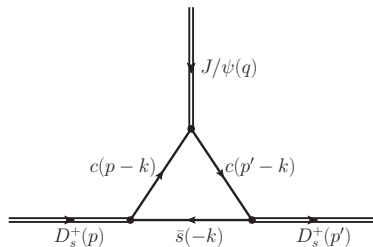
$$\rho D^* D^*$$

$$\pi D^* D$$

$$\pi D^* D^*$$

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# Os vértices estranhos e charmosos deste trabalho



# Histórico de apresentações na Retinha

- Retinha XXII (fevereiro de 2011) - *O vértice  $J/\psi D_s^* D_s^*$  sob a análise das Regras de Soma da QCD.*

$$g_{J/\psi D_s^* D_s^*} = 9.36 \quad (1)$$

- Retinha XXIII (dezembro de 2011) - *Obtendo as constantes de acoplamento  $g_{V D_s D_s}$  usando as RSQCD.*

$$g_{J/\psi D_s D_s} = 6.34 \quad (2)$$

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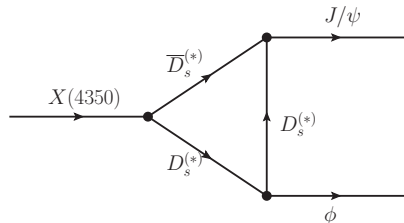
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- Retinha XXIV (dezembro de 2012) - *Adicionando condensados de glúons ao vértice  $J/\psi D_s D_s$ .*

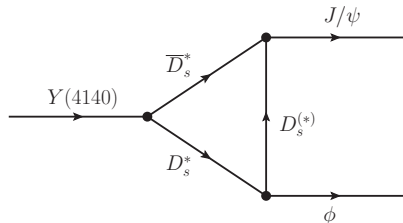
$$g_{J/\psi D_s D_s} = 6.14 \quad (3)$$

# Motivação - Mésons Exóticos

$X(4350) \rightarrow J/\psi\phi$



$Y(4140) \rightarrow J/\psi\phi$



Outros mésons exóticos que podem se beneficiar do estudo destes vértices incluem o  $Y(4274)$  e o  $Y(4660)$ .

## Esquema básico

$$\Pi(p, p') = \int \langle 0' | T \{ j_C(x) j_B^\dagger(y) j_A^\dagger(0) \} | 0' \rangle e^{ip'x} e^{-iqy} d^4x d^4y$$

↙  
Lado da QCD

↘  
Lado Fenomenologico

⇓  
*Transformada de Borel* ( $P^2 \rightarrow M^2$  e  $P'^2 \rightarrow M'^2$ )

⇓  
*Regras de Soma da QCD*

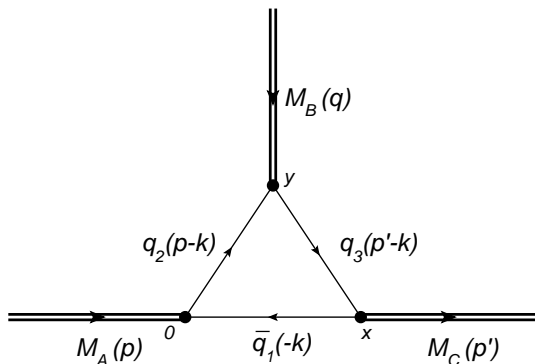
$$\mathcal{B}_{M^2} \mathcal{B}_{M'^2} [\Pi^{QCD}(p, p')] = \mathcal{B}_{M^2} \mathcal{B}_{M'^2} [\Pi^{Ph}(p, p')]$$



## Função correlação utilizada neste trabalho

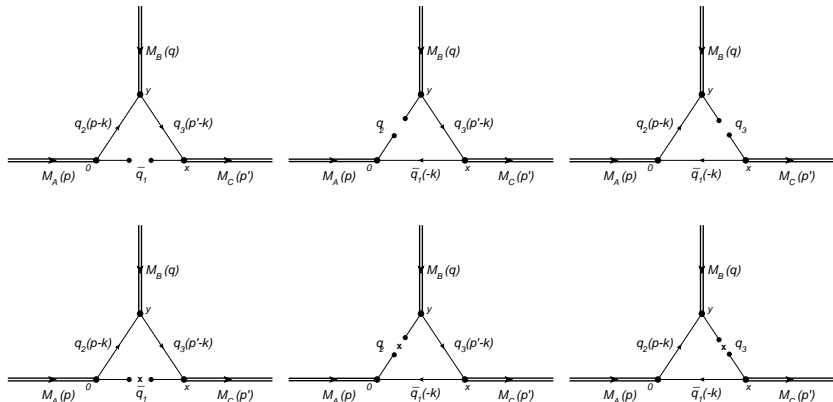
$$\Pi^{(QCD)} = \Pi^{pert} + \Pi^{\langle q\bar{q} \rangle} + \Pi^{\langle g^2 G^2 \rangle} + \Pi^{\langle \bar{q}\sigma g G q \rangle} \quad (4)$$

$\Pi^{pert} =$



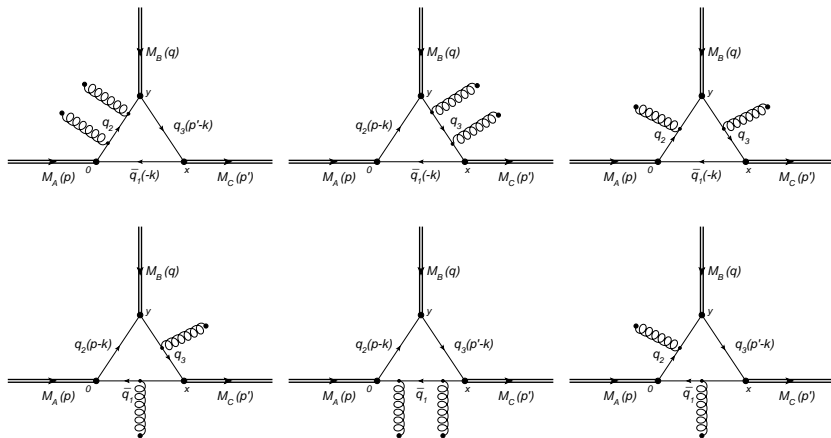
# Diagramas calculados - Condensados de Quarks

$$\Pi \langle q\bar{q} \rangle =$$



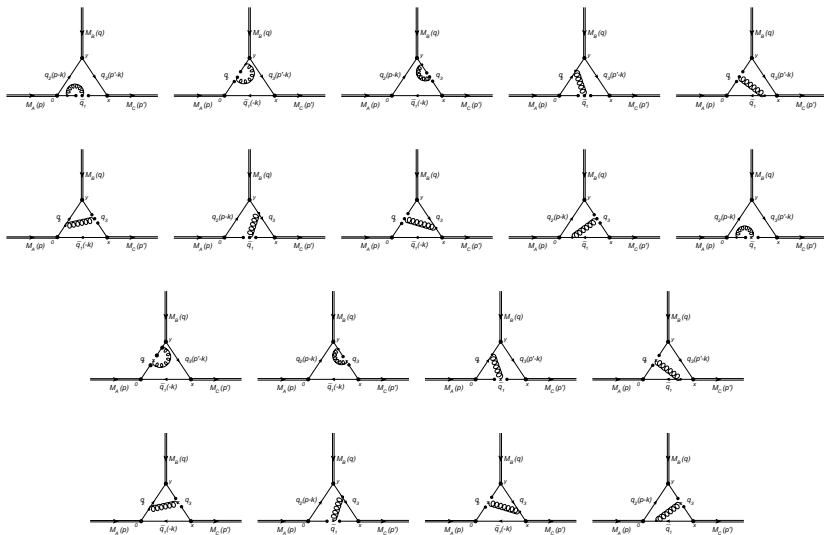
# Diagramas calculados - Condensados de Glúons

$$\Pi \langle g^2 G^2 \rangle =$$



# Diagramas calculados - Condensados Mistos

$$\Pi \langle \bar{q} \sigma g G q \rangle =$$



## Constantes de Decaimento:

$$f_{J/\psi} = 416 \pm 6 \text{ MeV}$$

$$f_{D_s^*} = 301 \pm 13 \text{ MeV}$$

$$f_{D_s} = 257.5 \pm 6.1 \text{ MeV}$$

## Condensados:

$$\langle s\bar{s} \rangle = -0.29^3 \text{ GeV}^3$$

$$\langle g^2 G^2 \rangle = 0.88 \text{ GeV}^4$$

$$\langle sg\sigma G\bar{s} \rangle = 0.8 \langle s\bar{s} \rangle \text{ GeV}^5$$

## Massas:

$$m_c = 1.27 \text{ GeV}$$

$$m_s = 0.101 \text{ GeV}$$

$$m_{J/\psi} = 3.097 \text{ GeV}$$

$$m_{D_s^*} = 2.112 \text{ GeV}$$

$$m_{D_s} = 1.968 \text{ GeV}$$

$$m_{J/\psi}(2s) = 3686 \text{ MeV}$$

$$m_{D_s^*}(2s) = 2688 \text{ MeV}$$

$$m_{D_s}(2s) = 2638 \text{ MeV}$$

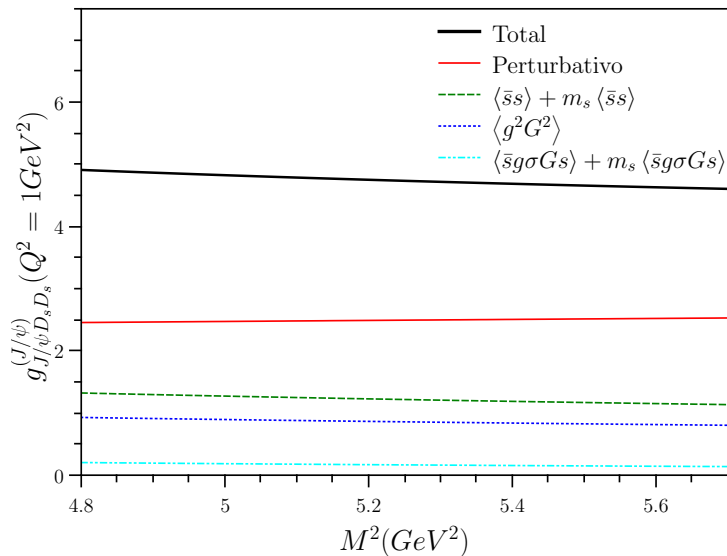
## Parâmetros de corte do contínuo:

$$\Delta_{J/\psi} < 0.6 \text{ GeV}$$

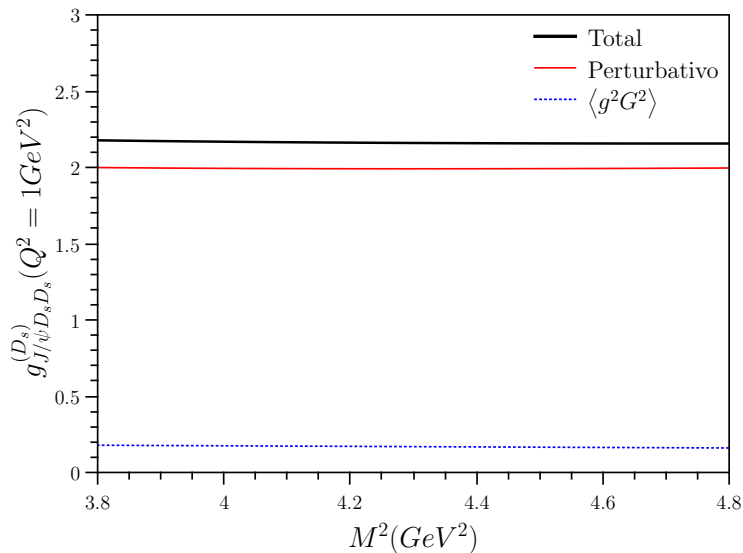
$$\Delta_{D_s^*} < 0.6 \text{ GeV}$$

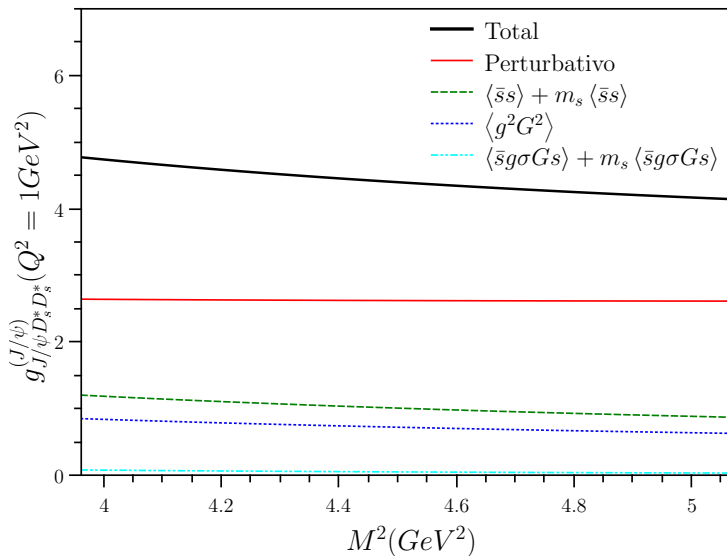
$$\Delta_{D_s} < 0.7 \text{ GeV}$$

# Contribuições da OPE - $J/\psi D_s D_s$

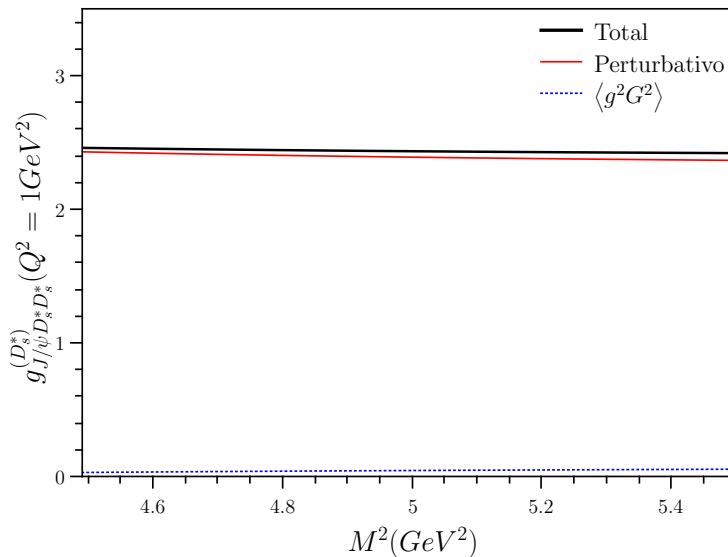


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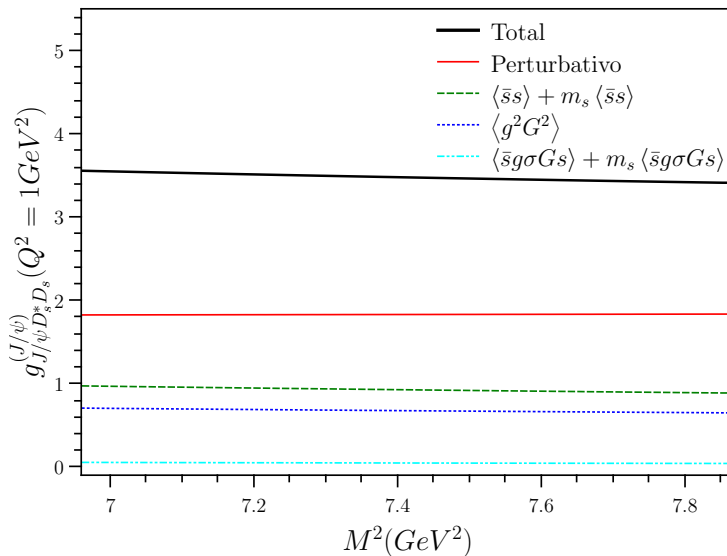




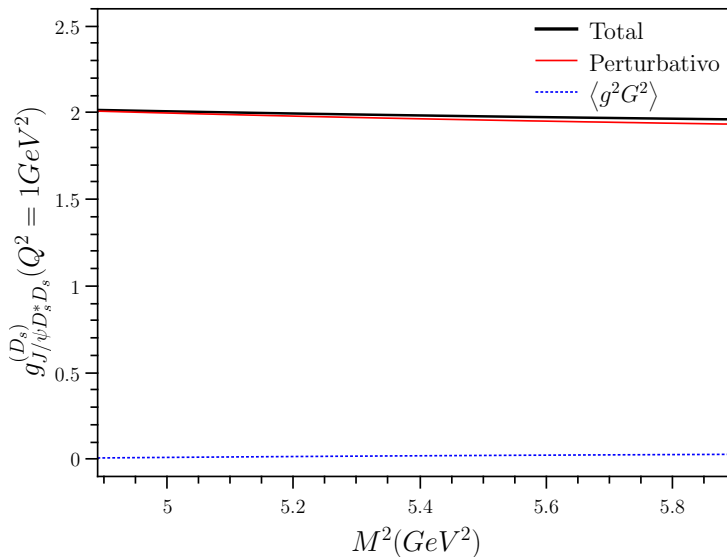




# Contribuições da OPE - $J/\psi D_s^* D_s$

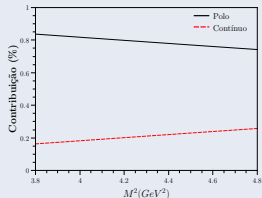
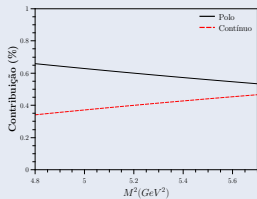


# Contribuições da OPE - $J/\psi D_s^* D_s$

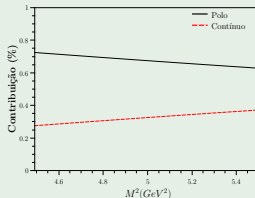
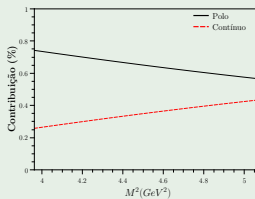


# Contribuição Polo/Contínuo

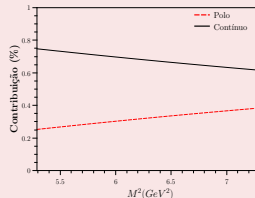
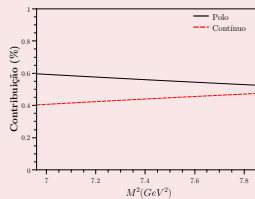
$$J/\psi D_s D_s$$



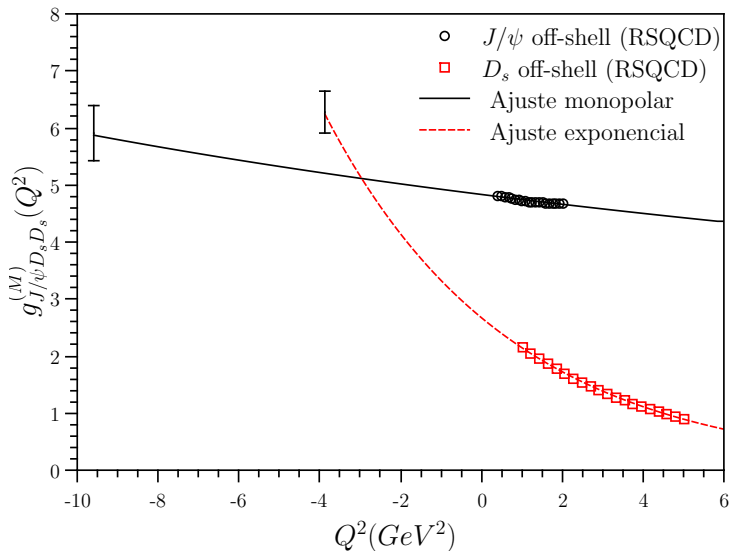
$$J/\psi D_s^* D_s^*$$



$$J/\psi D_s^* D_s$$



# Os fatores de forma do vértice $J/\psi D_s D_s$

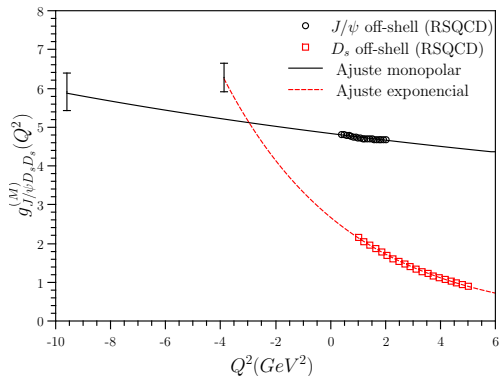


# A constante de acoplamento do vértice $J/\psi D_s D_s$

## Este trabalho

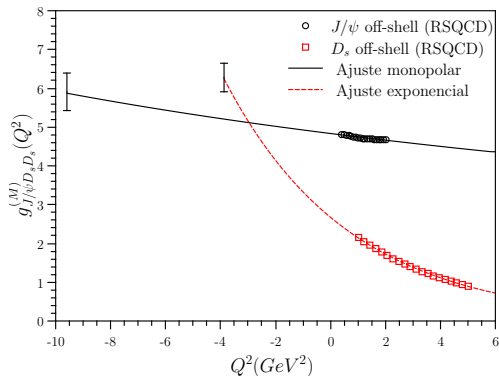
$$g_{J/\psi D_s D_s}^{(J/\psi)} = 5.87^{+0.52}_{-0.44}$$

$$g_{J/\psi D_s D_s}^{(D_s)} = 6.24^{+0.41}_{-0.36}$$



$$g_{J/\psi D_s D_s} = \lim_{Q^2 \rightarrow -m_M^2} g_{J/\psi D_s D_s}^{(M)}(Q^2)$$

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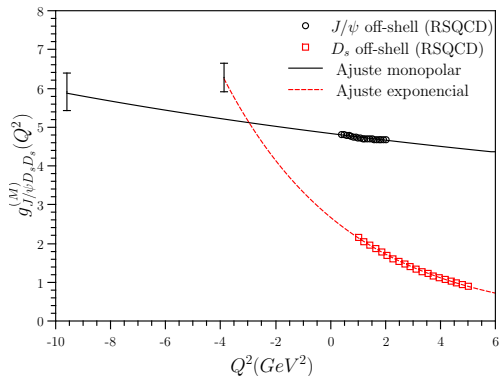
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## Retinha XXIII

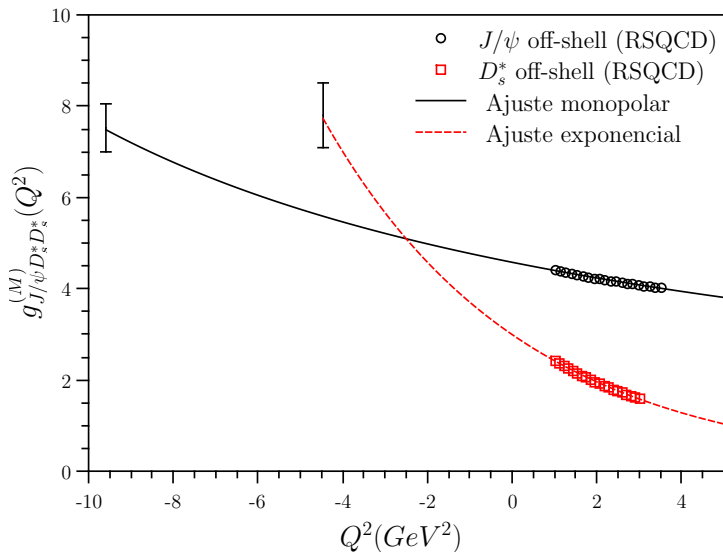
$$g_{J/\psi D_s D_s} = 6.34$$

## Retinha XXIV

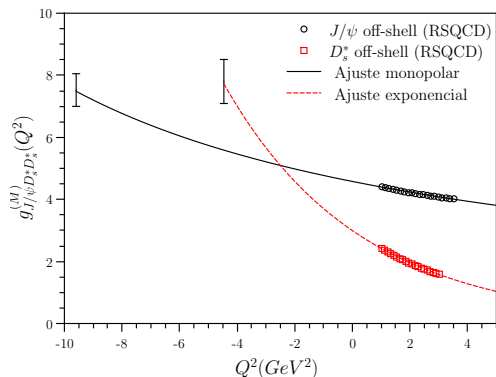
$$g_{J/\psi D_s D_s} = 6.14$$



# Os fatores de forma do vértice $J/\psi D_s^* D_s^*$



# A constante de acoplamento do vértice $J/\psi D_s^* D_s^*$



$$g_{J/\psi D_s^* D_s^*} = \lim_{Q^2 \rightarrow -m_M^2} g_{J/\psi D_s^* D_s^*}^{(M)}(Q^2)$$

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$$g_{J/\psi D_s^* D_s^*}^{(J/\psi)} = 7.48_{-0.49}^{+0.57}$$

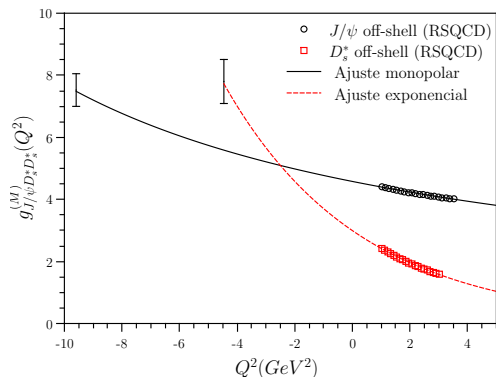
$$g_{J/\psi D_s^* D_s^*}^{(D_s^*)} = 7.16_{-0.40}^{+0.46}$$

$$g_{J/\psi D_s^* D_s^*} = 7.47_{-0.71}^{+1.04}$$

## Retinha XXII

$$g_{J/\psi D_s^* D_s^*} = 9.36$$

# A constante de acoplamento do vértice $J/\psi D_s^* D_s^*$



$$g_{J/\psi D_s^* D_s^*} = \lim_{Q^2 \rightarrow -m_M^2} g_{J/\psi D_s^* D_s^*}^{(M)}(Q^2)$$

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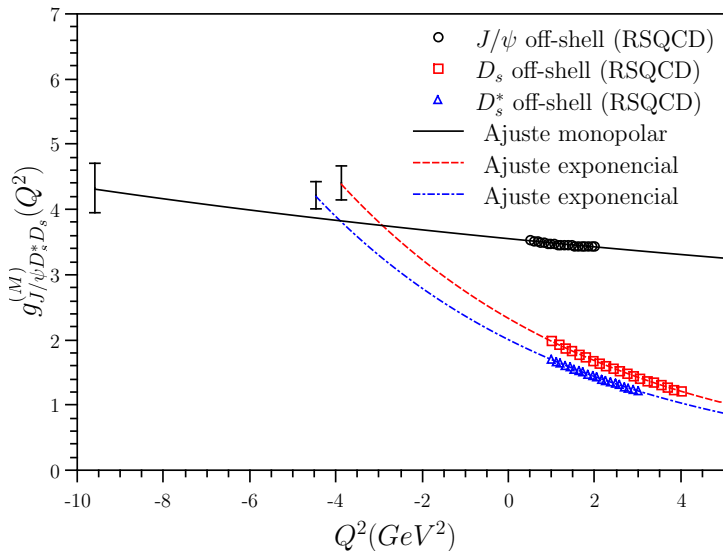
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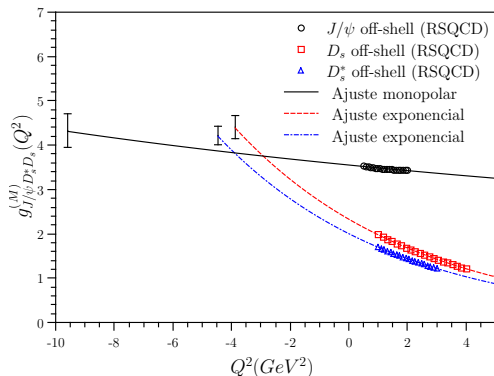
## Retinha XXII com $f_{D_s^*}$ atualizado

$$g_{J/\psi D_s^* D_s^*} = 7.64$$

# Os fatores de forma do vértice $J/\psi D_s^* D_s$



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## Este trabalho

$$g_{J/\psi D_s^* D_s}^{(J/\psi)} = 4.31_{-0.36}^{+0.40} \text{GeV}^{-1}$$

$$g_{J/\psi D_s^* D_s}^{(D_s)} = 4.38_{-0.23}^{+0.29} \text{GeV}^{-1}$$

$$g_{J/\psi D_s^* D_s}^{(D_s^*)} = 4.20_{-0.19}^{+0.23} \text{GeV}^{-1}$$

$$g_{J/\psi D_s^* D_s} = 4.30_{-0.35}^{+0.41} \text{GeV}^{-1}$$

- Constantes de acoplamento com erros entre 10% e 15%.
- Os três vértices tem comportamentos muito semelhantes em vários aspectos.

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- Apesar de mais completa, a OPE até dimensão 5 leva a resultados bastante semelhantes aos da OPE até condensados de quarks.

# Conclusões

- As três constantes de acoplamento não são compatíveis entre si pela SU(4) E HQET, com violações de até 30%.

**Tabela :** Constantes de acoplamento calculadas neste trabalho.

$g_{J/\psi D_s D_s}$	$g_{J/\psi D_s^* D_s}$	$g_{J/\psi D_s^* D_s^*}$
$5.98^{+0.67}_{-0.58}$	$4.30^{+0.41}_{-0.35} GeV^{-1}$	$7.47^{+1.04}_{-0.71}$



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- Utilizando-se a SU(4), os resultados aqui encontrados são compatíveis com os dos vértices já calculados pelo grupo

$g_{J/\psi DD}$	$g_{J/\psi D^* D}$	$g_{J/\psi D^* D^*}$
$5.8 \pm 0.9$	$4.0 \pm 0.6 GeV^{-1}$	$6.2 \pm 0.9$