Anti-triplet Charmed Baryon Weak Decays with SU(3) Flavor Symmetry

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C. Q. Geng, Y. K. Hsiao, C. W. Liu and T. H. Tsai,
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Motivation

- Unknown baryon wave functions
- Failure of the conventional factorization approach

$$\mathcal{B}(\Lambda_c^+ \to \Sigma^+\pi^0)_{EXP} = (1.24 \pm 0.10)\%$$

- Measurements with higher precision in Belle and BESSIII

$$\mathcal{B}(\Lambda_c^+ \to pK^-\pi^+) = (6.23 \pm 0.33)\%$$

- C. Q. Geng, Y. K. Hsiao, C. W. Liu and T. H. Tsai, JHEP **1711**, 147 (2017)
- C. Q. Geng, Y. K. Hsiao, C. W. Liu and T. H. Tsai, Eur. Phys. J. C **78**, 593 (2018)
- C. Q. Geng, Y. K. Hsiao, C. W. Liu and T. H. Tsai, Phys. Rev. D **97**, 073006 (2018)
- C. Q. Geng, Y. K. Hsiao, C. W. Liu and T. H. Tsai, arXiv:1810.01079 [hep-ph].

Outline

Introduction of SU(3) Flavor Symmetry

$$|_1\rangle = |u\rangle \ ,|_2\rangle = |d\rangle \ ,|_3\rangle = |s\rangle$$
$$|^1\rangle = |\bar{u}\rangle \ ,|^2\rangle = |\bar{d}\rangle \ ,|^3\rangle = |\bar{s}\rangle$$

$$\pi^+ = |^2_1\rangle = \delta_{i2}\delta^{j1}\,|^i_j\rangle = (\pi^+)^j_i\,|^i_j\rangle$$
$$M = (M)^j_i\,|^i_j\rangle$$

$$(M)^j_i = \begin{pmatrix} \frac{1}{\sqrt{2}}(\pi^0 + c\phi\eta + s\phi\eta') & \pi^- & K^- \\ \pi^+ & \frac{-1}{\sqrt{2}}(\pi^0 - c\phi\eta - s\phi\eta') & \bar{K}^0 \\ K^+ & K^0 & -s\phi\eta + c\phi\eta' \end{pmatrix}_{ij},$$

where $(c\phi, s\phi) = (\cos\phi, \sin\phi)$ and $\phi = (39.3 \pm 1.0)^\circ$.[1]

[1] T. Feldmann, P. Kroll and B. Stech, Phys. Rev. D **58**, 114006 (1998); Phys. Lett. B **449**, 339 (1999).

Introduction of SU(3) Flavor Symmetry

Invariant tensor

$$\epsilon^{ijk}|_{ijk}\rangle \qquad \delta^i_j|^j_i\rangle$$

Introduction of SU(3) Flavor Symmetry

Invariant tensor

$$\epsilon^{ijk}|_{ijk}\rangle \qquad \delta^i_j|^j_i\rangle$$

Antisymmetric tensor gives us singlet

$$\frac{1}{\sqrt{2}}\left(|\uparrow\downarrow\rangle - |\downarrow\uparrow\rangle\right) \ ,$$
$$\frac{1}{\sqrt{6}}\left(|rgb\rangle - |rbg\rangle + |gbr\rangle - |grb\rangle + |brg\rangle - |bgr\rangle\right)$$

Same thing happens in color states of mesons

$$\frac{1}{\sqrt{3}}\left(|r\bar{r}\rangle + |g\bar{g}\rangle + |b\bar{b}\rangle\right)$$

Introduction of SU(3) Flavor Symmetry

Singly charmed baryons

$$\Lambda_c^+ = |udc\rangle - |duc\rangle = |_{12}\rangle_{B_c} - |_{21}\rangle_{B_c} = \epsilon^{ijk}\delta_{k3}\,|_{ij}\rangle_{B_c}$$

$$(\mathbf{B}_c)_i \quad = \quad (\Xi_c^0, -\Xi_c^+, \Lambda_c^+)_i$$

Octet Baryons

$$\mathbf{B} = \mathbf{B}^{ijk}\,|_{ijk}\rangle = (\mathbf{B}_n)^i_l \epsilon^{ljk}\,|_{ijk}\rangle$$
$$p = |_{112}\rangle - |_{121}\rangle = (\delta^{i1}\delta^{j1}\delta^{k2} - \delta^{i1}\delta^{j2}\delta^{k1})\,|_{ijk}\rangle = (\delta^{i1}\delta_{l3}\epsilon^{ljk})\,|_{ijk}\rangle$$

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

Charmed Baryon Weak Decays

Effective Hamiltonian for c transition

$$\mathcal{H}_{eff} = \frac{G_F}{\sqrt{2}}\left(c_+ O_+ + c_- O_-\right) .$$

$$O_+ = \frac{1}{2}\sum_{q,q'=d,s} V_{uq}V^*_{cq'}\left((\bar{u}q)(\bar{q}'c)+(\bar{q}'q)(\bar{u}c)\right) ,$$

$$O_- = \frac{1}{2}\sum_{q,q'=d,s} V_{uq}V^*_{cq'}\left((\bar{u}q)(\bar{q}'c)-(\bar{q}'q)(\bar{u}c)\right) ,$$

where $(\bar{q}q') \equiv \bar{q}^\alpha\gamma_\mu(1-\gamma_5)q_\alpha$.

Charmed Baryon Weak Decays

Effective Hamiltonian for c transition

$$\mathcal{H}_{eff} = \frac{G_F}{2\sqrt{2}}\left(c_- H(6)_{lk}(\epsilon^{ijl}/2)O^k_{ij} + c_+ H(\overline{15})^{ij}_k O^k_{ij}\right)$$

$$O^k_{ij} = (\bar{q}_i q_k)_{V-A}(\bar{q}_j c)_{V-A} \qquad\qquad s_c \equiv V_{us}$$

$$H(6)_{ij} = \begin{pmatrix} 0 & 0 & 0 \\ 0 & 2 & -2s_c \\ 0 & -2s_c & 2s_c^2 \end{pmatrix}_{ij},$$

$$H(\overline{15})^{ij}_k = \left(\begin{pmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix}_{ij}, \begin{pmatrix} 0 & s_c & 1 \\ s_c & 0 & 0 \\ 1 & 0 & 0 \end{pmatrix}_{ij}, \begin{pmatrix} 0 & -s_c^2 & -s_c \\ -s_c^2 & 0 & 0 \\ -s_c & 0 & 0 \end{pmatrix}_{ij} \right)_k$$

Charmed Baryon Weak Decays

$$\mathcal{A}(I \to F) = \langle I | \mathcal{H}_{eff} | F \rangle = \frac{G_F}{\sqrt{2}} T(\mathbf{B}_c \to \mathbf{B}_n M)$$

$$= (\mathbf{B}_n)^i_j M^k_m H^{no}_p (\mathbf{B}_c)_q \langle \binom{j}{i}_{\mathbf{B}_n} \binom{m}{k}_M | O^p_{no} | ^q \rangle_{\mathbf{B}_c}$$

The process $B_c \to B_n M$ with $T^{ij} \equiv (\mathbf{B}_c)_k \epsilon^{ijk}$

$$\begin{aligned} T(\mathcal{O}_6) &= a_1 H(6)_{ij} T^{ik} (\mathbf{B}_n)^l_k (M)^j_l + a_2 H(6)_{ij} T^{ik} (M)^l_k (\mathbf{B}_n)^j_l \\ &+ a_3 H(6)_{ij} (\mathbf{B}_n)^i_k (M)^j_l T^{kl} + h H(6)_{ij} T^{ik} (\mathbf{B}_n)^j_k (M)^l_l , \\ T(\mathcal{O}_{\overline{15}}) &= a_4 H(\overline{15})^{li}_k (\mathbf{B}_c)_j (M)^j_i (\mathbf{B}_n)^k_l + a_5 (\mathbf{B}_n)^i_j (M)^l_i H(\overline{15})^{jk}_l (\mathbf{B}_c)_k \\ &+ a_6 (\mathbf{B}_n)^k_l (M)^i_j H(\overline{15})^{jl}_i (\mathbf{B}_c)_k + a_7 (\mathbf{B}_n)^l_i (M)^i_j H(\overline{15})^{jk}_l (\mathbf{B}_c)_k \\ &+ h' H(\overline{15})^{jk}_i (\mathbf{B}_n)^i_k (M)^l_l (\mathbf{B}_c)_j , \end{aligned}$$

Example

$$\mathcal{A}(\Lambda_c^+ \to \Sigma^+ \pi^0) = \sqrt{2}(a_1 - a_2 - a_3 - \frac{a_5 - a_7}{2})$$

Charmed Baryon Weak Decays

$$
\begin{aligned}
T(\mathcal{O}_6) &= a_1 H(6)_{ij} T^{ik} (\mathbf{B}_n)^l_k (M)^j_l + a_2 H(6)_{ij} T^{ik} (M)^l_k (\mathbf{B}_n)^j_l \\
&+ a_3 H(6)_{ij} (\mathbf{B}_n)^i_k (M)^j_l T^{kl} + h H(6)_{ij} T^{ik} (\mathbf{B}_n)^j_k (M)^l_l \,, \\
T(\mathcal{O}_{\overline{15}}) &= a_4 H(\overline{15})^{li}_k (\mathbf{B}_c)_j (M)^j_i (\mathbf{B}_n)^k_l + a_5 (\mathbf{B}_n)^i_j (M)^l_i H(\overline{15})^{jk}_l (\mathbf{B}_c)_k \\
&+ a_6 (\mathbf{B}_n)^k_l (M)^i_j H(\overline{15})^{jl}_i (\mathbf{B}_c)_k + a_7 (\mathbf{B}_n)^l_i (M)^i_j H(\overline{15})^{jk}_l (\mathbf{B}_c)_k \\
&+ h' H(\overline{15})^{jk}_i (\mathbf{B}_n)^i_k (M)^l_l (\mathbf{B}_c)_j \,,
\end{aligned}
$$

Λ_c^+	Transition Amplitude
$\Sigma^0\pi^+$	$-\sqrt{2}(a_1 - a_2 - a_3 - \frac{a_5 - a_7}{2})$
$\Sigma^+\pi^0$	$\sqrt{2}(a_1 - a_2 - a_3 - \frac{a_5 - a_7}{2})$
$\Sigma^+\eta$	$\sqrt{2}c\phi(-a_1 - a_2 + a_3 - 2h + \frac{a_5 + a_7 + 2h'}{2}) + s\phi(-a_4 + 2h - h')$
$\Sigma^+\eta'$	$\frac{\sqrt{2}s\phi}{2}(-a_1 - a_2 + a_3 - 2h + \frac{a_5 + a_7 + 2h'}{2}) - c\phi(-a_4 + 2h - h')$
$\Xi^0 K^+$	$-2(a_2 - \frac{a_4 + a_7}{2})$
$p\bar{K}^0$	$-2(a_1 - \frac{a_5 + a_6}{2})$
$\Lambda^0\pi^+$	$-\sqrt{\frac{2}{3}}(a_1 + a_2 + a_3 - \frac{a_5 - 2a_6 + a_7}{2})$

Charmed Baryon Weak Decays

Table: The T-amps of the $\mathbf{B}_c \to \mathbf{B}_n M$ decays.

Ξ_c^0	T-amp
$\Sigma^+ K^-$	$2(a_2 + \frac{a_4+a_7}{2})$
$\Sigma^0 \bar{K}^0$	$-\sqrt{2}(a_2 + a_3 - \frac{a_6-a_7}{2})$
$\Xi^0 \pi^0$	$-\sqrt{2}(a_1 - a_3 - \frac{a_4-a_5}{2})$
$\Xi^0 \eta$	$\sqrt{2}c\phi(a_1 - a_3 + 2h + \frac{a_4+a_5+2h'}{2}) -2s\phi(a_2 + h + \frac{a_7+h'}{2})$
$\Xi^0 \eta'$	$\sqrt{2}s\phi(a_1 - a_3 + 2h + \frac{a_4+a_5+2h'}{2}) +c\phi(a_2 + h + \frac{a_7+h'}{2})$
$\Xi^- \pi^+$	$2(a_1 + \frac{a_5+a_6}{2})$
$\Lambda^0 \bar{K}^0$	$-\sqrt{\frac{2}{3}}(2a_1 - a_2 - a_3 + \frac{2a_5-a_6-a_7}{2})$
$\Sigma^+ \pi^-$	$-2(a_2 + \frac{a_4+a_7}{2})s_c$
$\Sigma^- \pi^+$	$-2(a_1 + \frac{a_5+a_6}{2})s_c$
$\Sigma^0 \pi^0$	$-(a_2 + a_3 - \frac{a_4-a_5+a_6-a_7}{2})s_c$
$\Sigma^0 \eta$	$[-c\phi(a_1 + a_2 + 2h + \frac{a_4+a_5-a_6+a_7+2h'}{2}) -\sqrt{2}s\phi(a_3 - h - \frac{a_6+h'}{2})]s_c$
$\Sigma^0 \eta'$	$[-s\phi(a_1 + a_2 + 2h + \frac{a_4+a_5-a_6+a_7+2h'}{2}) +\sqrt{2}c\phi(a_3 - h - \frac{a_6+h'}{2})]s_c$
$\Xi^- K^+$	$2(a_1 + \frac{a_5+a_6}{2})s_c$
pK^-	$2(a_2 + \frac{a_4+a_7}{2})s_c$
$\Xi^0 K^0$	$2(a_1 - a_2 - a_3 + \frac{a_5-a_7}{2})s_c$
$n\bar{K}^0$	$-2(a_1 - a_2 - a_3 + \frac{a_5-a_7}{2})s_c$
$\Lambda^0 \pi^0$	$\sqrt{\frac{1}{3}}(a_1 + a_2 - 2a_3 + \frac{a_4-a_5-a_6-a_7}{2})s_c$
$\Lambda^0 \eta$	$[\frac{\sqrt{3}c\phi}{3}(a_1 + a_2 - 2a_3 + 6h + \frac{3a_4+a_5+a_6+a_7+6h'}{2}) - \frac{\sqrt{6}s\phi}{2}(2a_1 + 2a_2 - a_3 + 3h + \frac{2a_5-a_6+2a_7+3h'}{2})]s_c$
$\Lambda^0 \eta'$	$[\frac{\sqrt{3}s\phi}{3}(a_1 + a_2 - 2a_3 + 6h + \frac{3a_4+a_5+a_6+a_7+6h'}{2}) + \frac{\sqrt{6}c\phi}{2}(2a_1 + 2a_2 - a_3 + 3h + \frac{2a_5-a_6+2a_7+3h'}{2})]s_c$
$p\pi^-$	$-2(a_2 + \frac{a_4+a_7}{2})s_c^2$
$\Sigma^- K^+$	$-2(a_1 + \frac{a_5+a_6}{2})s_c^2$
$\Sigma^0 K^0$	$\sqrt{2}(a_1 + \frac{a_5-a_6}{2})s_c^2$
$n\pi^0$	$\sqrt{2}(a_2 - \frac{a_4-a_7}{2})s_c^2$
$n\eta$	$[-\sqrt{2}c\phi(a_2 - 2h + \frac{a_4-a_7-2h'}{2}) +2s\phi(a_1 - a_3 + h + \frac{a_5+h'}{2})]s_c^2$
$n\eta'$	$[-\sqrt{2}s\phi(a_2 - 2h + \frac{a_4-a_7-2h'}{2}) -2c\phi(a_1 - a_3 + h + \frac{a_5+h'}{2})]s_c^2$
$\Lambda^0 K^0$	$-\sqrt{\frac{2}{3}}(a_1 - 2a_2 - 2a_3 + \frac{a_5+a_6-2a_7}{2})s_c^2$

Ξ_c^+	T-amp
$\Sigma^+ \bar{K}^0$	$-2(a_3 - \frac{a_4+a_6}{2})$
$\Xi^0 \pi^+$	$2(a_3 + \frac{a_4+a_6}{2})$
$\Sigma^0 \pi^+$	$\sqrt{2}(a_1 - a_2 + \frac{a_4-a_5+a_6+a_7}{2})s_c$
$\Sigma^+ \pi^0$	$-\sqrt{2}(a_1 - a_2 - \frac{a_4+a_5+a_6-a_7}{2})s_c$
$\Sigma^+ \eta$	$[\sqrt{2}c\phi(a_1 + a_2 + 2h - \frac{a_4+a_5+a_6+a_7-2h'}{2}) +2s\phi(a_3 - h - \frac{a_6-h'}{2})]s_c$
$\Sigma^+ \eta'$	$[\sqrt{2}s\phi(a_1 + a_2 + 2h - \frac{a_4+a_5+a_6+a_7-2h'}{2}) -2c\phi(a_3 - h - \frac{a_6-h'}{2})]s_c$
$\Xi^0 K^+$	$2(a_2 + a_3 + \frac{a_6-a_7}{2})s_c$
$p\bar{K}^0$	$2(a_1 - a_3 + \frac{a_4-a_5}{2})s_c$
$\Lambda^0 \pi^+$	$\sqrt{\frac{2}{3}}(a_1 + a_2 - 2a_3 - \frac{3a_4+a_5+a_6+a_7}{2})s_c$
$\Sigma^0 K^+$	$\sqrt{2}(a_1 - \frac{a_5-a_6}{2})s_c^2$
$\Sigma^+ K^0$	$2(a_1 - \frac{a_5+a_6}{2})s_c^2$
$p\pi^0$	$\sqrt{2}(a_2 + \frac{a_4-a_7}{2})s_c^2$
$p\eta$	$[\sqrt{2}c\phi(-a_2 + 2h + \frac{a_4+a_7+2h'}{2}) +2s\phi(a_1 - a_3 + h - \frac{a_5-2h+h'}{2})]s_c$
$p\eta'$	$[\sqrt{2}s\phi(-a_2 + 2h + \frac{a_4+a_7+2h'}{2}) -2c\phi(a_1 - a_3 + h - \frac{a_5-2h+h'}{2})]s_c$
$n\pi^+$	$2(a_2 - \frac{a_4+a_7}{2})s_c^2$
$\Lambda^0 K^+$	$\sqrt{\frac{2}{3}}(a_1 - 2a_2 - 2a_3 - \frac{a_5+a_6-2a_7}{2})s_c^2$

Λ_c^+	T-amp
$\Sigma^0 \pi^+$	$-\sqrt{2}(a_1 - a_2 - a_3 - \frac{a_5-a_7}{2})$
$\Sigma^+ \pi^0$	$\sqrt{2}(a_1 - a_2 - a_3 - \frac{a_5-a_7}{2})$
$\Sigma^+ \eta$	$\sqrt{2}c\phi(-a_1 - a_2 + a_3 - 2h + \frac{a_5+a_7+2h'}{2}) +s\phi(-a_4 + 2h - h')$
$\Sigma^+ \eta'$	$\frac{\sqrt{2}s\phi}{2}(-a_1 - a_2 + a_3 - 2h + \frac{a_5+a_7+2h'}{2}) -c\phi(-a_4 + 2h - h')$
$\Xi^0 K^+$	$-2(a_2 - \frac{a_4+a_7}{2})$
$p\bar{K}^0$	$-2(a_1 - \frac{a_5+a_6}{2})$
$\Lambda^0 \pi^+$	$-\sqrt{\frac{2}{3}}(a_1 + a_2 + a_3 - \frac{a_5-2a_6+a_7}{2})$
$\Sigma^+ K^0$	$-2(a_1 - a_3 - \frac{a_4-a_5}{2})s_c$
$\Sigma^0 K^+$	$-\sqrt{2}(a_1 - a_3 - \frac{a_4+a_5}{2})s_c$
$p\pi^0$	$-\sqrt{2}(a_2 + a_3 - \frac{a_6-a_7}{2})s_c$
$p\eta$	$[\sqrt{2}c\phi(a_2 - a_3 + 2h + \frac{a_6-a_7-2h'}{2}) +2s\phi(-a_1 - h + \frac{a_4+a_5+a_6+h'}{2})]s_c$
$p\eta'$	$[\sqrt{2}s\phi(a_2 - a_3 + 2h + \frac{a_6-a_7-2h'}{2}) -2c\psi(-a_1 - h + \frac{a_4+a_5+a_6+h'}{2})]s_c$
$n\pi^+$	$-2(a_2 + a_3 - \frac{a_4+a_7}{2})s_c$
$\Lambda^0 K^+$	$-\sqrt{\frac{2}{3}}(a_1 - 2a_2 + a_3 - \frac{3a_4-a_5+2a_6+2a_7}{2})s_c$
pK^0	$2(a_3 - \frac{a_4+a_6}{2})s_c^2$
nK^+	$-2(a_3 + \frac{a_4+a_6}{2})s_c^2$

Charmed Baryon Weak Decays

We omit O_+ for two reasons

- $\frac{c_+}{c_-} \approx 0.4$
- Baryon pole: $\langle \mathbf{B}_i | O_+ | \mathbf{B}_p \rangle = 0$

H. Y. Cheng, X. W. Kang and F. Xu,

"Singly Cabibbo-suppressed hadronic decays of Λ_c^+,"

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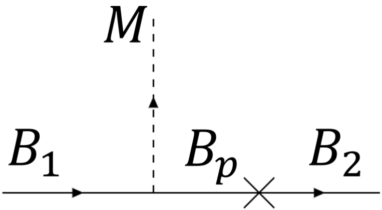

Figure: Baryon pole

Numerical Results

Fitting Results

$(a_1, a_2, a_3, h) = (0.244 \pm 0.006, 0.115 \pm 0.014, 0.088 \pm 0.019, 0.105 \pm 0.073)\ \mathrm{GeV}^3$,
$(\delta_{a_1}, \delta_{a_2}, \delta_{a_3}, \delta_h) = (0, 78.1 \pm 7.1, 35.1 \pm 8.7, 10.2 \pm 29.6)^\circ$,
$\chi^2/d.o.f = 5.32/3 = 1.77$.

Table: The data of the $\mathbf{B}_c \to \mathbf{B}_n M$ decays.

Branching ratios	Data	Branching ratios	Data
$10^2\mathcal{B}(\Lambda_c^+ \to p\bar{K}^0)$	3.16 ± 0.16	$10^2\mathcal{B}(\Lambda_c^+ \to \Sigma^+\eta)$	0.70 ± 0.23
$10^2\mathcal{B}(\Lambda_c^+ \to \Lambda\pi^+)$	1.30 ± 0.07	$10^4\mathcal{B}(\Lambda_c^+ \to \Lambda K^+)$	6.1 ± 1.2
$10^2\mathcal{B}(\Lambda_c^+ \to \Sigma^+\pi^0)$	1.24 ± 0.10	$10^4\mathcal{B}(\Lambda_c^+ \to \Sigma^0 K^+)$	5.2 ± 0.8
$10^2\mathcal{B}(\Lambda_c^+ \to \Sigma^0\pi^+)$	1.29 ± 0.07	$10^4\mathcal{B}(\Lambda_c^+ \to p\eta)$	12.4 ± 3.0
$10^2\mathcal{B}(\Lambda_c^+ \to \Xi^0 K^+)$	0.50 ± 0.12	$\mathcal{R} = \frac{\mathcal{B}(\Xi_c^0 \to \Lambda\bar{K}^0)}{\mathcal{B}(\Xi_c^0 \to \Xi^-\pi^+)}$	0.420 ± 0.056

Numerical Results

Fitting Results

$(a_1, a_2, a_3, h) = (0.244 \pm 0.006, 0.115 \pm 0.014, 0.088 \pm 0.019, 0.105 \pm 0.073)\ \mathrm{GeV}^3$,
$(\delta_{a_1}, \delta_{a_2}, \delta_{a_3}, \delta_h) = (0, 78.1 \pm 7.1, 35.1 \pm 8.7, 10.2 \pm 29.6)^\circ$,
$\chi^2/d.o.f = 5.32/3 = 1.77$.

Comparing with the experiment announcement in 2018 November

Decay branching ratio	$\mathcal{B}_{th}$	$\mathcal{B}_{ex}$
$\mathcal{B}(\Xi_c^0 \to \Xi^- \pi^+)$	$(1.57 \pm 0.07)\%$	$(1.80 \pm 0.52)\%$ [2]
$\mathcal{B}(\Lambda_c^+ \to \Sigma^+ \eta')$	$(1.0^{+1.8}_{-0.8})\%$	$(1.34 \pm 0.57)\%$[3]

[2] arXiv:1811.09738 [hep-ex]. "First measurements of absolute branching fractions of Ξ_c^0 at Belle,"

[3] arXiv:1811.08028 [hep-ex]. "Evidence for the decays of $\Lambda_c^+ \to \Sigma^+\eta$ and $\Sigma^+\eta'$,"

Numerical Results

Table: The numerical results of the $\mathbf{B}_c \to \mathbf{B}_n M$

Ξ_c^0	our results
$10^3\,\mathcal{B}_{\Sigma^+ K^-}$	3.5 ± 0.9
$10^3\,\mathcal{B}_{\Sigma^0 \bar{K}^0}$	4.7 ± 1.2
$10^3\,\mathcal{B}_{\Xi^0 \pi^0}$	4.3 ± 0.9
$10^3\,\mathcal{B}_{\Xi^0 \eta}$	$1.7^{+1.0}_{-1.7}$
$10^3\,\mathcal{B}_{\Xi^0 \eta'}$	$8.6^{+11.0}_{-6.3}$
$10^3\,\mathcal{B}_{\Xi^- \pi^+}$	15.7 ± 0.7
$10^3\,\mathcal{B}_{\Lambda^0 \bar{K}^0}$	8.3 ± 0.9
$10^4\,\mathcal{B}_{\Sigma^+ \pi^-}$	2.0 ± 0.5
$10^4\,\mathcal{B}_{\Sigma^- \pi^+}$	9.0 ± 0.4
$10^4\,\mathcal{B}_{\Sigma^0 \pi^0}$	3.2 ± 0.3
$10^4\,\mathcal{B}_{\Sigma^0 \eta}$	$3.6^{+1.0}_{-0.9}$
$10^4\,\mathcal{B}_{\Sigma^0 \eta'}$	$1.7^{+3.0}_{-1.5}$
$10^4\,\mathcal{B}_{\Xi^- K^+}$	7.6 ± 0.4
$10^4\,\mathcal{B}_{\Xi^0 K^0}$	6.3 ± 1.2
$10^4\,\mathcal{B}_{pK^-}$	2.1 ± 0.5
$10^4\,\mathcal{B}_{n\bar{K}^0}$	7.9 ± 1.4
$10^4\,\mathcal{B}_{\Lambda^0 \pi^0}$	0.2 ± 0.2
$10^4\,\mathcal{B}_{\Lambda^0 \eta}$	$1.6^{+1.2}_{-0.8}$
$10^4\,\mathcal{B}_{\Lambda^0 \eta'}$	$9.4^{+11.6}_{-6.8}$
$10^6\,\mathcal{B}_{p\pi^-}$	12.1 ± 3.1
$10^6\,\mathcal{B}_{\Sigma^- K^+}$	44.5 ± 2.1
$10^6\,\mathcal{B}_{\Sigma^0 K^0}$	22.3 ± 1.0
$10^6\,\mathcal{B}_{n\pi^0}$	6.0 ± 1.5
$10^6\,\mathcal{B}_{n\eta}$	$26.5^{+11.4}_{-10.1}$
$10^6\,\mathcal{B}_{n\eta'}$	$30.7^{+42.3}_{-24.4}$
$10^6\,\mathcal{B}_{\Lambda^0 K^0}$	14.4 ± 3.7

Ξ_c^+	our results
$10^3\,\mathcal{B}_{\Sigma^+ \bar{K}^0}$	8.0 ± 3.9
$10^3\,\mathcal{B}_{\Xi^0 \pi^+}$	8.1 ± 4.0
$10^4\,\mathcal{B}_{\Sigma^0 \pi^+}$	18.5 ± 2.2
$10^4\,\mathcal{B}_{\Sigma^+ \pi^0}$	18.5 ± 2.2
$10^4\,\mathcal{B}_{\Sigma^+ \eta}$	$28.4^{+8.2}_{-6.9}$
$10^4\,\mathcal{B}_{\Sigma^+ \eta'}$	$13.2^{+24.0}_{-11.9}$
$10^4\,\mathcal{B}_{\Xi^0 K^+}$	18.0 ± 4.7
$10^4\,\mathcal{B}_{p\bar{K}^0}$	20.3 ± 4.2
$10^4\,\mathcal{B}_{\Lambda^0 \pi^+}$	1.6 ± 1.2
$10^5\,\mathcal{B}_{\Sigma^0 K^+}$	8.8 ± 0.4
$10^5\,\mathcal{B}_{\Sigma^+ K^0}$	17.6 ± 0.8
$10^6\,\mathcal{B}_{p\pi^0}$	23.8 ± 6.1
$10^5\,\mathcal{B}_{p\eta}$	$10.5^{+4.5}_{-4.0}$
$10^5\,\mathcal{B}_{p\eta'}$	$12.1^{+16.7}_{-9.7}$
$10^6\,\mathcal{B}_{n\pi^+}$	47.6 ± 12.2
$10^6\,\mathcal{B}_{\Lambda^0 K^+}$	56.8 ± 14.5

Λ_c^+	our results
$10^3\,\mathcal{B}_{\Sigma^0 \pi^+}$	$(1.3 \pm 0.2)^\dagger$
$10^3\,\mathcal{B}_{\Sigma^+ \pi^0}$	$(1.3 \pm 0.2)^\dagger$
$10^2\,\mathcal{B}_{\Sigma^+ \eta}$	$(0.7^{+0.4}_{-0.3})^\dagger$
$10^2\,\mathcal{B}_{\Sigma^+ \eta'}$	$1.0^{+1.6}_{-0.8}$
$10^2\,\mathcal{B}_{\Xi^0 K^+}$	$(0.5 \pm 0.1)^\dagger$
$10^2\,\mathcal{B}_{p\bar{K}^0}$	$(3.3 \pm 0.2)^\dagger$
$10^2\,\mathcal{B}_{\Lambda^0 \pi^+}$	$(1.3 \pm 0.2)^\dagger$
$10^4\,\mathcal{B}_{\Sigma^+ K^0}$	8.0 ± 1.6
$10^4\,\mathcal{B}_{\Sigma^0 K^+}$	$(4.0 \pm 0.8)^\dagger$
$10^4\,\mathcal{B}_{p\pi^0}$	5.7 ± 1.5
$10^4\,\mathcal{B}_{p\eta}$	$(12.5^{+3.8}_{-3.6})^\dagger$
$10^4\,\mathcal{B}_{p\eta'}$	$12.2^{+14.3}_{-8.7}$
$10^4\,\mathcal{B}_{n\pi^+}$	11.3 ± 2.9
$10^4\,\mathcal{B}_{\Lambda^0 K^+}$	$(4.6 \pm 0.9)^\dagger$
$10^6\,\mathcal{B}_{pK^0}$	12.2 ± 6.0
$10^6\,\mathcal{B}_{nK^+}$	12.2 ± 6.0

Summary

- We find out

$$\mathcal{B}(\Xi_c^0 \to \Xi^- \pi^+) = (15.7 \pm 0.7) \times 10^{-3}\,,$$

which is consistent with the experiment.

- Through the experimental data, we predict the non-leptonic decays branching ratios.

THANKS FOR YOUR ATTENTION


HAPPY
NEW YEAR
2019