

The $T_{c\bar{s}}(2900)$ as a threshold effect from the interaction of the D^*K^* , $D_s^*\rho$ channels (and the T_{cs})

R. Molina, T. Branz, L. R. Dai and E. Oset



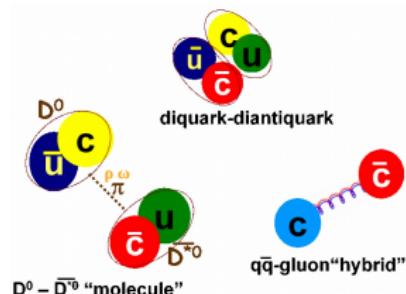
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Intro

Since the X(3872) many exotics discovered ...

- $Z_c(3900)$, BESIII, 2013
close to $D\bar{D}^*$, $c\bar{q}q\bar{c}$ ($q = u, d$)
- $Z_{cs}(3985)$, BESIII, 2021
close to $\bar{D}_s^* D / \bar{D}_s D^*$, $c\bar{q}s\bar{c}$
- $X_0(2866), X_1(2900)$ now $T_{cs}(2900)$,
LHCb, 2020
close to $D^* \bar{K}^*$, $c\bar{q}s\bar{q}$
- $T_{cc}(3875)$, LHCb, 2021
close to DD^* , $c\bar{q}c\bar{q}$
- $T_{c\bar{s}}(2900)$, LHCb, 2022
close to $D^* K^*$, $c\bar{s}q\bar{q}$



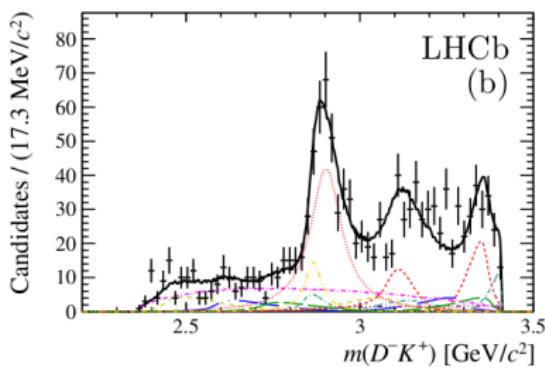
⇒ Do not fit into $q\bar{q}$ basic mesons of the quark model predictions
Are they meson-meson molecules? or compact tetraquarks?
Which is the type of interaction?

Flavor exotic tetraquark $T_{cs}(2900)$

LHCb (2020)

Two states $J^P = 0^+, 1^-$ decaying to $\bar{D}K$. First clear example of an heavy-flavor exotic tetraquark, $\sim \bar{c}\bar{s}ud$.

$X_0(2866) : M = 2866 \pm 7$ and $\Gamma = 57.2 \pm 12.9$ MeV,
 $X_1(2900) : M = 2904 \pm 5$ and $\Gamma = 110.3 \pm 11.5$ MeV.

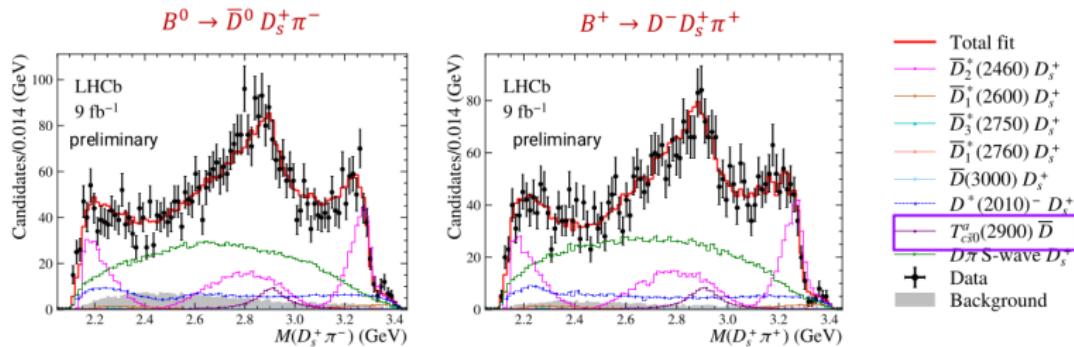


R. Aaij et al. (LHCb Collaboration), PRL125(2020), PRD102(2020)

New exotic tetraquark seen in $D_s^+\pi^+$

LHCb (2022)

One state decaying $T_{c\bar{s}}(2900)$ decaying to $D_s^+\pi^-$ and $D_s^+\pi^+$ has been observed $\sim c\bar{s}ud$.



- The analysis favors $J^P = 0^+$ [arXiv:2212.02717](https://arxiv.org/abs/2212.02717)
- Mass, $m = 2908 \pm 11 \pm 20$ MeV $D^* K^*$ th.: 2903 MeV
- Width, $\Gamma = 136 \pm 23 \pm 11$ MeV $D_s^* \rho$ th.: 2890 MeV

Flavour exotic states

- 2010. Prediction of several flavour exotic states

PHYSICAL REVIEW D 82, 014010 (2010)

New interpretation for the $D_{s2}^*(2573)$ and the prediction of novel exotic charmed mesons

R. Molina,¹ T. Branz,² and E. Oset¹

¹Departamento de Física Teórica and IFIC, Centro Mixto Universidad de Valencia-CSIC, Institutos de Investigación de Paterna, Apartado 22085, 46071 Valencia, Spain

²Institut für Theoretische Physik, Universität Tübingen, Kepler Center for Astro and Particle Physics, Auf der Morgenstelle 14, D-72076 Tübingen, Germany

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In this manuscript we study the vector-vector interaction within the hidden-gauge formalism in a coupled channel unitary approach. In the sector $C = 1, S = 1, J = 2$ we get a pole in the T matrix around 2572 MeV that we identify with the $D_{s2}^*(2573)$, coupling strongly to the $D^*K^*(D_s^*\phi(\omega))$ channels. In addition we obtain resonances in other exotic sectors which have not been studied before such as $C = 1, S = -1, C = 2, S = 0$ and $C = 2, S = 1$. These “flavor-exotic” states are interpreted as D^*K^* , D^*D^* and D^*D^* molecular states but have not been observed yet. In total we obtain nine states with different spin, isospin, charm, and strangeness of non- $C = 0, S = 0$ and $C = 1, S = 0$ character, which have been reported before.

DOI: 10.1103/PhysRevD.82.014010

PACS numbers: 14.40.Rt, 12.40.Vv, 13.75.Lb, 14.40.Lb

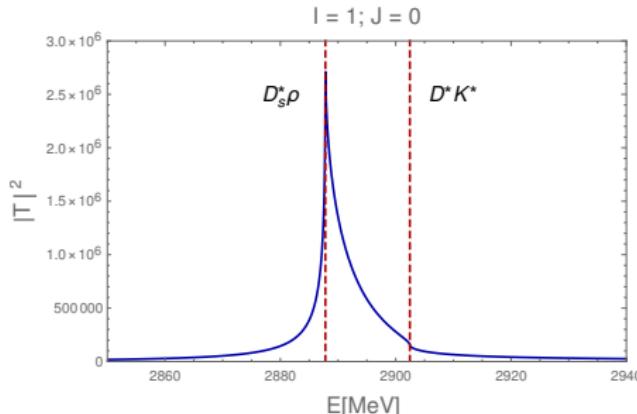
- Free parameter fixed with $D_{s2}(2573)$; couples to D^*K^* , $c\bar{q}q\bar{s}$
- Flavour exotic states with $I = 0, J^P = \{0, 1, 2\}^+$ coupling to $D^*\bar{K}^*$ are predicted, $c\bar{q}s\bar{q}$
- Doubly charm states, $I = 0; J^P = 1^+$, close to D^*D^* are predicted, $c\bar{q}c\bar{q}$, and $I = 1/2; J^P = 1^+$, close to $D^*D_s^*$ $c\bar{q}c\bar{s}$

The $T_{c\bar{s}}(2900)$

Phys. Rev. D 82 (2010), Molina, Branz, Oset

3.5 $C = 1; S = 1; I = 1$

In this sector the potential is attractive for the $D^*K^* \rightarrow D_s^*\rho$ reaction. For $J = 0$ and 1 this potential is around $-7g^2$ whereas it is by a factor of two bigger $-13g^2$ for $J = 2$ (see Table 14). In fact, we only obtain a pole for $J = 2$. For $J = 0$ and 1 we only observe a cusp in the $D_s^*\rho$ threshold. In Table 5 we show the pole position and couplings to the different channels. Both channels, D^*K^* and $D_s^*\rho$, are equally important as one can deduce from the corresponding couplings. The broad width of the ρ meson has to be taken into account



$$\alpha = -1.6$$

ρ width not included

$D^*K^* \rightarrow DK$ considered

Cusp around $D_s^*\rho$, D^*K^* th.
separated only by 14 MeV

Flavour exotic states

Molina, Branz, Oset, PRD82(2010)

C, S	Channels	$I[J^P]$	\sqrt{s}	$\Gamma_A(\Lambda = 1400)$	$\Gamma_B(\Lambda = 1200)$	State	\sqrt{s}_{exp}	Γ_{exp}
1, -1	$D^* \bar{K}^*$	$0[0^+]$	2848			$X_0(2866)$ or $T_{cs}(2900)$	2866	57
		$0[1^+]$	2839	23	59			
		$0[2^+]$	2733	3	3			
1, 1	$D^* K^*, D_s^* \omega$	$0[0^+]$	2683	20	71	$D_{s2}(2573)$	2572	20
		$0[1^+]$	2707	4×10^{-3}	4×10^{-3}			
	$D_s^* \phi$	$0[2^+]$	2572	7	23			
1, 1	$D^* K^*, D_s^* \rho$	$1[0^+]$	Cusp structure around $D_s^* \rho, D^* K^*$			new $T_{c\bar{s}}(2900)$	2908	136
1, 1		$1[1^+]$	Cusp structure around $D_s^* \rho, D^* K^*$					
1, 1		$1[2^+]$	2786	8	11			
2, 0	$D^* D^*$	$0[1^+]$	3969	0	0			
2, 1	$D^* D_s^*$	$1/2[1^+]$	4101	0	0			

Table 1: Summary of the nine states obtained. The width is given for the model A, Γ_A , and B, Γ_B . All the quantities here are in MeV. Repulsion in $C = 0, S = 1, I = 1/2$; $C = 1, S = -1, I = 1$; $C = 1, S = 2, I = 1/2$; $C = 2, S = 0, I = 1$ and $C = 2, S = 2, I = 0$ is found.

Form factors in the $D^* D \pi$ vertex; Model A: $F_1(q^2) = \frac{\Lambda_b^2 - m_\pi^2}{\Lambda_b^2 - q^2}$, Titov, Kampfer EPJA7, PRC65 with $\Lambda_b = 1.4, 1.5$ GeV and

$g = M_\rho / 2 f_\pi$. Model B: $F_2(q^2) = e q^2 / \Lambda^2$ Navarra, Nielsen, Bracco PRD65 (2002), $\Lambda = 1, 1.2$ GeV and $g_D = g_{D^* D \pi}^{\text{exp}} = 8.95$ (experimental value). Subtraction constant $\alpha = -1.6$.

Many studies appeared after these discoveries ...

- He, Wang, Zhu, EPJC80, 1026 (2020), Karliner, Rosner, PRD102(2020), $X_0(2866)$, compact tetraquark
- X. H. Liu, Yan et al., EPJC80(2020), $X_0(2866)$, Triangle Singularity
- M. Z. Liu, Xie, Geng, PRD102(2020), $X_0(2866)$, $D^* \bar{K}^*$ molecule (one-boson ex.), $X_1(2900)$ cannot be, Qi, Wang et al. EPJC81(2021), X_1 is a $\bar{D}_1 K$ molecule (ρ , ω ex.)
- Ying-Hui Ge, X.H. Liu and H. W. Kei, 2207.09900, the $T_{c\bar{s}}$ could be a TS from the $\chi_{c1} D^* K^*$ loop. However, the TS peak around the $D_s^* \rho$ threshold from the $D^{**} D_s^* \rho$ loop cannot explain the $T_{c\bar{s}}(2900)$
- Du, Baru, Dong, Filin, Nieves, F. K. Guo, T_{cc} , PRD105, (2022), 3-body dynamics, $D^0 D^0 \pi^+$, contact+OPE, DD^* molecule
- Albaladejo, T_{cc} from DD^* , can have $I = 0$ or 1
- Feijoo, Liang, Oset, PRD104(2021), T_{cc} as DD^* , has $I = 0$, decay width to $D^0 D^0 \pi^+ \sim 43$ MeV
- Padmanath, Prelovsek, virtual s-wave bound state for $m_\pi = 280$ MeV of DD^* in LatticeQCD ...

The Local Hidden Gauge Approach

The hidden gauge formalism

Bando, Kugo, Yamawaki, PRL54,1215

Lagrangian

$$\mathcal{L} = \mathcal{L}^{(2)} + \mathcal{L}_{III} \quad (1)$$

$$\mathcal{L}^{(2)} = \frac{1}{4} f^2 \langle D_\mu U D^\mu U^\dagger + \chi U^\dagger + \chi^\dagger U \rangle \quad (2)$$

$$\mathcal{L}_{III} = -\frac{1}{4} \langle V_{\mu\nu} V^{\mu\nu} \rangle + \frac{1}{2} M_V^2 \langle [V_\mu - \frac{i}{g} \Gamma_\mu]^2 \rangle$$

$$D_\mu U = \partial_\mu U - ieQA_\mu U + ieUQA_\mu, \quad U = e^{i\sqrt{2}P/f}$$

Upon expansion of $[V_\mu - \frac{i}{g} \Gamma_\mu]^2$, **$\mathcal{L}'s$**

$$\mathcal{L}_{V\gamma} = -M_V^2 \frac{e}{g} A_\mu \langle V^\mu Q \rangle, \mathcal{L}_{VPP} = -ig \langle V^\mu [P, \partial_\mu P] \rangle, \mathcal{L}_{\gamma PP} = ieA_\mu \langle Q[P, \partial_\mu P] \rangle, \dots$$

$$\frac{F_V}{M_V} = \frac{1}{\sqrt{2}g}, \quad \frac{G_V}{M_V} = \frac{1}{2\sqrt{2}g}, \quad F_V = \sqrt{2}f, \quad G_V = \frac{f}{\sqrt{2}}, \quad g = \frac{M_V}{2f}$$

Local Hidden Gauge Approach

Vector-vector scattering

$$\mathcal{L}_{III} = -\frac{1}{4} \langle V_{\mu\nu} V^{\mu\nu} \rangle$$

$$\mathcal{L}_{III}^{(3V)} = ig \langle (\partial_\mu V_\nu - \partial_\nu V_\mu) V^\mu V^\nu \rangle$$

$$\mathcal{L}_{III}^{(c)} = \frac{g^2}{2} \langle V_\mu V_\nu V^\mu V^\nu - V_\nu V_\mu V^\mu V^\nu \rangle$$

$$V_{\mu\nu} =$$

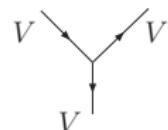
$$\partial_\mu V_\nu - \partial_\nu V_\mu - ig[V_\mu, V_\nu]$$

$$g = \frac{M_V}{2f}$$

$$V_\mu = \begin{pmatrix} \frac{\rho^0}{\sqrt{2}} + \frac{\omega}{\sqrt{2}} & \rho^+ & K^{*+} & \bar{D}^{*0} \\ \rho^- & -\frac{\rho^0}{\sqrt{2}} + \frac{\omega}{\sqrt{2}} & K^{*0} & D^{*-} \\ K^{*-} & \bar{K}^{*0} & \phi & D_s^{*-} \\ D^{*0} & D^{*+} & D_s^{*+} & J/\psi \end{pmatrix}_\mu$$



a)

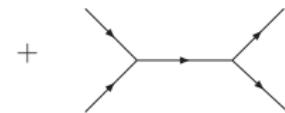


b)

→



c)



d)

Local Hidden Gauge Approach

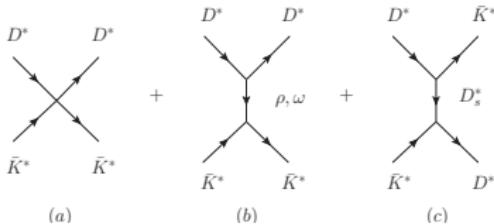


Figure 1: The $D^* \bar{K}^* \rightarrow D^* \bar{K}^*$ interaction at the tree level; (a) contact term; (b) exchange of light vectors; (c) exchange of a heavy vector.

Approximation

$$\epsilon_1^\mu = (0, 1, 0, 0)$$

$$\epsilon_2^\mu = (0, 0, 1, 0)$$

$$\epsilon_3^\mu = (|\vec{k}|, 0, 0, k^0)/m$$

$$k^\mu = (k^0, 0, 0, |\vec{k}|)$$

$$\vec{k}/m \simeq 0, k_j^\mu \epsilon_\mu^{(l)} \simeq 0$$

$$\epsilon_1^\mu = (0, 1, 0, 0)$$

$$\epsilon_2^\mu = (0, 0, 1, 0)$$

$$\epsilon_3^\mu = (0, 0, 0, 1)$$

$$\mathcal{L}_{III}^{(3V)} = ig \langle (\partial_\mu V_\nu - \partial_\nu V_\mu) V^\mu V^\nu \rangle = ig \langle [V_\mu, \partial_\nu V_\mu] V^\nu \rangle$$

Spin projectors

$$\mathcal{P}^{(0)} = \frac{1}{3} \epsilon_\mu \epsilon^\mu \epsilon_\nu \epsilon^\nu; \quad \mathcal{P}^{(1)} = \frac{1}{2} (\epsilon_\mu \epsilon_\nu \epsilon^\mu \epsilon^\nu - \epsilon_\mu \epsilon_\nu \epsilon^\nu \epsilon^\mu)$$

$$\mathcal{P}^{(2)} = \left\{ \frac{1}{2} (\epsilon_\mu \epsilon_\nu \epsilon^\mu \epsilon^\nu + \epsilon_\mu \epsilon_\nu \epsilon^\nu \epsilon^\mu) - \frac{1}{3} \epsilon_\mu \epsilon^\mu \epsilon_\nu \epsilon^\nu \right\} .$$

The $X_0(2866)$ or $T_{cs}(2900)$

Local Hidden Gauge Approach

Potential V : contact + vector-meson exchange (ρ, ω)

J	Amplitude	Contact	V-exchange	\sim Total
0	$D^* \bar{K}^* \rightarrow D^* \bar{K}^*$	$4g^2 - \frac{g^2(p_1+p_4).(p_2+p_3)}{m_{D_s^*}^2} + \frac{1}{2}g^2(\frac{1}{m_\omega^2} - \frac{3}{m_\rho^2})(p_1 + p_3).(p_2 + p_4)$		$-9.9g^2$
1	$D^* \bar{K}^* \rightarrow D^* \bar{K}^*$	$0 + \frac{g^2(p_1+p_4).(p_2+p_3)}{m_{D_s^*}^2} + \frac{1}{2}g^2(\frac{1}{m_\omega^2} - \frac{3}{m_\rho^2})(p_1 + p_3).(p_2 + p_4)$		$-10.2g^2$
2	$D^* \bar{K}^* \rightarrow D^* \bar{K}^*$	$-2g^2 - \frac{g^2(p_1+p_4).(p_2+p_3)}{m_{D_s^*}^2} + \frac{1}{2}g^2(\frac{1}{m_\omega^2} - \frac{3}{m_\rho^2})(p_1 + p_3).(p_2 + p_4)$		$-15.9g^2$

Table 2: Tree level amplitudes for $D^* \bar{K}^*$ in $I = 0$. Last column: ($V_{\text{th.}}$).

J	Amplitude	Contact	V-exchange	\sim Total
0	$D^* \bar{K}^* \rightarrow D^* \bar{K}^*$	$-4g^2 - \frac{g^2(p_1+p_4).(p_2+p_3)}{m_{D_s^*}^2} + \frac{1}{2}g^2(\frac{1}{m_\omega^2} + \frac{1}{m_\rho^2})(p_1 + p_3).(p_2 + p_4)$		$9.7g^2$
1	$D^* \bar{K}^* \rightarrow D^* \bar{K}^*$	$0 - \frac{g^2(p_1+p_4).(p_2+p_3)}{m_{D_s^*}^2} + \frac{1}{2}g^2(\frac{1}{m_\omega^2} + \frac{1}{m_\rho^2})(p_1 + p_3).(p_2 + p_4)$		$9.9g^2$
2	$D^* \bar{K}^* \rightarrow D^* \bar{K}^*$	$2g^2 + \frac{g^2(p_1+p_4).(p_2+p_3)}{m_{D_s^*}^2} + \frac{1}{2}g^2(\frac{1}{m_\omega^2} + \frac{1}{m_\rho^2})(p_1 + p_3).(p_2 + p_4)$		$15.7g^2$

Table 3: Tree level amplitudes for $D^* \bar{K}^*$ in $I = 1$. Last column: ($V_{\text{th.}}$).

The interaction is attractive for $I = 0$ and repulsive for $I = 1$.

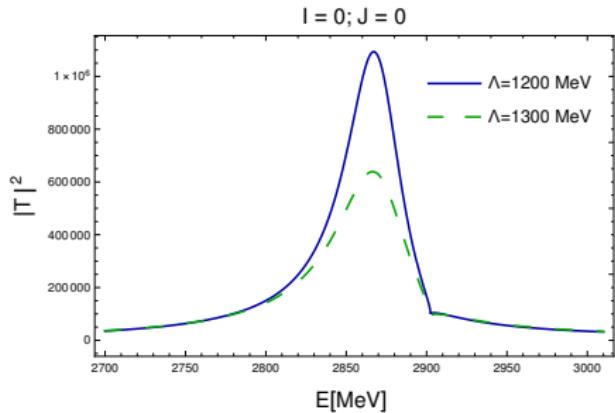
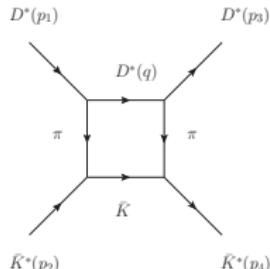
Decay of the $T_{cs}(2900)$ to $D^* \bar{K}$

Molina, Oset PLB811 2020, $\alpha = -1.474$, $\Lambda = 1300$.

$I(J^P)$	$M[\text{MeV}]$	$\Gamma[\text{MeV}]$	Coupled channels	state
$0(2^+)$	2775	38	$D^* \bar{K}^*$?
$0(1^+)$	2861	20	$D^* \bar{K}^*$?
$0(0^+)$	2866	57	$D^* \bar{K}^*$	$T_{cs}(2900)$

Table 4: New results including the width of the $D^* K$ channel.

$$T = [I - VG]^{-1} V$$



How can we observe the $J^P = 1^+$ $T_{cs}(2900)$ state?

Amo Sanchez et al. (BABAR), PRD83(2011).

The $\bar{B}^0 \rightarrow D^{*+} \bar{D}^{*0} K^-$ reaction:

- It proceeds via external emission (favoring the decay)
- It has the largest branching fraction (1.06%)
- It can produce the $D^{*+} K^-$ in $I = 0$ (decay mode of the 1^+ state).

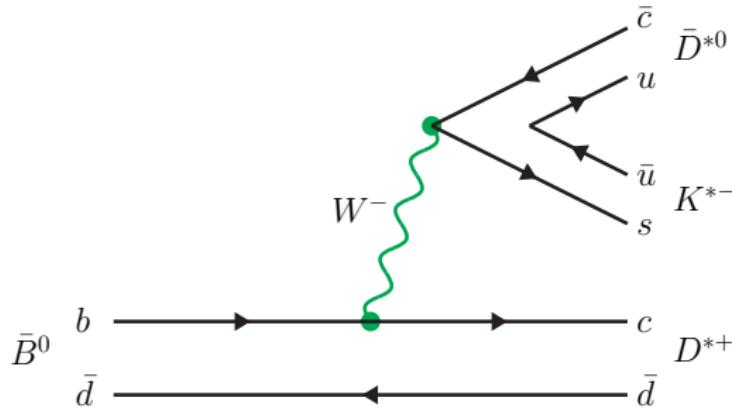


Figure 2: Diagrammatic decay of the $\bar{B}^0 \rightarrow \bar{D}^{*0} D^{*+} K^{*-}$ at the quark level.

How can we observe the $J^P = 1^+$ $T_{cs}(2900)$ state?

Hadronization + decay; $\bar{B}^0 \rightarrow D^{*+} \bar{D}^{*0} K^-$

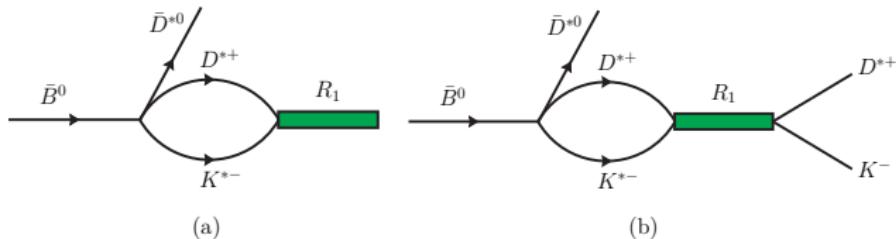


Figure 3: (a) Rescattering of $D^{*+} K^{*-}$ to produce R_1 ; (b) Decay of R_1 to $D^{*+} K^-$. [Dai, Molina and Oset, PLB832 \(2022\)](#)

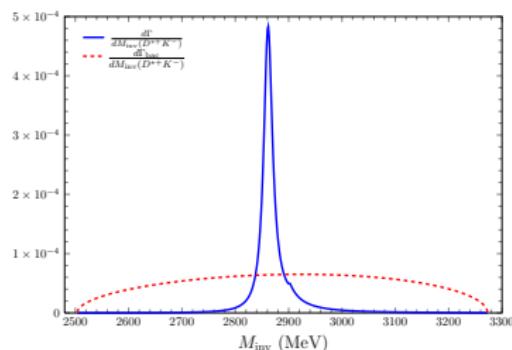
$$\frac{d\Gamma}{dM_{\text{inv}}(D^{*+} K^-)} = \frac{1}{(2\pi)^3} \frac{1}{4M_{\bar{B}^0}^2} \rho_{\bar{D}^{*0}} \tilde{\rho}_{K^-} - \sum |t'|^2$$

See also:

$\bar{B}^0 \rightarrow D^{*+} K^- \bar{K}^{*0}$, PRD105(2022);

2^+ : $B^+ \rightarrow D^+ D^- K^+$,

PLB833(2022), Bayar, Oset.



The $T_{c\bar{s}}(2900)$

The $T_{c\bar{s}}(2900)$ ($C = 1, S = 1, I = 1$)

J	Amplitude	Contact	V-exchange	\sim Total
0	$D^* K^* \rightarrow D^* K^*$	0	$\frac{g^2}{2} \left(\frac{1}{m_\rho^2} - \frac{1}{m_\omega^2} \right) (p_1 + p_3) \cdot (p_2 + p_4)$	0
0	$D^* K^* \rightarrow D_s^* \rho$	$4g^2$	$-\frac{g^2(p_1+p_4)(p_2+p_3)}{m_{D^*}^2} - \frac{g^2(p_1+p_3)(p_2+p_4)}{m_{K^*}^2}$	$-6.8g^2$
0	$D_s^* \rho \rightarrow D_s^* \rho$	0	0	0
1	$D^* K^* \rightarrow D^* K^*$	0	$\frac{g^2}{2} \left(\frac{1}{m_\rho^2} - \frac{1}{m_\omega^2} \right) (p_1 + p_3) \cdot (p_2 + p_4)$	0
1	$D^* K^* \rightarrow D_s^* \rho$	0	$\frac{g^2(p_1+p_4)(p_2+p_3)}{m_{D^*}^2} - \frac{g^2(p_1+p_3)(p_2+p_4)}{m_{K^*}^2}$	$-6.6g^2$
1	$D_s^* \rho \rightarrow D_s^* \rho$	0	0	0
2	$D^* K^* \rightarrow D^* K^*$	0	$\frac{g^2}{2} \left(\frac{1}{m_\rho^2} - \frac{1}{m_\omega^2} \right) (p_1 + p_3) \cdot (p_2 + p_4)$	0
2	$D^* K^* \rightarrow D_s^* \rho$	$-2g^2$	$-\frac{g^2(p_1+p_4)(p_2+p_3)}{m_{D^*}^2} - \frac{g^2(p_1+p_3)(p_2+p_4)}{m_{K^*}^2}$	$-12.8g^2$
2	$D_s^* \rho \rightarrow D_s^* \rho$	0	0	0

Table 5: Tree level amplitudes for $D^* K^*$, $D_s^* \rho$ in $I = 1$. $C = 1; S = 1; I = 1$.

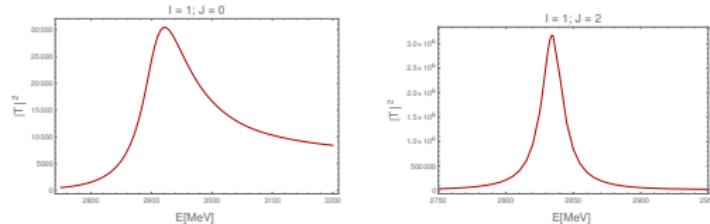
The interaction is attractive for both $I = 0$ and $I = 1$, favoring a $J^P = 2^+$ state. (see PRD82 (2010) Molina, Branz, Oset, for $I = 0$)

The $T_{c\bar{s}}(2900)$ ($C = 1, S = 1, I = 1$)

New results, $\alpha = -1.474$ to obtain the $T_{cs}(2900)$ state in $D^* \bar{K}^*$.

Convolution due to the vector meson mass distribution ρ , K^*

$$\tilde{G}(s) = \frac{1}{N} \int_{(M_1-4\Gamma_1)^2}^{(M_1+4\Gamma_1)^2} d\tilde{m}_1^2 \left(-\frac{1}{\pi}\right) \mathcal{I}m \frac{1}{\tilde{m}_1^2 - M_1^2 + i\Gamma(\tilde{m})\tilde{m}_1} G(s, \tilde{m}_1^2, M_2^2),$$

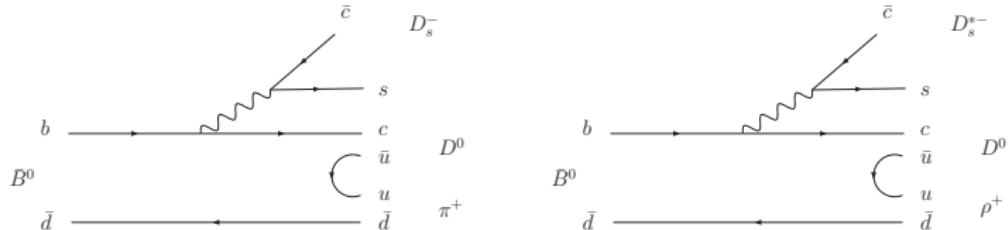


$I(J^P)$	M [MeV]	Γ [MeV]	Coupled channels	state
$1(0^+)$	2920	130	$D^* K^*, D_s \rho$	$T_{c\bar{s}}(2900)$
$1(1^+)$	2922	145		?
$1(2^+)$	2835	20		?

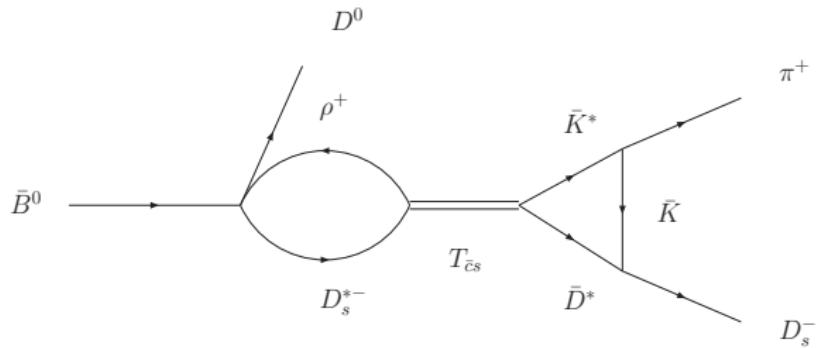
Table 6: PRD107(2023), Exp. $(m, \Gamma) = (2908 \pm 11 \pm 20, 136 \pm 23 \pm 11)$ MeV

Production of the $T_{\bar{c}s}(2900)$

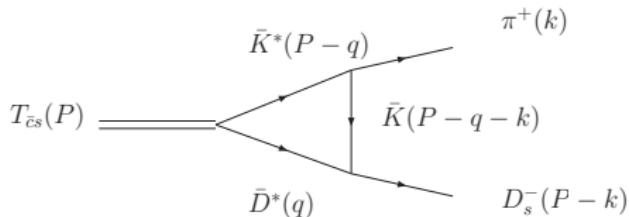
$\bar{B}^0 \rightarrow D_s^- D^0 \pi^+$ in B decays



The $T_{\bar{c}s}(2900)$ can be produced by means of **external emission**



Production of the $T_{\bar{c}s}(2900)$ in B decays



$$\begin{aligned}
 t_L = & -g^2 \int \frac{d^3 q}{(2\pi)^3} (2\vec{k} + \vec{q})^2 F(\vec{k} + \vec{q}) \frac{1}{2\omega_{K^*}(q)} \frac{1}{2\omega_{D^*}(q)} \frac{1}{2\omega_K(\vec{q} + \vec{k})} \\
 & \times \left\{ \frac{1}{P^0 - \omega_{D^*}(q) - \omega_{K^*}(q) + i\epsilon} \frac{1}{P^0 - \omega_{D^*} - k^0 - \omega_K(\vec{q} + \vec{k}) + i\epsilon} \right. \\
 & \left. - \frac{1}{P^0 - \omega_{K^*}(q) - \omega_{D^*}(q) + i\epsilon} \frac{1}{\omega_{K^*}(q) + \omega(\vec{k} + \vec{q}) - k^0 - i\epsilon} \right\}
 \end{aligned}$$

$T(E) = aG(E)_{D_s^*\rho} t_{D_s^*\rho \rightarrow \bar{D}^* \bar{K}^*}(E) t_L(E) + b$

(3)

$E = M_{inv}(\pi^+ D_s^-)$; a, b parameters; t_L amplitude for the triangle loop.

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$$\frac{d\Gamma}{dM_{Inv}} = \frac{1}{(2\pi)^3} \frac{1}{4M_B^2} p_D \tilde{p}_\pi |T|^2$$

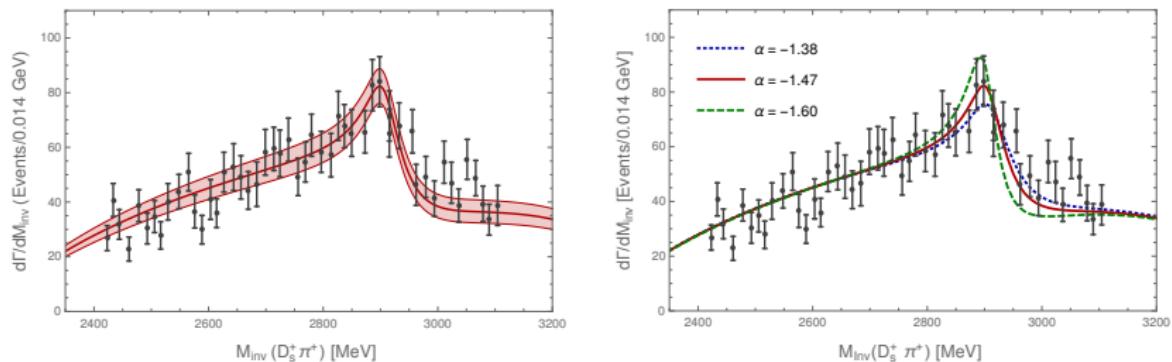


Figure 5: Left: Sensitivity to the background (b), and Right: variation with the subtraction constant (α).

Conclusions

Conclusions

- The $X_0(2866)$ or $T_{cs}(2900)$ is compatible with a $D^* \bar{K}^*$ resonance decaying to $D\bar{K}$. Its spin partners can be also searched for in B decays. **Proposed reactions to observe the 1^+ state:**
 $\bar{B}^0 \rightarrow D^{*+} \bar{D}^{*0} K^-$, PLB832 (2022), Dai, Molina, Oset,
 $\bar{B}^0 \rightarrow D^{*+} K^- \bar{K}^{*0}$, PRD105 (2022); **and the 2^+ state:**
 $B^+ \rightarrow D^+ D^- K^+$, PLB833 (2022), Bayar and Oset.
- The $T_{c\bar{s}}(2900)$ is more likely to be a failed bound state, or **cusp structure around the $D^* K^*$, $D_s^* \rho$ thresholds**. The **width of the ρ** is responsible for most of its width. Similar findings are obtained for $J = 1$, while there should be a **bound state for $J^P = 2^+$** with mass of around 2830 MeV and width 20 MeV. PRD 107 (2023).