Possibility of $T_{c\bar{s}}(2900)$ as the resonance-like structure induced by threshold effects

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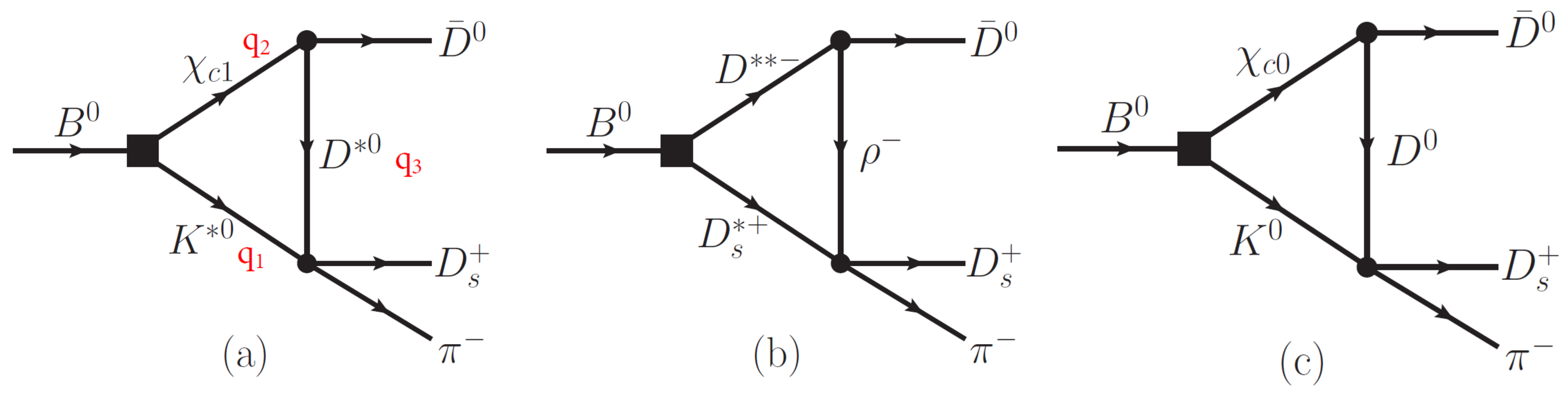
$B^0 \to \bar{D}^0 D_s^+ \pi^-$ via rescattering diagram



$\chi_{c1} D^* K^*$ loop

$$\mathcal{A}^{[\chi_{c1}K^*D^*]}_{B^0\to\bar{D}^0 D_s^+\pi^-} = -i\int \frac{d^4 q_1}{(2\pi)^4}\frac{\mathcal{A}(B^0\to\chi_{c1}K^{*0})}{(q_1^2-M_{K^*}^2+iM_{K^*}\Gamma_{K^*})}\times\frac{\mathcal{A}(\chi_{c1}\to\bar{D}^0 D^{*0})\mathcal{A}(D^{*0}K^{*0}\to D_s^+\pi^-)}{(q_2^2-M_{\chi_{c1}}^2+iM_{\chi_{c1}}\Gamma_{\chi_{c1}})(q_3^2-M_{D^*}^2)},$$

The complete amplitude of $B^0 \to \bar{D}^0 D_s^+ \pi^-$

$$\mathcal{A} = \mathcal{A}_{bk} + e^{i\phi}\mathcal{A}^{loop}, \qquad \mathcal{A}_{bk} = b_0 e^{i\theta_0} T_{S-wave} + b_1 e^{i\theta_1} T_{D^*} + b_2 e^{i\theta_2} T_{D_2},$$

where $e^{i\phi}$ describes the relative phase between the background and rescattering amplitude with the TS signal involved. The coefficients $b_j e^{i\theta_j}$ (j=0, 1, 2) are from experience, which describe the relative contribution of each intermediate process. The T_{S-wave}, T_{D^*} and T_{D_2} represent the $\bar{D}^0\pi^-$ S-wave, $D^*(2010)^-$ and $D_2(2460)$ contributions respectively.

Triangle Singularity (TS) Mechanism

Locations of the TS can be determined by solving the Landau Equations

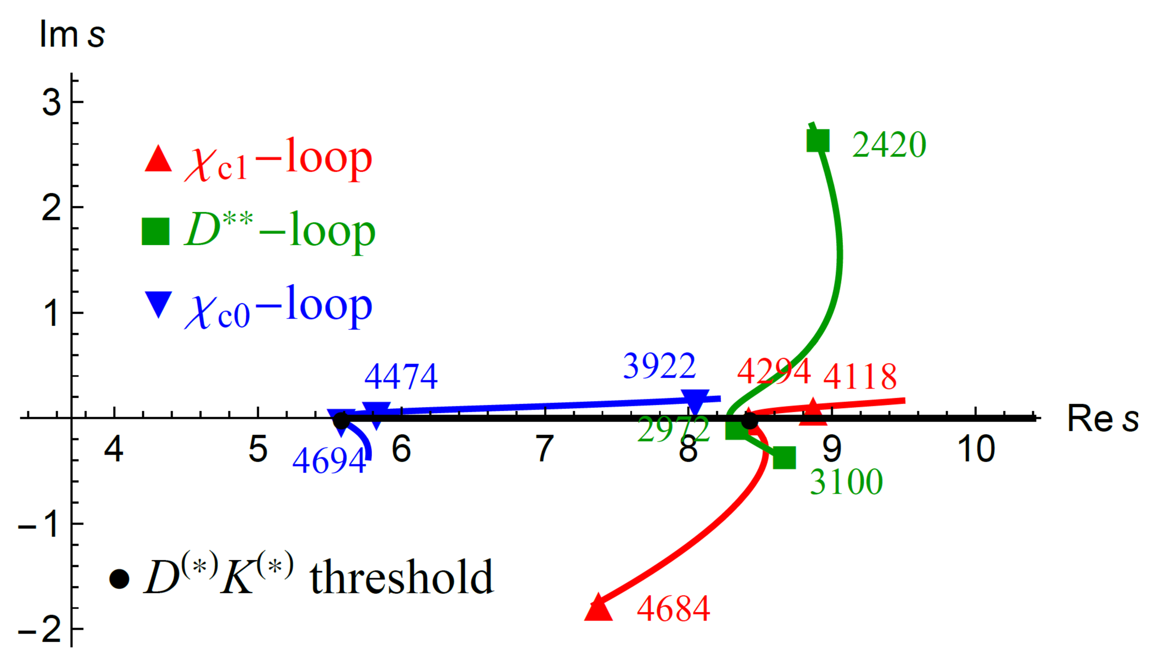
TS Location

$$\begin{aligned} s_{TS} &= (m_1+m_3)^2 + \frac{1}{2m_2^2}[(m_2^2+m_3^2-M_{\bar{D}^0}^2)\times(M_{B^0}^2-m_1^2-m_2^2) - 4m_2^2 m_1 m_3 \\ &- \lambda^{1/2}(M_{B^0}^2, m_1^2, m_2^2)\lambda^{1/2}(m_2^2, m_3^2, M_{\bar{D}^0}^2)], \end{aligned}$$

TS Kinematic Region

$$\frac{m_1 M_{\bar{D}^0}^2 + m_3 M_{B^0}^2}{m_1+m_3} - m_1 m_3 \le m_2^2 \le (M_{B^0}-m_1)^2,$$

$$(m_1+m_3)^2 \le s_{TS} \le (m_1+m_3)^2 + \frac{m_1[(m_2-m_3)^2 - M_{\bar{D}^0}^2]}{m_2}.$$

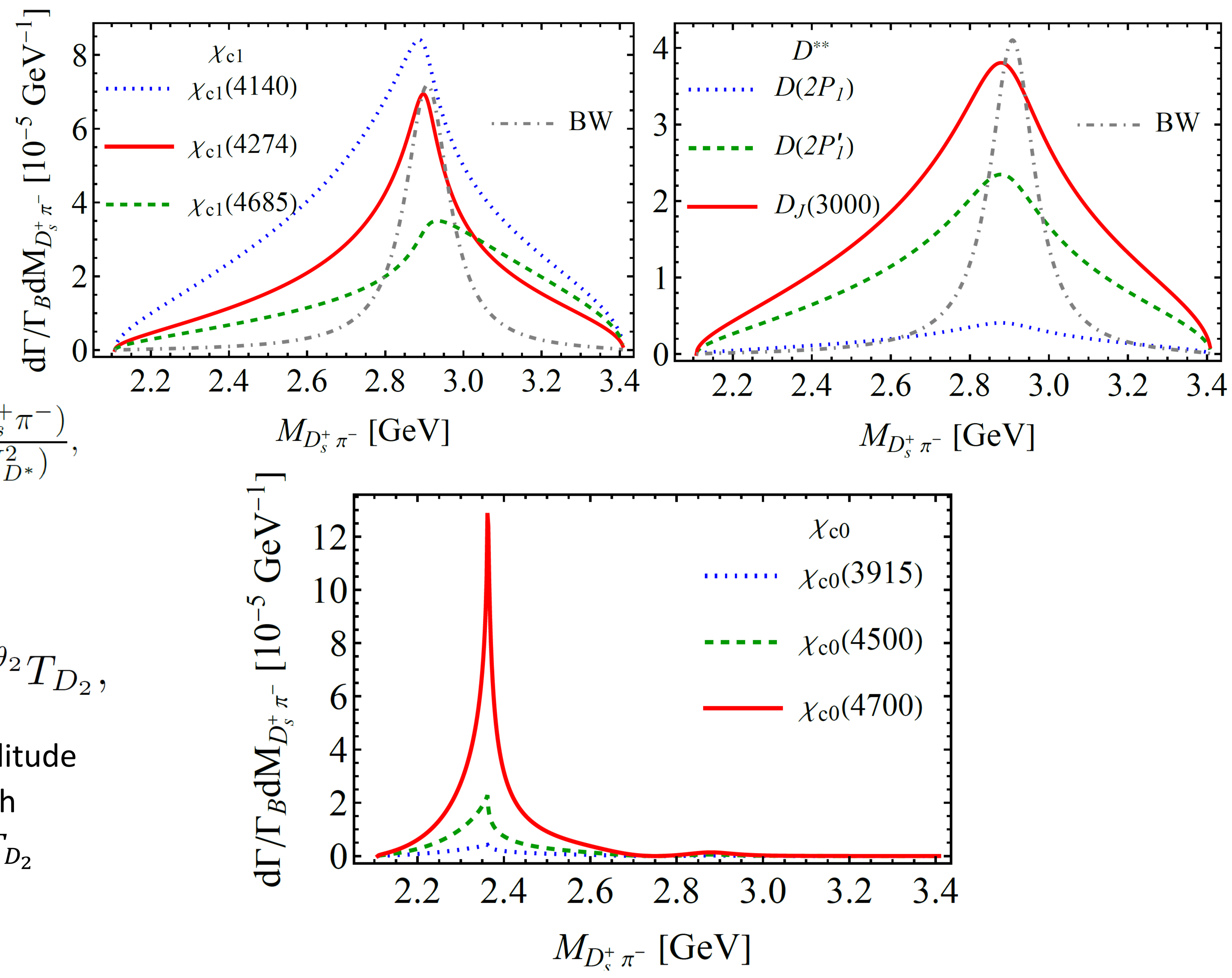


The TS location of the rescattering amplitude on the complex s-plane (in unit of GeV^2)

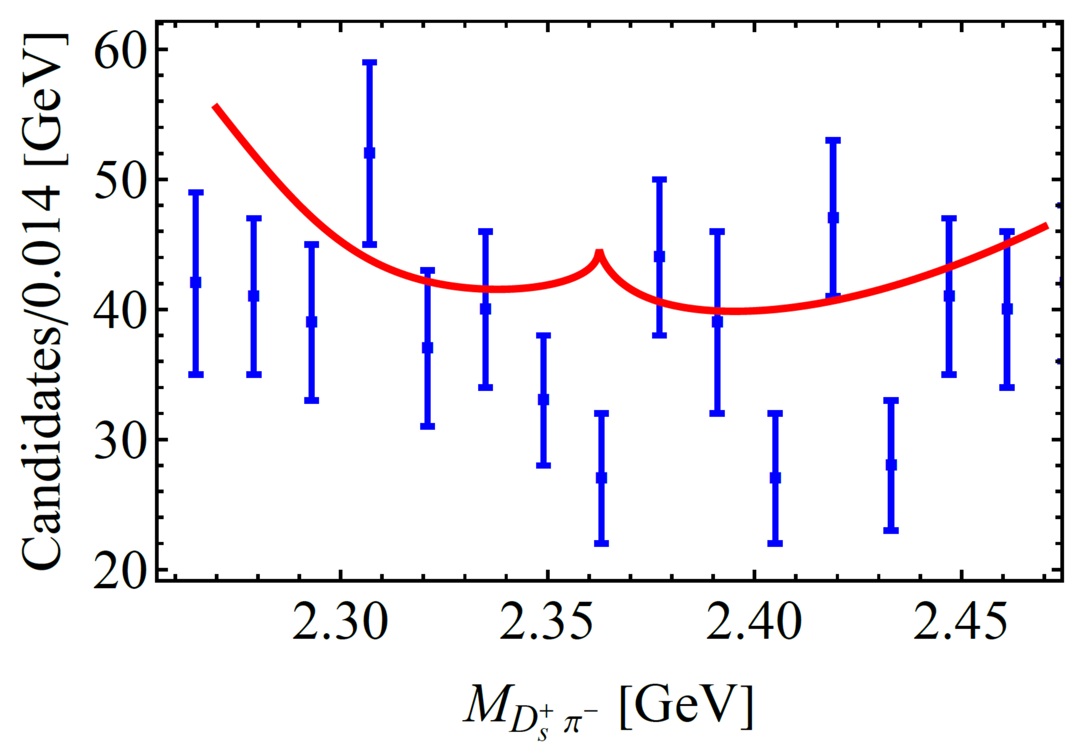
TS kinematic region (all masses are real) corresponding to the rescattering diagrams, in unit of MeV.

Diagram	m_2	$\sqrt{s_{TS}}$
Fig. 1(a)	χ_{c1}: 4307∼4384	2902∼2978
Fig. 1(b)	D^{**}: 2897∼3167	2887∼3136
Fig. 1(c)	χ_{c0}: 4670∼4782	2362∼2471

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



Invariant mass distributions of $D_s^+\pi^-$ via the rescattering diagrams (a),(b) and (c), respectively.



Invariant mass distributions of $D_s^+\pi^-$ via the rescattering diagram (c) with the interference contribution involved.

The TS peaks around the D^*K^* threshold generated from the $\chi_{c1}D^*K^*$ loop can simulate the resonance-like structure in the $D_s^+\pi^-$ distributions. The TS peak around the $D_s^*\rho$ threshold generated from the $D^{**}D_s^*\rho$ loop is smoothed by the broad width of ρ, which can hardly describe the $T_{c\bar{s}}(2900)$ structure. A non-resonance TS signal around the DK threshold generated from the $\chi_{c0}DK$ loop is also predicted.

References

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