CHARMED BARYON SEMI-LEPTONIC DECAYS WITH SU(3) FLAVOR SYMMETRY

Tien-Hsueh Tsai

National Tsing Hau University

OUTLINE

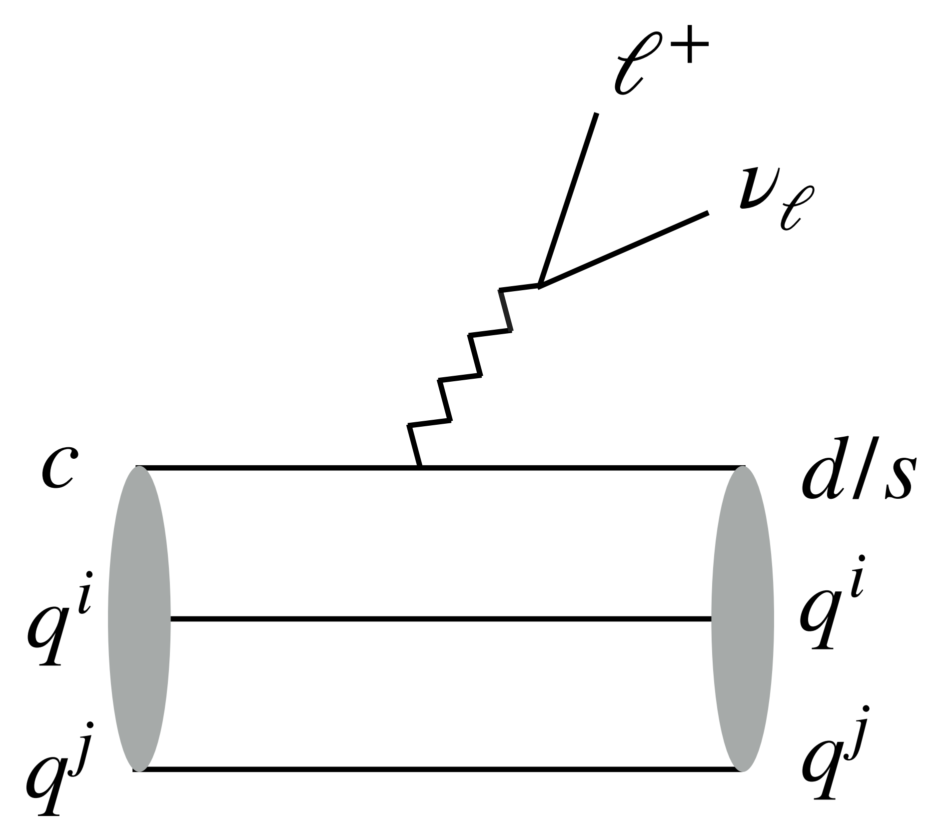
- Motivation
- Helicity amplitude and SU(3) flavor symmetry
- Decay width and up-down asymmetry
- Numerical Results
- Summary

C. Q. Geng, C. W. Liu, T. H. Tsai and S. W. Yeh, Phys. Lett. B **792**, 214 (2019).

MOTIVATION

- Cleanest processes to test SU(3) in charmed baryon
- Factorizable
- Large branching ratios difference in different theoretic models

$$\mathbf{B_c} \to \mathbf{B}\ell^+\nu_\ell$$



HELICITY AMPLITUDE

$$\mathcal{A}(\mathbf{B_c} \to \mathbf{B}\ell^+\nu_\ell) = \frac{G_F}{\sqrt{2}}\langle\mathbf{B}|J_\mu^{(V-A)}|\mathbf{B_c}\rangle\bar{u}_\nu\gamma^\mu\frac{(1-\gamma^5)}{2}u_\ell$$

$$J_\mu^{(V-A)} = V_{cq}\bar{q}\gamma_\mu\frac{(1-\gamma^5)}{2}c \qquad q = d, s$$

HELICITY AMPLITUDE

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$$\epsilon^\mu(t) = \frac{1}{\sqrt{q^2}}(q_0, 0, 0, -p)$$

$$\epsilon^\mu(\pm 1) = \frac{1}{\sqrt{2}}(0, \pm 1, -i, 0)$$

$$\epsilon^\mu(0) = \frac{1}{\sqrt{q^2}}(p, 0, 0, -q_0)$$

HELICITY AMPLITUDE

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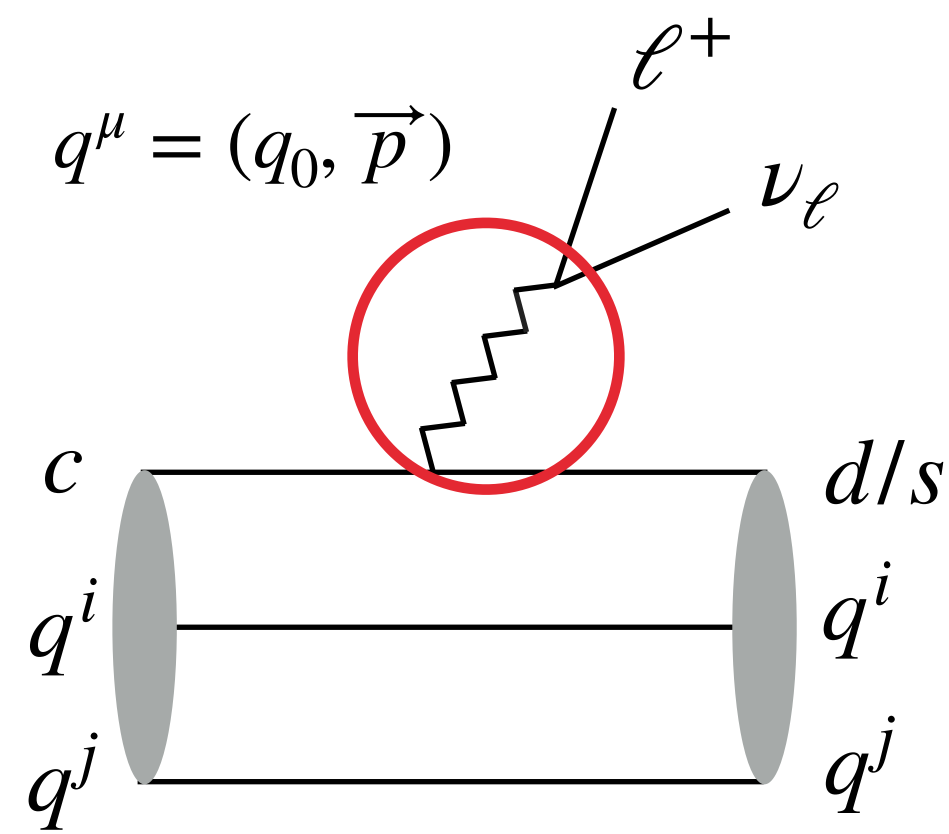


$$p = \frac{1}{2M_{\mathbf{B_c}}}\sqrt{Q_+ Q_-}\,,$$

$$Q_\pm = (M_{\mathbf{B_c}} \pm M_{\mathbf{B_n}})^2 - q^2\,,$$

HELICITY AMPLITUDE

$$\mathcal{A}(\mathbf{B_c} \to \mathbf{B}\ell^+\nu_\ell) = \frac{G_F}{\sqrt{2}} \langle \mathbf{B} | J_\mu^{(V-A)} | \mathbf{B_c} \rangle \bar{u}_\nu \gamma^\mu \frac{(1-\gamma^5)}{2} u_\ell$$

$$\mathcal{A}(\mathbf{B_c} \to \mathbf{B_n}\ell^+\nu_\ell) = \sum_{\lambda_W, \lambda'_W = \pm 1, 0, t} \frac{G_F}{\sqrt{2}} V_{cq} H_{\lambda_2 \lambda_W} \bar{u}_\nu \gamma_\beta \frac{(1-\gamma_5)}{2} v_\ell \epsilon^{*\beta}(\lambda'_W) g_{\lambda_W \lambda'_W}$$

$$H_{\lambda_2\lambda_W} = H^V_{\lambda_2\lambda_W} - H^A_{\lambda_2\lambda_W}\,, \qquad H^{V(A)}_{\lambda_2\lambda_W} = \langle \mathbf{B_n} | J_\mu^{V(A)} | \mathbf{B_c} \rangle \epsilon^\mu(\lambda_W)$$

$$\lambda_1 = \lambda_2 - \lambda_W$$

HELICITY AMPLITUDE

$$\langle \mathbf{B_n}|J_\mu^V|\mathbf{B_c}\rangle = \bar{u}_{\mathbf{B_n}}(p_{\mathbf{B_n}})\left[F_1^V(q^2)\gamma_\mu - \frac{F_2^V(q^2)}{M_{\mathbf{B_c}}}i\sigma_{\mu\nu}q^\nu + \frac{F_3^V(q^2)}{M_{\mathbf{B_c}}}q_\mu\right]u_{\mathbf{B_c}}(p_{\mathbf{B_c}})\ ,$$

$$\langle \mathbf{B_n}|J_\mu^A|B_{\mathbf{B_c}}\rangle = \bar{u}_{\mathbf{B_n}}(p_{\mathbf{B_n}})\left[F_1^A(q^2)\gamma_\mu - \frac{F_2^A(q^2)}{M_{\mathbf{B_c}}}i\sigma_{\mu\nu}q^\nu + \frac{F_3^A(q^2)}{M_{\mathbf{B_c}}}q_\mu\right]\gamma_5 u_{\mathbf{B_c}}(p_{\mathbf{B_c}})\ .$$

HELICITY AMPLITUDE

$$H^{V(A)}_{\lambda_2\lambda_W} = \langle \mathbf{B_n}|J^{V(A)}_\mu|\mathbf{B_c}\rangle\epsilon^\mu(\lambda_W)$$

$$H^V_{\frac{1}{2}1} = \sqrt{2Q_-}\left(-F^V_1 - \frac{M_{\mathbf{B_c}}+M_{\mathbf{B_n}}}{M_{\mathbf{B_c}}}F^V_2\right) ,$$

$$H^V_{\frac{1}{2}0} = \frac{\sqrt{Q_-}}{\sqrt{q^2}}\left((M_{\mathbf{B_c}}+M_{\mathbf{B_n}})F^V_1 + \frac{q^2}{M_{\mathbf{B_c}}}F^V_2\right) ,$$

$$H^V_{\frac{1}{2}t} = \frac{\sqrt{Q_+}}{\sqrt{q^2}}\left((M_{\mathbf{B_c}}-M_{\mathbf{B_n}})F^V_1 + \frac{q^2}{M_{\mathbf{B_c}}}F^V_3\right) ,$$

$$H^A_{\frac{1}{2}1} = \sqrt{2Q_+}\left(F^A_1 - \frac{M_{\mathbf{B_c}}-M_{\mathbf{B_n}}}{M_{\mathbf{B_c}}}F^A_2\right) ,$$

$$H^A_{\frac{1}{2}0} = \frac{\sqrt{Q_+}}{\sqrt{q^2}}\left(-(M_{\mathbf{B_c}}-M_{\mathbf{B_n}})F^A_1 + \frac{q^2}{M_{\mathbf{B_c}}}F^A_2\right) ,$$

$$H^A_{\frac{1}{2}t} = \frac{\sqrt{Q_-}}{\sqrt{q^2}}\left(-(M_{\mathbf{B_c}}+M_{\mathbf{B_n}})F^A_1 + \frac{q^2}{M_{\mathbf{B_c}}}F^A_3\right)$$

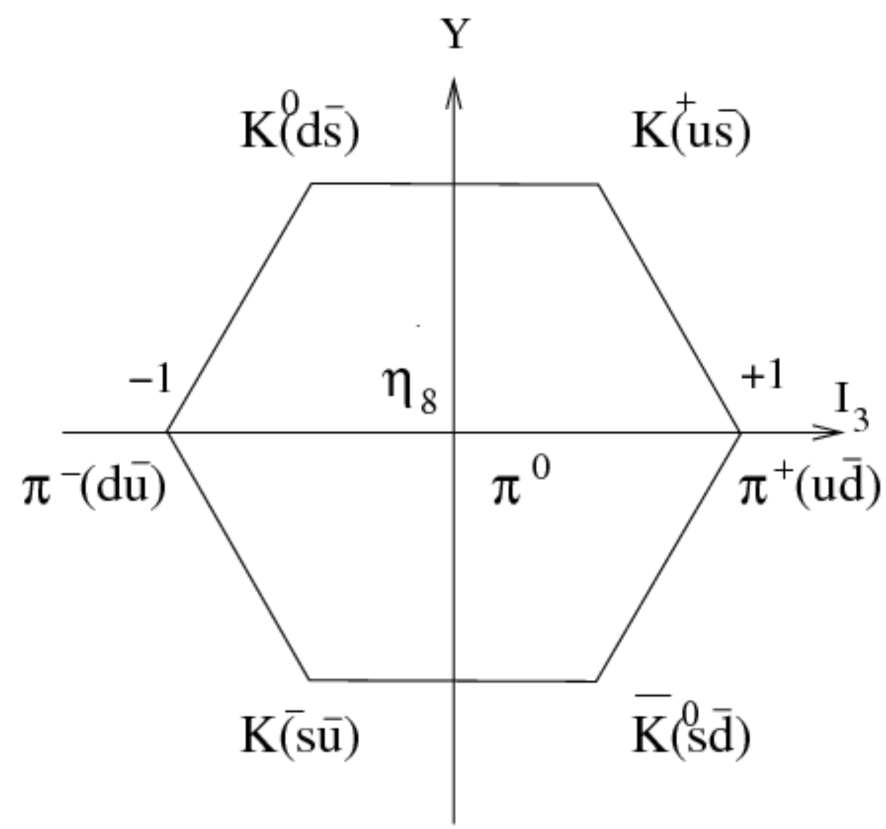
SU(3) FLAVOR SYMMETRY

- Quark triplet

$$q^i = \begin{bmatrix} u \\ d \\ s \end{bmatrix}$$

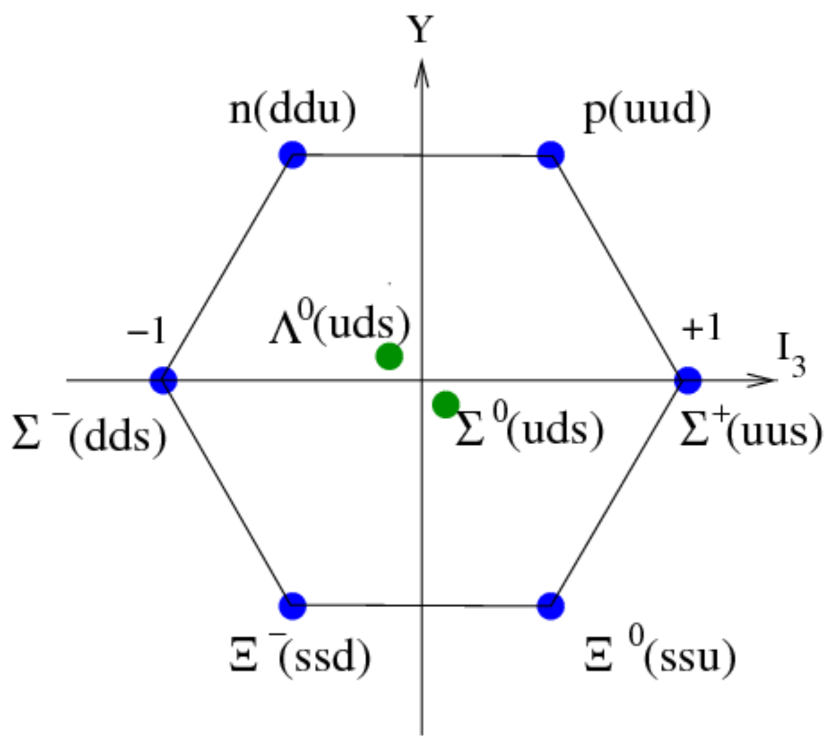
- Meson octet $q^i \bar{q}_j$

$$M = \begin{bmatrix} \frac{1}{\sqrt{2}}\pi^0 + \frac{1}{\sqrt{6}}\eta & \pi^- & K^- \\ \pi^+ & -\frac{1}{\sqrt{2}}\pi^0 + \frac{1}{\sqrt{6}}\eta & \bar{K}^0 \\ K^+ & K^0 & -\sqrt{\frac{2}{3}}\eta \end{bmatrix}$$



- Baryon octet $q^i q^j q^k$

$$\mathbf{B} = \begin{bmatrix} \frac{1}{\sqrt{6}}\Lambda + \frac{1}{\sqrt{2}}\Sigma^0 & \Sigma^+ & p \\ \Sigma^- & \frac{1}{\sqrt{6}}\Lambda - \frac{1}{\sqrt{2}}\Sigma^0 & n \\ \Xi^- & \Xi^0 & -\sqrt{\frac{2}{3}}\Lambda \end{bmatrix}$$



- Charmed baryon anti-triplet $q^i q^j c$

$$B_c = \begin{bmatrix} \Xi_c^0 & -\Xi_c^+ & \Lambda_c^+ \end{bmatrix}$$

HELICITY AMPLITUDE IN SU(3) LANGUAGE

- Baryon transition operator : $H^{V(A)}_{\lambda_2\lambda_W} = \langle \mathbf{B_n} | J^{V(A)}_\mu | \mathbf{B_c} \rangle \epsilon^\mu(\lambda_W)$

$$J^{(V-A)}_\mu \epsilon^\mu(\lambda_W) = (\bar{q}c)_{V-A} \quad \Rightarrow \quad T^i(\bar{3}) = (0, 1, 1)$$

- Helicity amplitude:

$$H^{V(A)}_{\lambda_2\lambda_W} = a^{V(A)}_{\lambda_2\lambda_W}(q^2)(\mathbf{B_n})^i_j T^j(\bar{3})(\mathbf{B_c})_i$$

HELICITY AMPLITUDE IN SU(3) LANGUAGE

channel	$H^{V(A)}_{\lambda_2\lambda_W}$
$\Lambda_c^+ \to \Lambda \ell^+ \nu_\ell$	$-\sqrt{\frac{2}{3}} a^{V(A)}_{\lambda_2\lambda_W}(q^2)$
$\Xi_c^+ \to \Xi^0 \ell^+ \nu_\ell$	$-a^{V(A)}_{\lambda_2\lambda_W}(q^2)$
$\Xi_c^0 \to \Xi^- \ell^+ \nu_\ell$	$a^{V(A)}_{\lambda_2\lambda_W}(q^2)$
$\Lambda_c^+ \to n \ell^+ \nu_\ell$	$a^{V(A)}_{\lambda_2\lambda_W}(q^2)$
$\Xi_c^+ \to \Sigma^0 \ell^+ \nu_\ell$	$\sqrt{\frac{1}{2}} a^{V(A)}_{\lambda_2\lambda_W}(q^2)$
$\Xi_c^+ \to \Lambda \ell^+ \nu_\ell$	$-\sqrt{\frac{1}{6}} a^{V(A)}_{\lambda_2\lambda_W}(q^2)$
$\Xi_c^0 \to \Sigma^- \ell^+ \nu_\ell$	$a^{V(A)}_{\lambda_2\lambda_W}(q^2)$

DECAY WIDTH

$$\frac{d\Gamma}{dq^2} = \frac{1}{3}\frac{G_F^2}{(2\pi)^3}|V_{qc}|^2\frac{(q^2-m_\ell^2)^2 p}{8M_{\mathbf{B_c}}^2 q^2}\Bigg[\left(1+\frac{m_\ell^2}{2q^2}\right)\left(|H_{\frac{1}{2}1}|^2+|H_{-\frac{1}{2}-1}|^2+|H_{\frac{1}{2}0}|^2+|H_{-\frac{1}{2}0}|^2\right)+\frac{3m_\ell^2}{2q^2}\left(|H_{\frac{1}{2}t}|^2+|H_{-\frac{1}{2}t}|^2\right)\Bigg]$$

DECAY WIDTH

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$\ell = e^+, \mu^+$ $\quad m_\ell \to 0$ $\quad$ Helicity suppression

$$\frac{d\Gamma}{dq^2} \simeq \frac{1}{3}\frac{G_F^2}{(2\pi)^3}|V_{qc}|^2\frac{q^2 p}{8M_{\mathbf{B_c}}^2}(|H_{\frac{1}{2}1}|^2+|H_{-\frac{1}{2}-1}|^2+|H_{\frac{1}{2}0}|^2+|H_{-\frac{1}{2}0}|^2)$$

UP-DOWN ASYMMETRY

$$\alpha(q^2) = \frac{|H_{\frac{1}{2}1}|^2 - |H_{-\frac{1}{2}-1}|^2 + |H_{\frac{1}{2}0}|^2 - |H_{-\frac{1}{2}0}|^2}{|H_{\frac{1}{2}1}|^2 + |H_{-\frac{1}{2}-1}|^2 + |H_{\frac{1}{2}0}|^2 + |H_{-\frac{1}{2}0}|^2}.$$

$$\langle\alpha\rangle = \frac{\int dq^2 \frac{q^2 p}{8M_{\mathbf{B_c}}^2} \left(|H_{\frac{1}{2}1}|^2 - |H_{-\frac{1}{2}-1}|^2 + |H_{\frac{1}{2}0}|^2 - |H_{-\frac{1}{2}0}|^2\right)}{\int dq^2 \frac{q^2 p}{8M_{\mathbf{B_c}}^2} \left(|H_{\frac{1}{2}1}|^2 + |H_{-\frac{1}{2}-1}|^2 + |H_{\frac{1}{2}0}|^2 + |H_{-\frac{1}{2}0}|^2\right)}$$

FORM FACTOR

$$F_i^V(q^2) = F_i^A(q^2) = F_i(q^2)$$

Heavy quark symmetry

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Heavy quark symmetry

$$F_i(q^2) = \frac{F_i}{(1 - q^2/M_V^2)^2}$$

$$M_V = 2.061 \ GeV$$

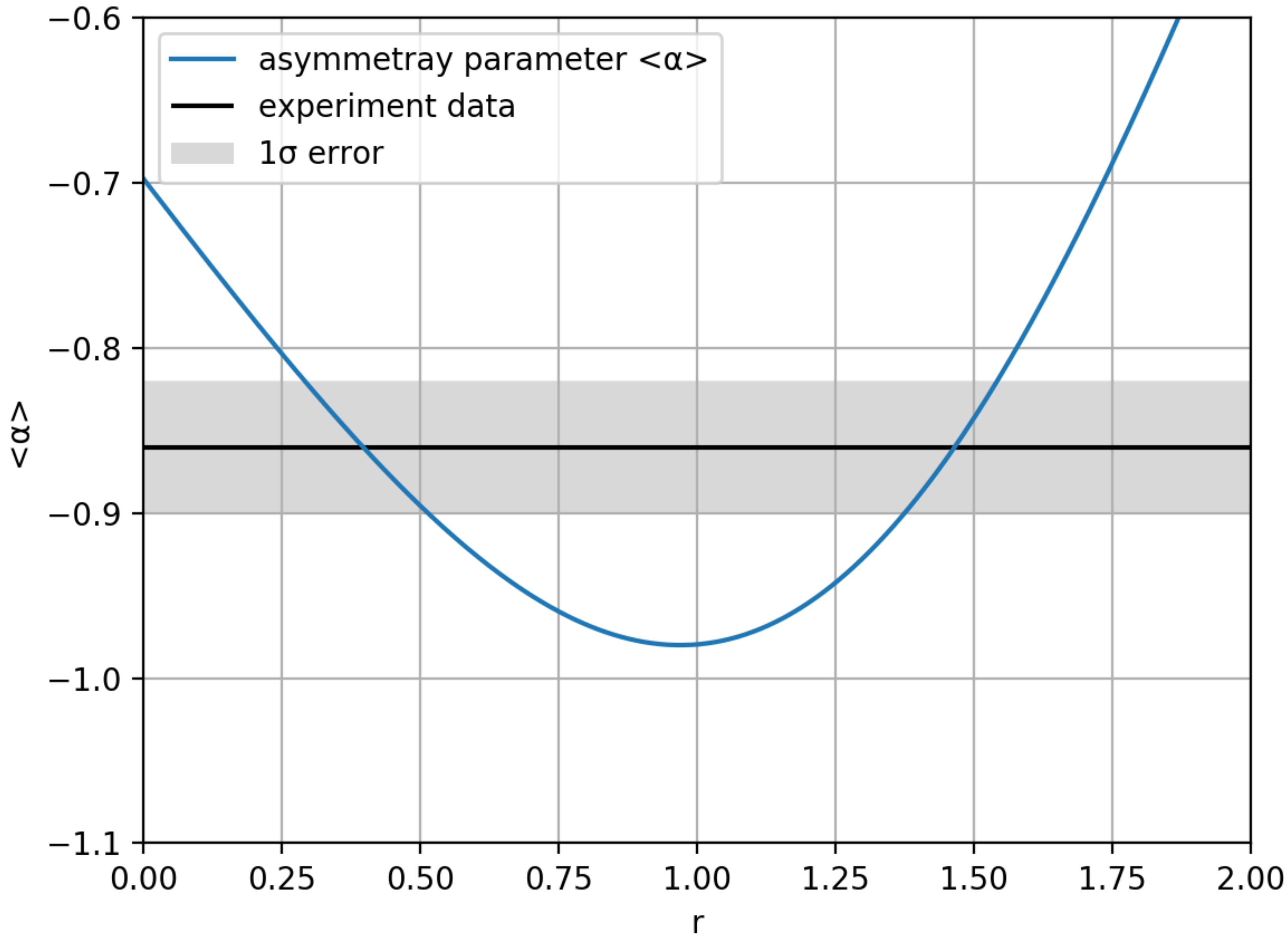
$$F_i = F_i(q^2 = 0)$$

CLEO Phys.Rev.Lett. 94 (2005) 191801

FORM FACTOR

$$\langle\alpha\rangle(\Lambda_c^+ \to \Lambda e^+ \nu_e) = -0.86 \pm 0.04$$

$$|r| = |\frac{F_2}{F_1}| < 1$$



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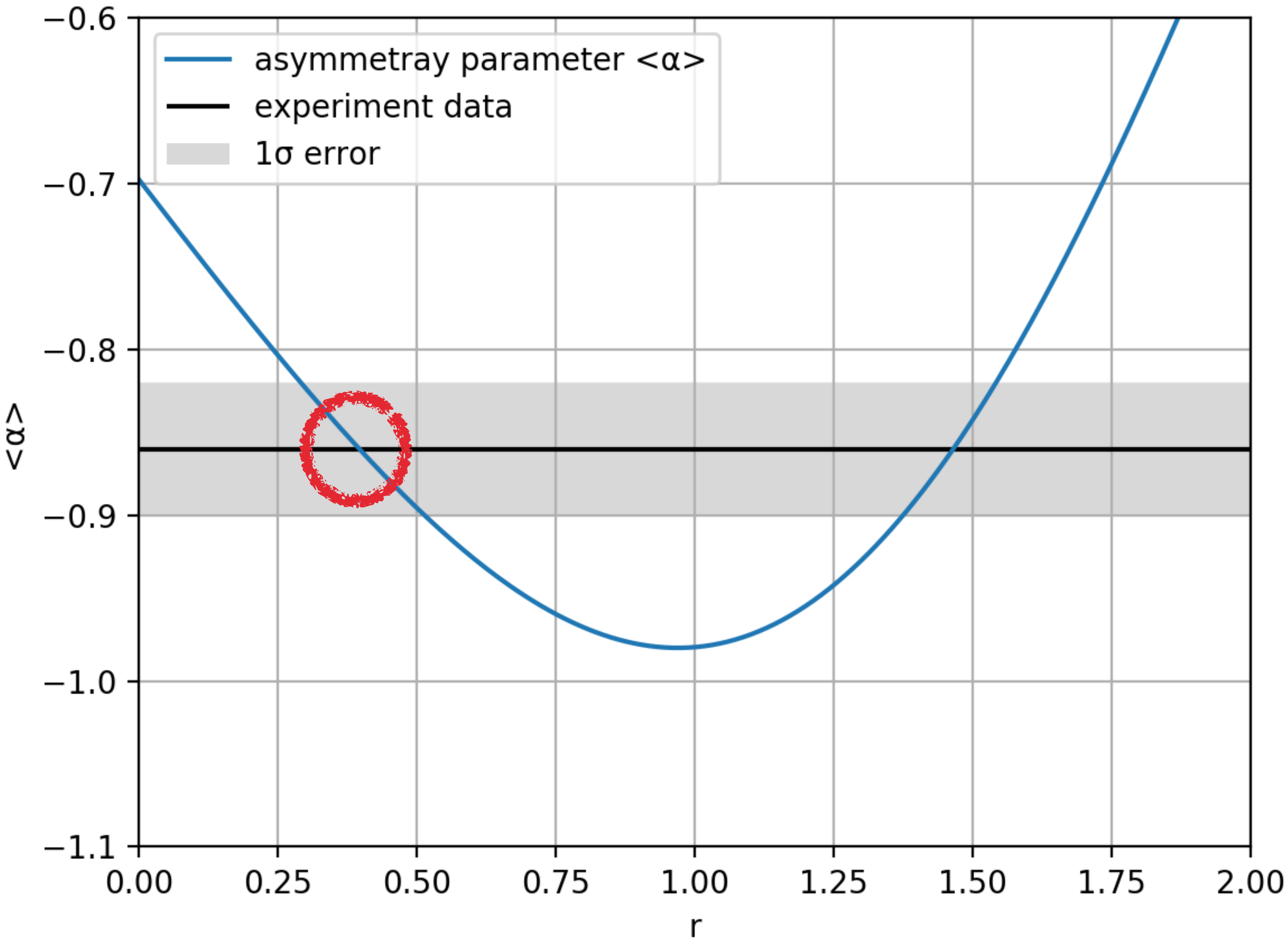

$$r \simeq 0.40^{+0.12}_{-0.11}$$

MINIMUM CHI-SQUARE FIT

$$\mathcal{B}(\Lambda_c^+ \to \Lambda e^+ \nu_e) = (3.6 \pm 0.4)\%$$

$$\mathcal{B}(\Lambda_c^+ \to \Lambda \mu^+ \nu_\mu) = (3.5 \pm 0.5)\%$$

$$\langle \alpha \rangle (\Lambda_c^+ \to \Lambda e^+ \nu_e) = -0.86 \pm 0.04$$

$$\mathcal{B}(\Xi_c^0 \to \Xi^- e^+ \nu_e) = (2.4 \pm 0.3)\%$$ Predict from SU(3)

Cabibbo-favored (S = −2) decays

Γ_1	$pK^-K^-\pi^+$	$(4.8 \pm 1.2) \times 10^{-3}$
Γ_2	$pK^-\overline{K}^*(892)^0$, $\overline{K}^{*0} \to K^-\pi^+$	$(2.0 \pm 0.6) \times 10^{-3}$
Γ_3	$pK^-K^-\pi^+$ (no $\overline{K}^{*0}$)	$(3.0 \pm 0.9) \times 10^{-3}$
Γ_4	ΛK^0_S	$(3.0 \pm 0.8) \times 10^{-3}$
Γ_5	$\Lambda K^-\pi^+$	$(1.45 \pm 0.33)\%$
Γ_6	$\Lambda \overline{K}^0 \pi^+\pi^-$	seen
Γ_7	$\Lambda K^-\pi^+\pi^+\pi^-$	seen
Γ_8	$\Xi^-\pi^+$	$(1.43 \pm 0.32)\%$
Γ_9	$\Xi^-\pi^+\pi^+\pi^-$	$(4.8 \pm 2.3)\%$
Γ_{10}	Ω^-K^+	$(4.2 \pm 1.0) \times 10^{-3}$
Γ_{11}	$\Xi^-e^+\nu_e$	$(1.8 \pm 1.2)\%$

MINIMUM CHI SQUARE FIT

$$(F_1, F_2) = (0.62 \pm 0.03, 0.25 \pm 0.08)$$

$$\chi^2/d.o.f = 1.2 \qquad d.o.f = 2$$

$$r = 0.40 \pm 0.11$$

BRANCHING RATIOS

Branching ratio	$SU(3)_f$	HQET	LF	MBM(NRQM)	LQCD	Data
$10^2\mathcal{B}(\Lambda_c^+ \to \Lambda e^+\nu_e)$	3.2 ± 0.3	1.42	1.63	2.96(3.60)	3.80 ± 0.22	3.6 ± 0.4
$10^2\mathcal{B}(\Lambda_c^+ \to \Lambda \mu^+\nu_\mu)$	3.2 ± 0.3	-	-	-	3.69 ± 0.22	3.5 ± 0.5
$10^2\mathcal{B}(\Xi_c^+ \to \Xi^0 e^+\nu_e)$	10.7 ± 0.9	-	5.39	1.33(1.01)	-	6.6 ± 3.7
$10^2\mathcal{B}(\Xi_c^+ \to \Xi^0 \mu^+\nu_\mu)$	10.8 ± 0.9	-	-	-	-	-
$10^2\mathcal{B}(\Xi_c^0 \to \Xi^- e^+\nu_e)$	2.7 ± 0.2	0.86	1.35	0.40(0.30)	-	1.8 ± 1.2
$10^2\mathcal{B}(\Xi_c^0 \to \Xi^- \mu^+\nu_\mu)$	2.7 ± 0.2	-	-	-	-	-
$10^3\mathcal{B}(\Lambda_c^+ \to n e^+\nu_e)$	5.1 ± 0.4	-	2.01	2.20(3.40)	4.10 ± 0.29	–
$10^3\mathcal{B}(\Xi_c^+ \to \Sigma^0 e^+\nu_e)$	4.6 ± 0.4	-	1.87	4.42(4.42)	-	–
$10^4\mathcal{B}(\Xi_c^+ \to \Lambda e^+\nu_e)$	21.8 ± 1.8	-	8.22	8.84(8.84)	-	–
$10^4\mathcal{B}(\Xi_c^0 \to \Sigma^- e^+\nu_e)$	23.2 ± 1.9	-	9.47	2.24(1.12)	-	–

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$10^2\mathcal{B}(\Xi_c^0 \to \Xi^- e^+\nu_e)$	2.7 ± 0.2	0.86	1.35	0.40(0.30)	-	1.8 ± 1.2
$10^2\mathcal{B}(\Xi_c^0 \to \Xi^- \mu^+\nu_\mu)$	2.7 ± 0.2	-	-	-	-	-
$10^3\mathcal{B}(\Lambda_c^+ \to n e^+\nu_e)$	5.1 ± 0.4	-	2.01	2.20(3.40)	4.10 ± 0.29	–
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UP-DOWN ASYMMETRY

Channel	Asymmetry $\langle\alpha\rangle$
$\Lambda_c^+ \to \Lambda\ell^+\nu_\ell$	-0.86 ± 0.04
$\Xi_c^+ \to \Xi^0\ell^+\nu_\ell$	-0.83 ± 0.04
$\Xi_c^0 \to \Xi^-\ell^+\nu_\ell$	-0.83 ± 0.04
$\Lambda_c^+ \to n\ell^+\nu_\ell$	-0.89 ± 0.04
$\Xi_c^+ \to \Sigma^0\ell^+\nu_\ell$	-0.85 ± 0.04
$\Xi_c^+ \to \Lambda\ell^+\nu_\ell$	-0.86 ± 0.04
$\Xi_c^0 \to \Sigma^-\ell^+\nu_\ell$	-0.85 ± 0.04

$$\langle\alpha\rangle(\Lambda_c^+ \to \Lambda e^+\nu_e) = -0.86 \pm 0.04$$

SUMMARY

- Predictions of charmed baryon semi-leptonic decay with SU(3) flavor symmetry are consistent with experiments and lattice QCD results
- SU(3) relations are preserved very well in light front QCD calculation

THANKS FOR YOUR ATTENTION

NAIVE SU(3) PREDICTION V.S. DIPOLE BEHAVIOR ASSUMPTION

Branching ratio	$SU(3)_f$
$10^2\mathcal{B}(\Lambda_c^+ \to \Lambda e^+ \nu_e)$	3.6 ± 0.4
$10^2\mathcal{B}(\Lambda_c^+ \to \Lambda \mu^+ \nu_\mu)$	3.5 ± 0.5
$10^2\mathcal{B}(\Xi_c^+ \to \Xi^0 e^+ \nu_e)$	11.9 ± 1.3
$10^2\mathcal{B}(\Xi_c^+ \to \Xi^0 \mu^+ \nu_\mu)$	11.6 ± 1.7
$10^2\mathcal{B}(\Xi_c^0 \to \Xi^- e^+ \nu_e)$	3.0 ± 0.3
$10^2\mathcal{B}(\Xi_c^0 \to \Xi^- \mu^+ \nu_\mu)$	2.9 ± 0.4
$10^3\mathcal{B}(\Lambda_c^+ \to n e^+ \nu_e)$	2.8 ± 0.4
$10^3\mathcal{B}(\Xi_c^+ \to \Sigma^0 e^+ \nu_e)$	3.1 ± 0.4
$10^4\mathcal{B}(\Xi_c^+ \to \Lambda e^+ \nu_e)$	10.3 ± 1.5
$10^4\mathcal{B}(\Xi_c^0 \to \Sigma^- e^+ \nu_e)$	15.7 ± 2.2

channel	$H^{V(A)}_{\lambda_2\lambda_W}$
$\Lambda_c^+ \to \Lambda \ell^+ \nu_\ell$	$-\sqrt{\frac{2}{3}} a^{V(A)}_{\lambda_2\lambda_W}(q^2)$
$\Xi_c^+ \to \Xi^0 \ell^+ \nu_\ell$	$-a^{V(A)}_{\lambda_2\lambda_W}(q^2)$
$\Xi_c^0 \to \Xi^- \ell^+ \nu_\ell$	$a^{V(A)}_{\lambda_2\lambda_W}(q^2)$
$\Lambda_c^+ \to n \ell^+ \nu_\ell$	$a^{V(A)}_{\lambda_2\lambda_W}(q^2)$
$\Xi_c^+ \to \Sigma^0 \ell^+ \nu_\ell$	$\sqrt{\frac{1}{2}} a^{V(A)}_{\lambda_2\lambda_W}(q^2)$
$\Xi_c^+ \to \Lambda \ell^+ \nu_\ell$	$-\sqrt{\frac{1}{6}} a^{V(A)}_{\lambda_2\lambda_W}(q^2)$
$\Xi_c^0 \to \Sigma^- \ell^+ \nu_\ell$	$a^{V(A)}_{\lambda_2\lambda_W}(q^2)$

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$10^2\mathcal{B}(\Xi_c^0 \to \Xi^- \mu^+\nu_\mu)$	2.9 ± 0.4
$10^3\mathcal{B}(\Lambda_c^+ \to n e^+\nu_e)$	2.8 ± 0.4
$10^3\mathcal{B}(\Xi_c^+ \to \Sigma^0 e^+\nu_e)$	3.1 ± 0.4
$10^4\mathcal{B}(\Xi_c^+ \to \Lambda e^+\nu_e)$	10.3 ± 1.5
$10^4\mathcal{B}(\Xi_c^0 \to \Sigma^- e^+\nu_e)$	15.7 ± 2.2

Branching ratio	$SU(3)_f$
$10^2\mathcal{B}(\Lambda_c^+ \to \Lambda e^+\nu_e)$	3.2 ± 0.3
$10^2\mathcal{B}(\Lambda_c^+ \to \Lambda \mu^+\nu_\mu)$	3.2 ± 0.3
$10^2\mathcal{B}(\Xi_c^+ \to \Xi^0 e^+\nu_e)$	10.7 ± 0.9
$10^2\mathcal{B}(\Xi_c^+ \to \Xi^0 \mu^+\nu_\mu)$	10.8 ± 0.9
$10^2\mathcal{B}(\Xi_c^0 \to \Xi^- e^+\nu_e)$	2.7 ± 0.2
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Ξ_c^0 BRANCHING RATIOS

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First Measurements of Absolute Branching Fractions of the Ξ_c^0 Baryon at Belle

Y. B. Li,[69] C. P. Shen,[2,10] C. Z. Yuan,[26] I. Adachi,[17,13] H. Aihara,[84] S. Al Said,[79,35] D. M. Asner,[3] T. Aushev,[54] R. Ayad,[79] I. Badhrees,[79,34] Y. Ban,[69] V. Bansal,[67] C. Beleño,[12] M. Berger,[76] V. Bhardwaj,[21] B. Bhuyan,[22] T. Bilka,[5] J. Biswal,[31] A. Bondar,[4,65] A. Bozek,[62] M. Bračko,[48,31] L. Cao,[32] D. Červenkov,[5] A. Chen,[59] B. G. Cheon,[15] K. Chilikin,[43] K. Cho,[37] S.-K. Choi,[14] Y. Choi,[77] D. Cinabro,[88] S. Cunliffe,[8] S. Di Carlo,[41] Z. Doležal,[5] T. V. Dong,[17,13] Z. Drásal,[5] S. Eidelman,[4,65,43] J. E. Fast,[67] B. G. Fulsom,[67] R. Garg,[68] V. Gaur,[87] N. Gabyshev,[4,65] A. Garmash,[4,65] A. Giri,[23] P. Goldenzweig,[32] D. Greenwald,[81] B. Grube,[81] K. Hayasaka,[64] H. Hayashii,[58] C.-L. Hsu,[78] T. Iijima,[56,55] K. Inami,[55] G. Inguglia,[8] A. Ishikawa,[82] R. Itoh,[17,13] M. Iwasaki,[66] Y. Iwasaki,[17] W. W. Jacobs,[25] S. Jia,[2] Y. Jin,[84] D. Joffe,[33] K. K. Joo,[6] G. Karyan,[8] T. Kawasaki,[36] H. Kichimi,[17] D. Y. Kim,[75] H. J. Kim,[40] J. B. Kim,[38] K. T. Kim,[38] S. H. Kim,[15] K. Kinoshita,[7] P. Kodyš,[5] S. Korpar,[48,31] D. Kotchetkov,[16] P. Križan,[44,31] R. Kroeger,[51] P. Krokovny,[4,65] T. Kumita,[86] A. Kuzmin,[4,65] Y.-J. Kwon,[90] J. Y. Lee,[73] S. C. Lee,[40] L. K. Li,[26] L. Li Gioi,[49] J. Libby,[24] D. Liventsev,[87,17] M. Lubej,[31] J. MacNaughton,[52] M. Masuda,[83] T. Matsuda,[52] M. Merola,[28,57] K. Miyabayashi,[58] H. Miyata,[64] R. Mizuk,[43,53,54] G. B. Mohanty,[80] R. Mussa,[29] E. Nakano,[66] M. Nakao,[17,13] K. J. Nath,[22] M. Nayak,[88,17] M. Niiyama,[39] S. Nishida,[17,13] H. Ono,[63,64] Y. Onuki,[84] P. Pakhlov,[43,53] G. Pakhlova,[43,54] B. Pal,[3] S. Pardi,[28] S.-H. Park,[90] S. Paul,[81] T. K. Pedlar,[46] R. Pestotnik,[31] L. E. Piilonen,[87] V. Popov,[43,54] E. Prencipe,[19] G. Russo,[28] Y. Sakai,[17,13] M. Salehi,[47,45] S. Sandilya,[7] L. Santelj,[17] T. Sanuki,[82] V. Savinov,[70] O. Schneider,[42] G. Schnell,[1,20] J. Schueler,[16] C. Schwanda,[27] A. J. Schwartz,[7] Y. Seino,[64] K. Senyo,[89] M. E. Sevior,[50] T.-A. Shibata,[85] J.-G. Shiu,[61] B. Shwartz,[4,65] E. Solovieva,[43,54] M. Starič,[31] M. Sumihama,[11] T. Sumiyoshi,[86] W. Sutcliffe,[32] M. Takizawa,[74,18,71] K. Tanida,[30] Y. Tao,[9] F. Tenchini,[8] K. Trabelsi,[17,13] M. Uchida,[85] T. Uglov,[43,54] Y. Unno,[15] S. Uno,[17,13] P. Urquijo,[50] R. Van Tonder,[32] G. Varner,[16] B. Wang,[7] C. H. Wang,[60] M.-Z. Wang,[61] P. Wang,[26] X. L. Wang,[10] E. Won,[38] S. B. Yang,[38] H. Ye,[8] J. Yelton,[9] J. H. Yin,[26] Y. Yusa,[64] Z. P. Zhang,[72] V. Zhilich,[4,65] and V. Zhukova[43]

(Belle Collaboration)

HEAVY QUARK SYMMETRY

- In Heavy quark effective theory Λ-type heavy baryon ($c[q^i q^j]$) heavy to light transition is describe by

$$\langle \mathbf{B}|\bar{q}_l \Gamma h_v|\xi_h(v)\rangle = \bar{u}_l(p)[F_1(p\cdot v) + \not{v}F_2(p\cdot v)]\Gamma u_{\xi_h}(v)$$

$$\Gamma = (1-\gamma^5)$$ In weak decay

HEAVY QUARK SYMMETRY

- Compared with standard form factor

$$\langle \mathbf{B_n}|J_\mu^V|\mathbf{B_c}\rangle = \bar{u}_{\mathbf{B_n}}(p_{\mathbf{B_n}})\left[F_1^V(q^2)\gamma_\mu - \frac{F_2^V(q^2)}{M_{\mathbf{B_c}}}i\sigma_{\mu\nu}q^\nu + \frac{F_3^V(q^2)}{M_{\mathbf{B_c}}}q_\mu\right]u_{\mathbf{B_c}}(p_{\mathbf{B_c}})\ ,$$

$$\langle \mathbf{B_n}|J_\mu^A|B_{\mathbf{B_c}}\rangle = \bar{u}_{\mathbf{B_n}}(p_{\mathbf{B_n}})\left[F_1^A(q^2)\gamma_\mu - \frac{F_2^A(q^2)}{M_{\mathbf{B_c}}}i\sigma_{\mu\nu}q^\nu + \frac{F_3^A(q^2)}{M_{\mathbf{B_c}}}q_\mu\right]\gamma_5 u_{\mathbf{B_c}}(p_{\mathbf{B_c}})\ .$$