第6届 LHCb 前沿物理研讨会

粲重子衰变拓扑图研究进展：矢量介子末态

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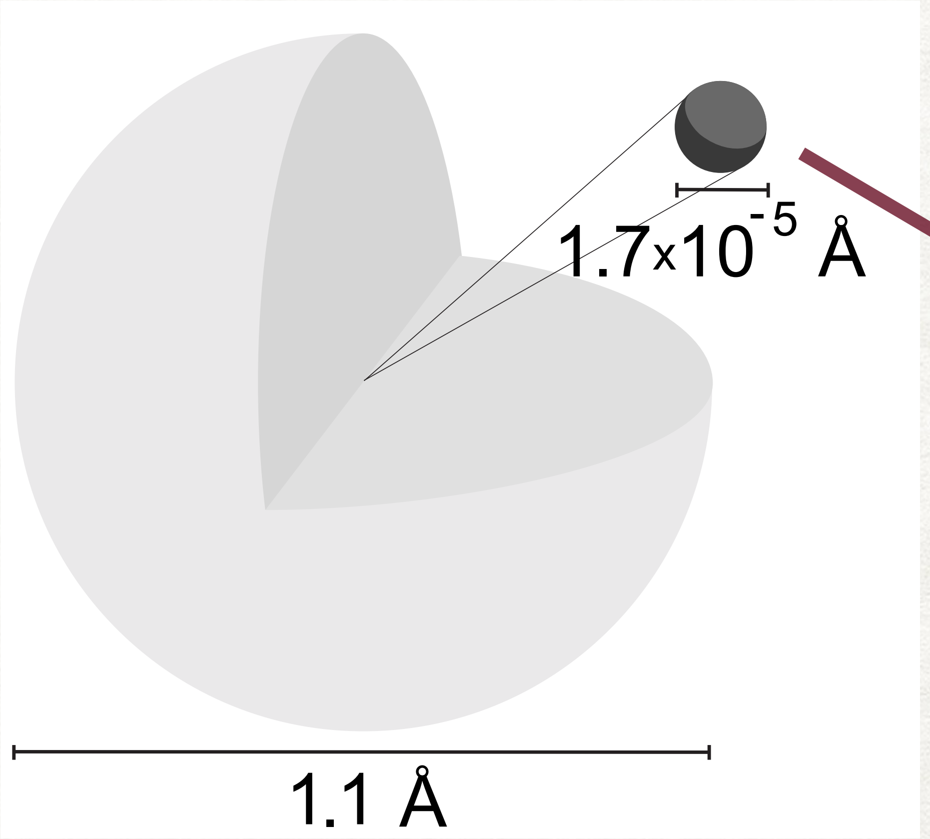
[2605.XXXXX]

2026.5.24

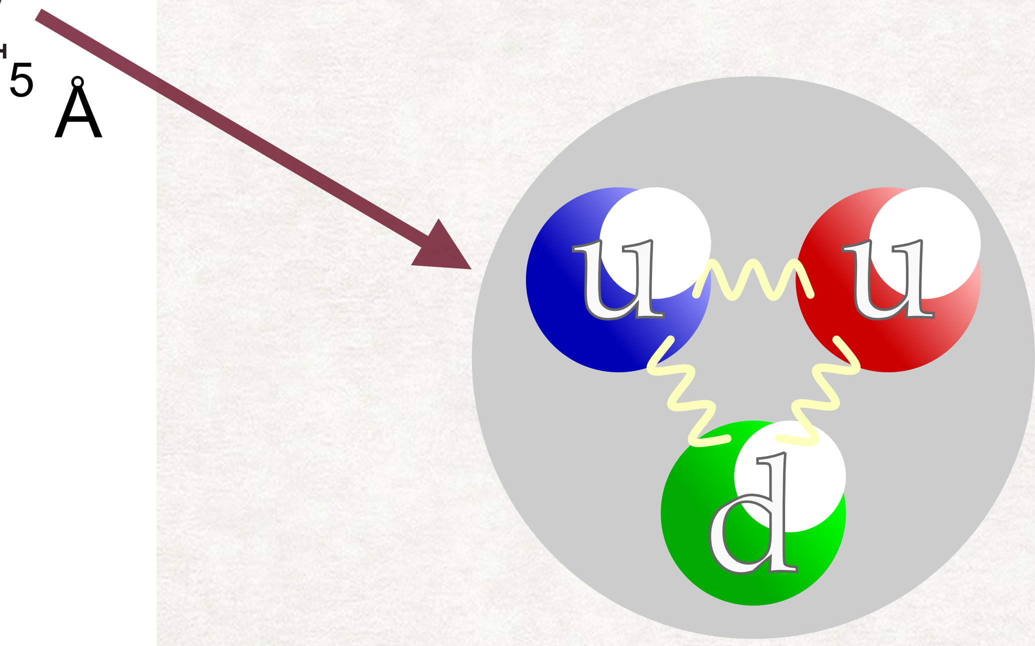
OUTLINE

- Introduction
- TDA framework
- Numerical analyses and results
- Summary

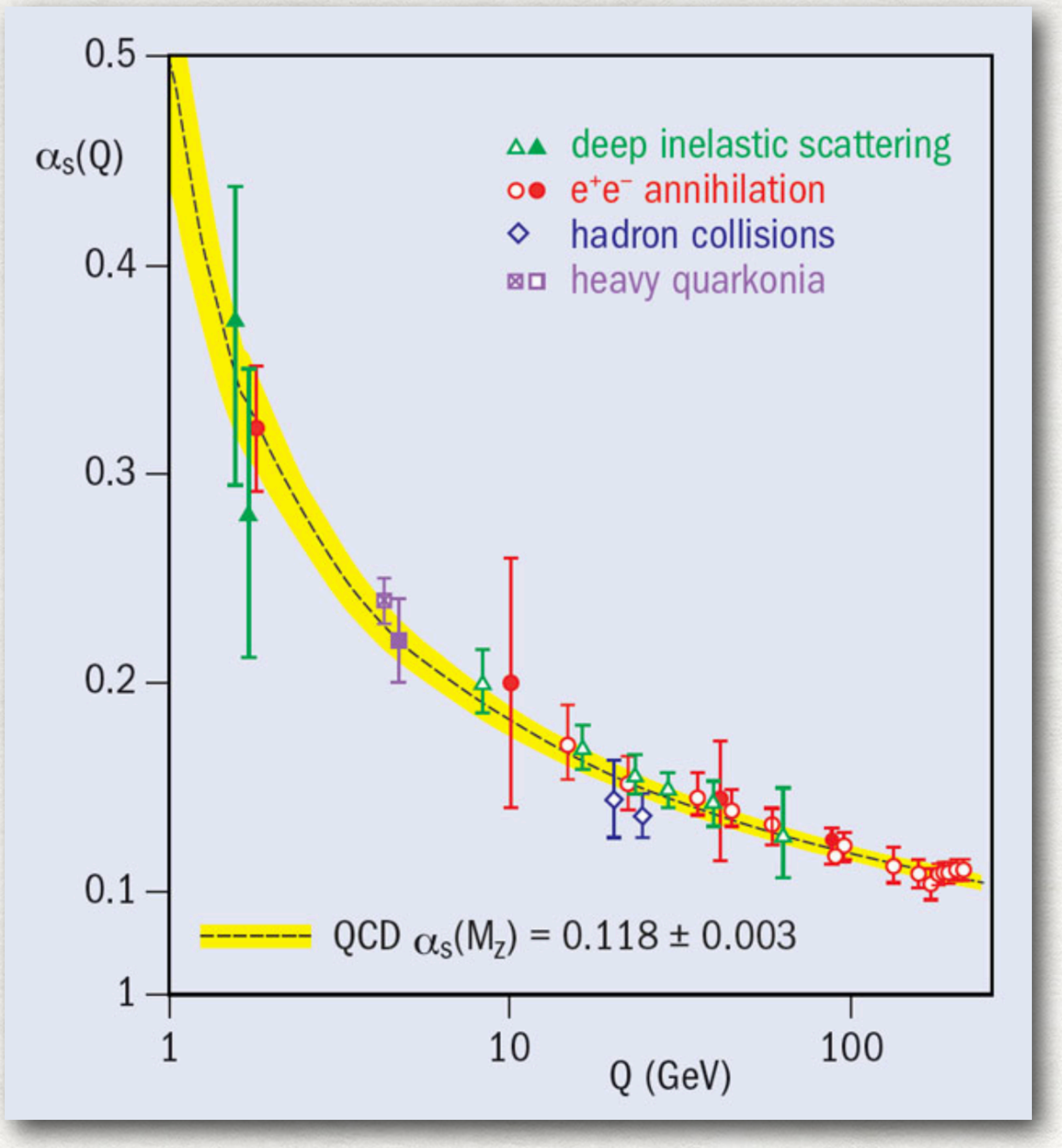
INTRODUCTION

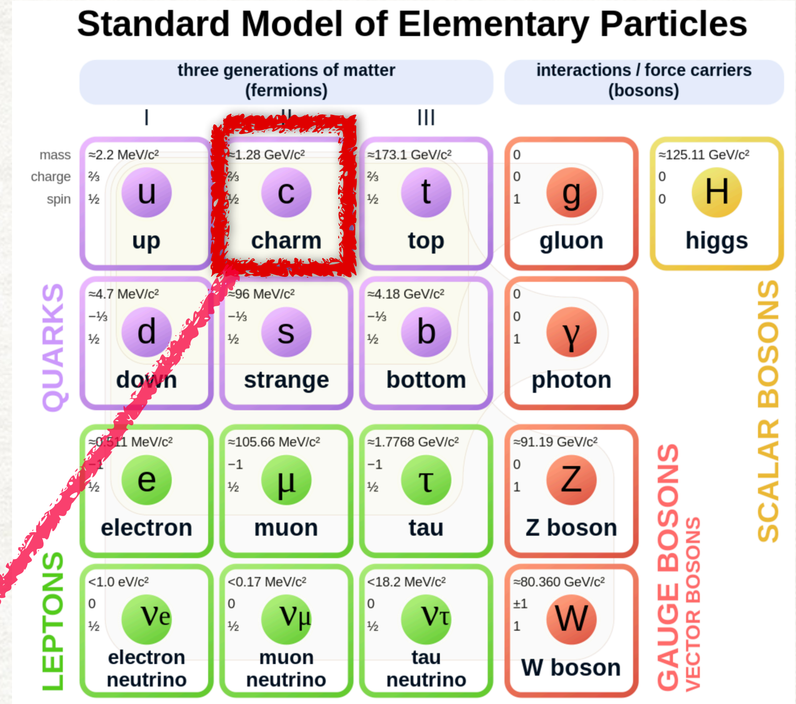


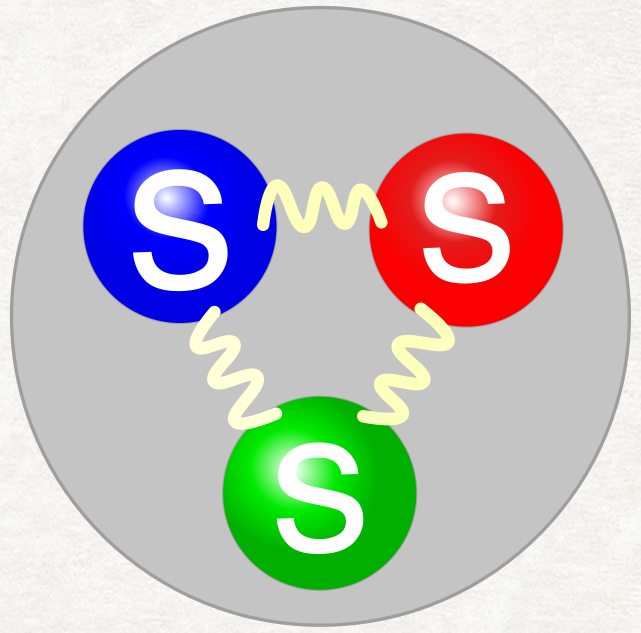
hydrogen atom



proton

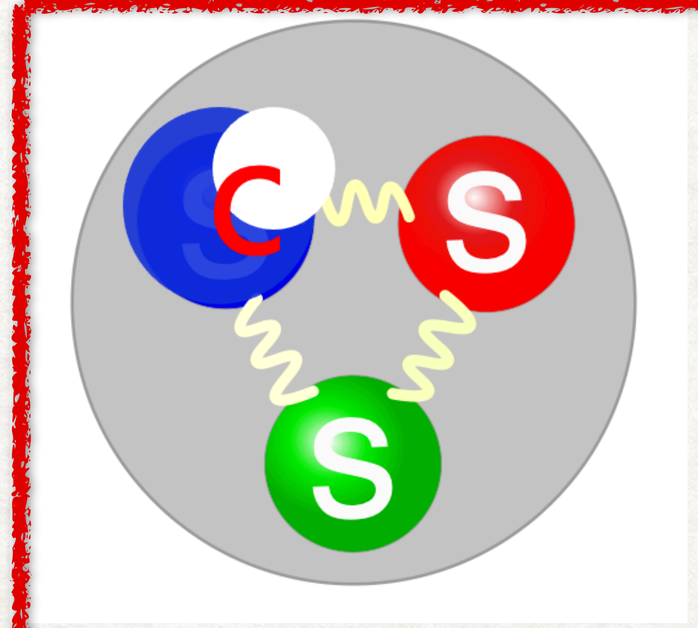






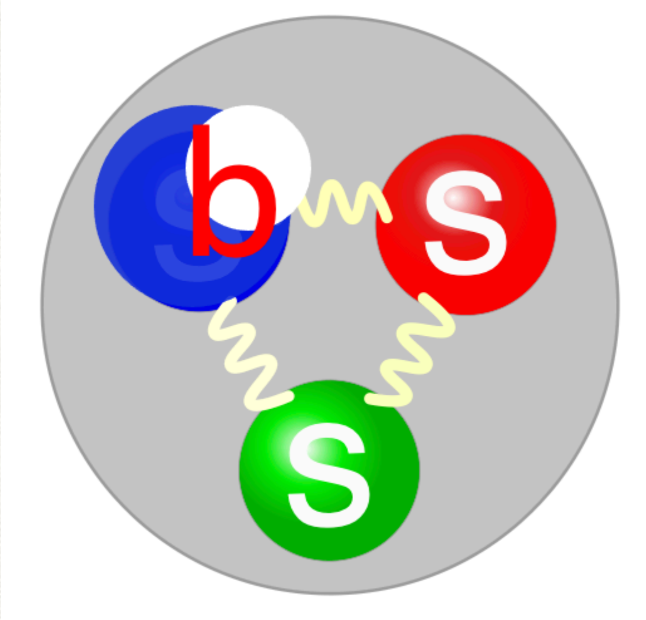
hyperon

e.g., Ω discovered at BNL in 1964



charmed baryon

e.g., charmed Ω discovered in 1985



bottom(ed) baryon

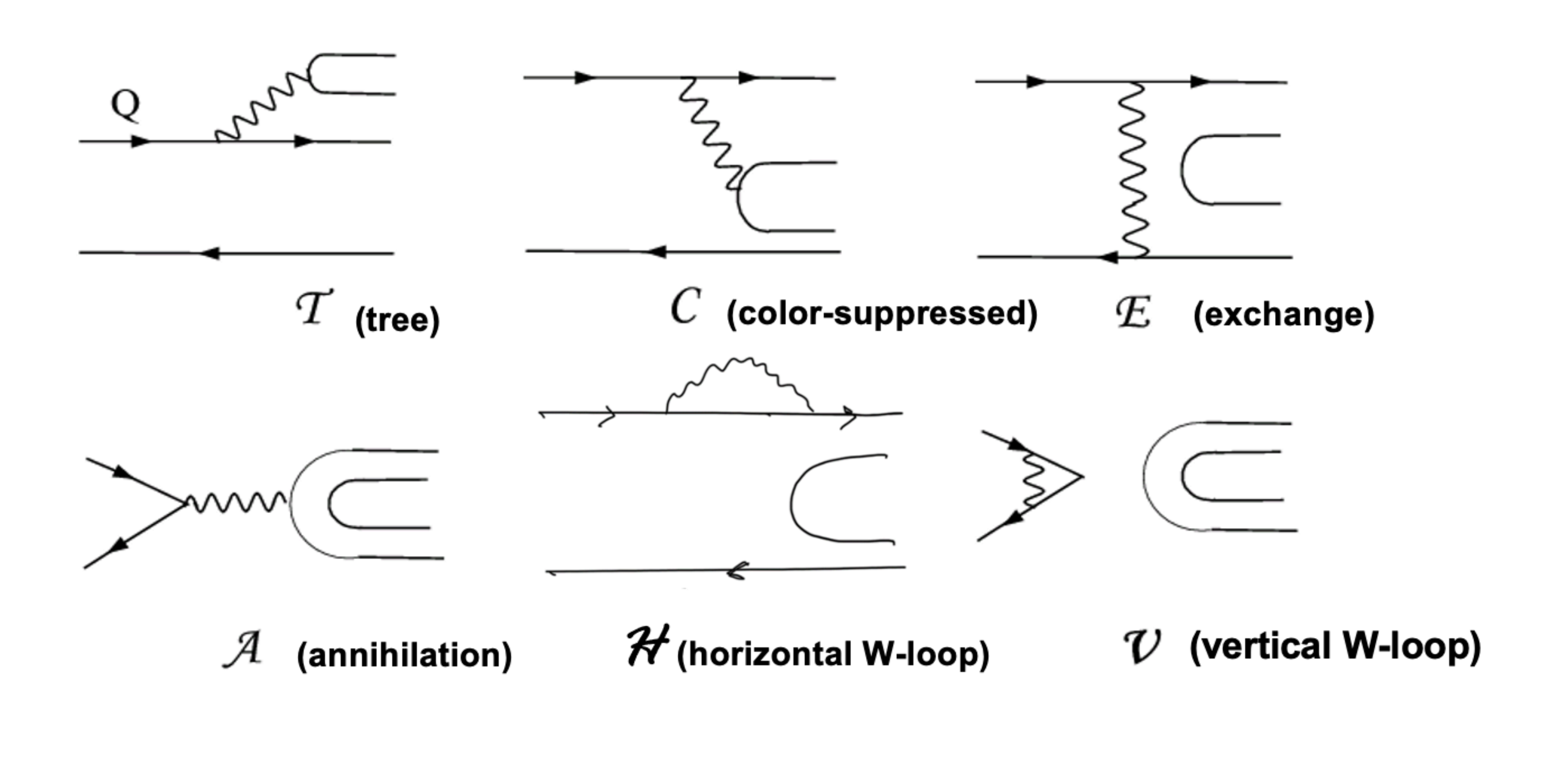
e.g., bottom Ω discovered in 2008 by DΦ

History of Topological Diagram (1)

Charmed meson

- two-body decays can be expressed in terms of six distinct topological diagrams [Chau (1980, 1983); Chau, Cheng (1986)]

L.-L. Chau in *Proceedings of 1980 Guangzhou Conference on Theoretical Particle Physics*

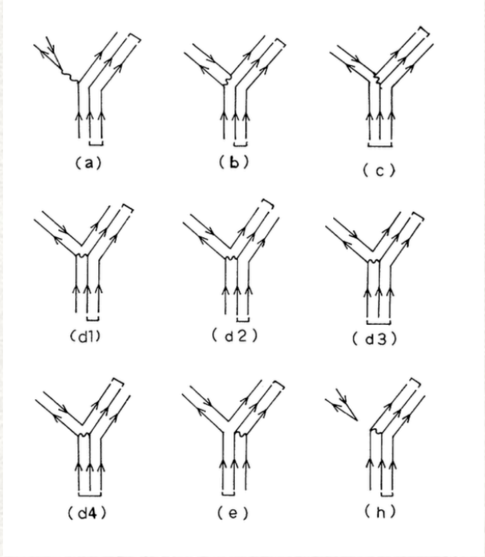


both magnitude and strong phase of each tree diagram can be determined

History of Topological Diagram (2)

Charmed baryon: early investigation

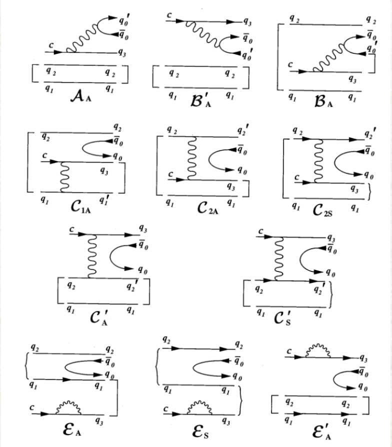
- Kohara (1991): parameterize by antisymmetric (12) and (23) for octet baryon wave function



$$\mathcal{A} = a\overline{B}^{3[ab]}B_{[ab]}M^1_2 + b\overline{B}^{1[ab]}B_{[ab]}M^3_2 + c\overline{B}^{b[13]}B_{[ab]}M^a_2 + d_1\overline{B}^{a[1b]}B_{[2b]}M^3_a + d_2\overline{B}^{b[1a]}B_{[2b]}M^3_a + d_3\overline{B}^{a[3b]}B_{[2b]}M^1_a + d_4\overline{B}^{b[3a]}B_{[2b]}M^1_a + e\overline{B}^{a[13]}B_{[2b]}M^b_a + h\overline{B}^{b[13]}B_{[2b]}M^a_a ,$$

$$|\tilde{\mathcal{B}}^{m,k}(8)\rangle = \alpha|\chi^m(1/2)_{A_{12}}\rangle|\psi^k(8)_{A_{12}}\rangle + \beta|\chi^m(1/2)_{A_{23}}\rangle|\psi^k(8)_{A_{23}}\rangle$$

- Chau, Cheng, Tseng (1996): parameterize symmetric and antisymmetric (12) for octet baryon wave function



$$|\mathcal{B}^{m,k}(8)\rangle = a|\chi^m(1/2)_{A_{12}}\rangle|\psi^k(8)_{A_{12}}\rangle + b|\chi^m(1/2)_{S_{12}}\rangle|\psi^k(8)_{S_{12}}\rangle$$

- Kohara (1997): physics is independent of the chosen convention

Recent developments in Topological Diagram

Charmed baryon: decays with pseudoscalars

- Hai-Yang Cheng, FX, Huiling Zhong (2024-2025):
  5 independent diagrams are found;
  all the CF, SCS, DCS modes are predicted;
  penguin included, CP violations are predicted.

Other groups

- Y.-K. Hsiao
- D. Wang

PHYSICAL REVIEW D **109,** 114027 (2024)

Analysis of hadronic weak decays of charmed baryons in the topological diagrammatic approach

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(Received 18 April 2024; accepted 20 May 2024; published 17 June 2024)

PHYSICAL REVIEW D **111,** 034011 (2025)

Hadronic weak decays of charmed baryons in the topological diagrammatic approach: An update

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(Received 9 October 2024; accepted 7 January 2025; published 11 February 2025)

PHYSICAL REVIEW D **112,** 054022 (2025)

***CP* violation in hadronic weak decays of charmed baryons in the topological diagrammatic approach**

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- A systematical framework to study charmed baryon has been established.
- Extend to other processes

Decays with vector mesons

Experimental progress

PHYSICAL REVIEW D **110,** 052007 (2024)

Search for the rare decay of charmed baryon Λ_c^+ into the $p\mu^+\mu^-$ final state

R. Aaij *et al.*[*]
(LHCb Collaboration)

(Received 22 July 2024; accepted 27 August 2024; published 24 September 2024)

A search for the nonresonant $\Lambda_c^+ \to p\mu^+\mu^-$ decay is performed using proton-proton collision data recorded at a center-of-mass energy of 13 TeV by the LHCb experiment, corresponding to an integrated luminosity of 5.4 fb^{-1}. No evidence for the decay is found in the dimuon invariant-mass regions where the expected contributions of resonances is subdominant. The upper limit on the branching fraction of the $\Lambda_c^+ \to p\mu^+\mu^-$ decay is determined to be $2.9(3.2) \times 10^{-8}$ at 90%(95%) confidence level. The branching fractions in the dimuon invariant-mass regions dominated by the η, ρ and ω resonances are also determined.

DOI: 10.1103/PhysRevD.110.052007

$$\mathcal{B}(\Lambda_c^+ \to p\omega) = (9.82 \pm 1.23(\text{stat}) \pm 0.73(\text{syst}) \pm 2.79(\text{ext})) \times 10^{-4},$$
$$\mathcal{B}(\Lambda_c^+ \to p\rho) = (1.52 \pm 0.34(\text{stat}) \pm 0.14(\text{syst}) \pm 0.24(\text{ext})) \times 10^{-3},$$

arXiv > hep-ex > arXiv:2603.08469

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High Energy Physics – Experiment

[Submitted on 9 Mar 2026]

Amplitude Analysis of Singly Cabibbo-Suppressed Decay $\Lambda_c^+ \to pK^+K^-$

BESIII Collaboration: M. Ablikim, M. N. Achasov, P. Adlarson, X. C. Ai, R. Aliberti, A. Amoroso, Q. An, Y. Bai, O. Bakina, Y. Ban, H.-R. Bao, V. Batozskaya, K. Begzsuren, N. Berger, M. Berlowski, M. B. Bertani, D. Bettoni, F. Bianchi, E. Bianco, A. Bortone, I. Boyko, R. A. Briere, A. Brueggemann, H. Cai, M. H. Cai, X. Cai, A. Calcaterra, G. F. Cao, N. Cao, S. A. Cetin, X. Y. Chai, J. F. Chang, T. T. Chang, G. R. Che, Y. Z. Che, C. H. Chen, Chao Chen, G. Chen, H. S. Chen, H. Y. Chen, M. L. Chen, S. J. Chen, S. M. Chen, T. Chen, X. R. Chen, X. T. Chen, X. Y. Chen, Y. B. Chen, Y. Q. Chen, Z. K. Chen, J. C. Cheng, L. N. Cheng, S. K. Choi, X. Chu, G. Cibinetto, F. Cossio, J. Cottee-Meldrum, H. L. Dai, J. P. Dai, X. C. Dai, A. Dbeyssi, R. E. de Boer, D. Dedovich, C. Q. Deng, Z. Y. Deng, A. Denig, I. Denisenko, M. Destefanis, F. De Mori, X. X. Ding, Y. Ding, Y. X. Ding, J. Dong, L. Y. Dong, M. Y. Dong, X. Dong, M. C. Du, S. X. Du, S. X. Du, X. L. Du, Y. Y. Duan, Z. H. Duan, P. Egorov, G. F. Fan, J. J. Fan, Y. H. Fan, J. Fang, J. Fang, S. S. Fang, W. X. Fang, Y. Q. Fang, L. Fava, F. Feldbauer, G. Felici, C. Q. Feng, J. H. Feng, L. Feng, Q. X. Feng, Y. T. Feng et al. (606 additional authors not shown)

The branching fraction of $\Lambda_c^+ \to p\phi(1020)$ is measured to be $(1.21 \pm 0.11 \pm 0.08 \pm 0.01) \times 10^{-3}$, representing the most precise determination to date. This value agrees well with theoretical predictions from the pole model [10, 11] and the covariant confined quark model (CCQM) [14], and is consistent with previous experimental results and the PDG average.

Decays with vector mesons

Summary of experiments

- BF: 19
- alpha: 5

arXiv > hep-ex > arXiv:2410.16912

High Energy Physics – Experiment

[Submitted on 22 Oct 2024]

Measurement of the branching fractions of the decays $\Lambda_c^+ \to \Lambda K_S^0 K^+$, $\Lambda_c^+ \to \Lambda K_S^0 \pi^+$ and $\Lambda_c^+ \to \Lambda K^{*+}$

TABLE VI. The comparison of the measured BFs (in 10^{-3}) with the PDG average and theoretical calculations.

Decay mode	PDG [6]	Theory [7] [8]	This work
$\Lambda K_S^0 K^+$	2.85 ± 0.55	2.8 ± 0.6	$3.04 \pm 0.30 \pm 0.16$
$\Lambda K_S^0 \pi^+$	-	4.4 ± 0.7	$1.73 \pm 0.26 \pm 0.10$
ΛK^{*+} (no interference)	-	1.97	$2.40 \pm 0.58 \pm 0.11$
ΛK^{*+} ($\theta_0 = 109^\circ$)			$5.21 \pm 0.71 \pm 0.25$
ΛK^{*+} ($\theta_0 = 221^\circ$)			$1.29 \pm 0.44 \pm 0.06$

Mode	$\mathcal{B}$ PDG	BES III	Belle	LHCb	Average	α
$\Lambda_c^+ \to p\overline{K}^{*0}$	1.40 ± 0.07				1.40 ± 0.07	0.87 ± 0.03 [1, 22]
$\Lambda_c^+ \to \Lambda\rho^+$	4.1 ± 0.5				4.1 ± 0.5	-0.76 ± 0.07
$\Lambda_c^+ \to \Sigma^+\rho^0$	< 1.7				< 1.7	
$\Lambda_c^+ \to \Sigma^+\omega$	1.72 ± 0.20				1.72 ± 0.20	
$\Xi_c^+ \to \Sigma^+\overline{K}^{*0}$	2.3 ± 1.1				2.3 ± 1.1	
$\Lambda_c^+ \to p\phi$	1.05 ± 0.14	1.21 ± 0.14 [23]			1.13 ± 0.10	
$\Lambda_c^+ \to \Sigma^+\phi$	4.0 ± 0.5				4.0 ± 0.5	
$\Lambda_c^+ \to \Sigma^+K^{*0}$	3.5 ± 1.0				3.5 ± 1.0	
$\Lambda_c^+ \to p\rho^0$	1.5 ± 0.4				1.5 ± 0.4	
$\Lambda_c^+ \to \Lambda K^{*+}$		1.29 ± 0.44 [24][a]			1.29 ± 0.44	
$\Lambda_c^+ \to \Sigma^0 K^{*+}$		1.23 ± 0.57 [11]			1.23 ± 0.57	
$\Xi_c^+ \to p\overline{K}^{*0}$	3.3 ± 1.7				3.3 ± 1.7	0.613 ± 0.065 [1, 20]
$\Xi_c^+ \to \Sigma^+\phi$	< 3.2				< 3.2	
$\Xi_c^0 \to \Lambda\overline{K}^{*0}$	2.6 ± 0.6				2.6 ± 0.6	0.15 ± 0.22
$\Xi_c^0 \to \Sigma^0\overline{K}^{*0}$	9.9 ± 1.9				9.9 ± 1.9	
$\Xi_c^0 \to \Sigma^+K^{*-}$	4.9 ± 1.3				4.9 ± 1.3	-0.50 ± 0.30
$\Lambda_c^+ \to p\omega$	8.9 ± 1.1			9.82 ± 3.30 [25]	9.0 ± 1.0	
$\Xi_c^+ \to p\phi$	1.2 ± 0.6				1.2 ± 0.6	
$\Xi_c^0 \to \Lambda\phi$	4.9 ± 1.3				4.9 ± 1.3	

[a] Among all the three results in [24], the branching fractions 2.40±0.59, 5.21±0.75 and 1.29±0.44 correspond $\theta_0 = 0$ (no interference), 109° and 221°, respectively.

14

Decays with vector mesons

existed theoretical studies

- Y.K. Hsiao, Y. Yu, H.J. Zhao (2019):
  PLB 792, 35 (2019)
  fit: under certain SU(3) symmetry

- C.Q. Geng, C.-W. Liu, T.-H. Tsai (2020):
  PRD 101, 053002 (2020)
  fit: under certain SU(3) symmetry, TDA

- C.P. Jia, H.Y. Jiang, J.P. Wang, F.S. Yu (2024):
  JHEP 11, 072 (2024)
  dynamical calculation: FSI mechanism

TDA FRAMEWORK

KINEMATICS

- amplitude in terms of 4 form factors

$$\mathcal{M}(\mathcal{B}_c \to \mathcal{B}V) = \bar{u}_f(p_f)\,\epsilon^{*\mu}\left[A_1\gamma_\mu\gamma_5 + A_2\frac{p_{f\mu}}{m_i}\gamma_5 + B_1\gamma_\mu + B_2\frac{p_{f\mu}}{m_i}\right]u_i(p_i),$$

$$\mathcal{L}_{\mathcal{B}'\mathcal{B}V} = g_{\mathcal{B}'\mathcal{B}V}\mathrm{Tr}(\overline{\mathcal{B}}'\gamma_\mu V^\mu \mathcal{B}) + \frac{f_{\mathcal{B}'\mathcal{B}V}}{m_{\mathcal{B}'}+m_{\mathcal{B}}}\mathrm{Tr}(\overline{\mathcal{B}}'\sigma_{\mu\nu}\mathcal{B}\,\partial^\mu V^\nu).$$

pole model

$$A_1 = -\sum_{\mathcal{B}_{n^*}(1/2^-)}\left[\frac{g_{\mathcal{B}_f\mathcal{B}_{n^*}V}b_{n^*i}}{m_i-m_n} + \frac{b_{fn^*}g_{\mathcal{B}_{n^*}\mathcal{B}_iV}}{m_f-m_n}\right],$$
$$B_1 = -\sum_{\mathcal{B}_n}\left[\frac{g_{\mathcal{B}_f\mathcal{B}_nV}a_{ni}}{m_i-m_n} + \frac{a_{fn}g_{\mathcal{B}_n\mathcal{B}_iV}}{m_f-m_n}\right],$$
$$A_2 = B_2 = 0,$$

$$A_1 = -\frac{m_i-m_f}{2(m_i+m_f)}\sum_{\mathcal{B}_{n^*}(1/2^-)}\left[\frac{f_{\mathcal{B}_f\mathcal{B}_{n^*}V}b_{n^*i}}{m_i-m_n} + \frac{b_{fn^*}f_{\mathcal{B}_{n^*}\mathcal{B}_iV}}{m_f-m_n}\right],$$
$$A_2 = \frac{2m_i}{m_i-m_f}A_1,$$
$$B_1 = \frac{1}{2}\sum_{\mathcal{B}_n}\left[\frac{f_{\mathcal{B}_f\mathcal{B}_nV}a_{ni}}{m_i-m_n} + \frac{a_{fn}f_{\mathcal{B}_n\mathcal{B}_iV}}{m_f-m_n}\right],$$
$$B_2 = -\frac{2m_i}{m_i+m_f}B_1.$$

H.-Y. Cheng, B. Tseng, PRD 46(1992) 1042

KINEMATICS

- observables in terms of 4 partial waves

$$\Gamma = \frac{p_c}{4\pi}\frac{E_f + m_f}{m_i}\left[2\left(|S|^2 + |P_2|^2\right) + \frac{E_V^2}{m_V^2}\left(|S+D|^2 + |P_1|^2\right)\right]$$

$$\begin{aligned} S &= -A_1, \\ P_1 &= -\frac{p_c}{E_V}\left(\frac{m_i + m_f}{E_f + m_f}B_1 + B_2\right), \\ P_2 &= \frac{p_c}{E_f + m_f}B_1, \\ D &= -\frac{p_c^2}{E_V(E_f + m_f)}(A_1 - A_2). \end{aligned}$$

$$\alpha = \frac{2E_V^2\,\mathrm{Re}[(S+D)^* P_1] + 4m_V^2\,\mathrm{Re}(S^* P_2)}{2m_V^2\left(|S|^2 + |P_2|^2\right) + E_V^2\left(|S+D|^2 + |P_1|^2\right)},$$

$$P_L = \frac{2E_V^2\,\mathrm{Re}[(S+D)^* P_1] - 4m_V^2\,\mathrm{Re}(S^* P_2)}{2m_V^2\left(|S|^2 + |P_2|^2\right) + E_V^2\left(|S+D|^2 + |P_1|^2\right)}.$$

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PARITY VIOLATION AND FLAVOR SELECTION RULES IN CHARMED BARYON DECAYS

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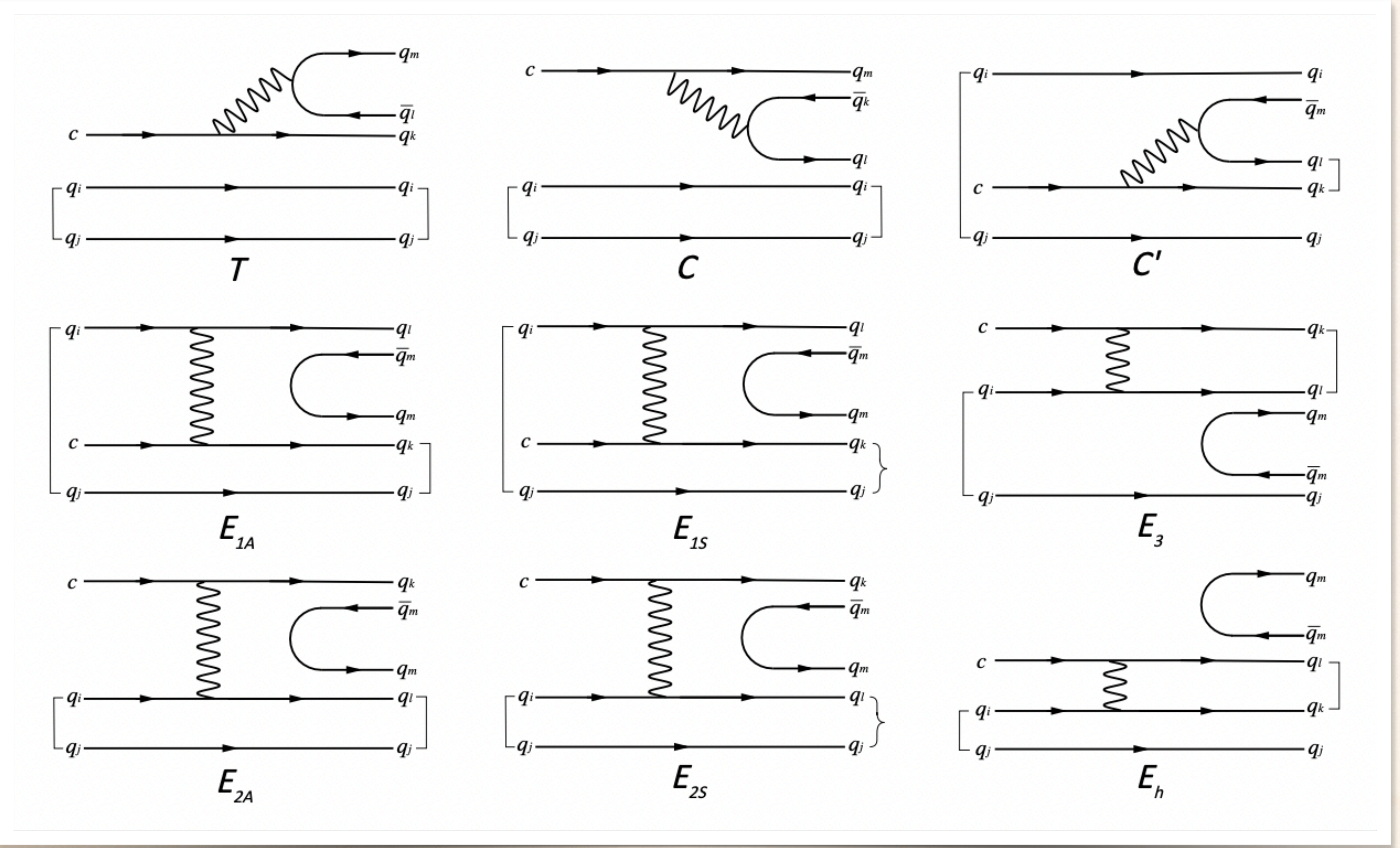
DYNAMICS: TOPOLOGICAL DIAGRAMS

Completeness vs. Redundancy



$$
\begin{aligned}
\mathcal{A}_{\rm TDA} = \;& T(\mathcal{B}_c)^{ij} H^{km}_l M^l_m \left[b_1 \,(\mathcal{B}_8)_{ijk} + b_2 \,(\mathcal{B}_8)_{ikj} + b_3 \,(\mathcal{B}_8)_{jki}\right] \\
&+ C(\mathcal{B}_c)^{ij} H^{ml}_k M^k_m \left[b_4 \,(\mathcal{B}_8)_{ijl} + b_5 \,(\mathcal{B}_8)_{ilj} + b_6 \,(\mathcal{B}_8)_{jli}\right] \\
&+ C'(\mathcal{B}_c)^{ij} H^{kl}_m M^m_i \left[b_7 \,(\mathcal{B}_8)_{klj} + b_8 \,(\mathcal{B}_8)_{kjl} + b_9 \,(\mathcal{B}_8)_{ljk}\right] \\
&+ E_1(\mathcal{B}_c)^{ij} H^{kl}_i M^m_l \left[b_{10} \,(\mathcal{B}_8)_{jkm} + b_{11} \,(\mathcal{B}_8)_{jmk} + b_{12} \,(\mathcal{B}_8)_{kmj}\right] \\
&+ E_2(\mathcal{B}_c)^{ij} H^{kl}_i M^m_k \left[b_{13} \,(\mathcal{B}_8)_{jlm} + b_{14} \,(\mathcal{B}_8)_{jml} + b_{15} \,(\mathcal{B}_8)_{lmj}\right] \\
&+ E_3(\mathcal{B}_c)^{ij} H^{kl}_i M^m_j \left[b_{16} \,(\mathcal{B}_8)_{klm} + b_{17} \,(\mathcal{B}_8)_{kml} + b_{18} \,(\mathcal{B}_8)_{lmk}\right] \\
&+ E_h(\mathcal{B}_c)^{ij} H^{kl}_i M^m_m \left[b_{19} \,(\mathcal{B}_8)_{jkl} + b_{20} \,(\mathcal{B}_8)_{jlk} + b_{21} \,(\mathcal{B}_8)_{klj}\right] ,
\end{aligned}
$$

$$
(\mathcal{B}_8)^i_j = \begin{pmatrix} \frac{1}{\sqrt{6}}\Lambda^0 + \frac{1}{\sqrt{2}}\Sigma^0 & \Sigma^+ & p \\ \Sigma^- & \frac{1}{\sqrt{6}}\Lambda^0 - \frac{1}{\sqrt{2}}\Sigma^0 & n \\ \Xi^- & \Xi^0 & -\sqrt{\frac{2}{3}}\Lambda^0 \end{pmatrix}
$$

$$
(\mathcal{B}_c)^{ij} = \begin{pmatrix} 0 & \Lambda_c^+ & \Xi_c^+ \\ -\Lambda_c^+ & 0 & \Xi_c^0 \\ -\Xi_c^+ & -\Xi_c^0 & 0 \end{pmatrix}
$$

$$
V^i_j = \begin{pmatrix} \frac{\rho^0+\omega}{\sqrt{2}} & \rho^+ & K^{*+} \\ \rho^- & \frac{-\rho^0+\omega}{\sqrt{2}} & K^{*0} \\ K^{*-} & \overline{K}^{*0} & \phi \end{pmatrix}
$$

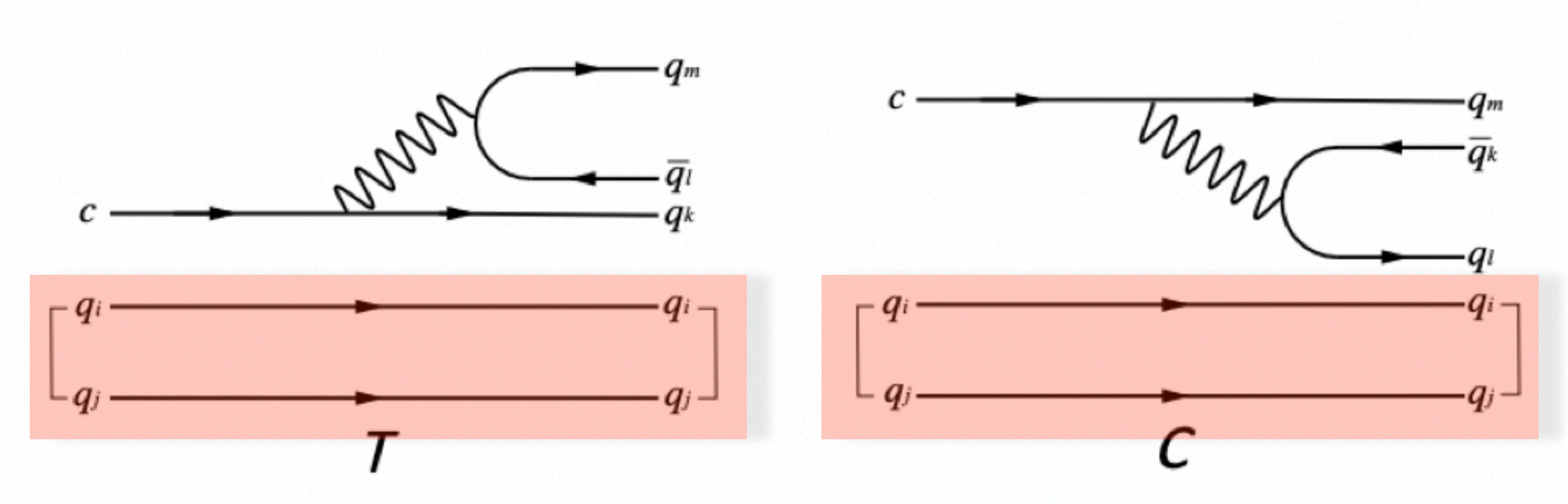
$$
(\mathcal{B}_8)_{ijk} = \epsilon_{ijl}(\mathcal{B}_8^T)^l_k
$$

$$
H^{31}_2 = V^*_{cs}V_{ud}, \quad H^{31}_3 = V^*_{cs}V_{us}, \quad H^{21}_2 = V^*_{cd}V_{ud}, \quad H^{21}_3 = V^*_{cd}V_{us}.
$$

$$
\begin{aligned}
\mathcal{A}_{\rm TDA} = \; & T(\mathcal{B}_c)^{ij} H^{km}_{l} M^{l}_{m} \left[b_1 \, (\mathcal{B}_8)_{ijk} + b_2 \, (\mathcal{B}_8)_{ikj} + b_3 \, (\mathcal{B}_8)_{jki} \right] \\
& + C(\mathcal{B}_c)^{ij} H^{ml}_{k} M^{k}_{m} \left[b_4 \, (\mathcal{B}_8)_{ijl} + b_5 \, (\mathcal{B}_8)_{ilj} + b_6 \, (\mathcal{B}_8)_{jli} \right] \\
& + C'(\mathcal{B}_c)^{ij} H^{kl}_{m} M^{m}_{i} \left[b_7 \, (\mathcal{B}_8)_{klj} + b_8 \, (\mathcal{B}_8)_{kjl} + b_9 \, (\mathcal{B}_8)_{ljk} \right] \\
& + E_1(\mathcal{B}_c)^{ij} H^{kl}_{i} M^{m}_{l} \left[b_{10} \, (\mathcal{B}_8)_{jkm} + b_{11} \, (\mathcal{B}_8)_{jmk} + b_{12} \, (\mathcal{B}_8)_{kmj} \right] \\
& + E_2(\mathcal{B}_c)^{ij} H^{kl}_{i} M^{m}_{k} \left[b_{13} \, (\mathcal{B}_8)_{jlm} + b_{14} \, (\mathcal{B}_8)_{jml} + b_{15} \, (\mathcal{B}_8)_{lmj} \right] \\
& + E_3(\mathcal{B}_c)^{ij} H^{kl}_{i} M^{m}_{j} \left[b_{16} \, (\mathcal{B}_8)_{klm} + b_{17} \, (\mathcal{B}_8)_{kml} + b_{18} \, (\mathcal{B}_8)_{lmk} \right] \\
& + E_h(\mathcal{B}_c)^{ij} H^{kl}_{i} M^{m}_{m} \left[b_{19} \, (\mathcal{B}_8)_{jkl} + b_{20} \, (\mathcal{B}_8)_{jlk} + b_{21} \, (\mathcal{B}_8)_{klj} \right] ,
\end{aligned}
$$

$$b_3 = -b_2$$

$$b_6 = -b_5$$



$$(\mathcal{B}_8)_{ijk} = \epsilon_{ijl} (\mathcal{B}_8^T)^l_k$$

$$
\begin{aligned}
\mathcal{A}_{\mathrm{TDA}} = \; & T(\mathcal{B}_c)^{ij} H^{km}_{l} M^{l}_{m} \left[b_1 (\mathcal{B}_8)_{ijk} + b_2 (\mathcal{B}_8)_{ikj} + b_3 (\mathcal{B}_8)_{jki} \right] \\
& + C(\mathcal{B}_c)^{ij} H^{ml}_{k} M^{k}_{m} \left[b_4 (\mathcal{B}_8)_{ijl} + b_5 (\mathcal{B}_8)_{ilj} + b_6 (\mathcal{B}_8)_{jli} \right] \\
& + C'(\mathcal{B}_c)^{ij} H^{kl}_{m} M^{m}_{i} \left[b_7 (\mathcal{B}_8)_{klj} + b_8 (\mathcal{B}_8)_{kjl} + b_9 (\mathcal{B}_8)_{ljk} \right] \\
& + E_1(\mathcal{B}_c)^{ij} H^{kl}_{i} M^{m}_{l} \left[b_{10} (\mathcal{B}_8)_{jkm} + b_{11} (\mathcal{B}_8)_{jmk} + b_{12} (\mathcal{B}_8)_{kmj} \right] \\
& + E_2(\mathcal{B}_c)^{ij} H^{kl}_{i} M^{m}_{k} \left[b_{13} (\mathcal{B}_8)_{jlm} + b_{14} (\mathcal{B}_8)_{jml} + b_{15} (\mathcal{B}_8)_{lmj} \right] \\
& + E_3(\mathcal{B}_c)^{ij} H^{kl}_{i} M^{m}_{j} \left[b_{16} (\mathcal{B}_8)_{klm} + b_{17} (\mathcal{B}_8)_{kml} + b_{18} (\mathcal{B}_8)_{lmk} \right] \\
& + E_h(\mathcal{B}_c)^{ij} H^{kl}_{i} M^{m}_{m} \left[b_{19} (\mathcal{B}_8)_{jkl} + b_{20} (\mathcal{B}_8)_{jlk} + b_{21} (\mathcal{B}_8)_{klj} \right] ,
\end{aligned}
$$

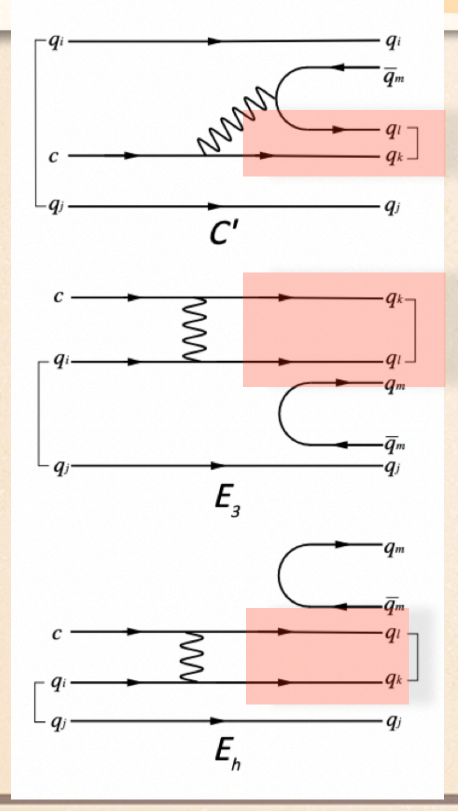
$b_3 = -b_2$

$b_6 = -b_5$

$b_9 = -b_8$

$b_{18} = -b_{17}$

$b_{20} = -b_{19}$



Korner-Pati-Woo theorem:

quark pair in a baryon produced by weak interactions
is required to be antisymmetric in flavor —> [l, k] asymmetric

$$
\begin{aligned}
\mathcal{A}_{\rm TDA} = \; & T(\mathcal{B}_c)^{ij} H^{km}_{l} M^{l}_{m} \left[b_1 \, (\mathcal{B}_8)_{ijk} + b_2 \, (\mathcal{B}_8)_{ikj} + b_3 \, (\mathcal{B}_8)_{jki} \right] \\
& + C(\mathcal{B}_c)^{ij} H^{ml}_{k} M^{k}_{m} \left[b_4 \, (\mathcal{B}_8)_{ijl} + b_5 \, (\mathcal{B}_8)_{ilj} + b_6 \, (\mathcal{B}_8)_{jli} \right] \\
& + C'(\mathcal{B}_c)^{ij} H^{kl}_{m} M^{m}_{i} \left[b_7 \, (\mathcal{B}_8)_{klj} + b_8 \, (\mathcal{B}_8)_{kjl} + b_9 \, (\mathcal{B}_8)_{ljk} \right] \\
& + E_1(\mathcal{B}_c)^{ij} H^{kl}_{i} M^{m}_{l} \left[b_{10} \, (\mathcal{B}_8)_{jkm} + b_{11} \, (\mathcal{B}_8)_{jmk} + b_{12} \, (\mathcal{B}_8)_{kmj} \right] \\
& + E_2(\mathcal{B}_c)^{ij} H^{kl}_{i} M^{m}_{k} \left[b_{13} \, (\mathcal{B}_8)_{jlm} + b_{14} \, (\mathcal{B}_8)_{jml} + b_{15} \, (\mathcal{B}_8)_{lmj} \right] \\
& + E_3(\mathcal{B}_c)^{ij} H^{kl}_{i} M^{m}_{j} \left[b_{16} \, (\mathcal{B}_8)_{klm} + b_{17} \, (\mathcal{B}_8)_{kml} + b_{18} \, (\mathcal{B}_8)_{lmk} \right] \\
& + E_h(\mathcal{B}_c)^{ij} H^{kl}_{i} M^{m}_{m} \left[b_{19} \, (\mathcal{B}_8)_{jkl} + b_{20} \, (\mathcal{B}_8)_{jlk} + b_{21} \, (\mathcal{B}_8)_{klj} \right] ,
\end{aligned}
$$

$b_3 = -b_2$

$b_6 = -b_5$

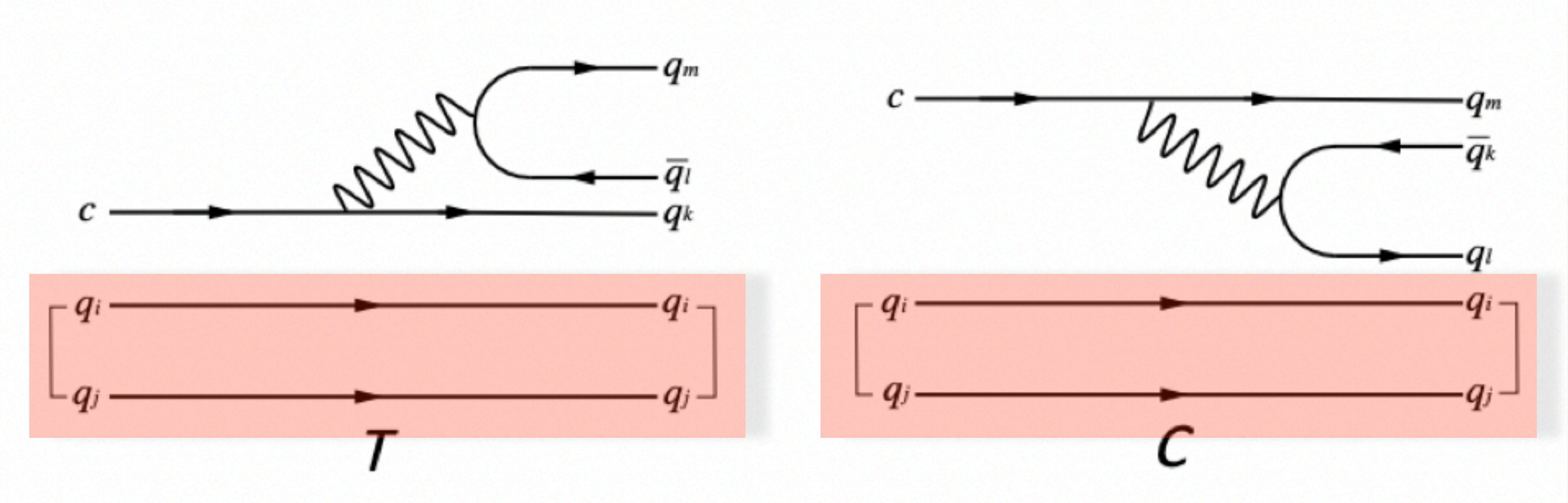
$b_9 = -b_8$

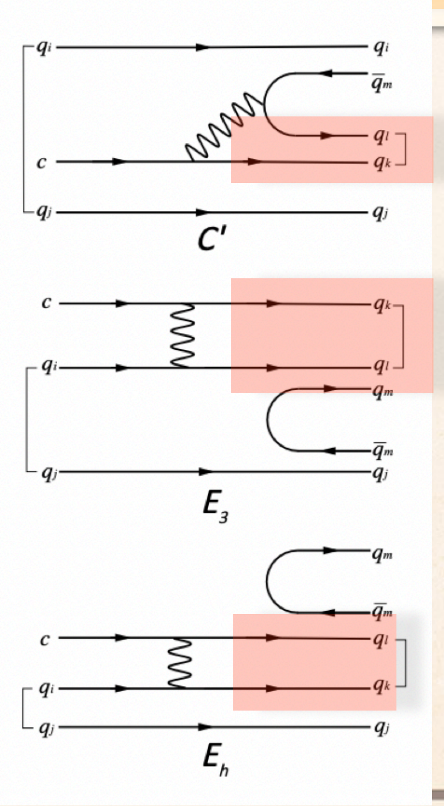
$b_{12} = b_{11}$

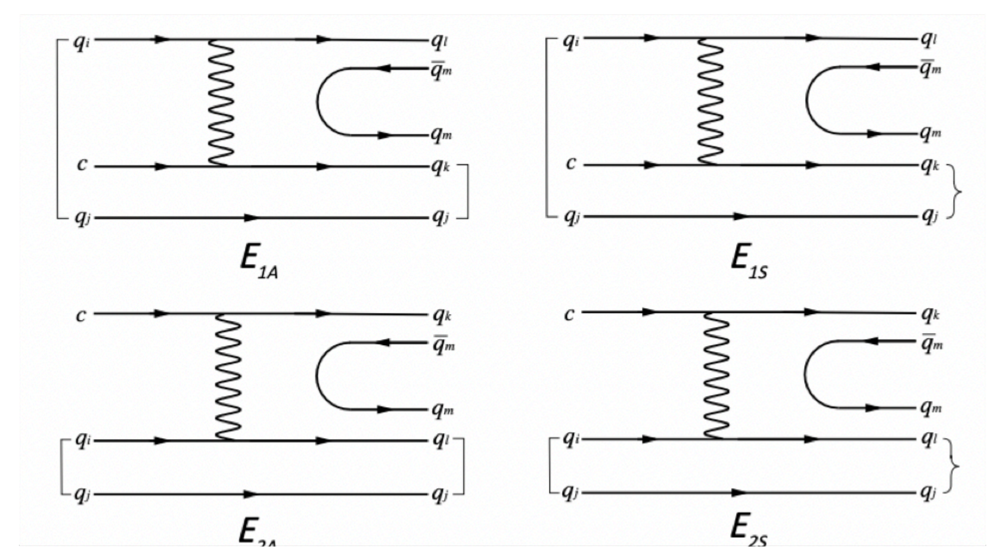
$b_{15} = b_{14}$

$b_{18} = -b_{17}$

$b_{20} = -b_{19}$

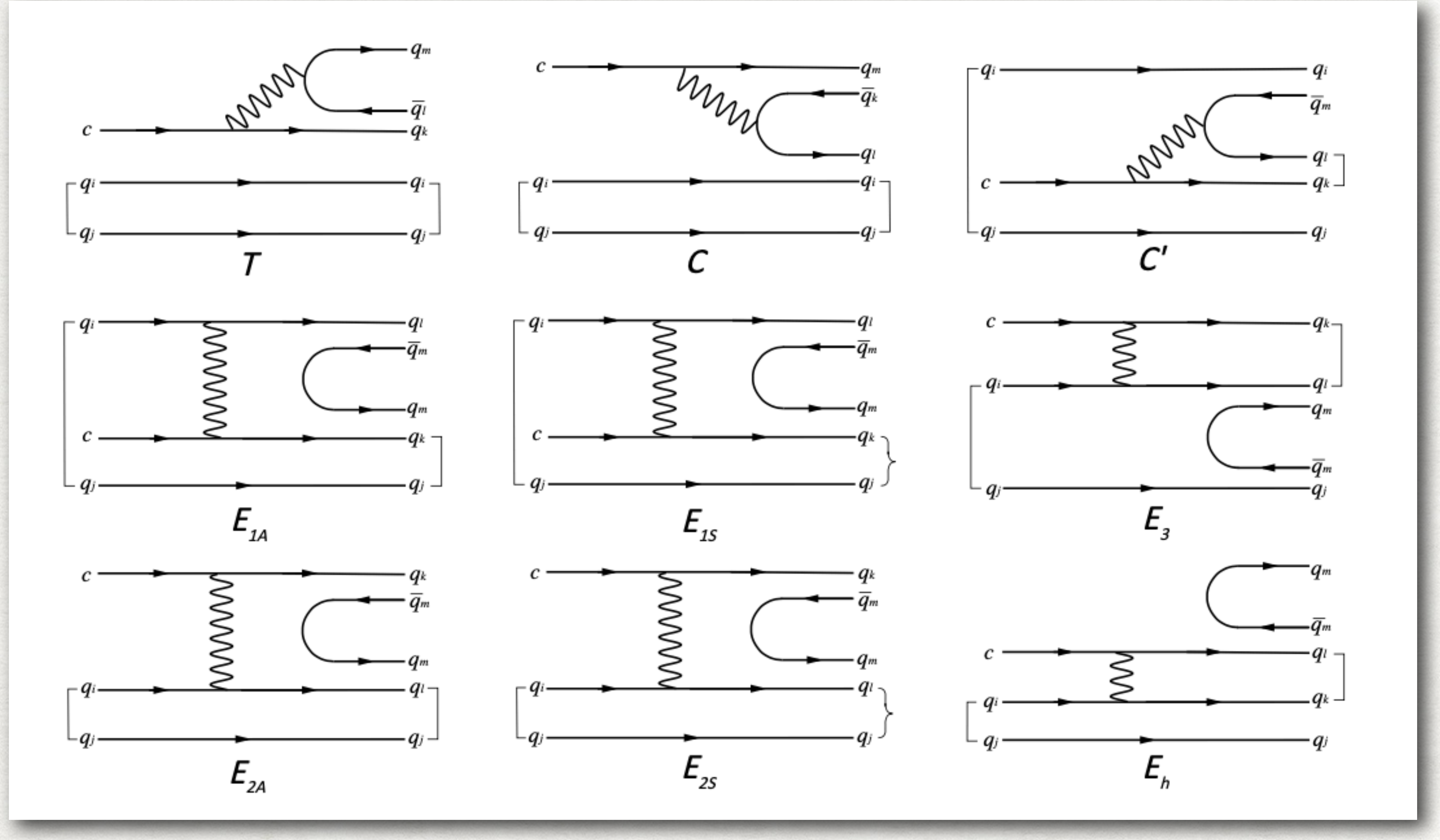






$$
|\mathcal{B}^{m,k}(8)\rangle = a|\chi^m(1/2)_{A_{12}}\rangle|\psi^k(8)_{A_{12}}\rangle + b|\chi^m(1/2)_{S_{12}}\rangle|\psi^k(8)_{S_{12}}\rangle
$$

DYNAMICS: TOPOLOGICAL DIAGRAMS



$$\mathcal{A} = T(\mathcal{B}_c)^{ij} H^{km}_l (\mathcal{B}_8)_{ijk} V^l_m + C(\mathcal{B}_c)^{ij} H^{ml}_k (\mathcal{B}_8)_{ijl} V^k_m + C'(\mathcal{B}_c)^{ij} H^{kl}_m (\mathcal{B}_8)_{klj} V^m_i$$
$$+E_{1A}(\mathcal{B}_c)^{ij} H^{kl}_i (\mathcal{B}_8)_{jkm} V^m_l + E_{1S}(\mathcal{B}_c)^{ij} H^{kl}_i \left[(\mathcal{B}_8)_{jmk} + (\mathcal{B}_8)_{kmj}\right] V^m_l$$
$$+E_{2A}(\mathcal{B}_c)^{ij} H^{kl}_i (\mathcal{B}_8)_{jlm} V^m_k + E_{2S}(\mathcal{B}_c)^{ij} H^{kl}_i \left[(\mathcal{B}_8)_{jml} + (\mathcal{B}_8)_{lmj}\right] V^m_k$$
$$+E_3(\mathcal{B}_c)^{ij} H^{kl}_i (\mathcal{B}_8)_{klm} V^m_j + E_h(\mathcal{B}_c)^{ij} H^{kl}_i (\mathcal{B}_8)_{klj} V^m_m.$$

$H^{kl}_m (\bar{q}_k c)(\bar{q}_l q^m)$ Weak interaction

$$V^i_j = \begin{pmatrix} \frac{\rho^0+\omega}{\sqrt{2}} & \rho^+ & K^{*+} \\ \rho^- & \frac{-\rho^0+\omega}{\sqrt{2}} & K^{*0} \\ K^{*-} & \bar{K}^{*0} & \phi \end{pmatrix}, \quad (\mathcal{B}_c)^{ij} = \begin{pmatrix} 0 & \Lambda_c^+ & \Xi_c^+ \\ -\Lambda_c^+ & 0 & \Xi_c^0 \\ -\Xi_c^+ & -\Xi_c^0 & 0 \end{pmatrix}$$

$$(\mathcal{B}_8)^i_j = \begin{pmatrix} \frac{1}{\sqrt{6}}\Lambda^0 + \frac{1}{\sqrt{2}}\Sigma^0 & \Sigma^+ & p \\ \Sigma^- & \frac{1}{\sqrt{6}}\Lambda^0 - \frac{1}{\sqrt{2}}\Sigma^0 & n \\ \Xi^- & \Xi^0 & -\sqrt{\frac{2}{3}}\Lambda^0 \end{pmatrix}.$$

- reduce independent diagrams to 7

$$E_{2A} = -E_{1A}, \qquad E_{2S} = -E_{1S}.$$

(KPW theorem)

- further reduction to 5 by redefinition

$$\tilde{T} = T - E_{1S}, \quad \tilde{C} = C + E_{1S}, \quad \tilde{C}' = C' - 2E_{1S},$$
$$\tilde{E}_1 = E_{1A} + E_{1S} - E_3, \quad \tilde{E}_h = E_h + 2E_{1S}.$$

AMPLITUDES

TABLE I. The expansions of Cabbibo-favored decay amplitudes, in which the common CKM factor $V_{cs}V_{ud}$ has been ignored.

Channel	TDA	$\widetilde{\text{TDA}}$
$\Lambda_c^+ \to \Xi^0 K^{*+}$	$E_{1A} + E_{1S} - E_3$	$\tilde{E}_1$
$\Lambda_c^+ \to \Lambda \rho^+$	$\frac{1}{\sqrt{6}}(-4T + C' + E_{1A} + 3E_{1S} - E_3)$	$\frac{1}{\sqrt{6}}(-4\tilde{T} + \tilde{C}' + \tilde{E}_1)$
$\Lambda_c^+ \to p\bar{K}^0$	$2C + 2E_{1S}$	$2\tilde{C}$
$\Lambda_c^+ \to \Sigma^0 \rho^+$	$\frac{1}{\sqrt{2}}(-C' - E_{1A} + E_{1S} + E_3)$	$\frac{1}{\sqrt{2}}(-\tilde{C}' - \tilde{E}_1)$
$\Lambda_c^+ \to \Sigma^+ \rho^0$	$\frac{1}{\sqrt{2}}(C' + E_{1A} - E_{1S} - E_3)$	$\frac{1}{\sqrt{2}}(\tilde{C}' + \tilde{E}_1)$
$\Lambda_c^+ \to \Sigma^+ \phi$	$-E_h - 2E_{1S}$	$-\tilde{E}_h$
$\Lambda_c^+ \to \Sigma^+ \omega$	$\frac{1}{\sqrt{2}}(-C' + E_{1A} - E_{1S} - E_3 - 2E_h)$	$\frac{1}{\sqrt{2}}(-\tilde{C}' + \tilde{E}_1 - 2\tilde{E}_h)$
$\Xi_c^0 \to \Lambda \bar{K}^{*0}$	$\frac{1}{\sqrt{6}}(2C - C' - E_{1A} + 3E_{1S} + E_3)$	$\frac{1}{\sqrt{6}}(2\tilde{C} - \tilde{C}' - \tilde{E}_1)$
$\Xi_c^0 \to \Sigma^0 \bar{K}^{*0}$	$\frac{1}{\sqrt{2}}(2C + C' + E_{1A} + E_{1S} - E_3)$	$\frac{1}{\sqrt{2}}(2\tilde{C} + \tilde{C}' + \tilde{E}_1)$
$\Xi_c^0 \to \Sigma^+ K^{*-}$	$-E_{1A} - E_{1S} + E_3$	$-\tilde{E}_1$
$\Xi_c^0 \to \Xi^0 \rho^0$	$\frac{1}{\sqrt{2}}(-C' + 2E_{1S})$	$\frac{1}{\sqrt{2}}(-\tilde{C}')$
$\Xi_c^0 \to \Xi^0 \phi$	$-E_{1A} + E_{1S} + E_3 + E_h$	$-\tilde{E}_1 + \tilde{E}_h$
$\Xi_c^0 \to \Xi^0 \omega$	$\frac{1}{\sqrt{2}}(C' + 2E_{1S} + 2E_h)$	$\frac{1}{\sqrt{2}}(\tilde{C}' + 2\tilde{E}_h)$
$\Xi_c^0 \to \Xi^- \rho^+$	$2T - 2E_{1S}$	$2\tilde{T}$
$\Xi_c^+ \to \Sigma^+ \bar{K}^{*0}$	$-2C - C'$	$-2\tilde{C} - \tilde{C}'$
$\Xi_c^+ \to \Xi^0 \rho^+$	$-2T + C'$	$-2\tilde{T} + \tilde{C}'$

$$M(\Lambda_c^+ \to \Sigma^0 \rho^+) = M(\Lambda_c^+ \to \Sigma^+ \rho^0),$$

$$M(\Lambda_c^+ \to \Xi^0 K^{*+}) = M(\Xi_c^0 \to \Sigma^+ K^{*-}),$$

$$\sqrt{2}\, M(\Lambda_c^+ \to \Sigma^0 K^{*+}) = M(\Lambda_c^+ \to \Sigma^+ K^{*0}) = M(\Xi_c^+ \to p\, \overline{K}^{*0}),$$

$$M(\Xi_c^0 \to \Sigma^- \rho^+) = M(\Xi_c^0 \to \Xi^- K^{*+}),$$

$$M(\Xi_c^0 \to \Xi^0 K^{*0}) = M(\Xi_c^0 \to n\, \overline{K}^{*0}),$$

$$\sqrt{2}\, M(\Xi_c^0 \to n\rho^0) = M(\Xi_c^0 \to p\rho^-) = \sqrt{2}\, M(\Xi_c^+ \to p\rho^0) = M(\Xi_c^+ \to n\rho^+),$$

$$\sqrt{2}\, M(\Xi_c^0 \to \Sigma^0 K^{*0}) = M(\Xi_c^+ \to \Sigma^+ K^{*0}),$$

$$\sqrt{2}\, M(\Xi_c^+ \to \Sigma^0 K^{*+}) = M(\Xi_c^0 \to \Sigma^- K^{*+}),$$

NUMERICAL RESULTS

FITTED PARAMETERS

TABLE V. The fitted partial-wave components of TDA amplitudes in units of 10^{-6}.

	S	P_1	P_2	D
$\tilde{T}$	0.45 ± 0.33	0.60 ± 0.40	-0.30 ± 0.40	-0.70 ± 0.60
$\tilde{C}$	0.12 ± 0.06	0.30 ± 0.04	0.02 ± 0.06	0.09 ± 0.08
$\tilde{C}'$	-0.28 ± 0.13	0.08 ± 0.10	-0.31 ± 0.20	0.06 ± 0.16
$\tilde{E}_1$	-0.02 ± 0.13	0.43 ± 0.11	0.28 ± 0.15	-0.07 ± 0.24
$\tilde{E}_h$	-0.15 ± 0.12	0.28 ± 0.14	0.34 ± 0.12	-0.30 ± 0.21

TABLE VI. The fitted form-factor components of TDA amplitudes in units of 10^{-6}.

	A_1	B_1	A_2	B_2
$\tilde{T}$	0.56 ± 0.18	0.50 ± 0.70	1.40 ± 2.40	-1.40 ± 1.50
$\tilde{C}$	-0.17 ± 0.05	0.47 ± 0.11	-1.68 ± 0.22	-0.27 ± 0.21
$\tilde{C}'$	0.36 ± 0.07	-1.04 ± 0.28	2.30 ± 0.70	2.00 ± 0.50
$\tilde{E}_1$	0.15 ± 0.07	1.70 ± 0.29	0.20 ± 1.70	-2.30 ± 0.50
$\tilde{E}_h$	0.40 ± 0.05	2.00 ± 0.40	2.20 ± 2.20	-3.20 ± 0.80

- $\tilde{T}$ gives the largest contribution in each partial wave;
- $\tilde{C}$ seems to have tiny contribution in P_2 and D waves;
- $\tilde{C}'$ seems to have tiny contribution in P_1 and D waves;

- Both A_2 and B_2 are comparable in magnitude to their corresponding one;

PREDICTIONS: SELECTED

TABLE VII. Predictions of observables in Cabibbo-favored decays.

Mode	$10^2\mathcal{B}$	α	P_L	α_V
$\Lambda_c^+ \to \Xi^0 K^{*+}$	0.29 ± 0.09	-0.31 ± 0.27	-0.18 ± 0.72	1.67 ± 4.04
$\Lambda_c^+ \to \Lambda \rho^+$	4.10 ± 0.49	-0.76 ± 0.07	0.32 ± 1.31	0.02 ± 2.61
$\Lambda_c^+ \to p\overline{K}^{*0}$	1.38 ± 0.07	0.87 ± 0.03	0.79 ± 0.27	12.71 ± 16.67
$\Lambda_c^+ \to \Sigma^0 \rho^+$	0.53 ± 0.13	-0.63 ± 0.38	-0.72 ± 0.52	5.01 ± 7.77
$\Lambda_c^+ \to \Sigma^+ \rho^0$	0.53 ± 0.13	-0.63 ± 0.38	-0.72 ± 0.52	5.03 ± 7.80
$\Lambda_c^+ \to \Sigma^+ \phi$	0.40 ± 0.05	-0.83 ± 0.29	-0.13 ± 0.49	1.30 ± 2.36
$\Lambda_c^+ \to \Sigma^+ \omega$	1.63 ± 0.16	-0.37 ± 0.30	-0.22 ± 0.60	4.31 ± 7.63
$\Xi_c^0 \to \Lambda \overline{K}^{*0}$	0.30 ± 0.05	0.23 ± 0.21	0.04 ± 0.55	2.03 ± 3.10
$\Xi_c^0 \to \Sigma^0 \overline{K}^{*0}$	1.08 ± 0.15	0.20 ± 0.30	0.20 ± 0.29	$5.80^{+22.41}_{-4.75}$
$\Xi_c^0 \to \Sigma^+ K^{*-}$	0.52 ± 0.12	-0.34 ± 0.26	-0.22 ± 0.68	2.73 ± 5.64
$\Xi_c^0 \to \Xi^0 \rho^0$	0.27 ± 0.15	0.64 ± 0.06	-0.92 ± 0.21	-0.46 ± 0.37
$\Xi_c^0 \to \Xi^0 \phi$	0.15 ± 0.05	0.45 ± 0.62	0.70 ± 0.49	7.94 ± 27.86
$\Xi_c^0 \to \Xi^0 \omega$	2.23 ± 0.23	-0.87 ± 0.13	-0.43 ± 0.52	5.01 ± 7.52
$\Xi_c^0 \to \Xi^- \rho^+$	5.52 ± 1.33	-0.81 ± 0.25	0.04 ± 1.28	1.24 ± 5.12
$\Xi_c^+ \to \Sigma^+ \overline{K}^{*0}$	3.14 ± 0.93	0.51 ± 0.24	0.43 ± 0.41	9.44 ± 19.07
$\Xi_c^+ \to \Xi^0 \rho^+$	17.00 ± 2.79	-0.42 ± 0.22	0.06 ± 1.38	0.32 ± 3.22

$$M(\Lambda_c^+ \to \Sigma^0 \rho^+) = M(\Lambda_c^+ \to \Sigma^+ \rho^0),$$

isospin symmetry respected

- promising to be measured soon!

PREDICTIONS: SELECTED

TABLE VIII. Predictions of observables in singly Cabibbo-suppressed decays.

Mode	$10^3\mathcal{B}$	α	P_L	α_V
$\Lambda_c^+ \to \Lambda K^{*+}$	2.4 ± 0.53	-0.44 ± 0.21	-0.26 ± 1.21	2.30 ± 7.33
$\Lambda_c^+ \to \Sigma^0 K^{*+}$	0.13 ± 0.07	0.71 ± 0.06	-0.94 ± 0.17	-0.59 ± 0.28
$\Lambda_c^+ \to \Sigma^+ K^{*0}$	0.25 ± 0.15	0.71 ± 0.06	-0.94 ± 0.17	-0.59 ± 0.28
$\Lambda_c^+ \to p\rho^0$	1.01 ± 0.14	0.20 ± 0.30	0.20 ± 0.29	$7.58^{+28.30}_{-5.99}$
$\Lambda_c^+ \to p\phi$	1.04 ± 0.11	0.16 ± 0.32	0.73 ± 0.29	3.79 ± 3.17
$\Lambda_c^+ \to p\omega$	0.91 ± 0.10	-0.92 ± 0.23	-0.79 ± 0.47	16.58 ± 41.44
$\Lambda_c^+ \to n\rho^+$	3.96 ± 1.40	-0.36 ± 0.35	0.63 ± 1.03	-0.04 ± 2.34
$\Xi_c^0 \to \Lambda\rho^0$	0.11 ± 0.09	0.59 ± 0.62	-0.48 ± 0.62	-0.71 ± 0.53
$\Xi_c^0 \to \Lambda\phi$	0.59 ± 0.07	0.34 ± 0.33	0.44 ± 0.48	4.55 ± 7.46
$\Xi_c^0 \to \Lambda\omega$	1.36 ± 0.16	-0.93 ± 0.13	-0.56 ± 0.49	7.38 ± 12.82
$\Xi_c^0 \to \Sigma^0\rho^0$	0.43 ± 0.05	0.63 ± 0.20	0.40 ± 0.35	13.35 ± 19.01
$\Xi_c^0 \to \Sigma^0\phi$	0.33 ± 0.04	-0.49 ± 0.31	-0.42 ± 0.32	31.86 ± 87.95
$\Xi_c^0 \to \Sigma^0\omega$	0.69 ± 0.10	0.35 ± 0.36	0.70 ± 0.31	7.26 ± 8.98
$\Xi_c^0 \to \Sigma^+\rho_-$	0.36 ± 0.08	-0.35 ± 0.27	-0.25 ± 0.66	3.60 ± 6.95
$\Xi_c^0 \to \Sigma^-\rho^+$	3.36 ± 0.97	-0.80 ± 0.31	-0.01 ± 1.29	1.54 ± 5.79
$\Xi_c^0 \to \Xi^0 K^{*0}$	0.37 ± 0.09	-0.60 ± 0.40	-0.71 ± 0.55	4.35 ± 6.92
$\Xi_c^0 \to \Xi^- K^{*+}$	2.21 ± 0.42	-0.82 ± 0.17	0.12 ± 1.27	0.83 ± 4.18
$\Xi_c^0 \to pK^{*-}$	0.34 ± 0.08	-0.35 ± 0.27	-0.25 ± 0.66	3.50 ± 6.79
$\Xi_c^0 \to n\overline{K}^{*0}$	0.56 ± 0.13	-0.66 ± 0.35	-0.74 ± 0.46	6.24 ± 9.37
$\Xi_c^+ \to \Lambda\rho^+$	2.84 ± 0.69	0.16 ± 0.40	-0.33 ± 1.18	0.78 ± 3.83
$\Xi_c^+ \to \Sigma^0\rho^+$	6.89 ± 2.56	-0.63 ± 0.3	-0.36 ± 1.09	5.25 ± 14.24
$\Xi_c^+ \to \Sigma^+\rho^0$	0.86 ± 0.23	0.09 ± 0.41	0.71 ± 0.40	3.42 ± 5.25
$\Xi_c^+ \to \Sigma^+\phi$	1.50 ± 0.34	-0.97 ± 0.13	-0.88 ± 0.43	23.5 ± 71.26
$\Xi_c^+ \to \Sigma^+\omega$	4.13 ± 0.63	0.35 ± 0.36	0.70 ± 0.31	7.26 ± 8.98
$\Xi_c^+ \to \Xi^0 K^{*+}$	7.55 ± 2.59	-0.41 ± 0.28	0.65 ± 1.00	-0.21 ± 1.92
$\Xi_c^+ \to p\overline{K}^{*0}$	0.89 ± 0.51	0.61 ± 0.06	-0.92 ± 0.22	-0.40 ± 0.41

$$\sqrt{2}\, M(\Lambda_c^+ \to \Sigma^0 K^{*+}) = M(\Lambda_c^+ \to \Sigma^+ K^{*0}) = M(\Xi_c^+ \to p\overline{K}^{*0}),$$

isospin symmetry respected

v-spin symmetry broken?

- kinematic factor effect

COMPARISON (1)

Mode	$\mathcal{B}_{\rm theo}$	$\mathcal{B}_{\rm exp}$	$\alpha_{\rm theo}$	$\alpha_{\rm exp}$
$\Lambda_c^+ \to p\overline{K}^{*0}$	1.38 ± 0.07	1.4 ± 0.07	0.87 ± 0.03	0.87 ± 0.03
$\Lambda_c^+ \to \Lambda\rho^+$	4.10 ± 0.49	4.1 ± 0.5	-0.76 ± 0.07	-0.76 ± 0.07
$\Lambda_c^+ \to \Sigma^+\rho^0$	0.53 ± 0.13	< 1.7		
$\Lambda_c^+ \to \Sigma^+\omega$	1.63 ± 0.16	1.72 ± 0.20		
$\Xi_c^+ \to \Sigma^+\overline{K}^{*0}$	3.14 ± 0.93	2.3 ± 1.1		
$\Lambda_c^+ \to p\phi$	1.04 ± 0.11	1.05 ± 0.14		
$\Lambda_c^+ \to \Sigma^+\phi$	4.00 ± 0.49	4.0 ± 0.5		
$\Lambda_c^+ \to \Sigma^+K^{*0}$	0.25 ± 0.15	3.5 ± 1.0		
$\Lambda_c^+ \to \Sigma^0K^{*+}$	0.13 ± 0.07	1.23 ± 0.57		
$\Lambda_c^+ \to p\rho^0$	1.01 ± 0.14	1.5 ± 0.4		
$\Lambda_c^+ \to \Lambda K^{*+}$	2.40 ± 0.53	2.40 ± 0.59		
$\Lambda_c^+ \to p\omega$	0.91 ± 0.10	0.90 ± 0.1		
$\Xi_c^0 \to \Lambda\overline{K}^{*0}$	3.04 ± 0.55	2.6 ± 0.6	0.23 ± 0.21	0.15 ± 0.22
$\Xi_c^0 \to \Sigma^0\overline{K}^{*0}$	10.81 ± 1.53	9.9 ± 1.9		
$\Xi_c^0 \to \Sigma^+K^{*-}$	5.18 ± 1.25	4.9 ± 1.3	-0.34 ± 0.26	-0.50 ± 0.30
$\Xi_c^0 \to \Lambda\phi$	0.59 ± 0.07	0.49 ± 0.13		
$\Xi_c^+ \to p\phi$	0.12 ± 0.01	0.12 ± 0.06		
$\Xi_c^+ \to p\overline{K}^{*0}$	0.89 ± 0.51	3.3 ± 1.7	0.61 ± 0.06	0.613 ± 0.065
$\Xi_c^+ \to \Sigma^+\phi$	1.98 ± 0.00	< 3.2		

- Most modes are consistent well with experiments
- The three modes within SU(3) symmetry, however, have deviation from experiments.

[21] J. M. Link *et al.* (FOCUS), Measurements of Relative Branching Ratios of Λ_c^+ Decays into States Containing Σ, Phys. Lett. B **540**, 25 (2002), arXiv:hep-ex/0206013.

[11] M. Ablikim *et al.* (BESIII), Measurements of branching fractions of $\Lambda_c^+ \to \Sigma^0 K_S^0 \pi^+$ and $\Lambda_c^+ \to \Sigma^0 K_S^0 K^+$, (2026), arXiv:2602.22754 [hep-ex].

[26] J. M. Link *et al.* (FOCUS), Measurement of the Relative Branching Ratio BR($\Xi_c^+ \to p^+K^-\pi^+$) / BR($\Xi_c^+ \to \Xi^-\pi^+\pi^+$), Phys. Lett. B **512**, 277 (2001), arXiv:hep-ex/0102040.

- More experimental progress is anticipated!

COMPARISON (2)

TABLE XI. Branching fractions (first row in units of 10^{-2}, second row in units of 10^{-3}) and the decay asymmetries α for the $\mathcal{B}_c \to \mathcal{B}V$ decays, where the upper entries correspond to the branching fractions and the lower entries to the decay asymmetries.

Mode	This work	Geng [9]	Jia [10]	Hsiao [8]	Expt
$\Lambda_c^+ \to \Lambda\rho^+$	4.10 ± 0.49	4.81 ± 0.58	$6.26^{+2.44}_{-1.39}$	0.74 ± 0.34	4.1 ± 0.5
	-0.76 ± 0.07	0.76 ± 0.07			-0.76 ± 0.07
$\Lambda_c^+ \to p\overline{K}^{*0}$	1.38 ± 0.07	2.03 ± 0.25	$3.70^{+1.29}_{-3.39}$	1.90 ± 0.30	1.4 ± 0.1
	0.87 ± 0.03	-0.18 ± 0.05			0.87 ± 0.03
$\Lambda_c^+ \to \Sigma^+\rho^0$	0.53 ± 0.13	1.43 ± 0.42	$0.77^{+1.38}_{-0.53}$	0.61 ± 0.46	< 1.7
$\Lambda_c^+ \to \Sigma^+\omega$	1.63 ± 0.16	1.81 ± 0.19	$2.06^{+0.40}_{-1.78}$	1.60 ± 0.70	1.7 ± 0.2
$\Xi_c^+ \to \Sigma^+\overline{K}^{*0}$	3.14 ± 0.93	1.40 ± 0.69		10.10 ± 2.90	2.3 ± 1.1
$\Xi_c^+ \to \Xi^0\rho^+$	17.00 ± 2.79	14.48 ± 2.44		9.90 ± 2.90	

Mode	This work	Geng [9]	Jia [10]	Hsiao [8]	Expt
$\Lambda_c^+ \to \Sigma^+\phi$	4.00 ± 0.49	3.90 ± 0.60	$3.30^{+0.80}_{-2.90}$	3.90 ± 0.60	4.0 ± 0.5
$\Lambda_c^+ \to p\phi$	1.04 ± 0.11	0.87 ± 0.14	$1.37^{+1.13}_{-0.65}$	1.04 ± 0.21	1.1 ± 0.1
$\Lambda_c^+ \to \Sigma^+K^{*0}$	0.25 ± 0.15	0.38 ± 0.09	$2.10^{+1.37}_{-0.86}$	2.30 ± 0.60	3.5 ± 1.0
$\Lambda_c^+ \to \Sigma^0K^{*+}$	0.13 ± 0.07	0.18 ± 0.04	$1.60^{+0.89}_{-0.62}$	1.2 ± 0.3	1.23 ± 0.57
$\Lambda_c^+ \to p\rho^0$	1.01 ± 0.14	$0.02^{+0.07}_{-0.02}$	$2.72^{+1.27}_{-1.87}$	0.35 ± 0.29	1.5 ± 0.4
$\Lambda_c^+ \to \Lambda K^{*+}$	2.40 ± 0.53	3.35 ± 0.37	$4.71^{+0.48}_{-0.20}$	2.00 ± 0.50	2.4 ± 0.6
$\Lambda_c^+ \to p\omega$	0.91 ± 0.10	0.63 ± 0.34	$1.26^{+0.45}_{-0.37}$	1.14 ± 0.54	0.9 ± 0.1
$\Xi_c^+ \to p\overline{K}^{*0}$	0.89 ± 0.51	4.71 ± 1.22		7.80 ± 2.20	3.3 ± 1.7
	0.61 ± 0.06	-0.12 ± 0.15			0.613 ± 0.065
$\Xi_c^+ \to \Sigma^+\phi$	1.98 ± 0.00	1.82 ± 0.40		1.90 ± 0.90	< 3.2
$\Xi_c^+ \to p\phi$	0.12 ± 0.01	0.23 ± 0.04		0.15 ± 0.07	0.12 ± 0.06
$\Xi_c^0 \to \Lambda\overline{K}^{*0}$	3.04 ± 0.55	13.70 ± 2.60		4.60 ± 2.10	2.6 ± 0.6
	0.23 ± 0.21	-0.28 ± 0.10			0.15 ± 0.22
$\Xi_c^0 \to \Sigma^0\overline{K}^{*0}$	10.81 ± 1.53	4.20 ± 2.30		2.70 ± 2.20	9.9 ± 1.9
$\Xi_c^0 \to \Sigma^+K^{*-}$	5.18 ± 1.25	2.40 ± 1.70		9.30 ± 2.90	4.9 ± 1.3
	-0.34 ± 0.26	-0.37 ± 0.31			-0.50 ± 0.30
$\Xi_c^0 \to \Lambda\phi$	0.59 ± 0.07	0.44 ± 0.08		0.84 ± 0.39	0.49 ± 0.13

MORE DISCUSSION

1. Modes such as $\Xi_c^0 \to \Xi^- \rho^+$ are predicted to exhibit a large up-down asymmetry but a relatively small longitudinal asymmetry, suggesting significant contributions from the A_2 and B_2 amplitudes.

- tensor coupling can be large

2. In contrast, modes such as $\Xi_c^+ \to \Sigma^+ \rho^0$ are predicted to have a small α but large P_L. This implies that $\mathrm{Re}[(S+D)^* P_1]$ and $\mathrm{Re}(S^* P_2)$ are comparable but opposite in signs. From Eq. (5), one can infer that $\mathrm{Re}(S^* P_2) \propto -A_1 B_1$ and $\mathrm{Re}[(S+D)^* P_1] \propto A_1 B_1$ if A_2 and B_2 are negligible. Therefore, decays with this type of decay asymmetry will have a small tensor coupling.

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- tensor coupling can be small

3. In addition, sizable decay asymmetries, α and P_L, are found in certain channels, such as $\Lambda_c^+ \to p \overline{K}^{*0}$ and $\Lambda_c^+ \to \Sigma^+ \rho^0$. This pattern can be interpreted as a result of a suppressed interference term $\mathrm{Re}(S^* P_2)$, which in turn suggests the smallness of either the A_1 or B_1 form factor.

SUMMARY

SUMMARY

- Current $\mathscr{B}_c \to \mathscr{B}V$ data can support a serious fit.
- TDA has successfully been extended to $\mathscr{B}_c \to \mathscr{B}V$.
- All the four form factors are important, hence cannot be neglected.
- Four partial waves are extracted.
- The importance of tensor coupling is channel dependent.
- TDA predictions mostly agree well with experiments, the remaining requires more data.