Weak Decays of Doubly Heavy Baryons

$$\mathcal{B}_{cc} \to \mathcal{B}_{c} V$$

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OUTLINE

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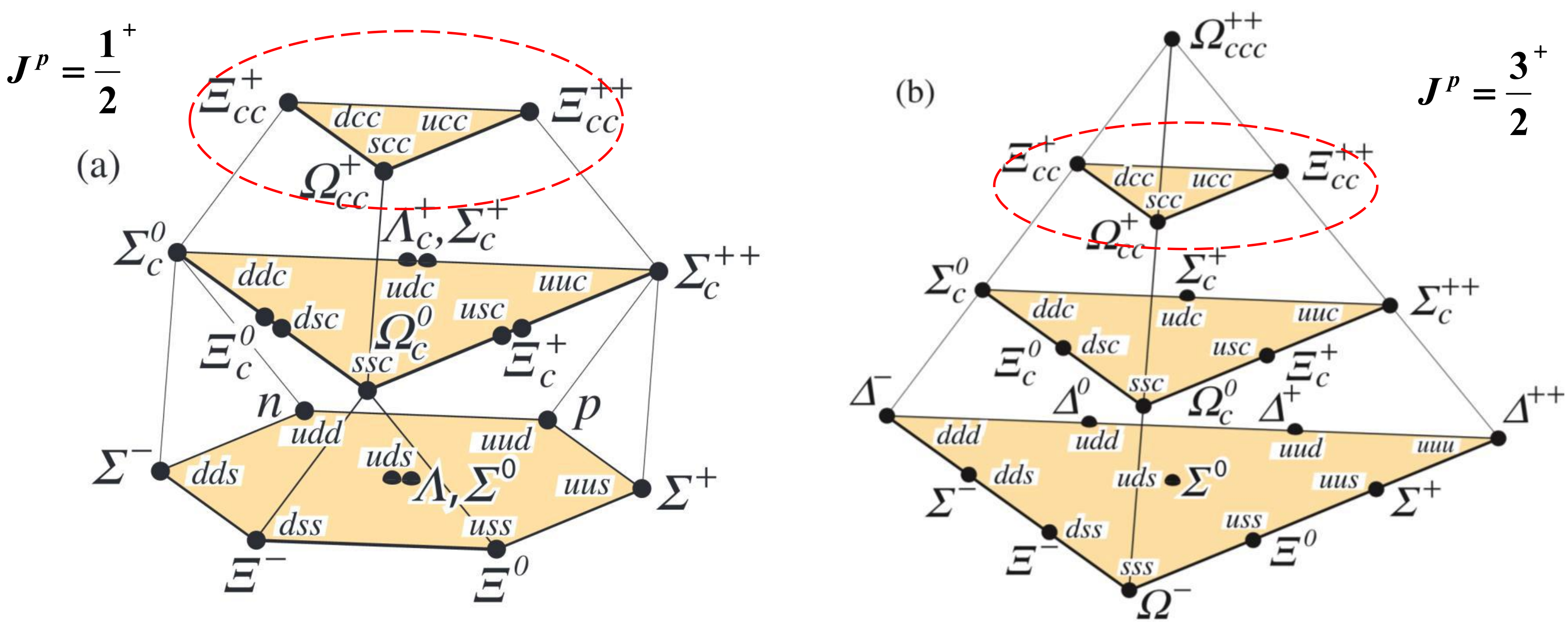
1 Introduction

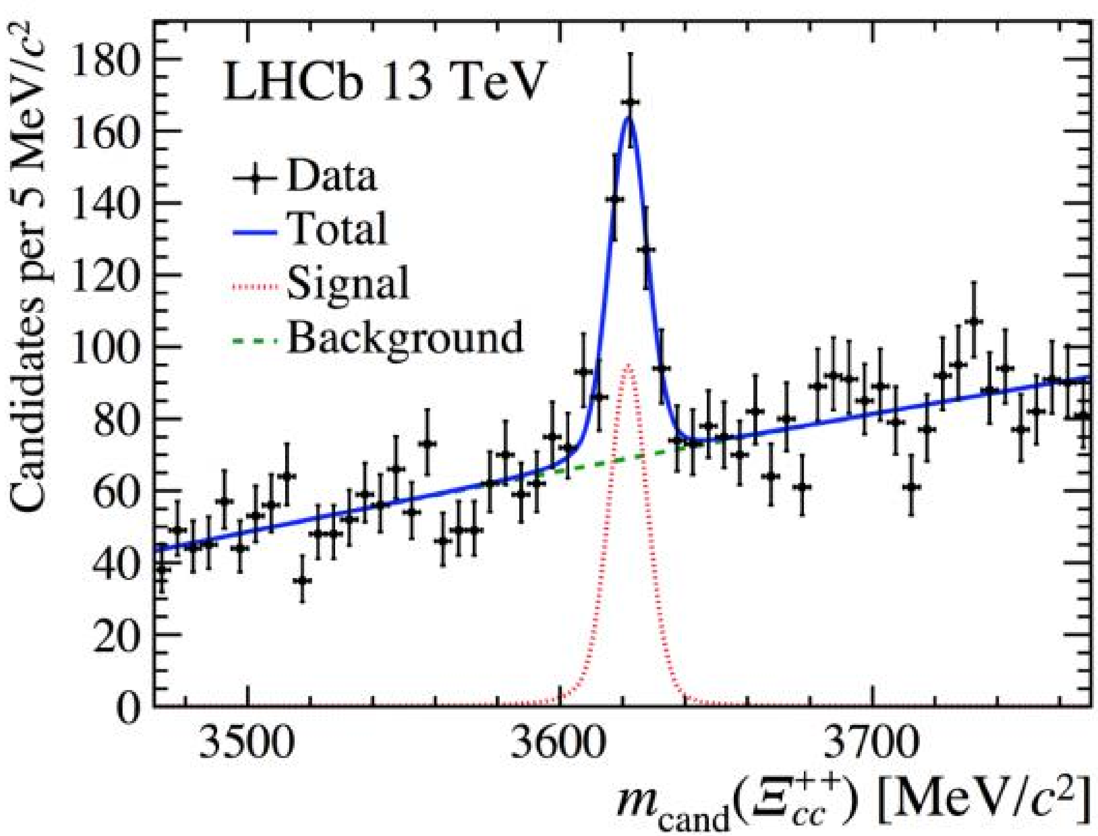
The doubly charm baryons

- Two SU(4) baryon 20-plets with $J^p=\frac{1}{2}^+$ and $J^p=\frac{3}{2}^+$, each contains a SU(3) triplet with two charm quarks: Ξ_{cc}^{++} (ccu) Ξ_{cc}^{+} (ccd) Ω_{cc}^{+} (ccs).
- $J^p=\frac{3}{2}^+$ expected to decay to $J^p=\frac{1}{2}^+$ states via strong/electromagnetic interaction.
- $J^p=\frac{1}{2}^+$ states decay weakly with a quark transformed to lighter quarks.



1 Introduction

- SELEX observed Ξ_{cc}^{+} in $\Xi_{cc}^{+} \to \Lambda_c^+ K^- \pi^+$ and $\Xi_{cc}^{+} \to p D^+ K^-$ decay
- LHCb observed the Ξ_{cc}^{++} state in the $\Lambda_c^+ K^- \pi^+ \pi^+$ decay



PRL119,112011

1 Introduction

- Theoretical work that proposed the discovery channel

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Discovery potentials of doubly charmed baryons *

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Abstract: The existence of doubly heavy flavor baryons has not been well established experimentally so far. In this Letter we systematically investigate the weak decays of the doubly charmed baryons, Ξ_{cc}^{++} and Ξ_{cc}^{+}, which should be helpful for experimental searches for these particles. The long-distance contributions are first studied in the doubly heavy baryon decays, and found to be significantly enhanced. Comparing all the processes, $\Xi_{cc}^{++}\to\Lambda_c^+K^-\pi^+\pi^+$ and $\Xi_c^+\pi^+$ are the most favorable decay modes for experiments to search for doubly heavy baryons.

Fu-Shenng Yu's report

- A phenomenological model is employed
- Under this framework we calculated the $\mathcal{BR}$ and Γ of $\mathcal{B}_{cc}\to\mathcal{B}_c V$

2 Framework and Calculations

➤ Effective Hamiltonian

We focus on weak decays induced by the charge current $c \to s/d$.

The contributing low energy effective Hamiltonian is given by

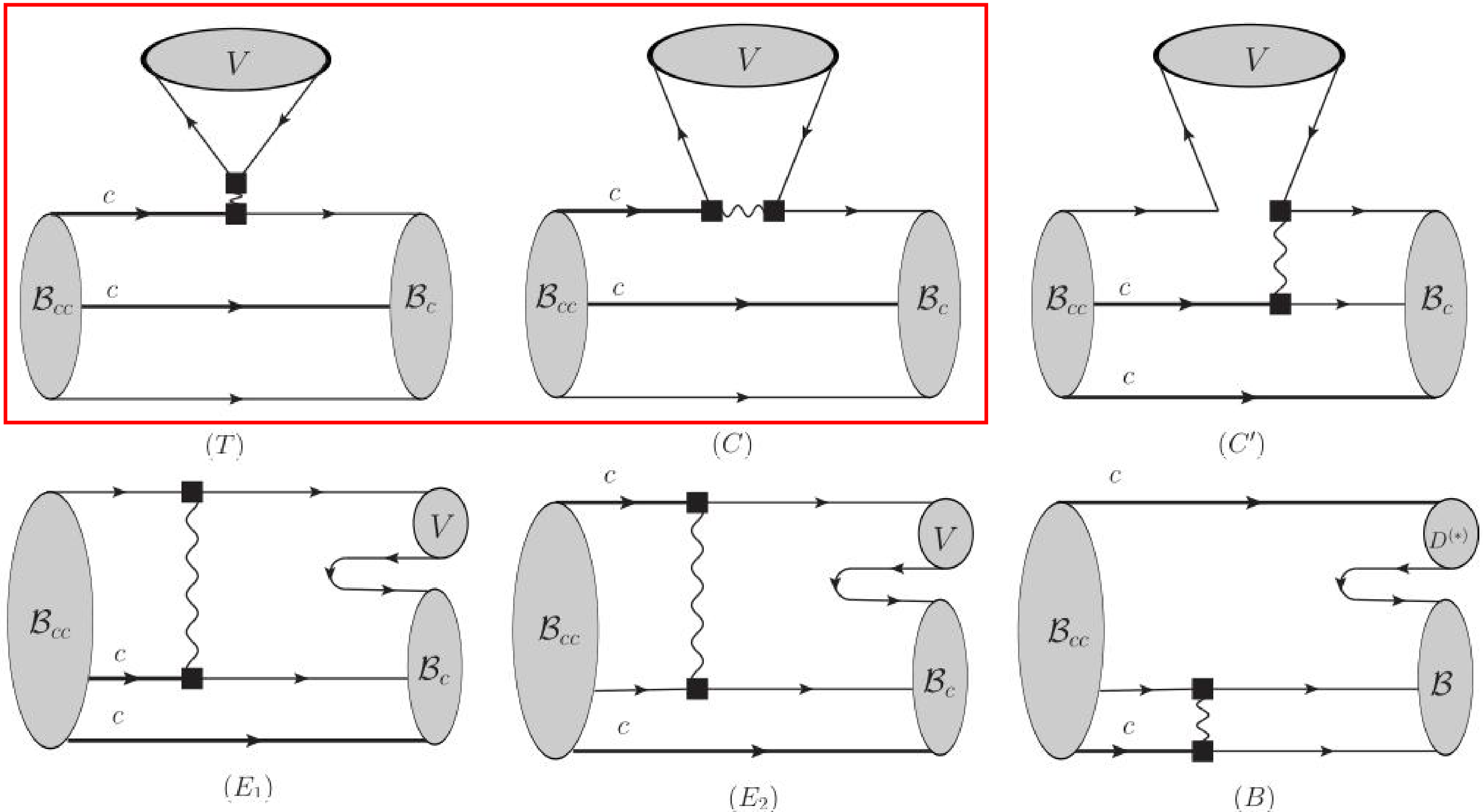
$$H_{eff} = \frac{G_F}{\sqrt{2}} \sum_{q=d,s} V_{cq}^{*} V_{uD} \left[C_1(\mu) O_1^q(\mu) + C_2(\mu) O_2^q(\mu) \right] + h.c.$$

$$O_1^q = (\bar{u}_\alpha D_\beta)_{V-A} (\bar{q}_\beta c_\alpha)_{V-A}, \qquad O_2^q = (\bar{u}_\alpha D_\alpha)_{V-A} (\bar{q}_\beta c_\beta)_{V-A}$$

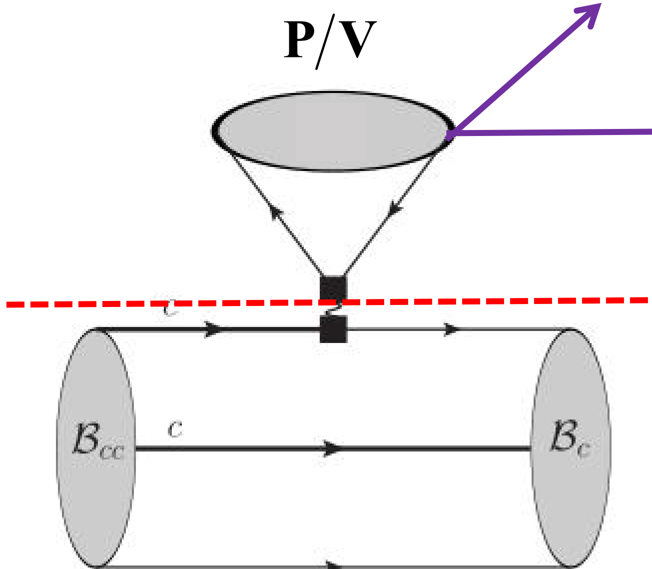
2 Framework and Calculations

➢ Topological Diagrams

Both short distance and long distance contributions are contained.



➢ Short Distance Amplitudes



(T)

pseudoscalar meson $\langle 0|A_\mu|P(q)\rangle = i f_P q_\mu \,,$

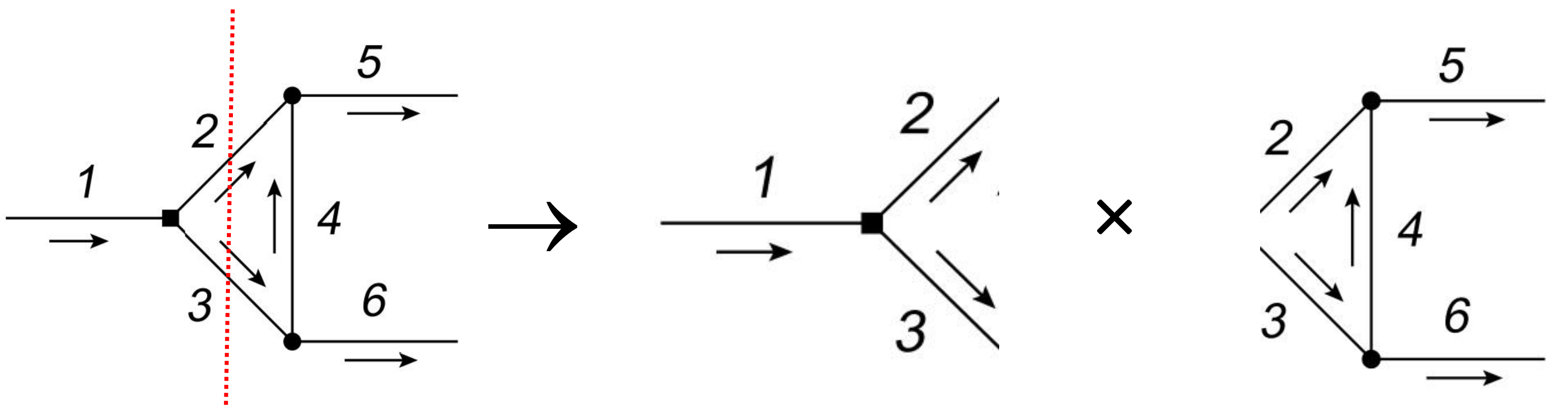
vector meson $\langle 0|V_\mu|V(q)\rangle = f_V m_V \epsilon_\mu \,.$

factorization hypothesis

$$\langle \mathcal{B}_c(p', s'_z)|(V-A)_\mu|\mathcal{B}_{cc}(p, s_z)\rangle = \bar{u}(p', s'_z)\left[\gamma_\mu f_1(q^2) + i\sigma_{\mu\nu}\frac{q^\nu}{M}f_2(q^2) + \frac{q^\mu}{M}f_3(q^2)\right]u(p, s_z)$$
$$-\bar{u}(p', s'_z)\left[\gamma_\mu g_1(q^2) + i\sigma_{\mu\nu}\frac{q^\nu}{M}g_2(q^2) + \frac{q^\mu}{M}g_3(q^2)\right]\gamma_5 u(p, s_z),$$

➢ Long Distance Contributions

The long distance contributions are modeled as final-state interactions (FSIs) and calculated under the one-particle-exchange model



H. Y. Cheng, C. K. Chua and A. Soni, Phys. Rev. D 71, 014030 (2005)

➢ Long Distance Contributions

We adopt Optical theorem to calculate the imaginary part of triangle diagram , treat the intermediate particles 2 and 3 as on-shell.

The absorptive part :

$$\mathcal{A}bs\, M(p_1 \to p_5 p_6) = \frac{1}{2} \int \frac{\mathrm{d}^3 p_2 \mathrm{d}^3 p_3}{(2\pi)^6 4E_2 E_3} (2\pi)^4 \delta^4 (p_5 + p_6 - p_2 - p_3) M(p_1 \to p_2 p_3) T^*(p_5 p_6 \to p_2 p_3).$$

The dispersive part can be calculated via the dispersion relation:

$$\mathcal{D}is\, A(m_1^2) = \frac{1}{\pi} \int_s^\infty \frac{\mathcal{A}bs\, A(s')}{s' - m_1^2} \mathrm{d}s',$$

We assume the absorptive part is dominating and neglect the dispersive part.

H. Y. Cheng, C. K. Chua and A. Soni, Phys. Rev. D 71, 014030 (2005)

➢ Long Distance Contributions

To proceed, the Lagrangian for the strong couplings is necessary:

$$\mathcal{L}_{\pi hh}=g_{\pi\mathcal{B}_6\mathcal{B}_6}Tr[\bar{\mathcal{B}}_6 i\gamma_5\Pi\mathcal{B}_6]+g_{\pi\mathcal{B}_{\bar{3}}\mathcal{B}_{\bar{3}}}Tr[\bar{\mathcal{B}}_{\bar{3}} i\gamma_5\Pi\mathcal{B}_{\bar{3}}]+\{g_{\pi\mathcal{B}_6\mathcal{B}_{\bar{3}}}Tr[\bar{\mathcal{B}}_6 i\gamma_5\Pi\mathcal{B}_{\bar{3}}]+h.c.\},$$

$$\mathcal{L}_{\rho hh}=f_{1\rho\mathcal{B}_6\mathcal{B}_6}Tr[\bar{\mathcal{B}}_6\gamma_\mu V^\mu\mathcal{B}_6]+\frac{f_{2\rho\mathcal{B}_6\mathcal{B}_6}}{2m_6}Tr[\bar{\mathcal{B}}_6\sigma_{\mu\nu}\partial^\mu V^\nu\mathcal{B}_6]$$

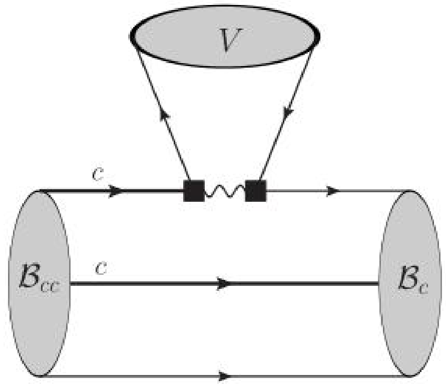
$$+f_{1\rho\mathcal{B}_{\bar{3}}\mathcal{B}_{\bar{3}}}Tr[\bar{\mathcal{B}}_{\bar{3}}\gamma_\mu V^\mu\mathcal{B}_{\bar{3}}]+\frac{f_{2\rho\mathcal{B}_{\bar{3}}\mathcal{B}_{\bar{3}}}}{2m_{\bar{3}}}Tr[\bar{\mathcal{B}}_{\bar{3}}\sigma_{\mu\nu}\partial^\mu V^\nu\mathcal{B}_{\bar{3}}]$$

$$+\{f_{1\rho\mathcal{B}_6\mathcal{B}_{\bar{3}}}Tr[\bar{\mathcal{B}}_6\gamma_\mu V^\mu\mathcal{B}_{\bar{3}}]+\frac{f_{2\rho\mathcal{B}_6\mathcal{B}_{\bar{3}}}}{m_6+m_{\bar{3}}}Tr[\bar{\mathcal{B}}_6\sigma_{\mu\nu}\partial^\mu V^\nu\mathcal{B}_{\bar{3}}]+h.c.\},$$

$$\mathcal{L}_{\rho\pi\pi}=\frac{\mathrm{i}g_{\rho\pi\pi}}{\sqrt{2}}Tr[V^\mu[\Pi,\partial_\mu\Pi]],$$

$$\mathcal{L}_{\rho\rho\rho}=\frac{\mathrm{i}g_{\rho\rho\rho}}{\sqrt{2}}Tr[(\partial_\nu V_\mu-\partial_\mu V_\nu)V^\mu V^\nu]=\frac{ig_{\rho\rho\rho}}{\sqrt{2}}Tr[(\partial_\nu V_\mu V^\mu-V^\mu\partial_\nu V_\mu)V^\nu],$$

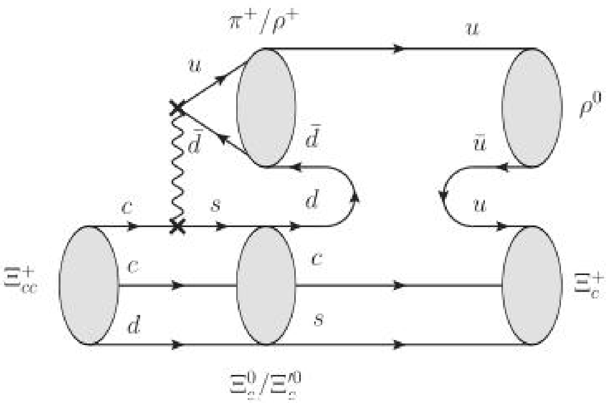
➢ An Example $\Xi_{cc}^{+} \rightarrow \Xi_{c}^{+}\rho^{0}$:Short Distance Contributions



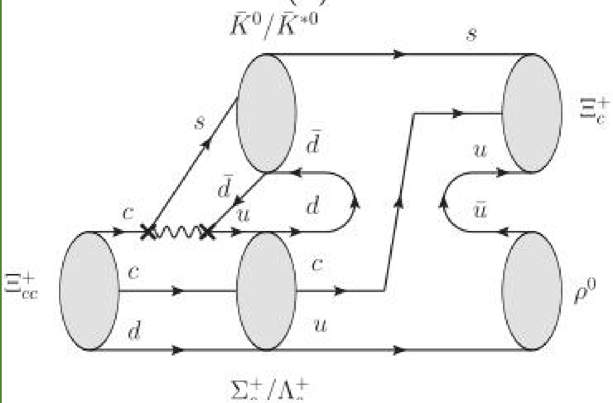
(C)

$$C_{\rm SD}(\Xi_{cc}^{+} \to \Xi_{c}^{+}\rho^{0}) = \frac{G_F}{\sqrt{2}} V_{cs}^{*} V_{ud} a_2 f_\rho \epsilon_\mu^{*} \bar{u}(p_6, s_z') \Bigg[\left(f_1(m_\rho^2) - \frac{m_{\Xi_{cc}^{+}} + m_{\Xi_{c}^{+}}}{m_{\Xi_{cc}^{+}}} f_2(m_\rho^2) \right) \gamma^\mu + \frac{2}{m_{\Xi_{cc}^{+}}} f_2(m_\rho^2) p_6^\mu - \left(g_1(m_\rho^2) + \frac{m_{\Xi_{cc}^{+}} - m_{\Xi_{c}^{+}}}{m_{\Xi_{cc}^{+}}} g_2(m_\rho^2) \right) \gamma^\mu \gamma_5 - \frac{2}{m_{\Xi_{cc}^{+}}} g_2(m_\rho^2) p_6^\mu \gamma_5 \Bigg] u(p_1, s_z) ,$$

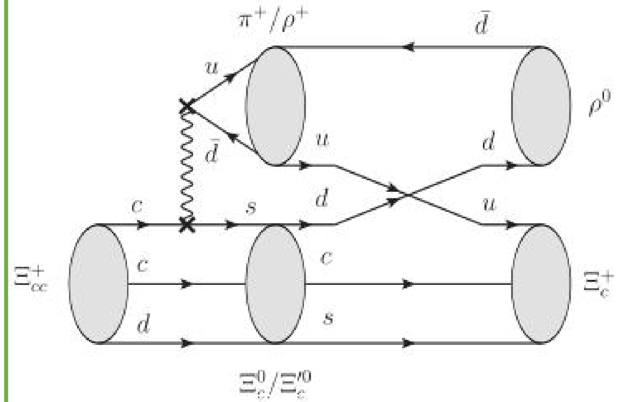
➢ An Example $\Xi_{cc}^{+} \to \Xi_{c}^{+}\rho^{0}$: long Distance Contributions



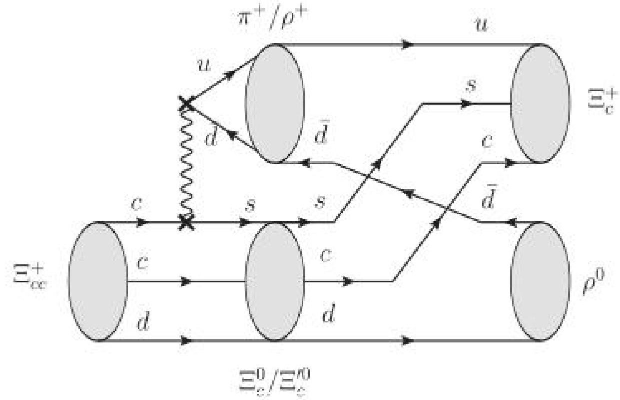
(a)



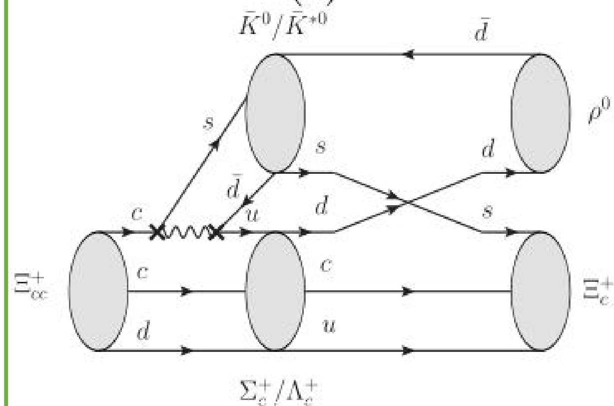
(d)



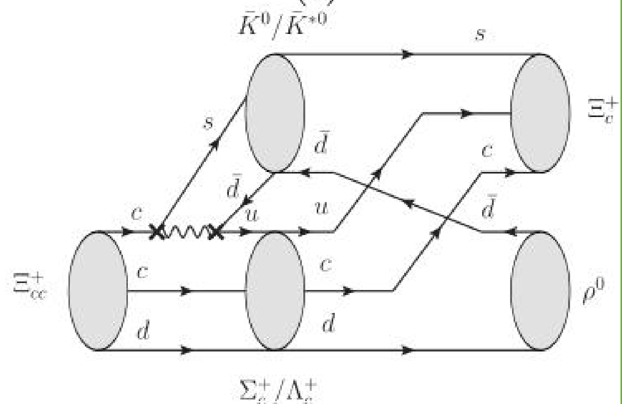
(b)



(c)



(e)



(f)

Which corresponds to two depictions at hadron level

Which corresponds to one depictions at hadron level

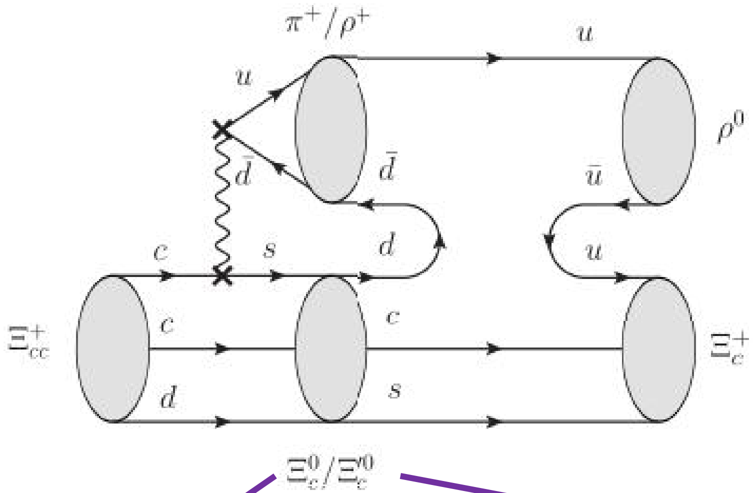
➢ An Example $\Xi_{cc}^{+} \to \Xi_{c}^{+}\rho^{0}$: long Distance Contributions

Ignored

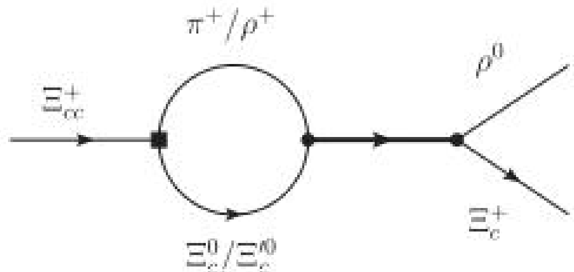
Which with a resonance-like structure is expected to be highly suppressed

Considered

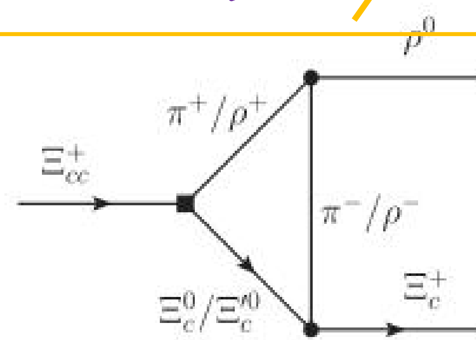
t-channel contribution with a light meson exchange



(a)



(a1)

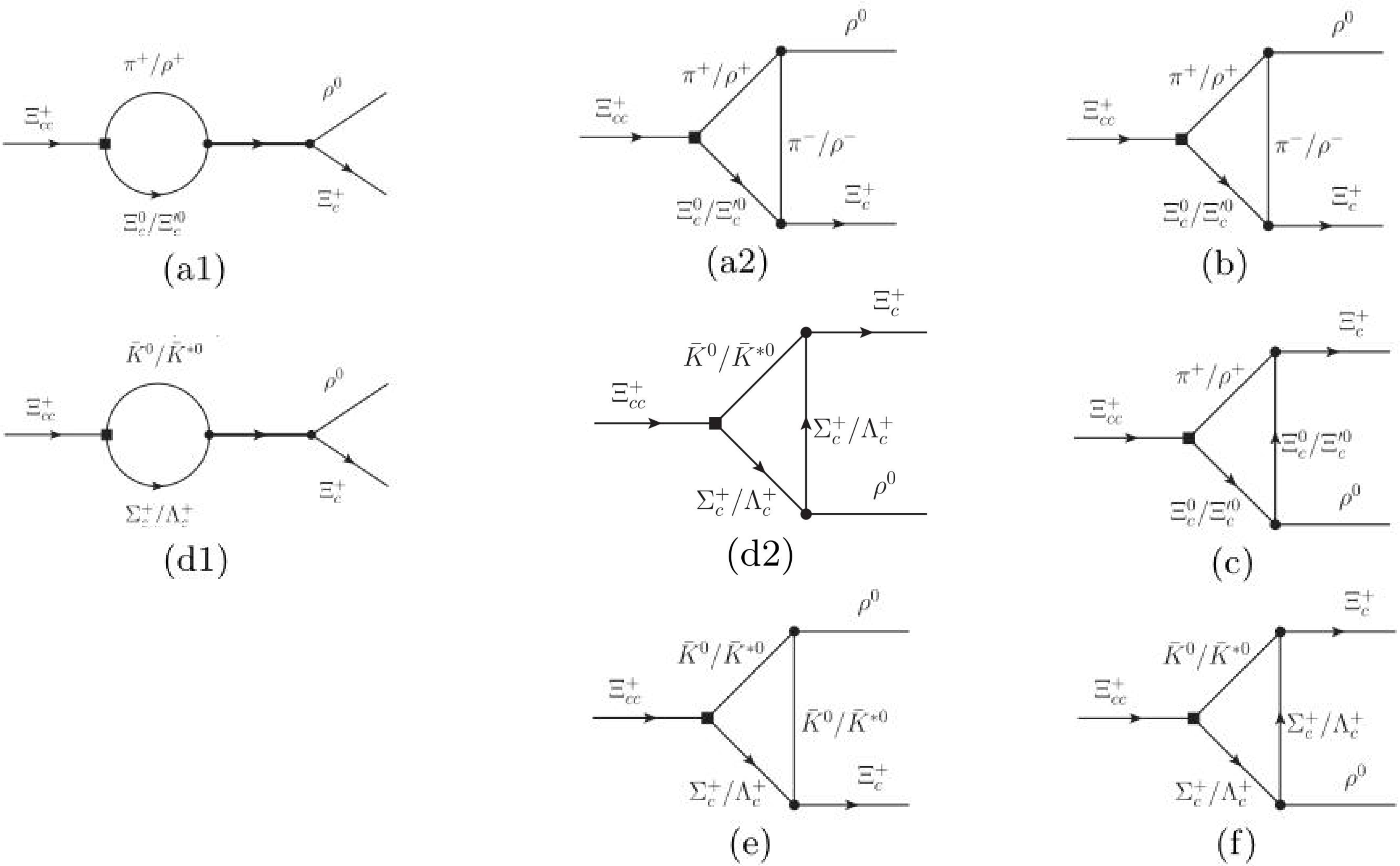


(a2)

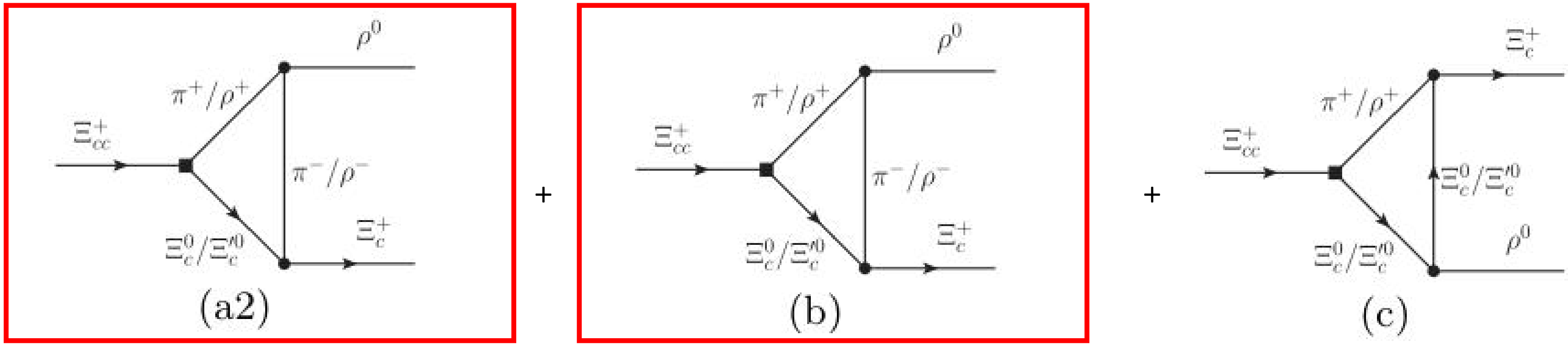
s-channel

t-channel

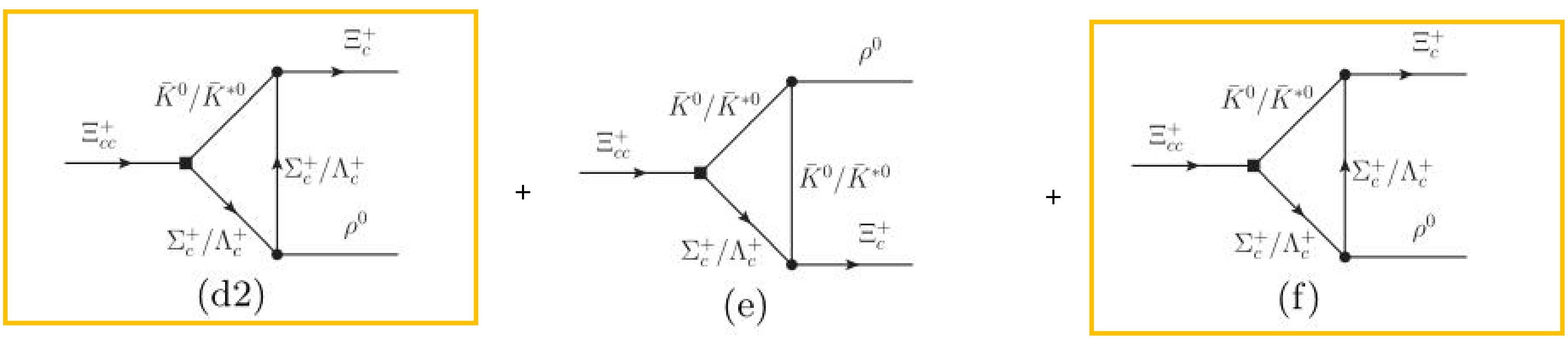
➢ An Example $\Xi_{cc}^{+} \to \Xi_{c}^{+}\rho^{0}$: long Distance Contributions



➢ An Example $\Xi_{cc}^{+} \to \Xi_{c}^{+} \rho^{0}$: long Distance Contributions



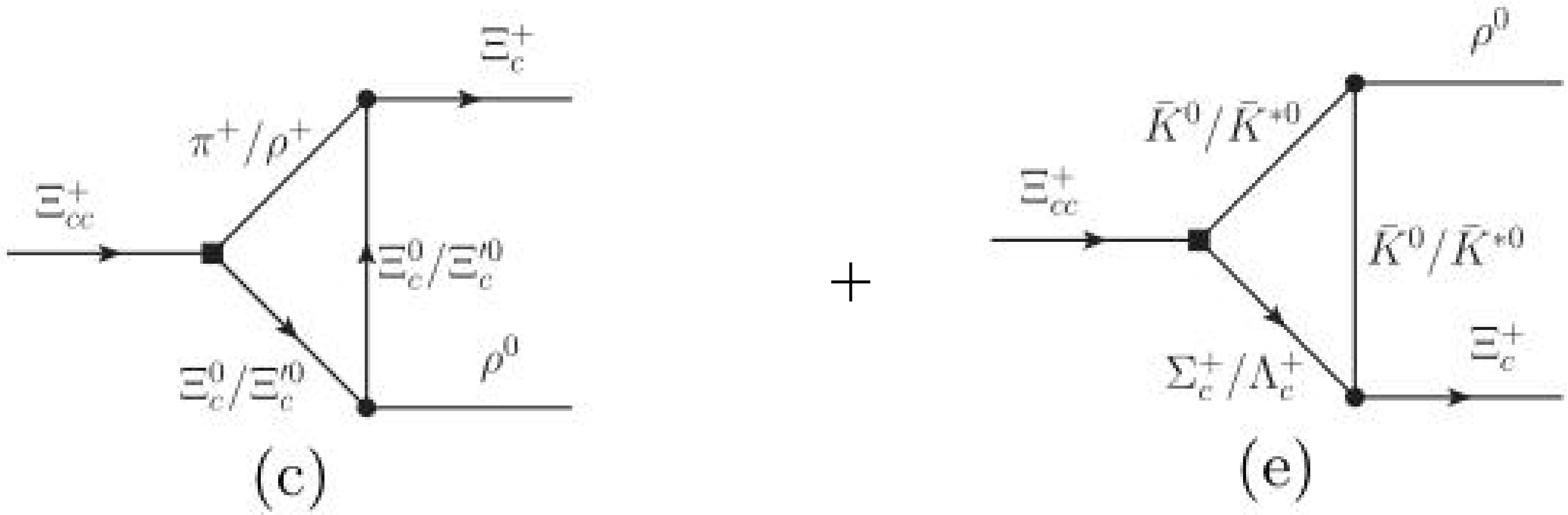
$u\bar{u}$ $d\bar{d}$



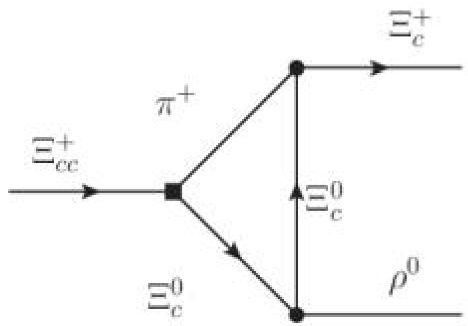
$u\bar{u}$ $d\bar{d}$

$u\bar{u}$ with an isospin factor $\frac{1}{\sqrt{2}}$, while $d\bar{d}$ with $-\frac{1}{\sqrt{2}}$

➢ An Example $\Xi_{cc}^{+} \to \Xi_{c}^{+}\rho^{0}$: long Distance Contributions



➢ An Example $\Xi_{cc}^{+} \to \Xi_{c}^{+}\rho^{0}$: long Distance Contributions



$=$

$$\mathcal{A}bs\,M_c(\pi^+;\Xi_c^0;\Xi_c^0) = -\frac{i}{\sqrt{2}}\int\frac{|\vec{p_2}|sin\theta d\theta d\varphi}{32\pi^2 m_{\Xi_{cc}^+}}\frac{G_F}{\sqrt{2}}V_{cs}^*V_{ud}a_1 f_\pi g_{\Xi_c^+\Xi_c^0\pi^+}\frac{F^2(t,m_{\Xi_c^0})}{t-m_{\Xi_c^0}^2}\epsilon_6^{*\nu}$$
$$\times\overline{u}(p_5,s_z')\gamma_5(\not{p}_4+m_{\Xi_c^0})\left(f_{1\Xi_c^0\Xi_c^0\rho^0}\gamma_\nu+i\frac{f_{2\Xi_c^0\Xi_c^0\rho^0}}{2m_{\Xi_c^0}}\sigma_{\mu\nu}p_6^\mu\right)$$
$$(\not{p}_3+m_{\Xi_c^0})\left[(m_{\Xi_{cc}^+}-m_{\Xi_c^0})f_1(m_\pi^2)+(m_{\Xi_{cc}^+}+m_{\Xi_c^0})g_1(m_\pi^2)\gamma_5\right]u(p_1,s_z),$$

where

$$F(t,m)=\left(\frac{\Lambda^2-m^2}{\Lambda^2-t}\right)^n, \qquad \Lambda = m+\eta\Lambda_{\rm QCD}$$

→ Cheng,Chua,Soni,PRD 71, 014030(2005)

➢ An Example $\Xi_{cc}^{+} \to \Xi_{c}^{+} \rho^{0}$

The amplitude of $\Xi_{cc}^{+} \to \Xi_{c}^{+} \rho^{0}$ is expressed by

$$
\begin{aligned}
\mathcal{A}(\Xi_{cc}^{+} \to \Xi_c^+ \rho^0) = \quad & C_{\rm SD}(\Xi_{cc} \to \Xi_c^+ \rho^0) + i\big[\mathcal{A}bs\, M_c(\pi^+; \Xi_c^0; \Xi_c^0) + \mathcal{A}bs\, M_c(\rho^+; \Xi_c^0; \Xi_c^0) \\
& + \mathcal{A}bs\, M_c(\pi^+; \Xi_c^0; \Xi_c^{\prime 0}) + \mathcal{A}bs\, M_c(\rho^+; \Xi_c^0; \Xi_c^{\prime 0}) + \mathcal{A}bs\, M_c(\pi^+; \Xi_c^{\prime 0}; \Xi_c^0) \\
& + \mathcal{A}bs\, M_c(\rho^+; \Xi_c^{\prime 0}; \Xi_c^0) + \mathcal{A}bs\, M_c(\pi^+; \Xi_c^{\prime 0}; \Xi_c^{\prime 0}) + \mathcal{A}bs\, M_c(\rho^+; \Xi_c^{\prime 0}; \Xi_c^{\prime 0}) \\
& + \mathcal{A}bs\, M_e(\bar{K}^0; \Lambda_c^+; K^0) + \mathcal{A}bs\, M_e(\bar{K}^{*0}; \Lambda_c^+; K^{*0}) + \mathcal{A}bs\, M_e(\bar{K}^0; \Sigma_c^+; K^0) \\
& + \mathcal{A}bs\, M_e(\bar{K}^{*0}; \Sigma_c^+; K^{*0})\big].
\end{aligned}
$$

➢ Inputs : Form Factors

Transition form factors with scalar (0+) and the axial vector (1+) diquarks.

F	$F(0)$	$m_{\rm fit}$	δ	F	$F(0)$	$m_{\rm fit}$	δ
$f_1^{\Xi_{cc}^{++}\to\Lambda_c^+}$	0.653	1.72	0.27	$f_2^{\Xi_{cc}^{++}\to\Lambda_c^+}$	−0.738	1.56	0.32
$g_1^{\Xi_{cc}^{++}\to\Lambda_c^+}$	0.533	2.03	0.38	$g_2^{\Xi_{cc}^{++}\to\Lambda_c^+}$	−0.053	1.12	1.10
$f_1^{\Xi_{cc}^{++}\to\Sigma_c^+}$	0.653	1.72	0.27	$f_2^{\Xi_{cc}^{++}\to\Sigma_c^+}$	−0.738	1.56	0.32
$g_1^{\Xi_{cc}^{++}\to\Sigma_c^+}$	0.533	2.03	0.38	$g_2^{\Xi_{cc}^{++}\to\Sigma_c^+}$	−0.053	1.12	1.10
$f_1^{\Xi_{cc}^{++}\to\Xi_c^+}$	0.754	1.84	0.25	$f_2^{\Xi_{cc}^{++}\to\Xi_c^+}$	−0.782	1.67	0.30
$g_1^{\Xi_{cc}^{++}\to\Xi_c^+}$	0.620	2.16	0.35	$g_2^{\Xi_{cc}^{++}\to\Xi_c^+}$	−0.080	1.29	0.52
$f_1^{\Xi_{cc}^{++}\to\Xi_c^{\prime+}}$	0.754	1.84	0.25	$f_2^{\Xi_{cc}^{++}\to\Xi_c^{\prime+}}$	−0.782	1.67	0.30
$g_1^{\Xi_{cc}^{++}\to\Xi_c^{\prime+}}$	0.620	2.16	0.35	$g_2^{\Xi_{cc}^{++}\to\Xi_c^{\prime+}}$	−0.080	1.29	0.52
$f_1^{\Xi_{cc}^{+}\to\Sigma_c^0}$	0.653	1.72	0.27	$f_2^{\Xi_{cc}^{+}\to\Sigma_c^0}$	−0.738	1.56	0.32
$g_1^{\Xi_{cc}^{+}\to\Sigma_c^0}$	0.533	2.03	0.38	$g_2^{\Xi_{cc}^{+}\to\Sigma_c^0}$	−0.053	1.12	1.10
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$f_1^{\Xi_{cc}^{+}\to\Xi_c^{\prime0}}$	0.754	1.84	0.25	$f_2^{\Xi_{cc}^{+}\to\Xi_c^{\prime0}}$	−0.782	1.67	0.30
$g_1^{\Xi_{cc}^{+}\to\Xi_c^{\prime0}}$	0.620	2.16	0.35	$g_2^{\Xi_{cc}^{+}\to\Xi_c^{\prime0}}$	−0.080	1.29	0.52
$f_1^{\Omega_{cc}^{+}\to\Xi_c^0}$	0.646	1.68	0.28	$f_2^{\Omega_{cc}^{+}\to\Xi_c^0}$	−0.770	1.54	0.33
$g_1^{\Omega_{cc}^{+}\to\Xi_c^0}$	0.528	1.99	0.40	$g_2^{\Omega_{cc}^{+}\to\Xi_c^0}$	−0.060	1.12	1.02
$f_1^{\Omega_{cc}^{+}\to\Xi_c^{\prime0}}$	0.646	1.68	0.28	$f_2^{\Omega_{cc}^{+}\to\Xi_c^{\prime0}}$	−0.770	1.54	0.33
$g_1^{\Omega_{cc}^{+}\to\Xi_c^{\prime0}}$	0.528	1.99	0.40	$g_2^{\Omega_{cc}^{+}\to\Xi_c^{\prime0}}$	−0.060	1.12	1.02
$f_1^{\Omega_{cc}^{+}\to\Omega_c^0}$	0.748	1.80	0.27	$f_2^{\Omega_{cc}^{+}\to\Omega_c^0}$	−0.819	1.64	0.32
$g_1^{\Omega_{cc}^{+}\to\Omega_c^0}$	0.615	2.11	0.36	$g_2^{\Omega_{cc}^{+}\to\Omega_c^0}$	−0.088	1.28	0.52

F	$F(0)$	$m_{\rm fit}$	δ	F	$F(0)$	$m_{\rm fit}$	δ
$f_1^{\Xi_{cc}^{++}\to\Lambda_c^+}$	0.637	1.49	0.37	$f_2^{\Xi_{cc}^{++}\to\Lambda_c^+}$	0.725	1.53	0.32
$g_1^{\Xi_{cc}^{++}\to\Lambda_c^+}$	−0.167	1.99	0.23	$g_2^{\Xi_{cc}^{++}\to\Lambda_c^+}$	−0.028*	2.03*	2.62*
$f_1^{\Xi_{cc}^{++}\to\Sigma_c^+}$	0.637	1.49	0.37	$f_2^{\Xi_{cc}^{++}\to\Sigma_c^+}$	0.725	1.53	0.32
$g_1^{\Xi_{cc}^{++}\to\Sigma_c^+}$	−0.167	1.99	0.23	$g_2^{\Xi_{cc}^{++}\to\Sigma_c^+}$	−0.028*	2.03*	2.62*
$f_1^{\Xi_{cc}^{++}\to\Xi_c^+}$	0.739	1.58	0.36	$f_2^{\Xi_{cc}^{++}\to\Xi_c^+}$	0.801	1.62	0.31
$g_1^{\Xi_{cc}^{++}\to\Xi_c^+}$	−0.198	2.10	0.21	$g_2^{\Xi_{cc}^{++}\to\Xi_c^+}$	−0.018*	1.62*	1.37*
$f_1^{\Xi_{cc}^{++}\to\Xi_c^{\prime+}}$	0.739	1.58	0.36	$f_2^{\Xi_{cc}^{++}\to\Xi_c^{\prime+}}$	0.801	1.62	0.31
$g_1^{\Xi_{cc}^{++}\to\Xi_c^{\prime+}}$	−0.198	2.10	0.21	$g_2^{\Xi_{cc}^{++}\to\Xi_c^{\prime+}}$	−0.018*	1.62*	1.37*
$f_1^{\Xi_{cc}^{+}\to\Sigma_c^0}$	0.637	1.49	0.37	$f_2^{\Xi_{cc}^{+}\to\Sigma_c^0}$	0.725	1.53	0.32
$g_1^{\Xi_{cc}^{+}\to\Sigma_c^0}$	−0.167	1.99	0.23	$g_2^{\Xi_{cc}^{+}\to\Sigma_c^0}$	−0.028*	2.03*	2.62*
$f_1^{\Xi_{cc}^{+}\to\Xi_c^0}$	0.739	1.58	0.36	$f_2^{\Xi_{cc}^{+}\to\Xi_c^0}$	0.801	1.62	0.31
$g_1^{\Xi_{cc}^{+}\to\Xi_c^0}$	−0.198	2.10	0.21	$g_2^{\Xi_{cc}^{+}\to\Xi_c^0}$	−0.018*	1.62*	1.37*
$f_1^{\Xi_{cc}^{+}\to\Xi_c^{\prime0}}$	0.739	1.58	0.36	$f_2^{\Xi_{cc}^{+}\to\Xi_c^{\prime0}}$	0.801	1.62	0.31
$g_1^{\Xi_{cc}^{+}\to\Xi_c^{\prime0}}$	−0.198	2.10	0.21	$g_2^{\Xi_{cc}^{+}\to\Xi_c^{\prime0}}$	−0.018*	1.62*	1.37*
$f_1^{\Omega_{cc}^{+}\to\Xi_c^0}$	0.632	1.47	0.38	$f_2^{\Omega_{cc}^{+}\to\Xi_c^0}$	0.734	1.52	0.33
$g_1^{\Omega_{cc}^{+}\to\Xi_c^0}$	−0.165	1.97	0.27	$g_2^{\Omega_{cc}^{+}\to\Xi_c^0}$	−0.031*	2.32*	3.92*
$f_1^{\Omega_{cc}^{+}\to\Xi_c^{\prime0}}$	0.632	1.47	0.38	$f_2^{\Omega_{cc}^{+}\to\Xi_c^{\prime0}}$	0.734	1.52	0.33
$g_1^{\Omega_{cc}^{+}\to\Xi_c^{\prime0}}$	−0.165	1.97	0.27	$g_2^{\Omega_{cc}^{+}\to\Xi_c^{\prime0}}$	−0.031*	2.32*	3.92*
$f_1^{\Omega_{cc}^{+}\to\Omega_c^0}$	0.735	1.57	0.37	$f_2^{\Omega_{cc}^{+}\to\Omega_c^0}$	0.812	1.61	0.32
$g_1^{\Omega_{cc}^{+}\to\Omega_c^0}$	−0.196	2.08	0.24	$g_2^{\Omega_{cc}^{+}\to\Omega_c^0}$	−0.021*	1.79*	1.77*

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➢ Inputs : Strong Coupling Constants

TABLE V: Strong coupling constants of VPP and VVV vertices.

vertex	g	vertex	g	vertex	g	vertex	g	vertex	g	vertex	g
$\rho^+ \to \pi^0\pi^+$	6.05	$\rho^0 \to \pi^-\pi^+$	6.05	$\rho^+ \to K^+\overline{K}^0$	4.60	$\rho^0 \to K^0\overline{K}^0$	-3.25	$\rho^0 \to K^+K^-$	3.25	$\omega \to K^+K^-$	3.25
$\phi \to K^-K^+$	4.60	$\overline{K}^{*0} \to \eta_8\overline{K}^0$	5.63	$\overline{K}^{*0} \to K^-\pi^+$	4.60	$\overline{K}^{*0} \to \overline{K}^0\pi^0$	-3.25	$K^{*+} \to K^+\pi^0$	3.25	$\phi \to \overline{K}^0K^0$	4.60
$K^{*+} \to \eta_8K^+$	5.63	$K^{*+} \to \pi^+K^0$	4.60	$K^{*0} \to \pi^-K^+$	4.60	$K^{*0} \to K^0\eta_8$	5.63	$K^{*0} \to \pi^0K^0$	-3.25	$\omega \to K^0\overline{K}^0$	3.25
$\rho^+ \to \rho^0\rho^+$	7.38	$\rho^0 \to \rho^-\rho^+$	7.38	$\rho^+ \to K^{*+}\overline{K}^{*0}$	5.22	$\rho^0 \to K^{*+}K^{*-}$	3.69	$\omega \to K^{*+}K^{*-}$	3.69	$\rho^0 \to K^{*0}\overline{K}^{*0}$	-3.69
$\overline{K}^{*0} \to \phi\overline{K}^{*0}$	5.22	$\overline{K}^{*0} \to \overline{K}^{*0}\rho^0$	-3.69	$\overline{K}^{*0} \to \overline{K}^{*0}\omega$	3.69	$K^{*+} \to \rho^+K^{*0}$	5.22	$K^{*+} \to \phi K^{*+}$	5.22	$K^{*+} \to K^{*+}\rho^0$	3.69
$K^{*+} \to \omega K^{*+}$	3.69	$K^{*0} \to \rho^0K^{*0}$	-3.69	$K^{*0} \to \omega K^{*0}$	3.69	$K^{*0} \to K^{*0}\phi$	5.22	$\phi \to K^{*-}K^{*+}$	5.22	$\overline{K}^{*0} \to K^{*-}\rho^+$	5.22
$\omega \to K^{*0}\overline{K}^{*0}$	3.69	$\phi \to \overline{K}^{*0}K^{*0}$	5.22								

TABLE VI: Strong coupling constants of $\mathcal{B}_{c3}\mathcal{B}_{c3}P$, $\mathcal{B}_{c3}\mathcal{B}_{c6}P$ and $\mathcal{B}_{c6}\mathcal{B}_{c6}P$ vertices.

vertex	g	vertex	g	vertex	g	vertex	g	vertex	g	vertex	g
$\Xi_c^0 \to \Xi_c^+\pi^-$	0.99	$\Xi_c^+ \to \Xi_c^0\pi^+$	0.99	$\Xi_c^0 \to \Xi_c^0\pi^0$	-0.70	$\Xi_c^0 \to \Lambda_c^+K^-$	-0.90	$\Xi_c^+ \to \Xi_c^+\pi^0$	0.70	$\Xi_c^0 \to \Xi_c^0\eta_8$	-0.70
$\Lambda_c^+ \to \Lambda_c^+\eta_1$	0.75	$\Xi_c^+ \to \Xi_c^+\eta_1$	0.07	$\Xi_c^0 \to \Xi_c^0\eta_1$	0.07	$\Lambda_c^+ \to \Lambda_c^+\eta_8$	0.81	$\Xi_c^+ \to \Xi_c^+\eta_8$	-0.70	$\Xi_c^+ \to \Lambda_c^+\overline{K}^0$	0.90
$\Sigma_c^0 \to \Sigma_c^+\pi^-$	8.0	$\Xi_c^{\prime 0} \to \Xi_c^{\prime 0}\pi^0$	-4.0	$\Xi_c^{\prime 0} \to \Sigma_c^0\overline{K}^0$	9.0	$\Sigma_c^+ \to \Sigma_c^0\pi^+$	8.0	$\Xi_c^{\prime 0} \to \Sigma_c^+K^-$	6.4	$\Xi_c^{\prime 0} \to \Xi_c^{\prime +}\pi^-$	5.7
$\Sigma_c^0 \to \Sigma_c^0\pi^0$	-8.0	$\Sigma_c^0 \to \Xi_c^{\prime 0}K^0$	9.0	$\Xi_c^{\prime +} \to \Xi_c^{\prime +}\pi^0$	4.0	$\Xi_c^{\prime +} \to \Sigma_c^{++}K^-$	9.0	$\Xi_c^{\prime +} \to \Xi_c^{\prime 0}\pi^+$	5.7	$\Sigma_c^{++} \to \Sigma_c^+\pi^+$	8.0
$\Sigma_c^{++} \to \Xi_c^{\prime +}K^+$	9.0	$\Sigma_c^+ \to \Xi_c^{\prime +}K^0$	6.4	$\Sigma_c^+ \to \Sigma_c^{++}\pi^-$	8.0	$\Xi_c^{\prime +} \to \Omega_c^0K^+$	9.0	$\Xi_c^{\prime +} \to \Sigma_c^+\overline{K}^0$	6.4	$\Sigma_c^+ \to \Xi_c^{\prime 0}K^+$	6.4
$\Omega_c^0 \to \Xi_c^{\prime +}K^-$	9.0	$\Xi_c^{\prime 0} \to \Omega_c^0K^0$	9.0	$\Sigma_c^0 \to \Sigma_c^0\eta_1$	-2.6	$\Omega_c^0 \to \Omega_c^0\eta_1$	-11.0	$\Omega_c^0 \to \Xi_c^{\prime 0}\overline{K}^0$	9.0	$\Sigma_c^0 \to \Sigma_c^0\eta_8$	4.6
$\Omega_c^0 \to \Omega_c^0\eta_8$	-10.4	$\Sigma_c^+ \to \Sigma_c^+\eta_1$	-2.6	$\Xi_c^{\prime 0} \to \Xi_c^{\prime 0}\eta_1$	-2.6	$\Xi_c^{\prime +} \to \Xi_c^{\prime +}\eta_1$	-2.6	$\Sigma_c^+ \to \Sigma_c^+\eta_8$	4.6	$\Xi_c^{\prime 0} \to \Xi_c^{\prime 0}\eta_8$	-2.3
$\Xi_c^0 \to \Xi_c^{\prime +}\pi^-$	4.4	$\Xi_c^{\prime +} \to \Xi_c^+\pi^0$	3.1	$\Xi_c^{\prime +} \to \Xi_c^0\pi^+$	4.4	$\Omega_c^0 \to \Xi_c^+K^-$	6.5	$\Xi_c^{\prime +} \to \Lambda_c^+\overline{K}^0$	-4.6	$\Sigma_c^+ \to \Lambda_c^+\pi^0$	6.5
$\Xi_c^0 \to \Omega_c^0K^0$	6.5	$\Omega_c^0 \to \Xi_c^0\overline{K}^0$	6.5	$\Sigma_c^0 \to \Xi_c^0K^0$	-7.1	$\Xi_c^{\prime +} \to \Lambda_c^+K^0$	-4.6	$\Xi_c^+ \to \Xi_c^{\prime 0}\pi^+$	4.4	$\Lambda_c^+ \to \Xi_c^{\prime 0}K^+$	4.6
$\Xi_c^0 \to \Sigma_c^+K^-$	-5.0	$\Xi_c^{\prime 0} \to \Xi_c^0\pi^0$	-3.1	$\Xi_c^+ \to \Xi_c^{\prime 0}\pi^+$	4.4	$\Xi_c^{\prime 0} \to \Lambda_c^+K^-$	4.6	$\Xi_c^{\prime 0} \to \Xi_c^+\pi^-$	4.4	$\Xi_c^+ \to \Omega_c^0K^+$	6.5
$\Sigma_c^{++} \to \Xi_c^+K^+$	-7.1	$\Xi_c^+ \to \Sigma_c^{++}K^-$	-7.1	$\Sigma_c^{++} \to \Lambda_c^+\pi^+$	-6.5	$\Xi_c^0 \to \Sigma_c^0\overline{K}^0$	-7.1	$\Lambda_c^+ \to \Sigma_c^{++}\pi^-$	-6.5	$\Lambda_c^+ \to \Sigma_c^0\pi^+$	6.5
$\Sigma_c^+ \to \Xi_c^0K^+$	-5.0	$\Sigma_c^0 \to \Lambda_c^+\pi^-$	6.5	$\Xi_c^{\prime +} \to \Xi_c^+\eta_8$	5.4	$\Sigma_c^+ \to \Xi_c^+K^0$	-5.0	$\Xi_c^+ \to \Sigma_c^+\overline{K}^0$	-5.0	$\Xi_c^{\prime 0} \to \Xi_c^0\eta_8$	5.4
$\Lambda_c^+ \to \Xi_c^0K^+$	-0.90	$\Xi_c^+ \to \Lambda_c^+K^0$	0.90	$\Xi_c^{\prime +} \to \Xi_c^{\prime +}\eta_8$	-2.3						

➢ Inputs : Strong Coupling Constants

TABLE VII: The strong coupling constants of $\mathcal{B}_{c3}\mathcal{B}_{c3}V$ vertices, each of which owns two $SU(3)$ triplet singly charm baryons and one light vector meson.

vertex	f_1	f_2	vertex	f_1	f_2	vertex	f_1	f_2	vertex	f_1	f_2
$\Xi_c^0 \to \Lambda_c^+ K^{*-}$	-4.6	-6.0	$\Xi_c^0 \to \Xi_c^0 \rho^0$	-6.0	-7.5	$\Xi_c^+ \to \Xi_c^0 \rho^+$	8.5	10.6	$\Lambda_c^+ \to \Xi_c^0 K^{*+}$	-4.6	-6.0
$\Xi_c^0 \to \Xi_c^0 \phi$	4.6	6.0	$\Xi_c^0 \to \Xi_c^0 \omega$	5.5	7.5	$\Lambda_c^+ \to \Lambda_c^+ \omega$	4.9	6.0	$\Xi_c^0 \to \Xi_c^+ \rho^-$	8.5	10.6
$\Xi_c^+ \to \Lambda_c^+ \overline{K}^{*0}$	4.6	6.0	$\Xi_c^+ \to \Xi_c^+ \rho^0$	6.0	7.5	$\Xi_c^+ \to \Xi_c^+ \omega$	5.5	7.5	$\Xi_c^+ \to \Xi_c^+ \phi$	4.6	6.0
$\Sigma_c^0 \to \Xi_c'^0 K^{*0}$	5.0	30.0	$\Xi_c'^0 \to \Xi_c'^0 \rho^0$	-2.5	-16.0	$\Xi_c'^0 \to \Xi_c'^+ \rho^-$	3.5	22.6	$\Xi_c'^0 \to \Xi_c'^0 \phi$	4.0	21.0
$\Xi_c'^+ \to \Xi_c'^0 \rho^+$	3.5	22.6	$\Sigma_c^+ \to \Xi_c'^0 K^{*+}$	3.5	21.2	$\Xi_c'^0 \to \Xi_c'^0 \omega$	2.4	15.0	$\Xi_c'^0 \to \Sigma_c^+ K^{*-}$	3.5	21.2
$\Xi_c'^0 \to \Sigma_c^0 \overline{K}^{*0}$	5.0	30.0	$\Sigma_c^+ \to \Sigma_c^{++} \rho^-$	4.0	27.0	$\Sigma_c^{++} \to \Xi_c'^+ K^{*+}$	5.0	30.0	$\Xi_c'^+ \to \Sigma_c^{++} K^{*-}$	5.0	30.0
$\Xi_c'^+ \to \Sigma_c^+ \overline{K}^{*0}$	3.5	21.2	$\Xi_c'^+ \to \Xi_c'^+ \rho^0$	2.5	16.0	$\Xi_c'^+ \to \Xi_c'^+ \phi$	4.0	21.0	$\Xi_c'^+ \to \Xi_c'^+ \omega$	2.4	15.0
$\Sigma_c^+ \to \Xi_c'^+ K^{*0}$	3.5	21.2	$\Sigma_c^{++} \to \Sigma_c^+ \rho^+$	4.0	27.0	$\Sigma_c^0 \to \Sigma_c^0 \rho^0$	-4.0	-27.0	$\Sigma_c^0 \to \Sigma_c^0 \omega$	3.5	24.0
$\Sigma_c^+ \to \Sigma_c^0 \rho^+$	4.0	27.0	$\Sigma_c^0 \to \Sigma_c^+ \rho^-$	4.0	27.0	$\Xi_c'^+ \to \Omega_c^0 K^{*+}$	7.0	35.0	$\Omega_c^0 \to \Xi_c'^0 K^{*0}$	7.0	35.0
$\Omega_c^0 \to \Omega_c^0 \phi$	11.0	52.0	$\Omega_c^0 \to \Xi_c'^+ K^{*-}$	7.0	35.0	$\Omega_c^0 \to \Xi_c'^0 \overline{K}^{*0}$	7.0	35.0	$\Sigma_c^+ \to \Sigma_c^+ \omega$	3.5	24.0
$\Xi_c'^0 \to \Xi_c^0 \rho^0$	-1.5	-11.0	$\Xi_c'^0 \to \Xi_c^0 \phi$	-2.1	-13.0	$\Xi_c'^0 \to \Xi_c^0 \omega$	1.2	8.0	$\Xi_c'^+ \to \Xi_c^+ \omega$	1.5	11.0
$\Lambda_c^+ \to \Xi_c'^0 K^{*+}$	2.3	14.1	$\Xi_c'^0 \to \Lambda_c^+ K^{*-}$	2.3	14.1	$\Xi_c^+ \to \Xi_c'^0 \rho^+$	2.1	15.6	$\Xi_c'^0 \to \Xi_c^+ \rho^-$	2.1	15.6
$\Xi_c'^+ \to \Lambda_c^+ \overline{K}^{*0}$	-2.3	-14.1	$\Sigma_c^+ \to \Xi_c^0 K^{*+}$	-2.2	-13.0	$\Xi_c^+ \to \Sigma_c^+ K^{*0}$	-2.2	-13.0	$\Xi_c'^+ \to \Xi_c^0 \rho^+$	2.1	15.6
$\Xi_c'^+ \to \Xi_c^+ \rho^0$	1.5	11.0	$\Xi_c'^+ \to \Xi_c^+ \phi$	-2.1	-13.0	$\Xi_c^0 \to \Xi_c'^+ \rho^-$	2.1	15.6	$\Sigma_c^+ \to \Xi_c^+ \overline{K}^{*0}$	-2.2	-13.0
$\Sigma_c^+ \to \Lambda_c^+ \rho^0$	2.6	16.0	$\Xi_c^+ \to \Omega_c^0 K^{*+}$	3.3	20.0	$\Lambda_c^+ \to \Xi_c'^+ K^{*0}$	-2.3	-14.1	$\Xi_c^0 \to \Sigma_c^+ K^{*-}$	-2.2	-13.0
$\Sigma_c^{++} \to \Xi_c^+ K^{*+}$	-3.1	-18.4	$\Xi_c^+ \to \Sigma_c^{++} K^{*-}$	-3.1	-18.4	$\Sigma_c^{++} \to \Lambda_c^+ \rho^+$	-2.6	-16.0	$\Lambda_c^+ \to \Sigma_c^{++} \rho^-$	-2.6	-16.0
$\Lambda_c^+ \to \Sigma_c^0 \rho^+$	2.6	16.0	$\Sigma_c^0 \to \Lambda_c^+ \rho^-$	2.6	16.0	$\Omega_c^0 \to \Xi_c^+ K^{*-}$	3.3	20.0	$\Xi_c^0 \to \Sigma_c^0 \overline{K}^{*0}$	-2.2	-13.0
$\Xi_c^0 \to \Omega_c^0 K^{*0}$	3.3	20.0	$\Sigma_c^0 \to \Xi_c^0 K^{*0}$	-2.2	-13.0	$\Omega_c^0 \to \Xi_c^0 \overline{K}^{*0}$	3.3	20.0	$\Lambda_c^+ \to \Xi_c^+ K^{*0}$	4.6	6.0

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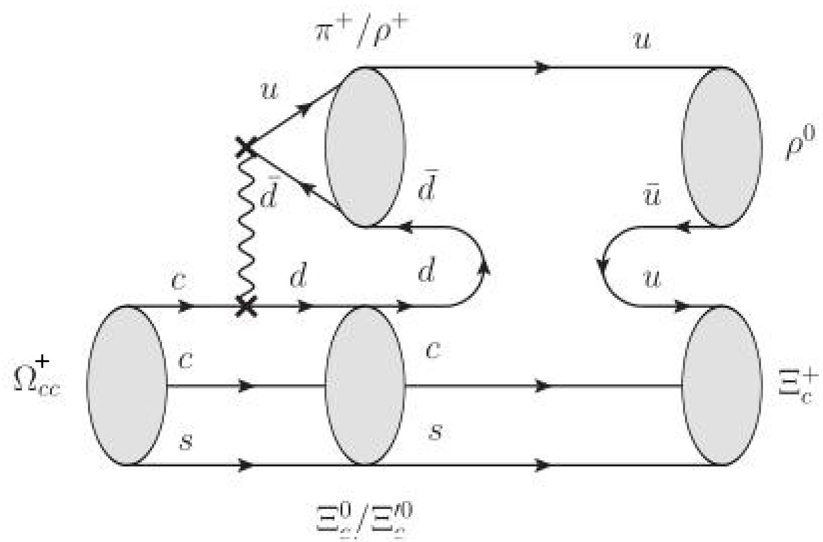
[2] T. M. Aliev, K. Azizi and M. Savci, Phys. Lett. B 696, 220 (2011) doi:10.1016/j.physletb.2010.12.027
[3] T. M. Aliev, K. Azizi and M. Savci, Nucl. Phys. A 852, 141 (2011) doi:10.1016/j.nuclphysa.2011.01.011

➢ Topological FCNC contributions Induced by FSI

An Example:



N

- The weak decay is induced at quark level by $c \to u d\bar{d}$. The $d\bar{d}$ pair annihilates subsequently, and the weak transition is equivalent to a flavor changing neutral current $c \to u\gamma/G$. The same situation exists in $c \to us\bar{s}$ inducing decays.
- Topologically, it looks the same as $O_{7\gamma}$ or O_{8G} operators in the low energy effective hamiltonian, which are purely loop effects and suppressed highly at short distance in the standard model.
- However, it is the long distance contributions that are considered here, thus they are kept.

3 Results and Discussions

For lack of experimental data we use $\eta = 1.5$ in this work and range it from 1 to 2 for error estimation.

Channels	$\mathcal{BR}(\%)$	Contributions	CKM	Channels	$\mathcal{BR}(\%)$	Contributions	CKM
$\Xi_{cc}^{++} \to \Sigma_c^{++} \bar{K}^{*0}$	$5.40^{+5.59}_{-3.66}$	$C_{\rm SD}, C$	CF	$\Xi_{cc}^{++} \to \Xi_c^{+} \rho^{+}$	$15.92^{+5.27}_{-3.03}$	$T_{\rm SD}, T, C'$	CF
$\Xi_{cc}^{++} \to \Xi_c^{'+} \rho^{+}$	$16.50^{+1.21}_{-0.69}$	$T_{\rm SD}, T, C'$	CF	$\Xi_{cc}^{++} \to \Sigma_c^{+} \rho^{+}$	$1.57^{+0.63}_{-0.40}$	$T_{\rm SD}, T, C', N$	SCS
$\Xi_{cc}^{++} \to \Lambda_c^{+} \rho^{+}$	$2.10^{+1.32}_{-0.82}$	$T_{\rm SD}, T, C', N$	SCS	$\Xi_{cc}^{++} \to \Sigma_c^{++} \rho^{0}$	$0.04^{+0.04}_{-0.03}$	$C_{\rm SD}, C, N$	SCS
$\Xi_{cc}^{++} \to \Sigma_c^{++} \omega$	$0.15^{+0.17}_{-0.10}$	$C_{\rm SD}, C, N$	SCS	$\Xi_{cc}^{++} \to \Sigma_c^{++} \phi$	$0.09^{+0.08}_{-0.06}$	$C_{\rm SD}, C$	SCS
$\Xi_{cc}^{++} \to \Xi_c^{+} K^{*+}$	$0.59^{+0.14}_{-0.10}$	$T_{\rm SD}, T, N, C'$	SCS	$\Xi_{cc}^{++} \to \Xi_c^{'+} K^{*+}$	$0.85^{+0.14}_{-0.09}$	$T_{\rm SD}, T, N, C'$	SCS
$\Xi_{cc}^{++} \to \Sigma_c^{+} K^{*+}$	$0.06^{+0.00}_{-0.01}$	$T_{\rm SD}, T, C'$	DCS	$\Xi_{cc}^{++} \to \Lambda_c^{+} K^{*+}$	$0.05^{+0.00}_{-0.00}$	$T_{\rm SD}, T, C'$	DCS
$\Xi_{cc}^{++} \to \Sigma_c^{++} K^{*0}$	$0.02^{+0.02}_{-0.01}$	$C_{\rm SD}, C$	DCS				

- The $\mathcal{BR}$ of singly CKM suppressed decays range from order of 10^{-3} to 10^{-2}. The doubly CKM suppressed decays have the smallest $\mathcal{BR}$ at the order of 10^{-4}.
- Among decays in the same CKM mode, those with T contributions tend to have largest $\mathcal{BR}$. The C type decays are about several times smaller than the T type. The other types of decays are suppressed highly.
- Checking the errors, one can find that the T contributions are not sensitive to the variation of η. However, the other types of contributions which increase or decrease rapidly as η changes.
- $\Xi_{cc}^{++} \to \Xi_c^{+} \rho^{+}$ $\Xi_{cc}^{++} \to \Xi_c^{'+} \rho^{+}$ have the largest $\mathcal{BR}$, whose values are around 16% (ρ^{+} may have a low reconstruction efficiency in experiments).

3 Results and Discussions

Because there is no experimental data for lifetime of Ξ_{cc}^{+} . Instead of branching fractions we present the decay widths in unit of GeV.

Channels	Γ/GeV	Contributions	CKM	Channels	Γ/GeV	Contributions	CKM
$\Xi_{cc}^{+}\to\Sigma_c^{+}\overline{K}^{*0}$	$(1.37^{+1.46}_{-0.93})*10^{-13}$	$C_{\rm SD},C,E_2$	CF	$\Xi_{cc}^{+}\to\Lambda_c^{+}\overline{K}^{*0}$	$(1.04^{+1.14}_{-0.72})*10^{-13}$	$C_{\rm SD},C,E_2$	CF
$\Xi_{cc}^{+}\to\Xi_c^{0}\rho^{+}$	$(3.83^{+0.48}_{-0.37})*10^{-13}$	$T_{\rm SD},T,E_1$	CF	$\Xi_{cc}^{+}\to\Xi_c^{\prime 0}\rho^{+}$	$(4.77^{+0.31}_{-0.24})*10^{-13}$	$T_{\rm SD},T,E_1$	CF
$\Xi_{cc}^{+}\to\Xi_c^{+}\rho^{0}$	$(1.01^{+1.15}_{-0.71})*10^{-14}$	C',E_1	CF	$\Xi_{cc}^{+}\to\Xi_c^{\prime +}\rho^{0}$	$(1.59^{+1.76}_{-1.10})*10^{-15}$	C',E_1	CF
$\Xi_{cc}^{+}\to\Xi_c^{+}\omega$	$(7.82^{+8.98}_{-5.46})*10^{-15}$	C',E_1	CF	$\Xi_{cc}^{+}\to\Xi_c^{\prime +}\omega$	$(1.33^{+1.46}_{-0.92})*10^{-15}$	C',E_1	CF
$\Xi_{cc}^{+}\to\Sigma_c^{++}K^{*-}$	$(7.38^{+7.83}_{-5.02})*10^{-16}$	E_2	CF	$\Xi_{cc}^{+}\to\Xi_c^{+}\phi$	$(5.12^{+5.59}_{-3.52})*10^{-15}$	E_2	CF
$\Xi_{cc}^{+}\to\Xi_c^{\prime +}\phi$	$(9.90^{+10.24}_{-6.72})*10^{-17}$	E_2	CF	$\Xi_{cc}^{+}\to\Omega_c^{0}K^{*+}$	$(2.33^{+2.16}_{-1.54})*10^{-14}$	E_1	CF
$\Xi_{cc}^{+}\to\Sigma_c^{+}\rho^{0}$	$(1.26^{+1.43}_{-0.88})*10^{-14}$	$C_{\rm SD},C,C',E_1,E_2,N$	SCS	$\Xi_{cc}^{+}\to\Lambda_c^{+}\rho^{0}$	$(4.97^{+5.93}_{-3.50})*10^{-15}$	$C_{\rm SD},C,C',E_1,E_2,N$	SCS
$\Xi_{cc}^{+}\to\Sigma_c^{+}\omega$	$(3.22^{+3.59}_{-2.23})*10^{-15}$	$C_{\rm SD},C,C',E_1,E_2,N$	SCS	$\Xi_{cc}^{+}\to\Lambda_c^{+}\omega$	$(1.60^{+1.91}_{-1.13})*10^{-15}$	$C_{\rm SD},C,C',E_1,E_2,N$	SCS
$\Xi_{cc}^{+}\to\Sigma_c^{0}\rho^{+}$	$(9.02^{+3.70}_{-2.45})*10^{-14}$	$T_{\rm SD},T,E_1,N$	SCS	$\Xi_{cc}^{+}\to\Sigma_c^{+}\phi$	$(1.54^{+1.40}_{-1.01})*10^{-15}$	$C_{\rm SD},C$	SCS
$\Xi_{cc}^{+}\to\Lambda_c^{+}\phi$	$(2.61^{+2.67}_{-1.76})*10^{-15}$	$C_{\rm SD},C$	SCS	$\Xi_{cc}^{+}\to\Xi_c^{0}K^{*+}$	$(1.30^{+0.00}_{-0.00})*10^{-14}$	$T_{\rm SD},T,E_1,N$	SCS
$\Xi_{cc}^{+}\to\Xi_c^{\prime 0}K^{*+}$	$(2.19^{+0.19}_{-0.10})*10^{-14}$	$T_{\rm SD},T,E_1,N$	SCS	$\Xi_{cc}^{+}\to\Xi_c^{+}K^{*0}$	$(1.06^{+0.97}_{-0.69})*10^{-15}$	C',E_2,N	SCS
$\Xi_{cc}^{+}\to\Xi_c^{\prime +}K^{*0}$	$(2.64^{+2.66}_{-1.77})*10^{-15}$	C',E_2,N	SCS	$\Xi_{cc}^{+}\to\Sigma_c^{++}\rho^{-}$	$(7.60^{+8.83}_{-5.33})*10^{-16}$	E_2,N	SCS
$\Xi_{cc}^{+}\to\Sigma_c^{+}K^{*0}$	$(1.96^{+2.03}_{-1.33})*10^{-15}$	$C_{\rm SD},C,C'$	DCS	$\Xi_{cc}^{+}\to\Lambda_c^{+}K^{*0}$	$(9.99^{+11.18}_{-6.95})*10^{-16}$	$C_{\rm SD},C,C'$	DCS
$\Xi_{cc}^{+}\to\Sigma_c^{0}K^{*+}$	$(2.88^{+0.00}_{-0.00})*10^{-16}$	$T_{\rm SD},T$	DCS				

- Estimated with the $\tau_{\Xi_{cc}^{+}}=45\,\text{fs}$,the four largest branching fractions are given as

$$\mathcal{BR}(\Xi_{cc}^{+}\to\Sigma_c^{+}\overline{K}^{*0})\in[0.3\%,1.9\%],\quad \mathcal{BR}(\Xi_{cc}^{+}\to\Lambda_c^{+}\overline{K}^{*0})\in[0.2\%,1.5\%],$$
$$\mathcal{BR}(\Xi_{cc}^{+}\to\Xi_c^{0}\rho^{+})\in[2.4\%,2.9\%],\quad \mathcal{BR}(\Xi_{cc}^{+}\to\Xi_c^{\prime 0}\rho^{+})\in[3.1\%,3.5\%].$$

- Some pure W exchange decays which are highly suppressed at short distance.These decays are thought to be activated almost by the long distance effects.

3 Results and Discussions

Channels	Γ/GeV	Contributions	CKM	Channels	Γ/GeV	Contributions	CKM
$\Omega_{cc}^+ \to \Xi_c^+ \overline{K}^{*0}$	$(5.53^{+5.96}_{-3.80}) * 10^{-13}$	C_{SD}, C, C'	CF	$\Omega_{cc}^+ \to \Xi_c^{'+} \overline{K}^{*0}$	$(1.06^{+1.09}_{-0.72}) * 10^{-12}$	C_{SD}, C, C'	CF
$\Omega_{cc}^+ \to \Omega_c^0 \rho^+$	$(8.75^{+0.00}_{-0.00}) * 10^{-13}$	T_{SD}, T	CF	$\Omega_{cc}^+ \to \Sigma_c^+ \overline{K}^{*0}$	$(3.26^{+3.62}_{-2.26}) * 10^{-15}$	C', E_2, N	SCS
$\Omega_{cc}^+ \to \Lambda_c^+ \overline{K}^{*0}$	$(2.59^{+3.21}_{-1.85}) * 10^{-16}$	C', E_2, N	SCS	$\Omega_{cc}^+ \to \Xi_c^+ \rho^0$	$(3.04^{+3.55}_{-2.13}) * 10^{-15}$	$C_{\mathrm{SD}}, C, E_1, N$	SCS
$\Omega_{cc}^+ \to \Xi_c^{'+} \rho^0$	$(2.75^{+2.96}_{-1.89}) * 10^{-15}$	$C_{\mathrm{SD}}, C, E_1, N$	SCS	$\Omega_{cc}^+ \to \Xi_c^+ \omega$	$(2.38^{+2.78}_{-1.67}) * 10^{-15}$	$C_{\mathrm{SD}}, C, E_1, N$	SCS
$\Omega_{cc}^+ \to \Xi_c^{'+} \omega$	$(2.53^{+2.70}_{-1.74}) * 10^{-15}$	$C_{\mathrm{SD}}, C, E_1, N$	SCS	$\Omega_{cc}^+ \to \Xi_c^0 \rho^+$	$(4.45^{+2.42}_{-1.57}) * 10^{-14}$	$T_{\mathrm{SD}}, T, E_1, N$	SCS
$\Omega_{cc}^+ \to \Xi_c^{'0} \rho^+$	$(5.59^{+3.04}_{-1.98}) * 10^{-14}$	$T_{\mathrm{SD}}, T, E_1, N$	SCS	$\Omega_{cc}^+ \to \Xi_c^+ \phi$	$(8.96^{+8.69}_{-5.98}) * 10^{-15}$	$C_{\mathrm{SD}}, C, C', E_2, N$	SCS
$\Omega_{cc}^+ \to \Xi_c^{'+} \phi$	$(4.54^{+4.33}_{-3.01}) * 10^{-14}$	$C_{\mathrm{SD}}, C, C', E_2, N$	SCS	$\Omega_{cc}^+ \to \Omega_c^0 K^{*+}$	$(4.18^{+0.03}_{-0.01}) * 10^{-14}$	$T_{\mathrm{SD}}, T, E_1, N$	SCS
$\Omega_{cc}^+ \to \Sigma_c^{++} K^{*-}$	$(6.77^{+7.64}_{-4.71}) * 10^{-16}$	E_2, N	SCS	$\Omega_{cc}^+ \to \Xi_c^{'+} K^{*0}$	$(8.17^{+8.97}_{-5.63}) * 10^{-16}$	$C_{\mathrm{SD}}, C, E_2, N$	DCS
$\Omega_{cc}^+ \to \Sigma_c^+ \phi$	$(8.45^{+9.15}_{-5.81}) * 10^{-17}$	C'	DCS	$\Omega_{cc}^+ \to \Lambda_c^+ \phi$	$(4.25^{+4.64}_{-2.93}) * 10^{-17}$	C'	DCS
$\Omega_{cc}^+ \to \Xi_c^0 K^{*+}$	$(1.00^{+0.02}_{-0.01}) * 10^{-15}$	T_{SD}, T, E_1	DCS	$\Omega_{cc}^+ \to \Xi_c^{'0} K^{*+}$	$(1.47^{+0.05}_{-0.03}) * 10^{-15}$	T_{SD}, T, E_1	DCS
$\Omega_{cc}^+ \to \Xi_c^+ K^{*0}$	$(8.13^{+8.64}_{-5.55}) * 10^{-16}$	$C_{\mathrm{SD}}, C, E_2, N$	DCS	$\Omega_{cc}^+ \to \Sigma_c^{++} \rho^-$	$(1.20^{+1.38}_{-0.84}) * 10^{-17}$	E_2, N	DCS
$\Omega_{cc}^+ \to \Sigma_c^+ \rho^0$	$(9.06^{+10.75}_{-6.41}) * 10^{-18}$	E_1, E_2, N	DCS	$\Omega_{cc}^+ \to \Lambda_c^+ \rho^0$	$(1.03^{+1.33}_{-0.74}) * 10^{-17}$	E_1, E_2, N	DCS
$\Omega_{cc}^+ \to \Sigma_c^+ \omega$	$(8.72^{+10.25}_{-6.15}) * 10^{-18}$	E_1, E_2, N	DCS	$\Omega_{cc}^+ \to \Lambda_c^+ \omega$	$(8.78^{+11.19}_{-6.31}) * 10^{-18}$	E_1, E_2, N	DCS
$\Omega_{cc}^+ \to \Sigma_c^0 \rho^+$	$(1.39^{+1.62}_{-0.97}) * 10^{-16}$	E_1	DCS				

- Estimated with $\tau_{\Omega_{cc}^+} = 75\,\mathrm{fs}$, the branching ratios of the three decays are given as

$$\mathcal{BR}(\Omega_{cc}^+ \to \Xi_c^+ \overline{K}^{*0}) \in [2.0\%, 13.1\%], \quad \mathcal{BR}(\Omega_{cc}^+ \to \Xi_c^{'+} \overline{K}^{*0}) \in [3.9\%, 24.5\%], \quad \mathcal{BR}(\Omega_{cc}^+ \to \Omega_c^0 \rho^+) \approx 10.0\%.$$

$$\Omega_{cc}^+ \to p K^+ \pi^- K^- \pi^+$$

4 Summary

- Calculation: **the $\mathcal{BR}$ and Γ of $\mathcal{B}_{cc} \to \mathcal{B}_c V$**
- Theoretical framework: **The factorization hypothesis; The final-state interactions (FSIs) with the one-particle-exchange model**
- Results and Discussions:

CF	**Large $\mathcal{BR}$**	**T , C**
SCS	**Smaller $\mathcal{BR}$**	
DCS	**Smallest $\mathcal{BR}$**	

- The largest $\mathcal{BR}$ s of $\mathcal{B}_{cc} \to \mathcal{B}_c V$ decays are at the percent level.
- It seems easy to track $\Omega_{cc}^{+} \to pK^{+}\pi^{-}K^{-}\pi^{+}$ in experiments.

Thank you for your attention !