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Global analysis for measured and unmeasured hadronic two body weak decays of anti-triplet charmed baryons

Zhi-Peng Xing

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NJNU

HFCPV-2023

- Introduction
- SU(3) symmetry
- Global analysis
- Analysis of undetermined SU(3) parameter

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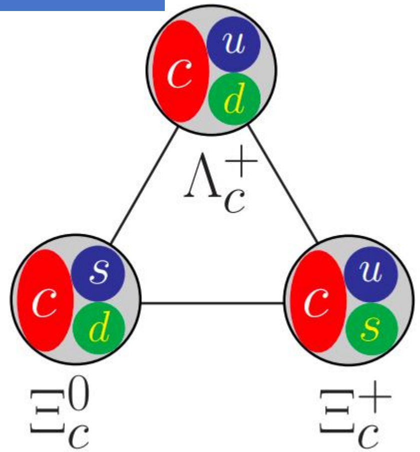
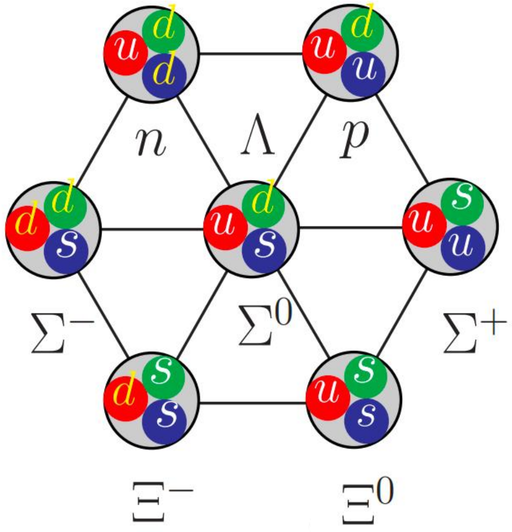
- Global analysis
- Analysis of undetermined SU(3) parameter

The charmed baryon two body decays

- Lower threshold
- More experiment data
- Richer phenomena

- Not good heavy quark symmetry
- More nonperturbative effect
- More complicated





Belle Collaboration

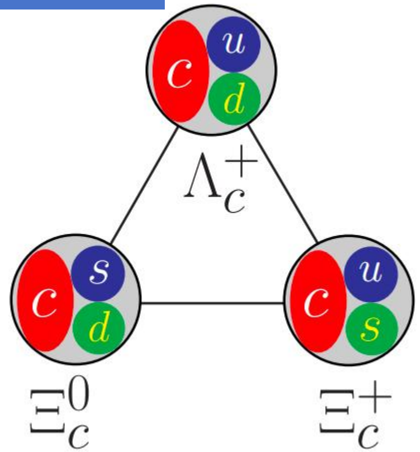
The charmed baryon two body decays

Symmetry analysis: SU(3)$_F$ symmetry!

- **No dynamics**
- **SU(3) relations**

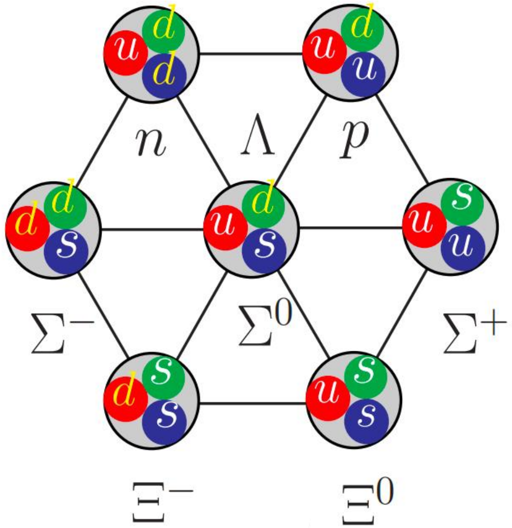
$$\Gamma(\Lambda_c^+ \to \Sigma^0\pi^+) = \Gamma(\Lambda_c^+ \to \Sigma^+\pi^0)$$

$\Lambda_c^+ \to \Sigma^0\pi^+$	1.29 ± 0.07
$\Lambda_c^+ \to \Sigma^+\pi^0$	1.25 ± 0.10



SU(3) analysis in recent years:

- **Nucl. Phys. B 956, 115048 (2020)**
- **JHEP 02, 165 (2020)**
- **JHEP 03, 143 (2022)**
- **JHEP 03, 143 (2022)**
- **Eur. Phys. J. C 82, no.4, 297 (2022)**
- **JHEP 09, 035 (2022)**
- **JHEP 02, 235 (2023)**
- **arXiv:2301.07443**



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The charmed baryon two body decays

The global analysis

21 experiment data

9 SU(3) rreducible amplitudes

channel	branching fraction				
	Experimental data (10^{-2})	SU(3) symmetry analysis (10^{-2})			Our work (10^{-2})
$\Lambda_c^+ \to pK_S^0$	1.59 ± 0.08	0.61 ± 0.07 [6]	1.46 ± 0.47 [7]	$1.36 \sim 1.80$ [8]	1.587 ± 0.077
$\Lambda_c^+ \to p\eta$	0.124 ± 0.03	0.124 ± 0.035 [6]	0.114 ± 0.035 [7]	—	0.127 ± 0.024
$\Lambda_c^+ \to \Lambda\pi^+$	1.3 ± 0.07	1.3 ± 0.07 [6]	1.32 ± 0.34 [7]	1.30 ± 0.17 [8]	1.307 ± 0.069
$\Lambda_c^+ \to \Sigma^0\pi^+$	1.29 ± 0.07	1.27 ± 0.06 [6]	1.26 ± 0.32 [7]	1.27 ± 0.17 [8]	1.272 ± 0.056
$\Lambda_c^+ \to \Sigma^+\pi^0$	1.25 ± 0.10	1.27 ± 0.06 [6]	1.23 ± 0.17 [7]	1.27 ± 0.17 [8]	1.283 ± 0.057
$\Lambda_c^+ \to \Xi^0 K^+$	0.55 ± 0.07	0.56 ± 0.09 [6]	0.59 ± 0.17 [7]	0.50 ± 0.12 [8]	0.548 ± 0.068
$\Lambda_c^+ \to \Lambda K^+$	0.061 ± 0.012	0.065 ± 0.010 [6]	0.059 ± 0.017 [7]	—	0.064 ± 0.010
$\Lambda_c^+ \to \Sigma^+\eta$	0.44 ± 0.20	0.32 ± 0.31 [6]	0.47 ± 0.22 [7]	—	0.45 ± 0.19
$\Lambda_c^+ \to \Sigma^+\eta'$	1.5 ± 0.60	1.44 ± 0.56 [6]	0.93 ± 0.28 [7]	—	1.5 ± 0.60
$\Lambda_c^+ \to \Sigma^0 K^+$	0.052 ± 0.008	0.054 ± 0.007 [6]	0.055 ± 0.016 [7]	—	0.0504 ± 0.0056
$\Xi_c^+ \to \Xi^0\pi^+$	1.6 ± 0.8	3.8 ± 2.0 [6]	0.93 ± 0.36 [7]	$0.01 \sim 10.22$ [8]	0.54 ± 0.18
$\Xi_c^0 \to \Lambda K_S^0$	0.334 ± 0.067	5.25 ± 0.3 [6]	4.15 ± 2.5 [7]	0.47 ± 0.08 [8]	0.334 ± 0.065
$\Xi_c^0 \to \Xi^-\pi^+$	1.43 ± 0.32	2.21 ± 0.14 [6]	0.37 ± 0.22 [7]	2.24 ± 0.34 [8]	1.21 ± 0.21
$\Xi_c^0 \to \Xi^- K^+$	0.039 ± 0.012	0.098 ± 0.006 [6]	0.056 ± 0.008 [7]	—	0.047 ± 0.0083
$\Xi_c^0 \to \Sigma^0 K_S^0$	0.069 ± 0.024	0.4 ± 0.4 [6]	3.95 ± 2.4 [7]	0.23 ± 0.07 [8]	0.069 ± 0.024
$\Xi_c^0 \to \Sigma^+ K^-$	0.221 ± 0.068	5.9 ± 1.1 [6]	22.0 ± 5.7 [7]	3.1 ± 0.9 [8]	0.221 ± 0.068
channel	asymmetry parameter α				
	Experimental data	SU(3) symmetry analysis			Our work
$\alpha(\Lambda_c^+ \to pK_S^0)$	0.18 ± 0.45	—	—	—	0.19 ± 0.41
$\alpha(\Lambda_c^+ \to \Lambda\pi^+)$	-0.84 ± 0.09	-0.87 ± 0.10 [6]	—	—	-0.841 ± 0.083
$\alpha(\Lambda_c^+ \to \Sigma^0\pi^+)$	-0.73 ± 0.18	-0.35 ± 0.27 [6]	—	—	-0.605 ± 0.088
$\alpha(\Lambda_c^+ \to \Sigma^+\pi^0)$	-0.55 ± 0.11	-0.35 ± 0.27 [6]	—	—	-0.603 ± 0.088
$\alpha(\Xi_c^0 \to \Xi^-\pi^+)$	-0.6 ± 0.4	$-0.98^{+0.07}_{-0.02}$ [6]	—	—	-0.56 ± 0.32
$\chi^2/d.o.f.$	—	—	—	—	0.744

$$
\begin{aligned}
\mathcal{M} = {} & a_{15}(T_{c\bar{3}})_i(H_{\overline{15}})_j^{\{ik\}}(\overline{T_8})_k^j P_l^l + b_{15}(T_{c\bar{3}})_i(H_{\overline{15}})_j^{\{ik\}}(\overline{T_8})_k^l P_l^j \\
& + c_{15}(T_{c\bar{3}})_i(H_{\overline{15}})_j^{\{ik\}}(\overline{T_8})_l^j P_k^l + d_{15}(T_{c\bar{3}})_i(H_{\overline{15}})_l^{\{jk\}}(\overline{T_8})_j^l P_k^i \\
& + e_{15}(T_{c\bar{3}})_i(H_{\overline{15}})_l^{\{jk\}}(\overline{T_8})_j^i P_k^l + a_6(T_{c\bar{3}})^{[ik]}(H_{\bar{6}})_{\{ij\}}(\overline{T_8})_k^j P_l^l \\
& + b_6(T_{c\bar{3}})^{[ik]}(H_{\bar{6}})_{\{ij\}}(\overline{T_8})_k^l P_l^j + c_6(T_{c\bar{3}})^{[ik]}(H_{\bar{6}})_{\{ij\}}(\overline{T_8})_l^j P_k^l \\
& + d_6(T_{c\bar{3}})^{[kl]}(H_{\bar{6}})_{\{ij\}}(\overline{T_8})_k^i P_l^j .
\end{aligned}
$$

18 form factors

$$
\begin{aligned}
q_6 &= G_F \bar{u}(f_6^q - g_6^q\gamma_5)u, \qquad q = a, b, c, d, \\
q_{15} &= G_F \bar{u}(f_{15}^q - g_{15}^q\gamma_5)u, \quad q = a, b, c, d, e,
\end{aligned}
$$

JHEP 03 (2022) 143

Introduction

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The charmed baryon two body decays

The global analysis

21 experiment data

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$\chi^2/d.o.f.$	—	—	—	—	0.744

parameters	Our work	
	scalar (f)	pseudoscalar (g)
b_6	-0.111 ± 0.0093	0.142 ± 0.026
c_6	-0.010 ± 0.018	-0.106 ± 0.078
d_6	-0.042 ± 0.015	0.02 ± 0.12
b_{15}	0.0448 ± 0.0091	-0.021 ± 0.019
c_{15}	0.063 ± 0.018	0.140 ± 0.052
d_{15}	-0.018 ± 0.014	-0.11 ± 0.12
e_{15}	0.0382 ± 0.0044	0.185 ± 0.024
a	0.121 ± 0.064	0.22 ± 0.77
a'	—	—
χ^2/d.o.f.	0.744	

$$a = a_6 - a_{15}, \quad a' = a_6 + a_{15}.$$

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The charmed baryon two body decays

The global analysis

$\Xi_c^0 \to \Xi^0 \eta$	$\cos\phi(2a_6+2a_{15}+b_6+b_{15}-d_6+d_{15})/\sqrt{2}-\sin\phi(a_6+a_{15}+c_6+c_{15})$	—	—
$\Xi_c^0 \to \Xi^0 \eta'$	$\sin\phi(2a_6+2a_{15}+b_6+b_{15}-d_6+d_{15})/\sqrt{2}+\cos\phi(a_6+a_{15}+c_6+c_{15})$	—	—
$\Xi_c^0 \to \Sigma^0 \eta$	$\sin\theta(\ cos\phi\,(2a_6+2a_{15}+b_6+b_{15}+c_6+c_{15}+d_{15}-e_{15})\,/2$ $-\sin\phi\,(a_6+a_{15}-d_6+e_{15})\,/\sqrt{2})$	—	—
$\Xi_c^0 \to \Sigma^0 \eta'$	$\sin\theta(\sin\phi\,(2a_6+2a_{15}+b_6+b_{15}+c_6+c_{15}+d_{15}-e_{15})\,/2$ $-\cos\phi\,(a_6+a_{15}-d_6+e_{15})\,/\sqrt{2})$	—	—
$\Xi_c^0 \to \Lambda \eta$	$\sin\theta(-\cos\phi\,(6a_6+6a_{15}+b_6+b_{15}+c_6+c_{15}-2d_6+3d_{15}+e_{15})\,/(2\sqrt{3})$ $-\sin\phi\,(-3a_6-3a_{15}-2b_6-2b_{15}-2c_6-2c_{15}+d_6+e_{15})\,/\sqrt{6})$	—	—
$\Xi_c^0 \to \Lambda \eta'$	$\sin\theta(-\sin\phi\,(6a_6+6a_{15}+b_6+b_{15}+c_6+c_{15}-2d_6+3d_{15}+e_{15})\,/(2\sqrt{3})$ $+\cos\phi\,(-3a_6-3a_{15}-2b_6-2b_{15}-2c_6-2c_{15}+d_6+e_{15})\,/\sqrt{6})$	—	—
$\Xi_c^0 \to n \eta$	$\sin^2\theta(\cos\phi\,(2a_6+2a_{15}+c_6+c_{15}+d_{15})\,/\sqrt{2}$ $-\sin\phi\,(a_6+a_{15}+b_6+b_{15}-d_6)\,)$	—	—
$\Xi_c^0 \to n \eta$	$\sin^2\theta(\sin\phi\,(2a_6+2a_{15}+c_6+c_{15}+d_{15})\,/\sqrt{2}$ $+\cos\phi\,(a_6+a_{15}+b_6+b_{15}-d_6)\,)$	—	—

parameters	Our work	
	scalar (f)	pseudoscalar (g)
b_6	-0.111 ± 0.0093	0.142 ± 0.026
c_6	-0.010 ± 0.018	-0.106 ± 0.078
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b_{15}	0.0448 ± 0.0091	-0.021 ± 0.019
c_{15}	0.063 ± 0.018	0.140 ± 0.052
d_{15}	-0.018 ± 0.014	-0.11 ± 0.12
e_{15}	0.0382 ± 0.0044	0.185 ± 0.024
a	0.121 ± 0.064	0.22 ± 0.77
a'	—	—
χ^2/d.o.f.	0.744	

The parameter a' can not be determined

$$a = a_6 - a_{15}, \quad a' = a_6 + a_{15}.$$

The charmed baryon two body decays

The global analysis

Strong predictive power

We predict 87 observables in 49 decays, using only 16 input form factors.

Very good symmetry

Very low chi^2 /degree of freedom

The SU(3) symmetry is a very powful tool in charmed baryon two body decays

The charmed baryon two body decays

Experiment data in 2022

Channel	Lastest measurement in 2022(%)
$\Lambda_c^+ \to p\eta'$	$0.0562^{+0.0246}_{-0.0204} \pm 0.0026$[30]
	$0.0473 \pm 0.0082 \pm 0.0046 \pm 0.0024$[34]
$\Lambda_c^+ \to \Lambda\pi^+$	$1.31 \pm 0.08 \pm 0.05$[33]
$\Lambda_c^+ \to \Sigma^0\pi^+$	$1.22 \pm 0.08 \pm 0.07$[33]
$\Lambda_c^+ \to \Lambda^0 K^+$	$0.0621 \pm 0.0044 \pm 0.0026 \pm 0.0034$[31]
	$0.0657 \pm 0.0017 \pm 0.0011 \pm 0.0035$[35]
$\Lambda_c^+ \to \Sigma^+\eta$	$0.416 \pm 0.075 \pm 0.021 \pm 0.033$[36]
$\Lambda_c^+ \to \Sigma^+\eta'$	$0.314 \pm 0.035 \pm 0.011 \pm 0.025$[36]
$\Lambda_c^+ \to \Sigma^0 K^+$	$0.047 \pm 0.009 \pm 0.001 \pm 0.003$[32]
	$0.0358 \pm 0.0019 \pm 0.0006 \pm 0.0019$[35]
$\Lambda_c^+ \to n\pi^+$	$0.066 \pm 0.012 \pm 0.004$[33]
$\Lambda_c^+ \to \Sigma^+ K_s^0$	$0.048 \pm 0.014 \pm 0.002 \pm 0.003$[32]
$\alpha(\Lambda_c^+ \to pK_S^0)$	–
$\alpha(\Lambda_c^+ \to \Lambda\pi^+)$	$-0.755 \pm 0.005 \pm 0.003$[35]
$\alpha(\Lambda_c^+ \to \Sigma^0\pi^+)$	$-0.463 \pm 0.016 \pm 0.008$[35]
$\alpha(\Lambda_c^+ \to \Sigma^+\pi^0)$	$-0.48 \pm 0.02 \pm 0.02$[36]
$\alpha(\Xi_c^0 \to \Xi^-\pi^+)$	–
$\alpha(\Lambda_c^+ \to \Sigma^0 K^+)$	$-0.54 \pm 0.18 \pm 0.09$[35]
$\alpha(\Lambda_c^+ \to \Lambda K^+)$	$-0.585 \pm 0.049 \pm 0.018$[35]
$\alpha(\Lambda_c^+ \to \Sigma^+\eta)$	$-0.99 \pm 0.03 \pm 0.05$[36]
$\alpha(\Lambda_c^+ \to \Sigma^+\eta')$	$-0.46 \pm 0.06 \pm 0.03$[36]

Totaly 28 experiment data

- **More data to test the SU(3) symmetry.**
- **Stronger constrain for SU(3) parameter.**
- **A good chance to study the undetermined parameters.**

BESIII~[30,31,32,33]
Belle~[34,35,36]

- Introduction
- SU(3) symmetry
- Global analysis
- Analysis of undetermined SU(3) parameter

The SU(3) symmetry in charm baryon two body decays

The decay of anti-triplet charmed baryons to an octet baryon and an octet or singlet pseudoscalar meson.

$$\langle P, T_8 | i\mathcal{H} | T_{c\bar{3}} \rangle$$

$$T_{8ijk} = \epsilon_{ijm} T_{8k}^{m}$$

$$P = \begin{pmatrix} \frac{\pi^0+\eta_q}{\sqrt{2}} & \pi^+ & K^+ \\ \pi^- & \frac{-\pi^0+\eta_q}{\sqrt{2}} & K^0 \\ K^- & \bar{K}^0 & \eta_s \end{pmatrix} \quad T_8 = \begin{pmatrix} \frac{\Sigma^0}{\sqrt{2}} + \frac{\Lambda}{\sqrt{6}} & \Sigma^+ & p \\ \Sigma^- & -\frac{\Sigma^0}{\sqrt{2}} + \frac{\Lambda}{\sqrt{6}} & n \\ \Xi^- & \Xi^0 & -\frac{2\Lambda}{\sqrt{6}} \end{pmatrix} \quad T_{c\bar{3}} = \begin{pmatrix} 0 & \Lambda_c^+ & \Xi_c^+ \\ -\Lambda_c^+ & 0 & \Xi_c^0 \\ -\Xi_c^+ & -\Xi_c^0 & 0 \end{pmatrix}$$

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The SU(3) symmetry in charm baryon two body decays

$$\mathcal{H}_{\text{eff}} = \sum_{i=1,2} \frac{G_F}{\sqrt{2}} C_i (V_{cs} V_{ud}^* O_i^{s\bar{d}u} + V_{cq} V_{uq}^* O_i^{q\bar{q}u} + V_{cd} V_{us}^* O_i^{d\bar{s}u}) + \text{h.c.}, \quad q = s, d,$$

$$O_1^{q_1 q_2 \bar{q}_3} = (\bar{q}_{1\alpha} c_\beta)_{V-A} (\bar{q}_{3\beta} q_{2\alpha})_{V-A}, \quad O_2^{q_1 q_2 \bar{q}_3} = (\bar{q}_{1\alpha} c_\alpha)_{V-A} (\bar{q}_{3\beta} q_{2\beta})_{V-A}$$

IRA or TDA method?

TDA Hamiltonian

Hamiltonian H_k^{ij} with $i = \bar{s}, \quad j = \bar{u}$ and $k = q$

SU(3) decompositions in IRA

$$(H_{\bar{6}})_2^{31} = -(H_{\bar{6}})_2^{13} = 1, \quad (H_{15})_2^{31} = (H_{15})_2^{13} = 1,$$
$$(H_{15})_3^{31} = (H_{15})_3^{13} = -(H_{15})_2^{21} = -(H_{15})_2^{12} = \sin\theta,$$
$$(H_{\bar{6}})_3^{31} = -(H_{\bar{6}})_3^{13} = (H_{\bar{6}})_2^{12} = -(H_{\bar{6}})_2^{21} = \sin\theta,$$
$$(H_{\bar{6}})_3^{21} = -(H_{\bar{6}})_3^{12} = (H_{15})_3^{21} = (H_{15})_3^{12} = \sin^2\theta,$$

with the assumption: $V_{ud} \approx V_{cs} \approx 1$ and $V_{cd} \approx -V_{us} \approx -\sin\theta \approx 0.2265.$

Eur. Phys. J. C 80, no.5, 359 (2020)

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The SU(3) symmetry in charm baryon two body decays

$$
\begin{aligned}
\mathcal{A}_u^{TDA} = &\bar{a}_1 T_{c\bar{3}}^{[ij]} H_m^{kl} (\overline{T}_8)_{ijk} P_l^m + \bar{a}_2 T_{c\bar{3}}^{[ij]} H_m^{kl} (\overline{T}_8)_{ijl} P_k^m \\
&+\bar{a}_3 T_{c\bar{3}}^{[ij]} H_i^{kl} (\overline{T}_8)_{jkl} P_m^m \\
&+\bar{a}_4 T_{c\bar{3}}^{[ij]} H_i^{kl} (\overline{T}_8)_{jkm} P_l^m \\
&+\bar{a}_5 T_{c\bar{3}}^{[ij]} H_i^{kl} (\overline{T}_8)_{jlk} P_m^m + \bar{a}_6 T_{c\bar{3}}^{[ij]} H_i^{kl} (\overline{T}_8)_{jmk} P_l^m \\
&+\bar{a}_7 T_{c\bar{3}}^{[ij]} H_i^{kl} (\overline{T}_8)_{ilm} P_k^m + \bar{a}_8 T_{c\bar{3}}^{[ij]} H_i^{kl} (\overline{T}_8)_{jml} P_k^m \\
&+\bar{a}_9 T_{c\bar{3}}^{[ij]} H_i^{kl} (\overline{T}_8)_{klj} P_m^m + \bar{a}_{10} T_{c\bar{3}}^{[ij]} H_i^{kl} (\overline{T}_8)_{kmj} P_l^m \\
&+\bar{a}_{11} T_{c\bar{3}}^{[ij]} H_i^{kl} (\overline{T}_8)_{lmj} P_k^m + \bar{a}_{12} T_{c\bar{3}}^{[ij]} H_i^{kl} (\overline{T}_8)_{klm} P_j^m \\
&+\bar{a}_{13} T_{c\bar{3}}^{[ij]} H_i^{kl} (\overline{T}_8)_{kml} P_j^m + \bar{a}_{14} T_{c\bar{3}}^{[ij]} H_i^{kl} (\overline{T}_8)_{lmk} P_j^m \\
&+\bar{a}_{15} T_{c\bar{3}}^{[ij]} H_m^{kl} (\overline{T}_8)_{ikj} P_l^m + \bar{a}_{16} T_{c\bar{3}}^{[ij]} H_m^{kl} (\overline{T}_8)_{ilj} P_m^k \\
&+\bar{a}_{17} T_{c\bar{3}}^{[ij]} H_m^{kl} (\overline{T}_8)_{ikl} P_j^m + \bar{a}_{18} T_{c\bar{3}}^{[ij]} H_m^{kl} (\overline{T}_8)_{ilk} P_j^m \\
&+\bar{a}_{19} T_{c\bar{3}}^{[ij]} H_m^{kl} (\overline{T}_8)_{klj} P_i^m .
\end{aligned}
$$

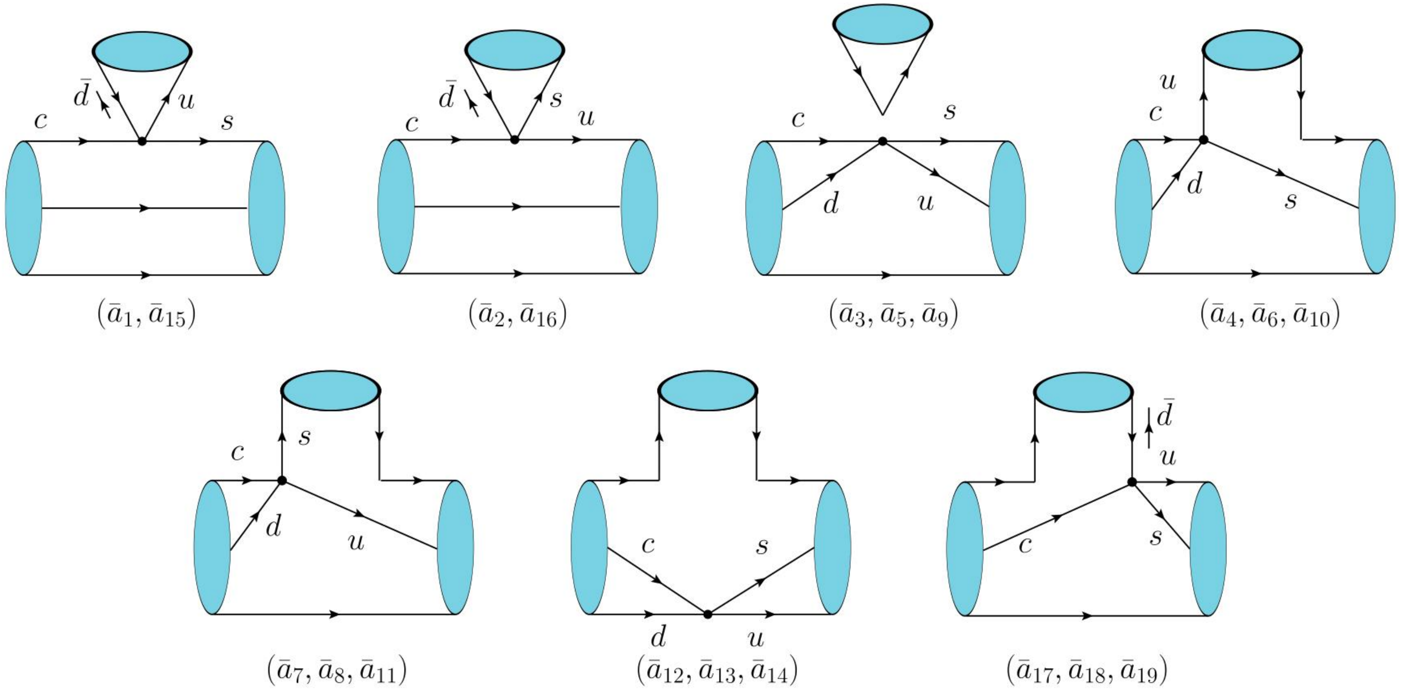
$$
\begin{aligned}
\mathcal{A}_u^{IRA} = &A_6^T (T_{c\bar{3}})_i (H_6)_j^{[ik]} (\overline{T}_8)_k^j P_l^l \\
&+B_6^T (T_{c\bar{3}})_i (H_6)_j^{[ik]} (\overline{T}_8)_k^l P_l^j \\
&+C_6^T (T_{c\bar{3}})_i (H_6)_j^{[ik]} (\overline{T}_8)_l^j P_k^l \\
&+E_6^T (T_{c\bar{3}})_i (H_6)_l^{[jk]} (\overline{T}_8)_j^i P_k^l \\
&+D_6^T (T_{c\bar{3}})_i (H_6)_l^{[jk]} (\overline{T}_8)_j^l P_k^i \\
&+A_{15}^T (T_{c\bar{3}})_i (H_{\overline{15}})_j^{\{ik\}} (\overline{T}_8)_k^j P_l^l \\
&+B_{15}^T (T_{c\bar{3}})_i (H_{\overline{15}})_j^{\{ik\}} (\overline{T}_8)_k^l P_l^j \\
&+C_{15}^T (T_{c\bar{3}})_i (H_{\overline{15}})_j^{\{ik\}} (\overline{T}_8)_l^j P_k^l \\
&+E_{15}^T (T_{c\bar{3}})_i (H_{\overline{15}})_l^{\{jk\}} (\overline{T}_8)_j^i P_k^l \\
&+D_{15}^T (T_{c\bar{3}})_i (H_{\overline{15}})_l^{\{ik\}} (\overline{T}_8)_j^l P_k^i .
\end{aligned}
$$

IRA or TDA method?

Eur. Phys. J. C 80, no.5, 359 (2020)

The SU(3) symmetry in charm baryon two body decays

$$
\begin{aligned}
\mathcal{A}_u^{TDA} = & \bar{a}_1 T_{c\bar{3}}^{[ij]} H_m^{kl} (\overline{T}_8)_{ijk} P_l^m + \bar{a}_2 T_{c\bar{3}}^{[ij]} H_m^{kl} (\overline{T}_8)_{ijl} P_k^m \\
& + \bar{a}_3 T_{c\bar{3}}^{[ij]} H_i^{kl} (\overline{T}_8)_{jkl} P_m^m \\
& + \bar{a}_4 T_{c\bar{3}}^{[ij]} H_i^{kl} (\overline{T}_8)_{jkm} P_l^m \\
& + \bar{a}_5 T_{c\bar{3}}^{[ij]} H_i^{kl} (\overline{T}_8)_{jlk} P_m^m + \bar{a}_6 T_{c\bar{3}}^{[ij]} H_i^{kl} (\overline{T}_8)_{jmk} P_l^m \\
& + \bar{a}_7 T_{c\bar{3}}^{[ij]} H_i^{kl} (\overline{T}_8)_{ilm} P_k^m + \bar{a}_8 T_{c\bar{3}}^{[ij]} H_i^{kl} (\overline{T}_8)_{jml} P_k^m \\
& + \bar{a}_9 T_{c\bar{3}}^{[ij]} H_i^{kl} (\overline{T}_8)_{klj} P_m^m + \bar{a}_{10} T_{c\bar{3}}^{[ij]} H_i^{kl} (\overline{T}_8)_{kmj} P_l^m \\
& + \bar{a}_{11} T_{c\bar{3}}^{[ij]} H_i^{kl} (\overline{T}_8)_{lmj} P_k^m + \bar{a}_{12} T_{c\bar{3}}^{[ij]} H_i^{kl} (\overline{T}_8)_{klm} P_j^m \\
& + \bar{a}_{13} T_{c\bar{3}}^{[ij]} H_i^{kl} (\overline{T}_8)_{kml} P_j^m + \bar{a}_{14} T_{c\bar{3}}^{[ij]} H_i^{kl} (\overline{T}_8)_{lmk} P_j^m \\
& + \bar{a}_{15} T_{c\bar{3}}^{[ij]} H_m^{kl} (\overline{T}_8)_{ikj} P_l^m + \bar{a}_{16} T_{c\bar{3}}^{[ij]} H_m^{kl} (\overline{T}_8)_{ilj} P_m^k \\
& + \bar{a}_{17} T_{c\bar{3}}^{[ij]} H_m^{kl} (\overline{T}_8)_{ikl} P_j^m + \bar{a}_{18} T_{c\bar{3}}^{[ij]} H_m^{kl} (\overline{T}_8)_{ilk} P_j^m \\
& + \bar{a}_{19} T_{c\bar{3}}^{[ij]} H_m^{kl} (\overline{T}_8)_{klj} P_i^m .
\end{aligned}
$$



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The SU(3) symmetry in charm baryon two body decays

$$
\begin{aligned}
\mathcal{A}_u^{TDA} = & \bar a_1 T_{c\bar3}^{[ij]} H^{kl}_m (\overline{T}_8)_{ijk} P^m_l + \bar a_2 T_{c\bar3}^{[ij]} H^{kl}_m (\overline{T}_8)_{ijl} P^m_k \\
& + \bar a_3 T_{c\bar3}^{[ij]} H^{kl}_i (\overline{T}_8)_{jkl} P^m_m \\
& + \bar a_4 T_{c\bar3}^{[ij]} H^{kl}_i (\overline{T}_8)_{jkm} P^m_l \\
& + \bar a_5 T_{c\bar3}^{[ij]} H^{kl}_i (\overline{T}_8)_{jlk} P^m_m + \bar a_6 T_{c\bar3}^{[ij]} H^{kl}_i (\overline{T}_8)_{jmk} P^m_l \\
& + \bar a_7 T_{c\bar3}^{[ij]} H^{kl}_i (\overline{T}_8)_{ilm} P^m_k + \bar a_8 T_{c\bar3}^{[ij]} H^{kl}_i (\overline{T}_8)_{jml} P^m_k \\
& + \bar a_9 T_{c\bar3}^{[ij]} H^{kl}_i (\overline{T}_8)_{klj} P^m_m + \bar a_{10} T_{c\bar3}^{[ij]} H^{kl}_i (\overline{T}_8)_{kmj} P^m_l \\
& + \bar a_{11} T_{c\bar3}^{[ij]} H^{kl}_i (\overline{T}_8)_{lmj} P^m_k + \bar a_{12} T_{c\bar3}^{[ij]} H^{kl}_i (\overline{T}_8)_{klm} P^m_j \\
& + \bar a_{13} T_{c\bar3}^{[ij]} H^{kl}_i (\overline{T}_8)_{kml} P^m_j + \bar a_{14} T_{c\bar3}^{[ij]} H^{kl}_i (\overline{T}_8)_{lmk} P^m_j \\
& + \bar a_{15} T_{c\bar3}^{[ij]} H^{kl}_m (\overline{T}_8)_{ikj} P^m_l + \bar a_{16} T_{c\bar3}^{[ij]} H^{kl}_m (\overline{T}_8)_{ilj} P^k_m \\
& + \bar a_{17} T_{c\bar3}^{[ij]} H^{kl}_m (\overline{T}_8)_{ikl} P^m_j + \bar a_{18} T_{c\bar3}^{[ij]} H^{kl}_m (\overline{T}_8)_{ilk} P^m_j \\
& + \bar a_{19} T_{c\bar3}^{[ij]} H^{kl}_m (\overline{T}_8)_{klj} P^m_i .
\end{aligned}
$$

relations between IRA and TDA

$$
\begin{aligned}
A_6^T &= \frac{1}{2}(\bar a_3 - \bar a_5 - 2\bar a_9 - \bar a_{13} + \bar a_{14}), \\
B_6^T &= \frac{1}{2}(\bar a_{13} - \bar a_{14} - \bar a_{17} + \bar a_{18} - 2\bar a_{19}), \\
C_6^T &= \frac{1}{2}(\bar a_4 - \bar a_7 - \bar a_{10} + \bar a_{11} - 2\bar a_{12}), \\
D_6^T &= \frac{1}{2}(\bar a_6 - \bar a_8 + \bar a_{10} - \bar a_{11} - \bar a_{13} + \bar a_{14}), \\
E_6^T &= \frac{1}{2}(2\bar a_1 - 2\bar a_2 - \bar a_6 + \bar a_8 - \bar a_{10} + \bar a_{11} + \bar a_{13} \\
&\quad - \bar a_{14} + \bar a_{15} - \bar a_{16} - \bar a_{17} + \bar a_{18} - 2\bar a_{19}), \\
A_{15}^T &= \frac{1}{2}(\bar a_3 + \bar a_5 - \bar a_{13} - \bar a_{14}), \\
B_{15}^T &= \frac{1}{2}(\bar a_{13} + \bar a_{14} - \bar a_{17} - \bar a_{18}), \\
C_{15}^T &= \frac{1}{2}(\bar a_4 + \bar a_7 - \bar a_{10} - \bar a_{11}), \\
D_{15}^T &= \frac{1}{2}(\bar a_6 + \bar a_8 + \bar a_{10} + \bar a_{11} + \bar a_{13} + \bar a_{14}), \\
E_{15}^T &= \frac{1}{2}(2\bar a_1 + 2\bar a_2 - \bar a_6 - \bar a_8 - \bar a_{10} - \bar a_{11} \\
&\quad - \bar a_{13} - \bar a_{14} + \bar a_{15} + \bar a_{16} + \bar a_{17} + \bar a_{18}).
\end{aligned}
$$

$$
\begin{aligned}
\mathcal{A}_u^{IRA} = & A_6^T (T_{c\bar3})_i (H_6)^{[ik]}_j (\overline{T}_8)^j_k P^l_l \\
& + B_6^T (T_{c\bar3})_i (H_6)^{[ik]}_j (\overline{T}_8)^l_k P^j_l \\
& + C_6^T (T_{c\bar3})_i (H_6)^{[ik]}_j (\overline{T}_8)^j_l P^l_k \\
& + E_6^T (T_{c\bar3})_i (H_6)^{[jk]}_l (\overline{T}_8)^i_j P^l_k \\
& + D_6^T (T_{c\bar3})_i (H_6)^{[jk]}_l (\overline{T}_8)^l_j P^i_k \\
& + A_{15}^T (T_{c\bar3})_i (H_{\overline{15}})^{\{ik\}}_j (\overline{T}_8)^j_k P^l_l \\
& + B_{15}^T (T_{c\bar3})_i (H_{\overline{15}})^{\{ik\}}_j (\overline{T}_8)^l_k P^j_l \\
& + C_{15}^T (T_{c\bar3})_i (H_{\overline{15}})^{\{ik\}}_j (\overline{T}_8)^j_l P^l_k \\
& + E_{15}^T (T_{c\bar3})_i (H_{\overline{15}})^{\{jk\}}_l (\overline{T}_8)^i_j P^l_k \\
& + D_{15}^T (T_{c\bar3})_i (H_{\overline{15}})^{\{ik\}}_l (\overline{T}_8)^l_j P^i_k .
\end{aligned}
$$

Eur. Phys. J. C 80, no.5, 359 (2020)

SU(3) symmetry

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The SU(3) symmetry in charm baryon two body decays

Find a consistent description in both TDA and IRA approaches.

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THE EUROPEAN PHYSICAL JOURNAL C

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Regular Article - Theoretical Physics

Unification of flavor SU(3) analyses of heavy Hadron weak decays

Xiao-Gang He[1,2,3,4,a], **Yu-Ji Shi**[1,b], **Wei Wang**[1,c]

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[3] Department of Physics, National Taiwan University, Taipei 106, Taiwan
[4] National Center for Theoretical Sciences, Hsinchu 300, Taiwan

Pointed out though the TDA approach is very intuitive, it suffers the difficulty in providing the independent amplitudes. On this point, the IRA approach is more helpful.

The IRA is suitable for global analysis

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- Introduction
- SU(3) symmetry
- **Global analysis**
- Analysis of undetermined SU(3) parameter

The globe fit of antitriplet charm baryon two body decays

$$
\begin{aligned}
\mathcal{M} = \quad & a_{15} \times (T_{c\bar{3}})_i (H_{\overline{15}})^{\{ik\}}_j (\overline{T_8})^j_k P^l_l \\
+ \; & b_{15} \times (T_{c\bar{3}})_i (H_{\overline{15}})^{\{ik\}}_j (\overline{T_8})^l_k P^j_l \\
+ \; & c_{15} \times (T_{c\bar{3}})_i (H_{\overline{15}})^{\{ik\}}_j (\overline{T_8})^j_l P^l_k \\
+ \; & d_{15} \times (T_{c\bar{3}})_i (H_{\overline{15}})^{\{jk\}}_l (\overline{T_8})^l_j P^i_k \\
+ \; & e_{15} \times (T_{c\bar{3}})_i (H_{\overline{15}})^{\{jk\}}_l (\overline{T_8})^i_j P^l_k \\
+ \; & a_6 \times (T_{c\bar{3}})^{[ik]} (H_{\overline{6}})_{\{ij\}} (\overline{T_8})^j_k P^l_l \\
+ \; & b_6 \times (T_{c\bar{3}})^{[ik]} (H_{\overline{6}})_{\{ij\}} (\overline{T_8})^l_k P^j_l \\
+ \; & c_6 \times (T_{c\bar{3}})^{[kl]} (H_{\overline{6}})_{\{ij\}} (\overline{T_8})^j_l P^l_k \\
+ \; & d_6 \times (T_{c\bar{3}})^{[ik]} (H_{\overline{6}})_{\{ij\}} (\overline{T_8})^i_k P^j_l .
\end{aligned}
$$

$\Lambda_c^+ \to \Sigma^0 \pi^+$	$(-b_6 + b_{15} + c_6 - c_{15} + d_6)/\sqrt{2}$
$\Lambda_c^+ \to \Lambda \pi^+$	$-(b_6 - b_{15} + c_6 - c_{15} + d_6 + 2e_{15})/\sqrt{6}$
$\Lambda_c^+ \to \Sigma^+ \pi^0$	$(b_6 - b_{15} - c_6 + c_{15} - d_6)/\sqrt{2}$
$\Lambda_c^+ \to p K_S^0$	$(\sin^2\theta\,(-d_6 + d_{15} + e_{15}) + b_6 - b_{15} - e_{15})/\sqrt{2}$
$\Lambda_c^+ \to \Xi^0 K^+$	$-c_6 + c_{15} + d_{15}$
$\Xi_c^+ \to \Sigma^+ K_S^0$	$(\sin^2\theta\,(b_6 - b_{15} - e_{15}) - d_6 + d_{15} + e_{15})/\sqrt{2}$
$\Xi_c^+ \to \Xi^0 \pi^+$	$-d_6 - d_{15} - e_{15}$
$\Xi_c^0 \to \Sigma^0 K_S^0$	$(-\sin^2\theta\,(b_6 + b_{15} - e_{15}) + (c_6 + c_{15} + d_6 - e_{15}))/2$
$\Xi_c^0 \to \Lambda K_S^0$	$\sqrt{3}\sin^2\theta\,(b_6 + b_{15} - 2c_6 - 2c_{15} - 2d_6 + e_{15})/6$ $+\sqrt{3}(2b_6 + 2b_{15} - c_6 - c_{15} - d_6 - e_{15})/6$
$\Xi_c^0 \to \Sigma^+ K^-$	$c_6 + c_{15} + d_{15}$
$\Xi_c^0 \to \Xi^- \pi^+$	$b_6 + b_{15} + e_{15}$
$\Xi_c^0 \to \Xi^0 \pi^0$	$(-b_6 - b_{15} + d_6 + d_{15})/\sqrt{2}$

The globe fit of antitriplet charm baryon two body decays

$$
\begin{aligned}
\mathcal{M} = \quad & a_{15} \times (T_{c\bar{3}})_i (H_{\overline{15}})^{\{ik\}}_j (\overline{T_8})^j_k P^l_l \\
+ \; & b_{15} \times (T_{c\bar{3}})_i (H_{\overline{15}})^{\{ik\}}_j (\overline{T_8})^l_k P^j_l \\
+ \; & c_{15} \times (T_{c\bar{3}})_i (H_{\overline{15}})^{\{ik\}}_j (\overline{T_8})^j_l P^l_k \\
+ \; & d_{15} \times (T_{c\bar{3}})_i (H_{\overline{15}})^{\{jk\}}_l (\overline{T_8})^l_j P^i_k \\
+ \; & e_{15} \times (T_{c\bar{3}})_i (H_{\overline{15}})^{\{jk\}}_l (\overline{T_8})^i_j P^l_k \\
+ \; & a_6 \times (T_{c\bar{3}})^{[ik]} (H_{\overline{6}})_{\{ij\}} (\overline{T_8})^j_k P^l_l \\
+ \; & b_6 \times (T_{c\bar{3}})^{[ik]} (H_{\overline{6}})_{\{ij\}} (\overline{T_8})^l_k P^j_l \\
+ \; & c_6 \times (T_{c\bar{3}})^{[kl]} (H_{\overline{6}})_{\{ij\}} (\overline{T_8})^j_l P^l_k \\
+ \; & d_6 \times (T_{c\bar{3}})^{[ik]} (H_{\overline{6}})_{\{ij\}} (\overline{T_8})^i_k P^j_l .
\end{aligned}
$$

$\Lambda_c^+ \to \Sigma^0 K^+$	$\sin\theta\,(-b_6 + b_{15} + d_6 + d_{15})\,/\sqrt{2}$
$\Lambda_c^+ \to \Lambda K^+$	$-\sin\theta\,(b_6 - b_{15} - 2c_6 + 2c_{15} + d_6 + 3d_{15} + 2e_{15})\,/\sqrt{6}$
$\Lambda_c^+ \to \Sigma^+ K_S^0/K_L^0$	$\sin\theta\,(-b_6 + b_{15} + d_6 - d_{15})\,/\sqrt{2}$
$\Lambda_c^+ \to p\pi^0$	$\sin\theta\,(-c_6 + c_{15} - d_6 + e_{15})\,/\sqrt{2}$
$\Lambda_c^+ \to n\pi^+$	$-\sin\theta\,(c_6 - c_{15} + d_6 + e_{15})$
$\Xi_c^+ \to \Sigma^0\pi^+$	$-\sin\theta\,(b_6 - b_{15} - c_6 + c_{15} + d_{15} + e_{15})\,/\sqrt{2}$
$\Xi_c^+ \to \Lambda\pi^+$	$\sin\theta\,(-b_6 + b_{15} - c_6 + c_{15} + 2d_6 + 3d_{15} + e_{15})\,/\sqrt{6}$
$\Xi_c^+ \to \Sigma^+\pi^0$	$\sin\theta\,(b_6 - b_{15} - c_6 + c_{15} - d_{15} - e_{15})\,/\sqrt{2}$
$\Xi_c^+ \to pK_S^0/K_L^0$	$\sin\theta\,(-b_6 + b_{15} + d_6 - d_{15})$
$\Xi_c^+ \to \Xi^0 K^+$	$-\sin\theta\,(c_6 - c_{15} + d_6 + e_{15})$
$\Xi_c^0 \to \Sigma^0\pi^0$	$-\frac{1}{2}\sin\theta\,(b_6 + b_{15} + c_6 + c_{15} - d_{15} - e_{15})$
$\Xi_c^0 \to \Lambda\pi^0$	$\sin\theta\,(b_6 + b_{15} + c_6 + c_{15} - 2d_6 - 3d_{15} + e_{15})\,/2\sqrt{3}$
$\Xi_c^0 \to \Sigma^+\pi^-$	$-\sin\theta\,(c_6 + c_{15} + d_{15})$
$\Xi_c^0 \to pK^-$	$\sin\theta\,(c_6 + c_{15} + d_{15})$
$\Xi_c^0 \to \Sigma^-\pi^+$	$-\sin\theta\,(b_6 + b_{15} + e_{15})$
$\Xi_c^0 \to nK_S^0/K_L^0$	$\sin\theta\,(-b_6 - b_{15} + c_6 + c_{15} + d_6)$
$\Xi_c^0 \to \Xi^- K^+$	$\sin\theta\,(b_6 + b_{15} + e_{15})$
$\Xi_c^0 \to \Xi^0 K_S^0/K_L^0$	$\sin\theta\,(b_6 + b_{15} - c_6 - c_{15} - d_6)$

The globe fit of antitriplet charm baryon two body decays

$$
\begin{aligned}
\mathcal{M} = \quad & a_{15} \times (T_{c\bar{3}})_i (H_{\overline{15}})^{\{ik\}}_j (\overline{T_8})^j_k P^l_l \\
+ \; & b_{15} \times (T_{c\bar{3}})_i (H_{\overline{15}})^{\{ik\}}_j (\overline{T_8})^l_k P^j_l \\
+ \; & c_{15} \times (T_{c\bar{3}})_i (H_{\overline{15}})^{\{ik\}}_j (\overline{T_8})^j_l P^l_k \\
+ \; & d_{15} \times (T_{c\bar{3}})_i (H_{\overline{15}})^{\{jk\}}_l (\overline{T_8})^l_j P^i_k \\
+ \; & e_{15} \times (T_{c\bar{3}})_i (H_{\overline{15}})^{\{jk\}}_l (\overline{T_8})^i_j P^l_k \\
+ \; & a_6 \times (T_{c\bar{3}})^{[ik]} (H_{\bar{6}})_{\{ij\}} (\overline{T_8})^j_k P^l_l \\
+ \; & b_6 \times (T_{c\bar{3}})^{[ik]} (H_{\bar{6}})_{\{ij\}} (\overline{T_8})^l_k P^j_l \\
+ \; & c_6 \times (T_{c\bar{3}})^{[kl]} (H_{\bar{6}})_{\{ij\}} (\overline{T_8})^j_l P^l_k \\
+ \; & d_6 \times (T_{c\bar{3}})^{[ik]} (H_{\bar{6}})_{\{ij\}} (\overline{T_8})^i_k P^j_l .
\end{aligned}
$$

$\Lambda_c^+ \to p K_L^0$	$(\sin^2\theta\,(-d_6 + d_{15} + e_{15}) - b_6 + b_{15} + e_{15})/\sqrt{2}$
$\Lambda_c^+ \to n K^+$	$\sin^2\theta\,(d_6 + d_{15} + e_{15})$
$\Xi_c^+ \to \Sigma^0 K^+$	$\sin^2\theta\,(b_6 - b_{15} + e_{15})/\sqrt{2}$
$\Xi_c^+ \to \Lambda K^+$	$\sin^2\theta\,(b_6 - b_{15} - 2c_6 + 2c_{15} - 2d_6 - e_{15})/\sqrt{6}$
$\Xi_c^+ \to \Sigma^+ K_L^0$	$(\sin^2\theta\,(b_6 - b_{15} - e_{15}) + d_6 - d_{15} - e_{15})/\sqrt{2}$
$\Xi_c^+ \to p\pi^0$	$\sin^2\theta\,(c_6 - c_{15} + d_{15})/\sqrt{2}$
$\Xi_c^+ \to n\pi^+$	$\sin^2\theta\,(c_6 - c_{15} - d_{15})$
$\Xi_c^0 \to \Sigma^0 K_L^0$	$(-\sin^2\theta\,(b_6 + b_{15} - e_{15}) - (c_6 + c_{15} + d_6 - e_{15}))/2$
$\Xi_c^0 \to \Lambda K_L^0$	$\sqrt{3}\sin^2\theta\,(b_6 + b_{15} - 2c_6 - 2c_{15} - 2d_6 + e_{15})/6$ $-\sqrt{3}(2b_6 + 2b_{15} - c_6 - c_{15} - d_6 - e_{15})/6$
$\Xi_c^0 \to p\pi^-$	$\sin^2\theta\,(c_6 + c_{15} + d_{15})$
$\Xi_c^0 \to \Sigma^- K^+$	$\sin^2\theta\,(b_6 + b_{15} + e_{15})$
$\Xi_c^0 \to n\pi^0$	$-\sin^2\theta\,(c_6 + c_{15} - d_{15})/\sqrt{2}$

The globe fit of antitriplet charm baryon two body decays

Form factors

$$q_6 = G_F \bar{u}(f_6^q - g_6^q \gamma_5) u, \quad q = a, b, c, d,$$
$$q_{15} = G_F \bar{u}(f_{15}^q - g_{15}^q \gamma_5) u, \quad q = a, b, c, d, e.$$

Assumption: Form factors are real
No CP violation

decay width

$$\frac{d\Gamma}{d\cos\theta_M} = \frac{G_F^2 |\vec{p}_{B_n}|(E_{B_n} + M_{B_n})}{8\pi M_{B_c}} (|F|^2 + \kappa^2 |G|^2) \times (1 + \alpha \hat{\omega}_i \cdot \hat{p}_{B_n}),$$

polarization parameters

$$\alpha = 2\mathrm{Re}(\mathrm{F} * \mathrm{G})\kappa / (|\mathrm{F}|^2 + \kappa^2 |\mathrm{G}|^2)$$
$$\kappa = |\vec{p}_{B_n}| / (E_{B_n} + M_{B_n}).$$

The globe fit of antitriplet charm baryon two body decays

$$
\begin{aligned}
\mathcal{M} = \quad & a_{15} \times (T_{c\bar{3}})_i (H_{\overline{15}})^{\{ik\}}_j (\overline{T_8})^j_k P^l_l \\
+ \; & b_{15} \times (T_{c\bar{3}})_i (H_{\overline{15}})^{\{ik\}}_j (\overline{T_8})^l_k P^j_l \\
+ \; & c_{15} \times (T_{c\bar{3}})_i (H_{\overline{15}})^{\{ik\}}_j (\overline{T_8})^j_l P^l_k \\
+ \; & d_{15} \times (T_{c\bar{3}})_i (H_{\overline{15}})^{\{jk\}}_l (\overline{T_8})^l_j P^i_k \\
+ \; & e_{15} \times (T_{c\bar{3}})_i (H_{\overline{15}})^{\{jk\}}_l (\overline{T_8})^i_j P^l_k \\
+ \; & a_6 \times (T_{c\bar{3}})^{[ik]} (H_{\bar{6}})_{\{ij\}} (\overline{T_8})^j_k P^l_l \\
+ \; & b_6 \times (T_{c\bar{3}})^{[ik]} (H_{\bar{6}})_{\{ij\}} (\overline{T_8})^l_k P^j_l \\
+ \; & c_6 \times (T_{c\bar{3}})^{[kl]} (H_{\bar{6}})_{\{ij\}} (\overline{T_8})^j_l P^l_k \\
+ \; & d_6 \times (T_{c\bar{3}})^{[ik]} (H_{\bar{6}})_{\{ij\}} (\overline{T_8})^i_k P^j_l \,.
\end{aligned}
$$

$$
P = \begin{pmatrix} \frac{\pi^0+\eta_q}{\sqrt{2}} & \pi^+ & K^+ \\ \pi^- & \frac{-\pi^0+\eta_q}{\sqrt{2}} & K^0 \\ K^- & \bar{K}^0 & \eta_s \end{pmatrix}
$$

$\Lambda_c^+ \to \Sigma^+\eta$	$\cos\phi(-2a_6+2a_{15}-b_6+b_{15}-c_6+c_{15}+d_6)/\sqrt{2}-\sin\phi(-a_6+a_{15}+d_{15})$
$\Lambda_c^+ \to \Sigma^+\eta'$	$\sin\phi(-2a_6+2a_{15}-b_6+b_{15}-c_6+c_{15}+d_6)/\sqrt{2}+\cos\phi(-a_6+a_{15}+d_{15})$
$\Lambda_c^+ \to p\eta$	$\sin\theta\big(\cos\phi\,(-2a_6+2a_{15}-c_6+c_{15}+d_6-e_{15})/\sqrt{2}$ $-\sin\phi\,(-a_6+a_{15}-b_6+b_{15}+d_{15}+e_{15})\big)$
$\Lambda_c^+ \to p\eta'$	$\sin\theta\big(\sin\phi\,(-2a_6+2a_{15}-c_6+c_{15}+d_6-e_{15})/\sqrt{2}$ $+\cos\phi\,(-a_6+a_{15}-b_6+b_{15}+d_{15}+e_{15})\big)$
$\Xi_c^+ \to \Sigma^+\eta$	$\sin\theta\big(\cos\phi\,(-2a_6+2a_{15}-b_6+b_{15}-c_6+c_{15}+d_{15}+e_{15})/\sqrt{2}$ $-\sin\phi\,(-a_6+a_{15}+d_6-e_{15})\big)$
$\Xi_c^+ \to \Sigma^+\eta'$	$\sin\theta\big(\sin\phi\,(-2a_6+2a_{15}-b_6+b_{15}-c_6+c_{15}+d_{15}+e_{15})/\sqrt{2}$ $+\cos\phi\,(-a_6+a_{15}+d_6-e_{15})\big)$
$\Xi_c^+ \to p\eta$	$\sin^2\theta\big(\cos\phi\,(2a_6-2a_{15}+c_6-c_{15}-d_{15})/\sqrt{2}$ $-\sin\phi\,(a_6-a_{15}+b_6-b_{15}-d_6)\big)$
$\Xi_c^+ \to p\eta'$	$\sin^2\theta\big(\sin\phi\,(2a_6-2a_{15}+c_6-c_{15}-d_{15})/\sqrt{2}$ $+\cos\phi\,(a_6-a_{15}+b_6-b_{15}-d_6)\big)$
$\Xi_c^0 \to \Xi^0\eta$	$\cos\phi(2a_6+2a_{15}+b_6+b_{15}-d_6+d_{15})/\sqrt{2}-\sin\phi(a_6+a_{15}+c_6+c_{15})$
$\Xi_c^0 \to \Xi^0\eta'$	$\sin\phi(2a_6+2a_{15}+b_6+b_{15}-d_6+d_{15})/\sqrt{2}+\cos\phi(a_6+a_{15}+c_6+c_{15})$
$\Xi_c^0 \to \Sigma^0\eta$	$\sin\theta\big(\cos\phi\,(2a_6+2a_{15}+b_6+b_{15}+c_6+c_{15}+d_{15}-e_{15})/2$ $-\sin\phi\,(a_6+a_{15}-d_6+e_{15})/\sqrt{2}\big)$
$\Xi_c^0 \to \Sigma^0\eta'$	$\sin\theta(\sin\phi\,(2a_6+2a_{15}+b_6+b_{15}+c_6+c_{15}+d_{15}-e_{15})/2$ $-\cos\phi\,(a_6+a_{15}-d_6+e_{15})/\sqrt{2})$
$\Xi_c^0 \to \Lambda\eta$	$\big(-\cos\phi\,(6a_6+6a_{15}+b_6+b_{15}+c_6+c_{15}-2d_6+3d_{15}+e_{15})/(2\sqrt{3})$ $-\sin\phi\,(-3a_6-3a_{15}-2b_6-2b_{15}-2c_6-2c_{15}+d_6+e_{15})/\sqrt{6}\big)\sin\theta$
$\Xi_c^0 \to \Lambda\eta'$	$\big(-\sin\phi\,(6a_6+6a_{15}+b_6+b_{15}+c_6+c_{15}-2d_6+3d_{15}+e_{15})/(2\sqrt{3})$ $+\cos\phi\,(-3a_6-3a_{15}-2b_6-2b_{15}-2c_6-2c_{15}+d_6+e_{15})/\sqrt{6}\big)\sin\theta$
$\Xi_c^0 \to n\eta$	$\sin^2\theta(\cos\phi\,(2a_6+2a_{15}+c_6+c_{15}+d_{15})/\sqrt{2}$ $-\sin\phi\,(a_6+a_{15}+b_6+b_{15}-d_6)\big)$
$\Xi_c^0 \to n\eta'$	$\sin^2\theta(\sin\phi\,(2a_6+2a_{15}+c_6+c_{15}+d_{15})/\sqrt{2}$ $+\cos\phi\,(a_6+a_{15}+b_6+b_{15}-d_6)\big)$

The globe fit of antitriplet charm baryon two body decays

Redefination

$$a = a_6 - a_{15}, \quad a' = a_6 + a_{15},$$
$$f^a = f^a_6 - f^a_{15}, \quad g^a = g^a_6 - g^a_{15},$$
$$f^{a\prime} = f^a_6 + f^a_{15}, \quad g^{a\prime} = g^a_6 + g^a_{15}.$$

The channel depend on a

The channel depend on a'

$\Lambda_c^+ \to \Sigma^+\eta$	$\cos\phi(-2a_6+2a_{15}-b_6+b_{15}-c_6+c_{15}+d_6)/\sqrt{2}-\sin\phi(-a_6+a_{15}+d_{15})$
$\Lambda_c^+ \to \Sigma^+\eta'$	$\sin\phi(-2a_6+2a_{15}-b_6+b_{15}-c_6+c_{15}+d_6)/\sqrt{2}+\cos\phi(-a_6+a_{15}+d_{15})$
$\Lambda_c^+ \to p\eta$	$\sin\theta\big(\cos\phi\,(-2a_6+2a_{15}-c_6+c_{15}+d_6-e_{15})/\sqrt{2}$ $-\sin\phi\,(-a_6+a_{15}-b_6+b_{15}+d_{15}+e_{15})\big)$
$\Lambda_c^+ \to p\eta'$	$\sin\theta\big(\sin\phi\,(-2a_6+2a_{15}-c_6+c_{15}+d_6-e_{15})/\sqrt{2}$ $+\cos\phi\,(-a_6+a_{15}-b_6+b_{15}+d_{15}+e_{15})\big)$
$\Xi_c^+ \to \Sigma^+\eta$	$\sin\theta\big(\cos\phi\,(-2a_6+2a_{15}-b_6+b_{15}-c_6+c_{15}+d_{15}+e_{15})/\sqrt{2}$ $-\sin\phi\,(-a_6+a_{15}+d_6-e_{15})\big)$
$\Xi_c^+ \to \Sigma^+\eta'$	$\sin\theta\big(\sin\phi\,(-2a_6+2a_{15}-b_6+b_{15}-c_6+c_{15}+d_{15}+e_{15})/\sqrt{2}$ $+\cos\phi\,(-a_6+a_{15}+d_6-e_{15})\big)$
$\Xi_c^+ \to p\eta$	$\sin^2\theta\big(\cos\phi\,(2a_6-2a_{15}+c_6-c_{15}-d_{15})/\sqrt{2}$ $-\sin\phi\,(a_6-a_{15}+b_6-b_{15}-d_6)\big)$
$\Xi_c^+ \to p\eta'$	$\sin^2\theta\big(\sin\phi\,(2a_6-2a_{15}+c_6-c_{15}-d_{15})/\sqrt{2}$ $+\cos\phi\,(a_6-a_{15}+b_6-b_{15}-d_6)\big)$
$\Xi_c^0 \to \Xi^0\eta$	$\cos\phi(2a_6+2a_{15}+b_6+b_{15}-d_6+d_{15})/\sqrt{2}-\sin\phi(a_6+a_{15}+c_6+c_{15})$
$\Xi_c^0 \to \Xi^0\eta'$	$\sin\phi(2a_6+2a_{15}+b_6+b_{15}-d_6+d_{15})/\sqrt{2}+\cos\phi(a_6+a_{15}+c_6+c_{15})$
$\Xi_c^0 \to \Sigma^0\eta$	$\sin\theta\big(\cos\phi\,(2a_6+2a_{15}+b_6+b_{15}+c_6+c_{15}+d_{15}-e_{15})/2$ $-\sin\phi\,(a_6+a_{15}-d_6+e_{15})/\sqrt{2}\big)$
$\Xi_c^0 \to \Sigma^0\eta'$	$\sin\theta(\sin\phi\,(2a_6+2a_{15}+b_6+b_{15}+c_6+c_{15}+d_{15}-e_{15})/2$ $-\cos\phi\,(a_6+a_{15}-d_6+e_{15})/\sqrt{2}\big)$
$\Xi_c^0 \to \Lambda\eta$	$\big(-\cos\phi\,(6a_6+6a_{15}+b_6+b_{15}+c_6+c_{15}-2d_6+3d_{15}+e_{15})/(2\sqrt{3})$ $-\sin\phi\,(-3a_6-3a_{15}-2b_6-2b_{15}-2c_6-2c_{15}+d_6+e_{15})/\sqrt{6}\big)\sin\theta$
$\Xi_c^0 \to \Lambda\eta'$	$\big(-\sin\phi\,(6a_6+6a_{15}+b_6+b_{15}+c_6+c_{15}-2d_6+3d_{15}+e_{15})/(2\sqrt{3})$ $+\cos\phi\,(-3a_6-3a_{15}-2b_6-2b_{15}-2c_6-2c_{15}+d_6+e_{15})/\sqrt{6}\big)\sin\theta$
$\Xi_c^0 \to n\eta$	$\sin^2\theta(\cos\phi\,(2a_6+2a_{15}+c_6+c_{15}+d_{15})/\sqrt{2}$ $-\sin\phi\,(a_6+a_{15}+b_6+b_{15}-d_6)\big)$
$\Xi_c^0 \to n\eta'$	$\sin^2\theta(\sin\phi\,(2a_6+2a_{15}+c_6+c_{15}+d_{15})/\sqrt{2}$ $+\cos\phi\,(a_6+a_{15}+b_6+b_{15}-d_6)\big)$

Global analysis

Channel	Branching ratio: Latest measurement in 2022 (%)	Experimental data (%)	Previous work (%) [14]	This work (%)
$\Lambda_c^+ \to pK_S^0$	···	1.59 ± 0.08 [37]	1.587 ± 0.077	1.606 ± 0.077
$\Lambda_c^+ \to p\eta$	···	0.142 ± 0.012 [37]	0.127 ± 0.024	0.141 ± 0.011
$\Lambda_c^+ \to p\eta'$	$0.0562^{+0.0246}_{-0.0204} \pm 0.0026$ [30] $0.0473 \pm 0.0082 \pm 0.0046 \pm 0.0024$ [34]	0.0484 ± 0.0091 [30,34]	0.27 ± 0.38	0.0468 ± 0.0066
$\Lambda_c^+ \to \Lambda\pi^+$	$1.31 \pm 0.08 \pm 0.05$ [33]	1.30 ± 0.06 [33,37]	1.307 ± 0.069	1.328 ± 0.055
$\Lambda_c^+ \to \Sigma^0\pi^+$	$1.22 \pm 0.08 \pm 0.07$ [33]	1.27 ± 0.06 [33,37]	1.272 ± 0.056	1.260 ± 0.046
$\Lambda_c^+ \to \Sigma^+\pi^0$	···	1.25 ± 0.10 [37]	1.283 ± 0.057	1.274 ± 0.047
$\Lambda_c^+ \to \Xi^0 K^+$	···	0.55 ± 0.07 [37]	0.548 ± 0.068	0.430 ± 0.030
$\Lambda_c^+ \to \Lambda^0 K^+$	$0.0621 \pm 0.0044 \pm 0.0026 \pm 0.0034$ [31] $0.0657 \pm 0.0017 \pm 0.0011 \pm 0.0035$ [35]	0.064 ± 0.003 [31,35,37]	0.064 ± 0.010	0.0646 ± 0.0028
$\Lambda_c^+ \to \Sigma^+\eta$	$0.416 \pm 0.075 \pm 0.021 \pm 0.033$ [36]	0.32 ± 0.043 [36,37]	0.45 ± 0.19	0.329 ± 0.042
$\Lambda_c^+ \to \Sigma^+\eta'$	$0.314 \pm 0.035 \pm 0.011 \pm 0.025$ [36]	0.437 ± 0.084 [36,37]	1.5 ± 0.6	0.444 ± 0.070
$\Lambda_c^+ \to \Sigma^0 K^+$	$0.047 \pm 0.009 \pm 0.001 \pm 0.003$ [32] $0.0358 \pm 0.0019 \pm 0.0006 \pm 0.0019$ [35]	0.0382 ± 0.0025 [32,35,37]	0.0504 ± 0.0056	0.0381 ± 0.0017
$\Lambda_c^+ \to n\pi^+$	$0.066 \pm 0.012 \pm 0.004$ [33]	0.066 ± 0.0126 [33]	0.035 ± 0.011	0.0651 ± 0.0026
$\Lambda_c^+ \to \Sigma^+ K_s^0$	$0.048 \pm 0.014 \pm 0.002 \pm 0.003$ [32]	0.048 ± 0.0145 [32]	0.0103 ± 0.0042	0.0327 ± 0.0029
$\Xi_c^+ \to \Xi^0\pi^+$	···	1.6 ± 0.8 [37]	0.54 ± 0.18	0.887 ± 0.080
$\Xi_c^0 \to \Lambda K_S^0$	···	0.32 ± 0.07 [37]	0.334 ± 0.065	0.261 ± 0.043
$\Xi_c^0 \to \Xi^-\pi^+$	···	1.43 ± 0.32 [37]	1.21 ± 0.21	1.06 ± 0.20
$\Xi_c^0 \to \Xi^- K^+$	···	0.039 ± 0.012 [37]	0.047 ± 0.0083	0.0474 ± 0.0090
$\Xi_c^0 \to \Sigma^0 K_S^0$	···	0.054 ± 0.016 [37]	0.069 ± 0.024	0.054 ± 0.016
$\Xi_c^0 \to \Sigma^+ K^-$	···	0.18 ± 0.04 [37]	0.221 ± 0.068	0.188 ± 0.039

Channel	Asymmetry parameter α: Lastest measurement in 2022	Experimental data	Previous work [14]	This work
$\alpha(\Lambda_c^+ \to pK_S^0)$	···	0.18 ± 0.45 [37]	0.19 ± 0.41	0.49 ± 0.20
$\alpha(\Lambda_c^+ \to \Lambda\pi^+)$	$-0.755 \pm 0.005 \pm 0.003$ [35]	-0.755 ± 0.0058 [35,37]	-0.841 ± 0.083	-0.7542 ± 0.0058
$\alpha(\Lambda_c^+ \to \Sigma^0\pi^+)$	$-0.463 \pm 0.016 \pm 0.008$ [35]	-0.466 ± 0.0178 [35,37]	-0.605 ± 0.088	-0.471 ± 0.015
$\alpha(\Lambda_c^+ \to \Sigma^+\pi^0)$	$-0.48 \pm 0.02 \pm 0.02$ [36]	-0.48 ± 0.03 [36,37]	-0.603 ± 0.088	-0.468 ± 0.015
$\alpha(\Xi_c^0 \to \Xi^-\pi^+)$	···	-0.64 ± 0.051 [37]	-0.56 ± 0.32	-0.654 ± 0.050
$\alpha(\Lambda_c^+ \to \Sigma^0 K^+)$	$-0.54 \pm 0.18 \pm 0.09$ [35]	-0.54 ± 0.20 [35]	-0.953 ± 0.040	-0.9958 ± 0.0045
$\alpha(\Lambda_c^+ \to \Lambda K^+)$	$-0.585 \pm 0.049 \pm 0.018$ [35]	-0.585 ± 0.052 [35]	-0.24 ± 0.15	-0.545 ± 0.046
$\alpha(\Lambda_c^+ \to \Sigma^+\eta)$	$-0.99 \pm 0.03 \pm 0.05$ [36]	-0.99 ± 0.058 [36]	0.3 ± 3.8	-0.970 ± 0.046
$\alpha(\Lambda_c^+ \to \Sigma^+\eta')$	$-0.46 \pm 0.06 \pm 0.03$ [36]	-0.46 ± 0.067 [36]	0.8 ± 1.9	-0.455 ± 0.064

The globe fit of antitriplet charm baryon two body decays

SU(3) symmetry parameters from fitting (χ^2/d.o.f.=1.21)				
Vector(f)	$f^a = 0.0110 \pm 0.0028$	$f_6^b = 0.0152 \pm 0.0065$	$f_6^c = 0.0252 \pm 0.0050$	$f_6^d = -0.00976 \pm 0.00566$
	$f_{15}^b = -0.0114 \pm 0.0030$	$f_{15}^c = 0.0105 \pm 0.0057$	$f_{15}^d = -0.0179 \pm 0.0022$	$f_{15}^e = 0.0564 \pm 0.0062$
Axial-vector(g)	$g^a = -0.028 \pm 0.008$	$g_6^b = -0.169 \pm 0.008$	$g_6^c = 0.086 \pm 0.013$	$g_6^d = -0.047 \pm 0.010$
	$g_{15}^b = 0.0801 \pm 0.0052$	$g_{15}^c = 0.010 \pm 0.012$	$g_{15}^d = -0.0274 \pm 0.0060$	$g_{15}^e = 0.0148 \pm 0.0065$

The observable provide the most chi^2:

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$$\alpha(\Lambda_c \to \Sigma^0 K^+) = -0.9958 \pm 0.0045$$

$$\alpha(\Lambda_c \to \Sigma^0 K^+)_{exp} = -0.54 \pm 0.18 \pm 0.09$$

2σ standard deviation

L. K. Li et al. [Belle], Sci. Bull. 68, 583-592 (2023) doi:10.1016/j.scib.2023.02.017 [arXiv:2208.08695 [hep_x0002_ex]].

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predictions

Channel	Branching ratio(10^{-2})	α
$\Lambda_c^+ \to \Sigma^0\pi^+$	1.260 ± 0.046	-0.470 ± 0.015
$\Lambda_c^+ \to \Lambda\pi^+$	1.328 ± 0.055	-0.7542 ± 0.0058
$\Lambda_c^+ \to \Sigma^+\pi^0$	1.274 ± 0.047	-0.468 ± 0.015
$\Lambda_c^+ \to pK_S^0$	1.606 ± 0.077	0.49 ± 0.20
$\Lambda_c^+ \to \Xi^0 K^+$	0.430 ± 0.030	0.955 ± 0.018
$\Xi_c^+ \to \Sigma^+ K_S^0$	0.77 ± 0.32	0.29 ± 0.29
$\Xi_c^+ \to \Xi^0\pi^+$	0.887 ± 0.080	-0.902 ± 0.039
$\Xi_c^0 \to \Sigma^0 K_S^0$	0.054 ± 0.016	-0.75 ± 0.24
$\Xi_c^0 \to \Lambda K_S^0$	0.261 ± 0.043	0.984 ± 0.084
$\Xi_c^0 \to \Sigma^+ K^-$	0.188 ± 0.039	0.98 ± 0.20
$\Xi_c^0 \to \Xi^-\pi^+$	1.06 ± 0.20	-0.654 ± 0.050
$\Xi_c^0 \to \Xi^0\pi^0$	0.130 ± 0.051	-0.28 ± 0.18

$\Lambda_c^+ \to \Sigma^0 K^+$	0.0381 ± 0.0017	-0.9959 ± 0.0044
$\Lambda_c^+ \to \Lambda K^+$	0.0646 ± 0.0028	-0.545 ± 0.046
$\Lambda_c^+ \to \Sigma^+ K_S^0/K_L^0$	0.0327 ± 0.0029	-0.52 ± 0.11
$\Lambda_c^+ \to p\pi^0$	0.021 ± 0.010	-0.21 ± 0.18
$\Lambda_c^+ \to n\pi^+$	0.0651 ± 0.0026	0.533 ± 0.047
$\Xi_c^+ \to \Sigma^0\pi^+$	0.3194 ± 0.0088	-0.728 ± 0.018
$\Xi_c^+ \to \Lambda\pi^+$	0.0222 ± 0.0032	-0.16 ± 0.17
$\Xi_c^+ \to \Sigma^+\pi^0$	0.247 ± 0.020	0.46 ± 0.19
$\Xi_c^+ \to pK_S^0/K_L^0$	0.177 ± 0.016	-0.361 ± 0.081
$\Xi_c^+ \to \Xi^0 K^+$	0.1361 ± 0.0063	0.371 ± 0.036
$\Xi_c^0 \to \Sigma^0\pi^0$	0.00014 ± 0.00030	0.3 ± 2.3
$\Xi_c^0 \to \Lambda\pi^0$	0.0375 ± 0.0076	0.74 ± 0.16
$\Xi_c^0 \to \Sigma^+\pi^-$	0.0116 ± 0.0026	0.96 ± 0.25
$\Xi_c^0 \to pK^-$	0.0138 ± 0.0045	0.89 ± 0.38
$\Xi_c^0 \to \Sigma^-\pi^+$	0.057 ± 0.011	-0.723 ± 0.050
$\Xi_c^0 \to nK_S^0/K_L^0$	0.0234 ± 0.0060	0.66 ± 0.34
$\Xi_c^0 \to \Xi^- K^+$	0.0474 ± 0.0090	-0.610 ± 0.048
$\Xi_c^0 \to \Xi^0 K_S^0/K_L^0$	0.0114 ± 0.0023	0.87 ± 0.30

$\Lambda_c^+ \to pK_L^0$	1.688 ± 0.080	0.56 ± 0.20
$\Lambda_c^+ \to nK^+$	0.001022 ± 0.000091	-0.980 ± 0.019
$\Xi_c^+ \to \Sigma^0 K^+$	0.01156 ± 0.00033	-0.9961 ± 0.0014
$\Xi_c^+ \to \Lambda K^+$	0.00441 ± 0.00019	0.624 ± 0.033
$\Xi_c^+ \to \Sigma^+ K_L^0$	0.95 ± 0.35	0.57 ± 0.28
$\Xi_c^+ \to p\pi^0$	0.00046 ± 0.00021	-0.29 ± 0.38
$\Xi_c^+ \to n\pi^+$	0.00619 ± 0.00040	0.945 ± 0.020
$\Xi_c^0 \to \Sigma^0 K_L^0$	0.069 ± 0.019	-0.51 ± 0.29
$\Xi_c^0 \to \Lambda K_L^0$	0.243 ± 0.043	0.996 ± 0.043
$\Xi_c^0 \to p\pi^-$	0.00082 ± 0.00029	0.87 ± 0.40
$\Xi_c^0 \to \Sigma^- K^+$	0.00258 ± 0.00049	-0.689 ± 0.050
$\Xi_c^0 \to n\pi^0$	0.00194 ± 0.00031	0.9997 ± 0.0091

We predict 80 observables in 45 decays!

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predictions

arXiv:2311.06883: $Br(\Lambda_c^+ \to p\pi^0)_{exp} = (1.56^{+0.72}_{-0.58} \pm 0.20) \times 10^{-4}$ $Br(\Lambda_c^+ \to p\pi^0) = (2.1 \pm 1.0) \times 10^{-4}$

arXiv:2309.02774: $\alpha(\Lambda_c^+ \to \Xi^0 K^+)_{exp} = 0.01 \pm 0.16 \pm 0.03$ $\alpha(\Lambda_c^+ \to \Xi^0 K^+) = 0.995 \pm 0.018$

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JHEP 11 (2023) 137 $Br(\Lambda_c^+ \to p\eta)_{exp} = (1.57 \pm 0.11 \pm 0.04) \times 10^{-3}$ $Br(\Lambda_c^+ \to p\eta) = (1.41 \pm 0.11) \times 10^{-3}$

The SU(3) symmetry is still a very powful tool in charmed baryon two body decays

- Introduction
- SU(3) symmetry
- Global analysis
- Analysis of undetermined SU(3) parameter

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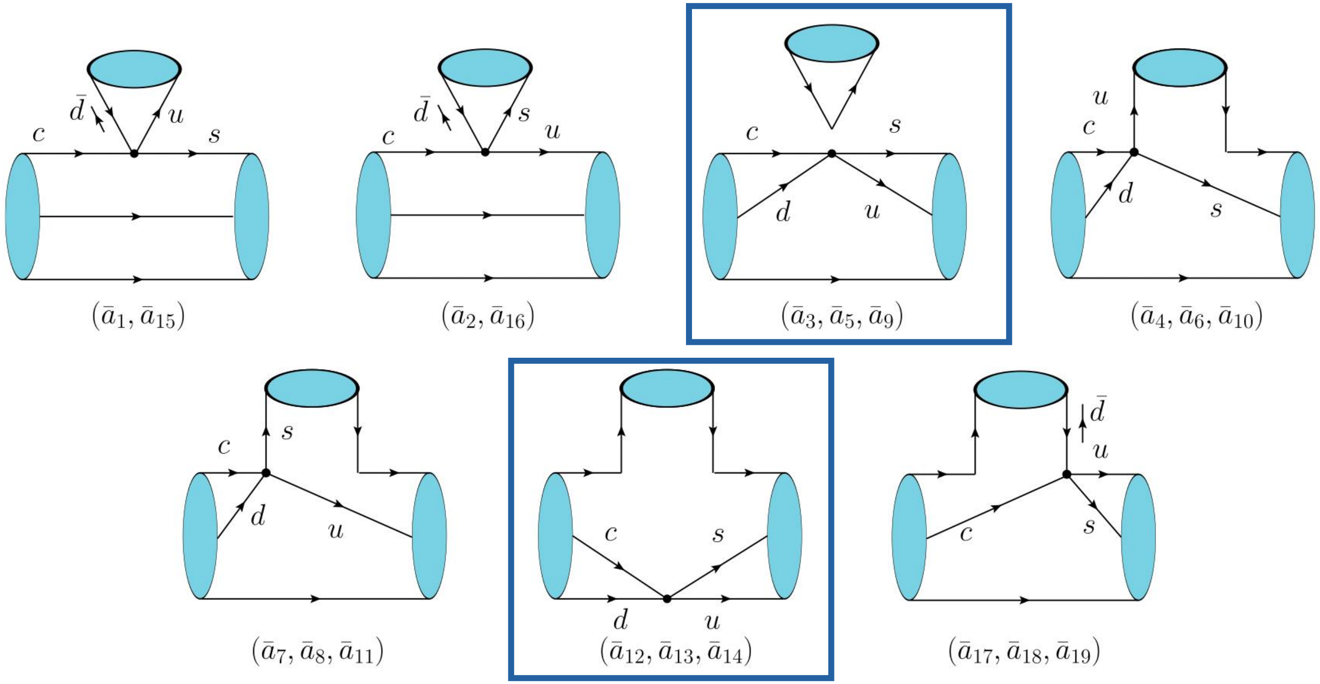
relations between IRA and TDA

$$
\begin{aligned}
\mathcal{A}_u^{TDA} = {} & \bar{a}_1 T_{c\bar{3}}^{[ij]} H_m^{kl} (\overline{T}_8)_{ijk} P_l^m + \bar{a}_2 T_{c\bar{3}}^{[ij]} H_m^{kl} (\overline{T}_8)_{ijl} P_k^m \\
& + \bar{a}_3 T_{c\bar{3}}^{[ij]} H_i^{kl} (\overline{T}_8)_{jkl} P_m^m \\
& + \bar{a}_4 T_{c\bar{3}}^{[ij]} H_i^{kl} (\overline{T}_8)_{jkm} P_l^m \\
& + \bar{a}_5 T_{c\bar{3}}^{[ij]} H_i^{kl} (\overline{T}_8)_{jlk} P_m^m + \bar{a}_6 T_{c\bar{3}}^{[ij]} H_i^{kl} (\overline{T}_8)_{jmk} P_l^m \\
& + \bar{a}_7 T_{c\bar{3}}^{[ij]} H_i^{kl} (\overline{T}_8)_{ilm} P_k^m + \bar{a}_8 T_{c\bar{3}}^{[ij]} H_i^{kl} (\overline{T}_8)_{jml} P_k^m \\
& + \bar{a}_9 T_{c\bar{3}}^{[ij]} H_i^{kl} (\overline{T}_8)_{klj} P_m^m + \bar{a}_{10} T_{c\bar{3}}^{[ij]} H_i^{kl} (\overline{T}_8)_{kmj} P_l^m \\
& + \bar{a}_{11} T_{c\bar{3}}^{[ij]} H_i^{kl} (\overline{T}_8)_{lmj} P_k^m + \bar{a}_{12} T_{c\bar{3}}^{[ij]} H_i^{kl} (\overline{T}_8)_{klm} P_j^m \\
& + \bar{a}_{13} T_{c\bar{3}}^{[ij]} H_i^{kl} (\overline{T}_8)_{kml} P_j^m + \bar{a}_{14} T_{c\bar{3}}^{[ij]} H_i^{kl} (\overline{T}_8)_{lmk} P_j^m \\
& + \bar{a}_{15} T_{c\bar{3}}^{[ij]} H_m^{kl} (\overline{T}_8)_{ikj} P_l^m + \bar{a}_{16} T_{c\bar{3}}^{[ij]} H_m^{kl} (\overline{T}_8)_{ilj} P_m^k \\
& + \bar{a}_{17} T_{c\bar{3}}^{[ij]} H_m^{kl} (\overline{T}_8)_{ikl} P_j^m + \bar{a}_{18} T_{c\bar{3}}^{[ij]} H_m^{kl} (\overline{T}_8)_{ilk} P_j^m \\
& + \bar{a}_{19} T_{c\bar{3}}^{[ij]} H_m^{kl} (\overline{T}_8)_{klj} P_i^m .
\end{aligned}
$$

$$
\begin{aligned}
A_6^T &= \frac{1}{2} (\bar{a}_3 - \bar{a}_5 - 2\bar{a}_9 - \bar{a}_{13} + \bar{a}_{14}) , \\
B_6^T &= \frac{1}{2} (\bar{a}_{13} - \bar{a}_{14} - \bar{a}_{17} + \bar{a}_{18} - 2\bar{a}_{19}) , \\
C_6^T &= \frac{1}{2} (\bar{a}_4 - \bar{a}_7 - \bar{a}_{10} + \bar{a}_{11} - 2\bar{a}_{12}) , \\
D_6^T &= \frac{1}{2} (\bar{a}_6 - \bar{a}_8 + \bar{a}_{10} - \bar{a}_{11} - \bar{a}_{13} + \bar{a}_{14}) , \\
E_6^T &= \frac{1}{2} (2\bar{a}_1 - 2\bar{a}_2 - \bar{a}_6 + \bar{a}_8 - \bar{a}_{10} + \bar{a}_{11} + \bar{a}_{13} \\
&\quad - \bar{a}_{14} + \bar{a}_{15} - \bar{a}_{16} - \bar{a}_{17} + \bar{a}_{18} - 2\bar{a}_{19}) , \\
A_{15}^T &= \frac{1}{2} (\bar{a}_3 + \bar{a}_5 - \bar{a}_{13} - \bar{a}_{14}) , \\
B_{15}^T &= \frac{1}{2} (\bar{a}_{13} + \bar{a}_{14} - \bar{a}_{17} - \bar{a}_{18}) , \\
C_{15}^T &= \frac{1}{2} (\bar{a}_4 + \bar{a}_7 - \bar{a}_{10} - \bar{a}_{11}) , \\
D_{15}^T &= \frac{1}{2} (\bar{a}_6 + \bar{a}_8 + \bar{a}_{10} + \bar{a}_{11} + \bar{a}_{13} + \bar{a}_{14}) , \\
E_{15}^T &= \frac{1}{2} (2\bar{a}_1 + 2\bar{a}_2 - \bar{a}_6 - \bar{a}_8 - \bar{a}_{10} - \bar{a}_{11} \\
&\quad - \bar{a}_{13} - \bar{a}_{14} + \bar{a}_{15} + \bar{a}_{16} + \bar{a}_{17} + \bar{a}_{18}) .
\end{aligned}
$$

$$
\begin{aligned}
\mathcal{A}_u^{IRA} = {} & A_6^T (T_{c\bar{3}})_i (H_6)_j^{[ik]} (\overline{T}_8)_k^j P_l^l \\
& + B_6^T (T_{c\bar{3}})_i (H_6)_j^{[ik]} (\overline{T}_8)_k^l P_l^j \\
& + C_6^T (T_{c\bar{3}})_i (H_6)_j^{[ik]} (\overline{T}_8)_l^j P_k^l \\
& + E_6^T (T_{c\bar{3}})_i (H_6)_l^{[jk]} (\overline{T}_8)_j^i P_k^l \\
& + D_6^T (T_{c\bar{3}})_i (H_6)_l^{[jk]} (\overline{T}_8)_j^l P_k^i \\
& + A_{15}^T (T_{c\bar{3}})_i (H_{\overline{15}})_j^{\{ik\}} (\overline{T}_8)_k^j P_l^l \\
& + B_{15}^T (T_{c\bar{3}})_i (H_{\overline{15}})_j^{\{ik\}} (\overline{T}_8)_k^l P_l^j \\
& + C_{15}^T (T_{c\bar{3}})_i (H_{\overline{15}})_j^{\{ik\}} (\overline{T}_8)_l^j P_k^l \\
& + E_{15}^T (T_{c\bar{3}})_i (H_{\overline{15}})_l^{\{jk\}} (\overline{T}_8)_j^i P_k^l \\
& + D_{15}^T (T_{c\bar{3}})_i (H_{\overline{15}})_l^{\{ik\}} (\overline{T}_8)_j^l P_k^i .
\end{aligned}
$$

Analysis of undetermined SU(3) parameter



relations between IRA and TDA

$$A_6^T = \frac{1}{2}(\bar a_3 - \bar a_5 - 2\bar a_9 - \bar a_{13} + \bar a_{14}),$$

$$B_6^T = \frac{1}{2}(\bar a_{13} - \bar a_{14} - \bar a_{17} + \bar a_{18} - 2\bar a_{19}),$$

$$C_6^T = \frac{1}{2}(\bar a_4 - \bar a_7 - \bar a_{10} + \bar a_{11} - 2\bar a_{12}),$$

$$D_6^T = \frac{1}{2}(\bar a_6 - \bar a_8 + \bar a_{10} - \bar a_{11} - \bar a_{13} + \bar a_{14}),$$

$$E_6^T = \frac{1}{2}(2\bar a_1 - 2\bar a_2 - \bar a_6 + \bar a_8 - \bar a_{10} + \bar a_{11} + \bar a_{13} - \bar a_{14} + \bar a_{15} - \bar a_{16} - \bar a_{17} + \bar a_{18} - 2\bar a_{19}),$$

$$A_{15}^T = \frac{1}{2}(\bar a_3 + \bar a_5 - \bar a_{13} - \bar a_{14}),$$

$$B_{15}^T = \frac{1}{2}(\bar a_{13} + \bar a_{14} - \bar a_{17} - \bar a_{18}),$$

$$C_{15}^T = \frac{1}{2}(\bar a_4 + \bar a_7 - \bar a_{10} - \bar a_{11}),$$

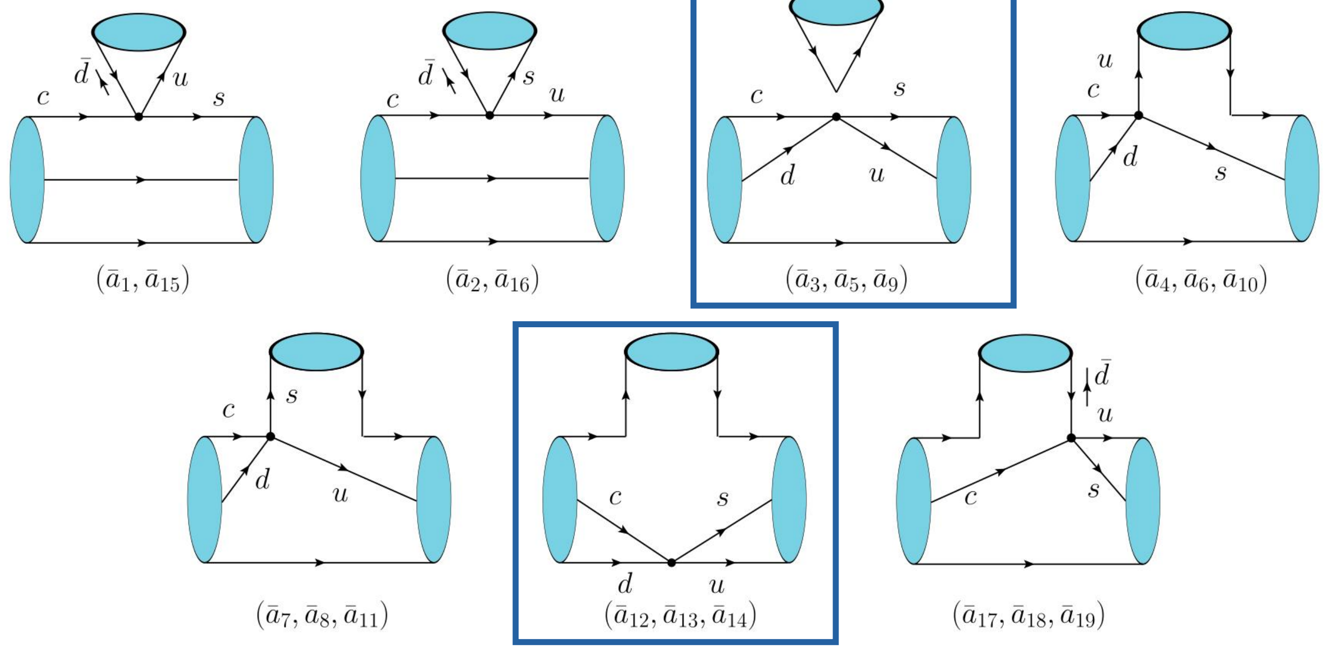
$$D_{15}^T = \frac{1}{2}(\bar a_6 + \bar a_8 + \bar a_{10} + \bar a_{11} + \bar a_{13} + \bar a_{14}),$$

$$E_{15}^T = \frac{1}{2}(2\bar a_1 + 2\bar a_2 - \bar a_6 - \bar a_8 - \bar a_{10} - \bar a_{11} - \bar a_{13} - \bar a_{14} + \bar a_{15} + \bar a_{16} + \bar a_{17} + \bar a_{18}).$$

$$\begin{aligned}
\mathcal{A}_u^{IRA} = & A_6^T (T_{c\bar 3})_i (H_6)^{[ik]}_j (\overline{T}_8)^j_k P^l_l + A_{15}^T (T_{c\bar 3})_i (H_{\overline{15}})^{\{ik\}}_j (\overline{T}_8)^j_k P^l_l \\
& + B_6^T (T_{c\bar 3})_i (H_6)^{[ik]}_j (\overline{T}_8)^l_k P^j_l + B_{15}^T (T_{c\bar 3})_i (H_{\overline{15}})^{\{ik\}}_j (\overline{T}_8)^l_k P^j_l \\
& + C_6^T (T_{c\bar 3})_i (H_6)^{[ik]}_j (\overline{T}_8)^j_l P^l_k + C_{15}^T (T_{c\bar 3})_i (H_{\overline{15}})^{\{ik\}}_j (\overline{T}_8)^j_l P^l_k \\
& + E_6^T (T_{c\bar 3})_i (H_6)^{[jk]}_l (\overline{T}_8)^i_j P^l_k + E_{15}^T (T_{c\bar 3})_i (H_{\overline{15}})^{\{jk\}}_l (\overline{T}_8)^i_j P^l_k \\
& + D_6^T (T_{c\bar 3})_i (H_6)^{[jk]}_l (\overline{T}_8)^l_j P^i_k + D_{15}^T (T_{c\bar 3})_i (H_{\overline{15}})^{\{ik\}}_l (\overline{T}_8)^l_j P^i_k .
\end{aligned}$$

Analysis of undetermined SU(3) parameter

Helpfull for estimating in theory



relations between IRA and TDA

$$A_6^T = \frac{1}{2}(\bar a_3 - \bar a_5 - 2\bar a_9 - \bar a_{13} + \bar a_{14}),$$
$$B_6^T = \frac{1}{2}(\bar a_{13} - \bar a_{14} - \bar a_{17} + \bar a_{18} - 2\bar a_{19}),$$
$$C_6^T = \frac{1}{2}(\bar a_4 - \bar a_7 - \bar a_{10} + \bar a_{11} - 2\bar a_{12}),$$
$$D_6^T = \frac{1}{2}(\bar a_6 - \bar a_8 + \bar a_{10} - \bar a_{11} - \bar a_{13} + \bar a_{14}),$$
$$E_6^T = \frac{1}{2}(2\bar a_1 - 2\bar a_2 - \bar a_6 + \bar a_8 - \bar a_{10} + \bar a_{11} + \bar a_{13} - \bar a_{14} + \bar a_{15} - \bar a_{16} - \bar a_{17} + \bar a_{18} - 2\bar a_{19}),$$
$$A_{15}^T = \frac{1}{2}(\bar a_3 + \bar a_5 - \bar a_{13} - \bar a_{14}),$$
$$B_{15}^T = \frac{1}{2}(\bar a_{13} + \bar a_{14} - \bar a_{17} - \bar a_{18}),$$
$$C_{15}^T = \frac{1}{2}(\bar a_4 + \bar a_7 - \bar a_{10} - \bar a_{11}),$$
$$D_{15}^T = \frac{1}{2}(\bar a_6 + \bar a_8 + \bar a_{10} + \bar a_{11} + \bar a_{13} + \bar a_{14}),$$
$$E_{15}^T = \frac{1}{2}(2\bar a_1 + 2\bar a_2 - \bar a_6 - \bar a_8 - \bar a_{10} - \bar a_{11} - \bar a_{13} - \bar a_{14} + \bar a_{15} + \bar a_{16} + \bar a_{17} + \bar a_{18}).$$

$$\begin{aligned}
\mathcal{A}_u^{IRA} = & A_6^T (T_{c\bar 3})_i (H_6)^{[ik]}_j (\overline{T}_8)^j_k P^l_l + A_{15}^T (T_{c\bar 3})_i (H_{\overline{15}})^{\{ik\}}_j (\overline{T}_8)^j_k P^l_l \\
& + B_6^T (T_{c\bar 3})_i (H_6)^{[ik]}_j (\overline{T}_8)^l_k P^j_l + B_{15}^T (T_{c\bar 3})_i (H_{\overline{15}})^{\{ik\}}_j (\overline{T}_8)^l_k P^j_l \\
& + C_6^T (T_{c\bar 3})_i (H_6)^{[ik]}_j (\overline{T}_8)^j_l P^l_k + C_{15}^T (T_{c\bar 3})_i (H_{\overline{15}})^{\{ik\}}_j (\overline{T}_8)^j_l P^l_k \\
& + E_6^T (T_{c\bar 3})_i (H_6)^{[jk]}_l (\overline{T}_8)^i_j P^l_k + E_{15}^T (T_{c\bar 3})_i (H_{\overline{15}})^{\{jk\}}_l (\overline{T}_8)^i_j P^l_k \\
& + D_6^T (T_{c\bar 3})_i (H_6)^{[jk]}_l (\overline{T}_8)^l_j P^i_k + D_{15}^T (T_{c\bar 3})_i (H_{\overline{15}})^{\{ik\}}_l (\overline{T}_8)^l_j P^i_k .
\end{aligned}$$

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The channels depend on a'

$\Xi_c^0 \to \Xi^0 \eta$	$\cos\phi(2a_6+2a_{15}+b_6+b_{15}-d_6+d_{15})/\sqrt{2}-\sin\phi(a_6+a_{15}+c_6+c_{15})$
$\Xi_c^0 \to \Xi^0 \eta'$	$\sin\phi(2a_6+2a_{15}+b_6+b_{15}-d_6+d_{15})/\sqrt{2}+\cos\phi(a_6+a_{15}+c_6+c_{15})$
$\Xi_c^0 \to \Sigma^0 \eta$	$\sin\theta(\ cos\phi\,(2a_6+2a_{15}+b_6+b_{15}+c_6+c_{15}+d_{15}-e_{15})/2$ $-\sin\phi\,(a_6+a_{15}-d_6+e_{15})/\sqrt{2})$
$\Xi_c^0 \to \Sigma^0 \eta'$	$\sin\theta(\sin\phi\,(2a_6+2a_{15}+b_6+b_{15}+c_6+c_{15}+d_{15}-e_{15})/2$ $-\cos\phi\,(a_6+a_{15}-d_6+e_{15})/\sqrt{2})$
$\Xi_c^0 \to \Lambda \eta$	$(-\cos\phi\,(6a_6+6a_{15}+b_6+b_{15}+c_6+c_{15}-2d_6+3d_{15}+e_{15})/(2\sqrt{3})$ $-\sin\phi\,(-3a_6-3a_{15}-2b_6-2b_{15}-2c_6-2c_{15}+d_6+e_{15})/\sqrt{6})\sin\theta$
$\Xi_c^0 \to \Lambda \eta'$	$(-\sin\phi\,(6a_6+6a_{15}+b_6+b_{15}+c_6+c_{15}-2d_6+3d_{15}+e_{15})/(2\sqrt{3})$ $+\cos\phi\,(-3a_6-3a_{15}-2b_6-2b_{15}-2c_6-2c_{15}+d_6+e_{15})/\sqrt{6})\sin\theta$
$\Xi_c^0 \to n\eta$	$\sin^2\theta(\cos\phi\,(2a_6+2a_{15}+c_6+c_{15}+d_{15})/\sqrt{2}$ $-\sin\phi\,(a_6+a_{15}+b_6+b_{15}-d_6))$
$\Xi_c^0 \to n\eta'$	$\sin^2\theta(\sin\phi\,(2a_6+2a_{15}+c_6+c_{15}+d_{15})/\sqrt{2}$ $+\cos\phi\,(a_6+a_{15}+b_6+b_{15}-d_6))$

Define the ratio:

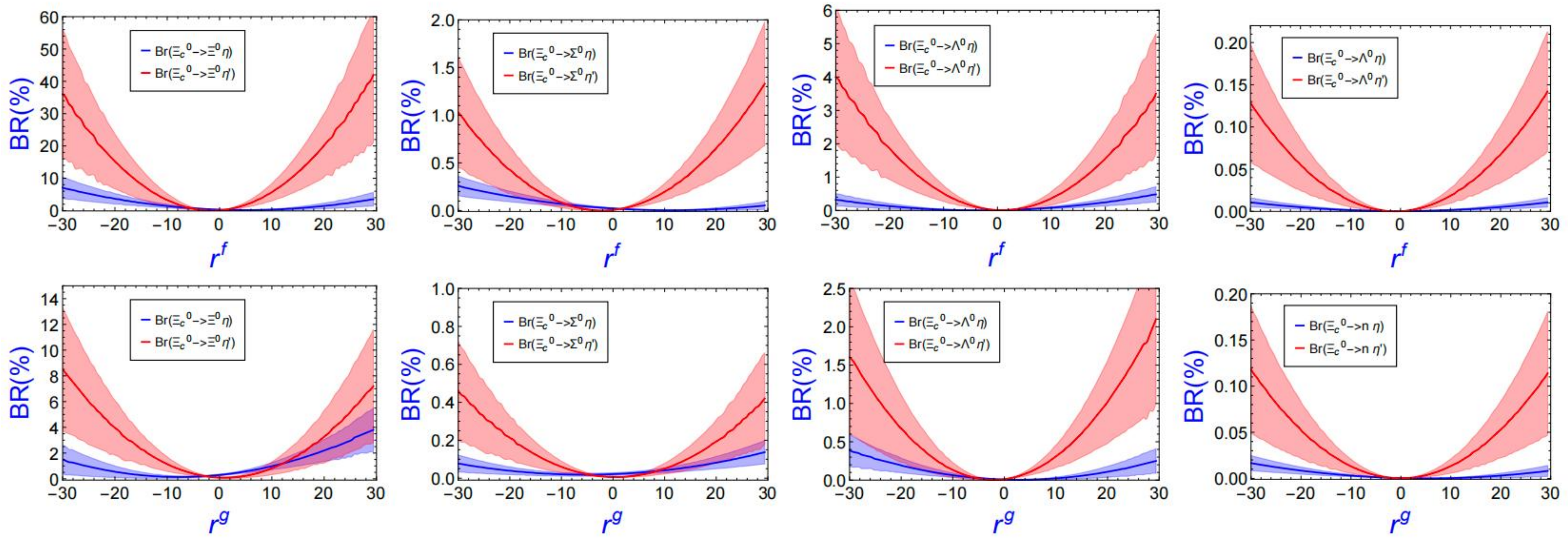
$$r^f = f^{a'}/f^a, \quad r^g = g^{a'}/g^a$$

Reasonable range:

$$r^{f(g)} \in [-1, 1]$$

Analysis of undetermined SU(3) parameter

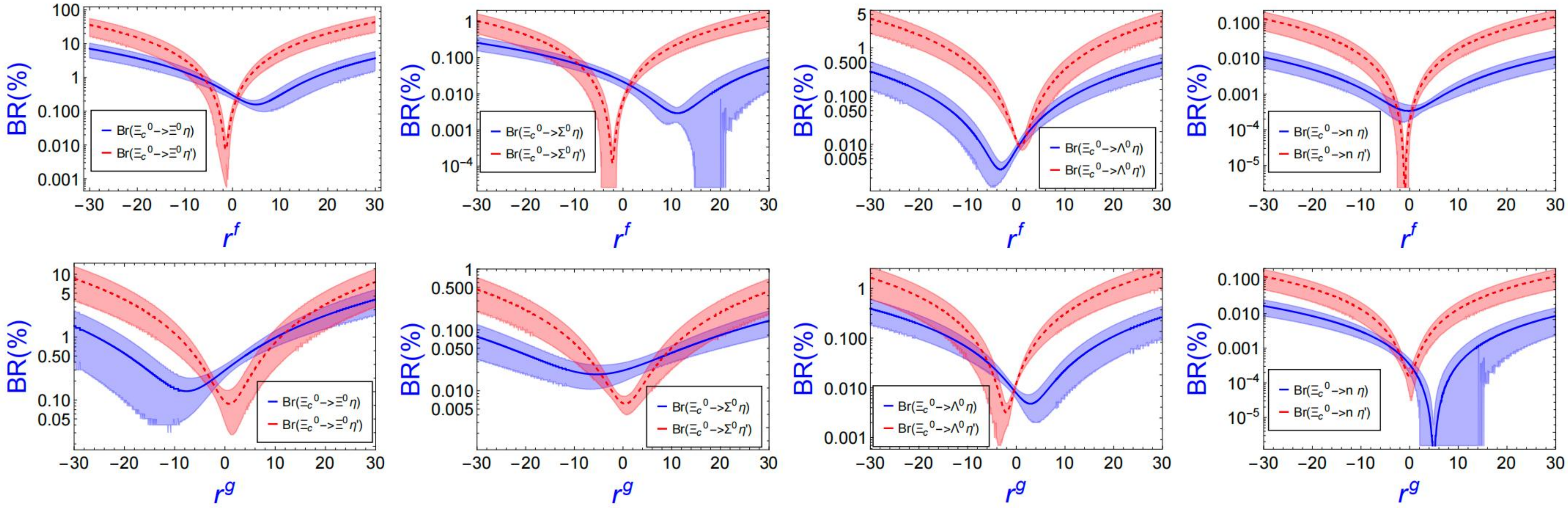
The dependence of r^f and r^g



- the branching ratios of decays which involve final state η change slowly.
- decays involving η′ exhibit high dependence on $r^{f(g)}$.

Analysis of undetermined SU(3) parameter

The dependence of r^f and r^g



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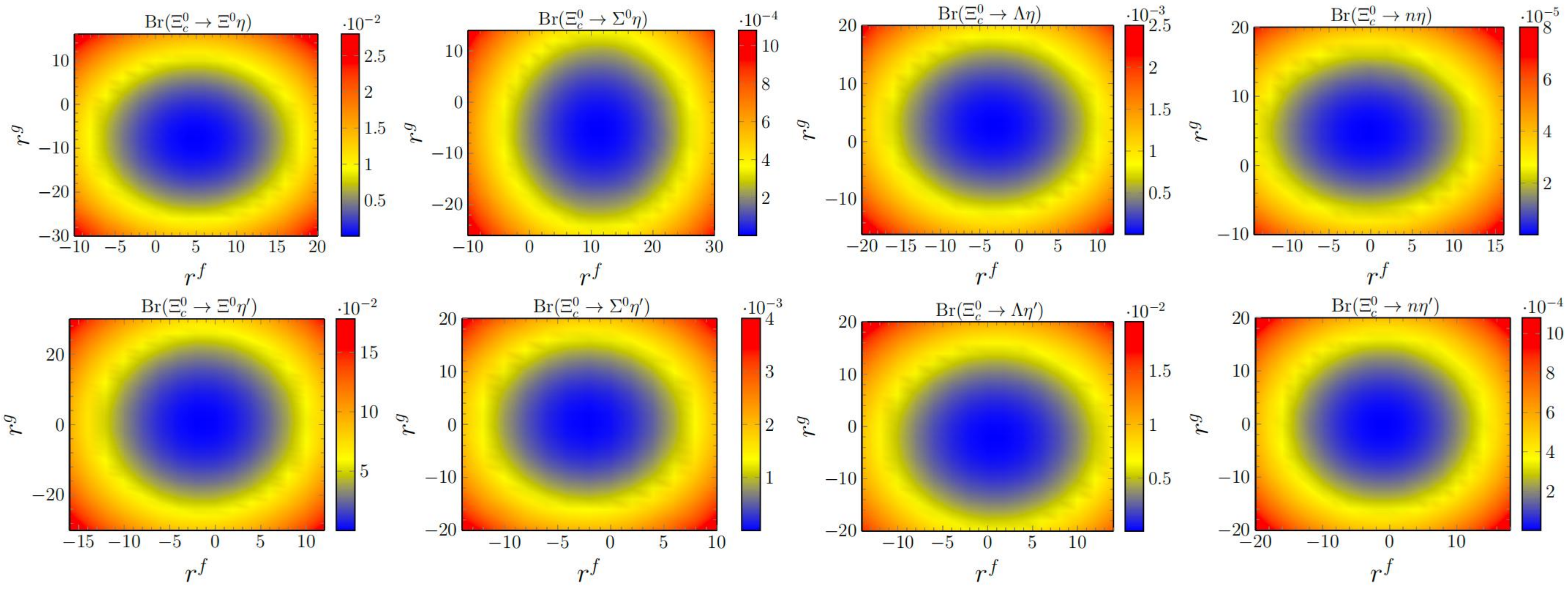
The dependence of r^f and r^g



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prediction

varying $r^{f(g)} \in [-1, 1]$.

scanning the branching fraction on the $r^f - r^g$ plane

$$Br(\Xi_c^0 \to \Xi^0 \eta) \sim [0.193, 0.446]\%,$$
$$Br(\Xi_c^0 \to \Sigma^0 \eta) \sim [0.0118, 0.0333]\%,$$
$$Br(\Xi_c^0 \to \Lambda^0 \eta) \sim [0.0039, 0.0139]\%,$$
$$Br(\Xi_c^0 \to n\eta) \sim [0.00009, 0.00066]\%.$$

$$Br(\Xi_c^0 \to \Xi^0 \eta') \geq 0.002\%,$$
$$Br(\Xi_c^0 \to \Sigma^0 \eta') \geq 9 \times 10^{-7},$$
$$Br(\Xi_c^0 \to \Lambda^0 \eta') \geq 4.8 \times 10^{-6},$$
$$Br(\Xi_c^0 \to n\eta') \geq 6 \times 10^{-8}.$$

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Conclusion

- We carried out an SU(3) symmetry analysis for charmed baryon two body decays.
- We can obtain 16 SU(3) irreducible amplitudes with χ2/d.o.f. of 1.21 indicating a very reasonable fit conforming to the results that SU(3) sym_x0002_metry describes T3 → T8P very well.
- We find one observable provide the most chi^2:
- There is one parameter a' still can not be determine.
- By vary the r^f and r^g in a reasonable region, we can give a roughly prediction.

$$\Xi_c^0 \to \Xi^0\eta^{(\prime)}, \Xi_c^0 \to \Sigma^0\eta^{(\prime)}, \Xi_c^0 \to \Lambda^0\eta^{(\prime)}, \Xi_c^0 \to n\eta^{(\prime)}$$

We eagerly await data from future experimental searches!

Thanks!