Two-body baryonic B decays in PQCD

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Outline

Why baryonic B physics?

PQCD calculations of $B^+ \to p\bar{\Lambda}$

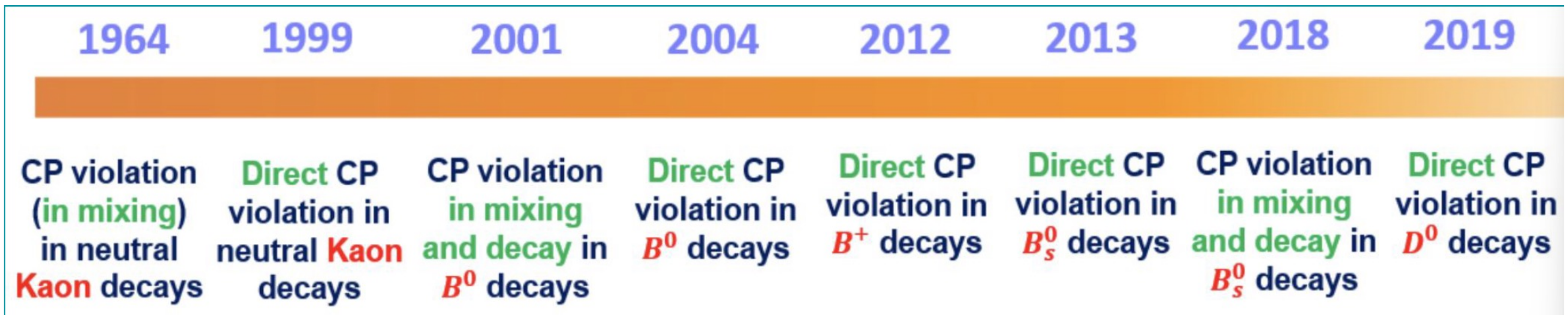
Predict CPVs of $B^+ \to p\bar{\Lambda}$

Summary

Why baryonic B decays ?

- **CPV is an intriguing topic of heavy flavor physics.**

- **CPV established in strange, beauty and charm meson decays in the past 60 years.**



- **First observation of CPV in baryonic decays,** arXiv:2503.16954

$$A_{CP}(\Lambda_b^0 \to R(p\pi^+\pi^-)K^-) = (5.4 \pm 0.9 \pm 0.1)\% \qquad 6.0\sigma$$

- **Searching for other sources of CPV —— Baryonic B decays.**

Why baryonic B decays ?

- B meson is heavy enough to allow a baryon-antibaryon pair production in the final state.
- Baryonic B decays offer alternative robust ways to test the SM and search for new physics, complementing searches with mesonic B decays.
- At least two baryons with half-integer spin in the final state: more plentiful CPV observations in the angular distribution.
- Not only direct CPV but also mixing induced CPV.
- First evidence (4.0σ) for CPV in $B \to p\bar{p}K$ decays. PRL 113, 141801 (2014)
- First observation of $B^+ \to p\bar{\Lambda}$, which may be the first step towards studies of CP violation in this decay.

$$\mathcal{B}(B^+ \to p\bar{\Lambda}) = (1.24 \pm 0.17 \pm 0.05 \pm 0.03) \times 10^{-7}$$ PRL136, 051802 (2026)

- Searching for CPV in baryonic B decays might mark a new milestone in the discovery of CPV.

New phenomena in baryonic B decays

- **Threshold enhancement**

  [Hou and Soni, Phys. Rev. Lett. 86, 4247 (2001)]

- **Multiplicity effects**

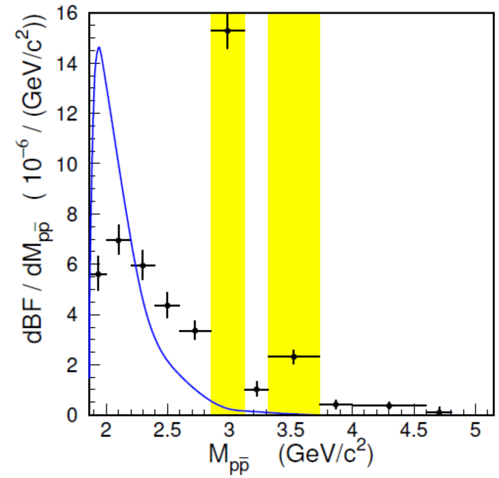
$$\mathcal{B}(\overline{B}^0 \to \Lambda_c^+ \overline{p} \pi^+ \pi^-) \gg \mathcal{B}(\overline{B}^0 \to \Lambda_c^+ \overline{p} \pi^0) \gg \mathcal{B}(\overline{B}^0 \to \Lambda_c^+ \overline{p}),$$

- **Angular correlation puzzle**

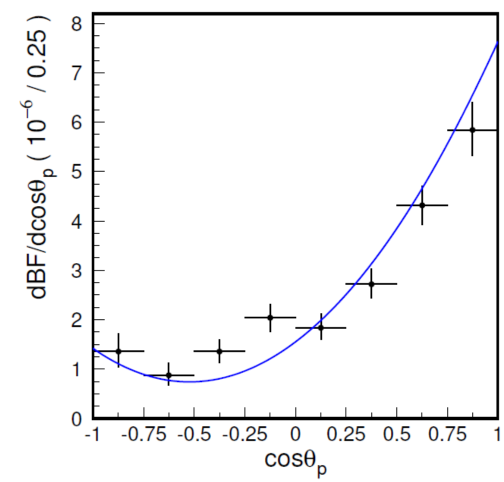
  [IJMPA 21 (2006) 4209–4232]

- **Status of baryonic B decays:**

  Cheng(2005,2007,2009), Huang, Hsiao, Wang, and Sun (2022), The Physics of the B Factories, Eur. Phys. J. C (2014) 74:3026.



(a) $B^+ \to p\overline{p}K^+$ (Wei, 2008b)



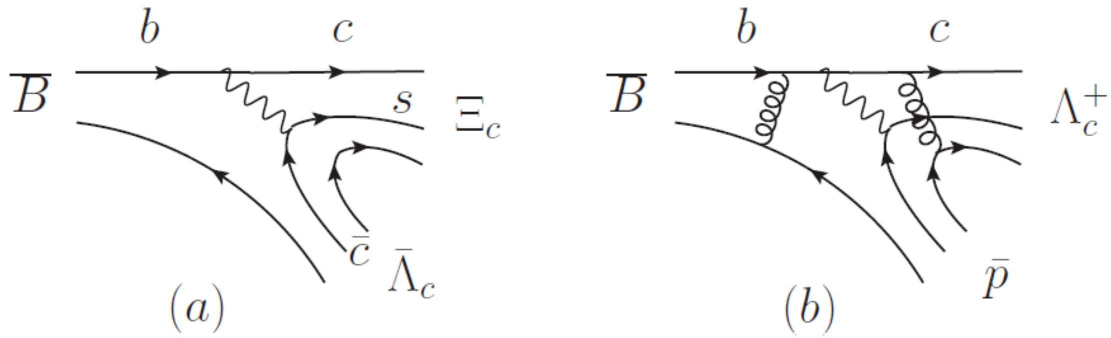
(a) $B^+ \to p\overline{p}K^+$ (Wei, 2008b)

➢ Theoretical progresses since 1990:

- QCD sum rule, Chernyak and Zhitnitsky (1990);
- Pole model, Jarfi et al. (1990) , Cheng and Yang (2002);
- Diquark model, Ball and Dosch (1991), Chang and Hou(2002);
- $3P_0$ model, Cheng et al. , (2006,2009);
- PQCD, He, Li ,Li, and Wang(2006);
- Topological Diagrammatic Approach, Chua (2014,2015,2022);
- Bag model+SU3, Geng, Liu, and Jin (2022);
- $3P0$ model and chiral selection rule , Geng, Liu, and Jin (2023);
- SU(3) flavor symmetry, Hsiao(2023) ;
- Final state interactions, Geng, Liu, Jin, and Yu (2024,2025).

- **Dynamics of B-meson baryonic decays are not well understood.**

$$\mathcal{B}(B^- \to \overline{\Lambda}_c^- \Xi_c^0)(\sim 10^{-3}) \gg \mathcal{B}(\bar{B}^0 \to \bar{p}\Lambda_c^+)(\sim 10^{-5}) \gg \mathcal{B}(\bar{B}^0 \to \bar{p}p)(\sim 10^{-8})$$



Most of the previous theoretical predictions are not trustworthy: for example, predictions based on the QCD sum rule, the pole model and the diquark model are too large compared to experiment. The most reliable predictions are based on pQCD, which has been successfully applied to $B \to \Lambda_c \overline{p}$ (He, Li, Li, and Wang, 2007). The

The Physics of the B Factories, Eur. Phys. J. C (2014) 74:3026

- **The quantitative analyses on the baryonic B decays based on the QCD-inspired approaches are greatly required and urgent.**

- **However, baryonic B decays are more challenging for the calculations based on QCD-inspired approaches**

1) More complex dynamics

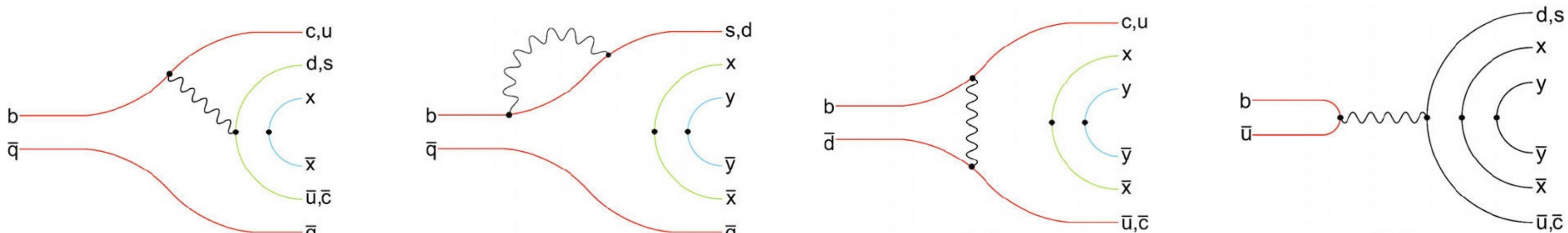
Baryons are made of three quarks, one more quark requires one more gluon.

2) Baryon LCDAs are not well determined

A primary source of theoretical uncertainties.

3) Factorization assumption may not work well

The nonfactorizable internal W-emission is not necessarily color suppressed, while the factorizable W-exchange and W annihilation are expected to be helicity suppressed in baryonic B decays.



(a) (b) (c) (d)

Advantages in PQCD

- **Keeping the parton transverse momenta to avoid the endpoint singularity.**

- **Large logarithmic corrections are organized to all orders by Sudakov resummation.**

- **PQCD successfully predict CPV in $B \to \pi\pi, K\pi$ decays.**
  [Keum, H.n.Li, Sanda, 2000; C.D.Lu, Ukai, M.Z.Yang, 2000]

- **The PQCD approach had been applied to deal with the exclusive heavy baryon decays more than a decade ago:**

  Hsiang-Nan Li, (1993), Sudakov suppression and the proton form factors;
  H.H.Shih, S.C.Lee, Hsiang-Nan Li, (1998), The $\Lambda b \to pl\nu$ decay in PQCD;
  H.H.Shih, S.C.Lee, Hsiang-Nan Li, (1999), Applicability of PQCD to $\Lambda b \to \Lambda c$ decays
  C.H.Chou, H.H.Shih, S.C.Lee, Hsiang-Nan Li, (2002), $\Lambda b \to \Lambda J/\psi$ decay in PQCD;
  P.Guo, H.W.K, Yu-Ming Wang, et.al. (2007), Diquarks and semi-leptonic decay of Λb in the hybrid scheme;
  X. G. He, T. Li, X. Q. Li, and Y. M. Wang,(2006), PQCD calculation for $\Lambda b \to \Lambda\gamma$ in the standard model
  Cai-Dian Lv, Yu-Ming Wang, Hao Zou, (2009), $\Lambda b \to p\pi$, pK decays in PQCD.

- **Over the last three years:**

  $\Lambda_b \to p, ph$ [JJH, YL, HNL, YLS, ZJX, FSY, 2022-2025]

  $\Lambda_b \to \Lambda$ [LY,JJH, QC, FSY, 2025]

  $\Lambda_b \longrightarrow \Lambda_c\pi(K), \Lambda(J/\psi, \phi, \eta, \eta'), \Sigma(\phi, J/\psi), \Xi_b \longrightarrow \Xi_c, \Sigma, \Lambda,$ [ZR,ZZT,YL,2022-2025]

- **These advances will serve as an indicator and guide for forthcoming studies on baryonic decay.**

  - ✓ **Establishing CPV in b-Baryon Decay.** [Han,Yu,Li,LI,Wang,Xiao,Yu,2024, PRL134,221801 (2025)]

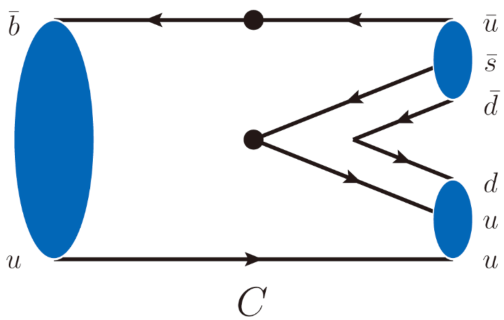
  - ✓ Nonfactorizable diagrams including internal W-emission diagrams provide abundant sources of strong phase required for direct CPV.

  - ✓ Many asymmetries in the angular distribution can be evaluated reliably in PQCD.

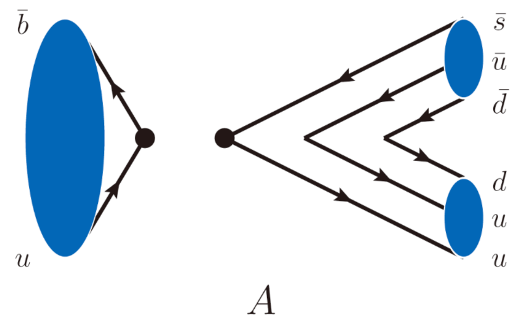
- **PQCD approach is powerful for predicting CPV in baryonic B decays.**

Topological diagrams

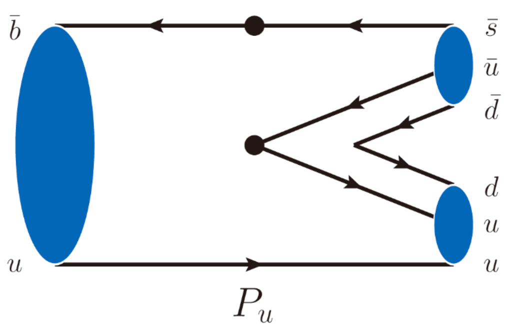
$$B^+ \to p\overline{\Lambda}$$

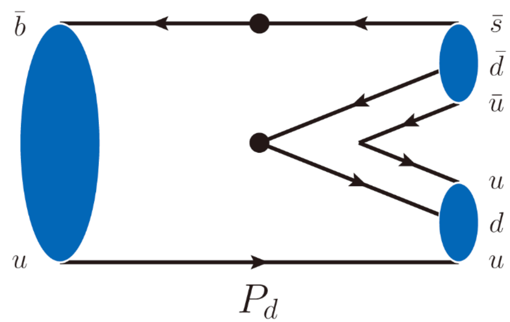


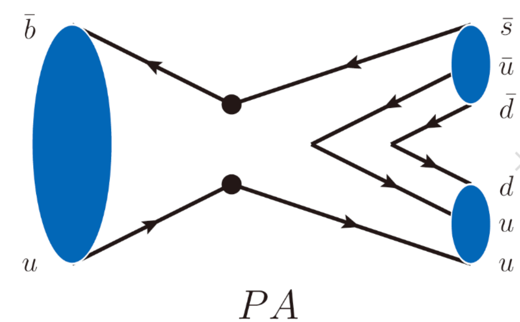
Internal W-emission diagrams (C)



Annihilation diagrams (A)







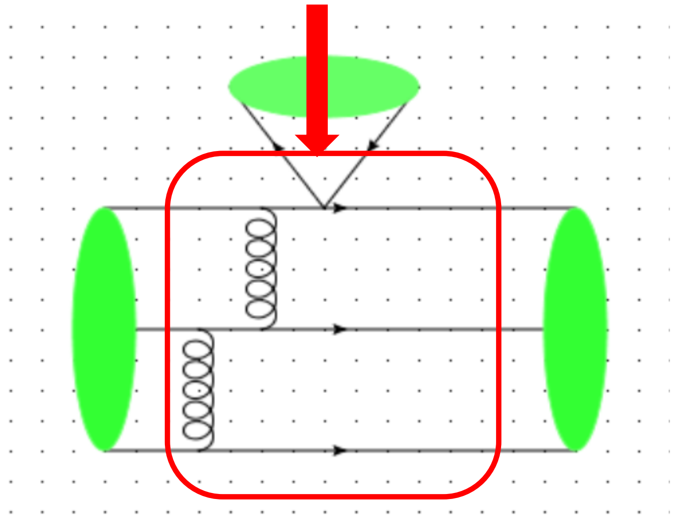
Penguin diagrams (P)

PQCD calculations

➢ The decay amplitudes are factorized into the convolution of hard scattering kernels with the hadronic LCDAs

$B \longrightarrow \mathcal{B}\overline{\mathcal{B}}$

$M \propto \psi_{\mathrm{B}} \otimes H \otimes \psi_{\mathcal{B}} \otimes \psi_{\overline{\mathcal{B}}}$



- The hard amplitude involves eight external on shell quarks, four of which correspond to the four-fermion operators and four of which are the spectator quarks in the final states.
- The hard kernels start at α_s^2 in the PQCD approach.
- Hadronic LCDAs are the necessary inputs in PQCD calculations.

Heavy hadronic LCDA

B-meson LCDAs: [Phys. Rev. D 74 (2006) 014027]

$$\Phi_B = -\frac{i}{\sqrt{2N_c}}(\not{q} + M)\gamma_5 \left(\phi_B^- + \frac{\not{n}_+}{\sqrt{2}}(\phi_B^- - \phi_B^+)\right)$$

$\phi_B = \phi_B^-$ leading, $\bar{\phi}_B = \phi_B^- - \phi_B^+$ subleading

$$\phi_B^-(y, b_q) = N_B y^2(1-y)^2 \exp\left[-\frac{M^2y^2}{2\omega_b^2} - \frac{\omega_b^2 b_q^2}{2}\right]$$

$$\phi_B^+(y, b_q) = N_B \frac{2\omega^4}{M^4} \exp\left(-\frac{1}{2}\omega_b^2 b_q^2\right) \times \left\{\sqrt{\pi}\frac{M}{\sqrt{2}\omega_b}\mathrm{Erf}\left(\frac{M}{\sqrt{2}\omega_b}, \frac{yM}{\sqrt{2}\omega_b}\right) + \left[1 + \left(\frac{M\bar{y}}{\sqrt{2}\omega_b}\right)^2\right]\exp\left[-\left(\frac{yM}{\sqrt{2}\omega_b}\right)^2\right] - \exp\left(-\frac{M^2}{2\omega_b^2}\right)\right\}.$$

In the SM, low-energy effective Hamiltonian is given:

Fermi coupling constant

Local four-quark operators

$$\mathcal{H}_W = \frac{G_F}{\sqrt{2}}\left\{V_{ub}V_{uq}^*[C_1(\mu)O_1^u(\mu) + C_2(\mu)O_2^u(\mu)] - V_{tb}V_{tq}^*\left[\sum_{i=3}^{10} C_i(\mu)O_i(\mu)\right]\right\},$$

CKM matrix elements

Wilson coefficient

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

$$O_3 = (\bar{q}_\alpha b_\alpha)_{V-A}\sum_{q'}(\bar{q}'_\beta q'_\beta)_{V-A}, \qquad O_4 = (\bar{q}_\beta b_\alpha)_{V-A}\sum_{q'}(\bar{q}'_\alpha q'_\beta)_{V-A},$$

$$O_5 = (\bar{q}_\alpha b_\alpha)_{V-A}\sum_{q'}(\bar{q}'_\beta q'_\beta)_{V+A}, \qquad O_6 = (\bar{q}_\beta b_\alpha)_{V-A}\sum_{q'}(\bar{q}'_\alpha q'_\beta)_{V+A},$$

$$O_7 = \frac{3}{2}(\bar{q}_\alpha b_\alpha)_{V-A}\sum_{q'}e_{q'}(\bar{q}'_\beta q'_\beta)_{V+A}, \qquad O_8 = \frac{3}{2}(\bar{q}_\beta b_\alpha)_{V-A}\sum_{q'}e_{q'}(\bar{q}'_\alpha q'_\beta)_{V+A},$$

$$O_9 = \frac{3}{2}(\bar{q}_\alpha b_\alpha)_{V-A}\sum_{q'}e_{q'}(\bar{q}'_\beta q'_\beta)_{V-A}, \qquad O_{10} = \frac{3}{2}(\bar{q}_\beta b_\alpha)_{V-A}\sum_{q'}e_{q'}(\bar{q}'_\alpha q'_\beta)_{V-A},$$

- The strong phases of the penguin amplitudes from O3,4 are close to those of the tree amplitudes;
- The contributions from the (V − A)⊗(V+A) operators O5,6 make the substantial strong phase differences between the penguin and tree amplitudes. PRD112,053007(2025)

LCDA-baryons

$$
\begin{aligned}
(\overline{Y}_P)_{\alpha\beta\gamma}(x_i',\mu) = \frac{-1}{8\sqrt{2}N_c}\Big\{ & S_1 m_p C_{\beta\alpha}(\bar{N}^+\gamma_5)_\gamma + S_2 m_p C_{\beta\alpha}(\bar{N}^-\gamma_5)_\gamma + P_1 m_p (C\gamma_5)_{\beta\alpha}\bar{N}^+_\gamma \\
& + P_2 m_p (C\gamma_5)_{\beta\alpha}\bar{N}^-_\gamma + V_1(C\not{P})_{\beta\alpha}(\bar{N}^+\gamma_5)_\gamma + V_2(C\not{P})_{\beta\alpha}(\bar{N}^-\gamma_5)_\gamma \\
& + V_3\frac{m_p}{2}(C\gamma_\perp)_{\beta\alpha}(\bar{N}^+\gamma_5\gamma^\perp)_\gamma + V_4\frac{m_p}{2}(C\gamma_\perp)_{\beta\alpha}(\bar{N}^-\gamma_5\gamma^\perp)_\gamma + V_5\frac{m_p^2}{2Pz}(C\not{z})_{\beta\alpha}(\bar{N}^+\gamma_5)_\gamma \\
& + V_6\frac{m_p^2}{2Pz}(C\not{z})_{\beta\alpha}(\bar{N}^-\gamma_5)_\gamma + A_1(C\gamma_5\not{P})_{\beta\alpha}(\bar{N}^+)_\gamma + A_2(C\gamma_5\not{P})_{\beta\alpha}(\bar{N}^-)_\gamma \\
& + A_3\frac{m_p}{2}(C\gamma_5\gamma_\perp)_{\beta\alpha}(\bar{N}^+\gamma^\perp)_\gamma + A_4\frac{m_p}{2}(C\gamma_5\gamma_\perp)_{\beta\alpha}(\bar{N}^-\gamma^\perp)_\gamma + A_5\frac{m_p^2}{2Pz}(C\gamma_5\not{z})_{\beta\alpha}(\bar{N}^+)_\gamma \\
& + A_6\frac{m_p^2}{2Pz}(C\gamma_5\not{z})_{\beta\alpha}(\bar{N}^-)_\gamma - T_1(iC\sigma_{\perp P})_{\beta\alpha}(\bar{N}^+\gamma_5\gamma^\perp)_\gamma - T_2(iC\sigma_{\perp P})_{\beta\alpha}(\bar{N}^-\gamma_5\gamma^\perp)_\gamma \\
& - T_3\frac{m_p}{Pz}(iC\sigma_{Pz})_{\beta\alpha}(\bar{N}^+\gamma_5)_\gamma - T_4\frac{m_p}{Pz}(iC\sigma_{zP})_{\beta\alpha}(\bar{N}^-\gamma_5)_\gamma - T_5\frac{m_p^2}{2Pz}(iC\sigma_{\perp z})_{\beta\alpha}(\bar{N}^+\gamma_5\gamma^\perp)_\gamma \\
& - T_6\frac{m_p^2}{2Pz}(iC\sigma_{\perp z})_{\beta\alpha}(\bar{N}^-\gamma_5\gamma^\perp)_\gamma + T_7\frac{m_p}{2}(C\sigma_{\perp\perp'})_{\beta\alpha}(\bar{N}^+\gamma_5\sigma^{\perp\perp'})_\gamma \\
& + T_8\frac{m_p}{2}(C\sigma_{\perp\perp'})_{\beta\alpha}(\bar{N}^-\gamma_5\sigma^{\perp\perp'})_\gamma\Big\}, \qquad (16)
\end{aligned}
$$

After performing the charge conjugation transform, we get the expression for the outgoing antibaryon

$$
\epsilon^{ijk}\langle\bar{\mathcal{B}}|q^i_{1\alpha}(x_1)q^j_{2\beta}(x_2)q^k_{3\gamma}(x_3)|0\rangle = C_{\alpha\alpha'}C_{\beta\beta'}C_{\gamma\gamma'}\epsilon^{ijk}\langle\mathcal{B}|\bar{q}^i_{1\alpha'}(x_1)\bar{q}^j_{2\beta'}(x_2)\bar{q}^k_{3\gamma'}(x_3)|0\rangle.
$$

Kinematics

✓ In the rest frame of B meson in the light-cone coordinates

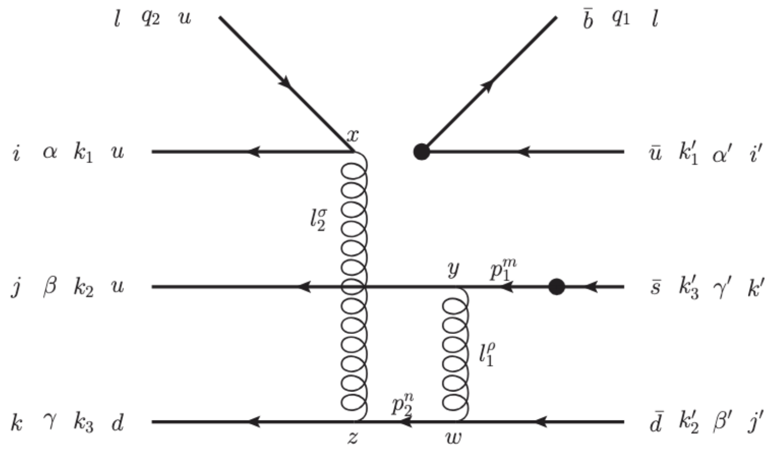


FIG. 1: Feynman diagram C_{a1} for $B \to p\bar{\Lambda}$, where w, x, y, z denotes the coordinate, $k_i^{(\prime)}$ the valence quark momentum, $\alpha^{(\prime)}, \beta^{(\prime)}, \gamma^{(\prime)}$ the spinor index, ρ, σ the Lorentz index, $i^{(\prime)}, j^{(\prime)}, k^{(\prime)}, l, m, n$ the color index, and p_i, l_i the propagator momentum.

$$q = \frac{M}{\sqrt{2}}(1, 1, \mathbf{0}_{\mathrm{T}}), \quad p = \frac{M}{\sqrt{2}}(f^+, f^-, \mathbf{0}_{\mathrm{T}}), \quad p' = \frac{M}{\sqrt{2}}(1-f^+, 1-f^-, \mathbf{0}_{\mathrm{T}}),$$

$$q_1 = \left(\frac{M}{\sqrt{2}}, \frac{M}{\sqrt{2}}y, \mathbf{q}_{\mathrm{T}}\right), \quad q_2 = \left(0, \frac{M}{\sqrt{2}}(1-y), -\mathbf{q}_{\mathrm{T}}\right),$$

$$k_1 = \left(\frac{M}{\sqrt{2}}f^+x_1, 0, \mathbf{k}_{1\mathrm{T}}\right), \quad k_2 = \left(\frac{M}{\sqrt{2}}f^+x_2, 0, \mathbf{k}_{2\mathrm{T}}\right), \quad k_3 = \left(\frac{M}{\sqrt{2}}f^+x_3, 0, \mathbf{k}_{3\mathrm{T}}\right),$$

$$k'_1 = \left(0, \frac{M}{\sqrt{2}}(1-f^-)x'_1, \mathbf{k}'_{1\mathrm{T}}\right), \quad k'_2 = \left(0, \frac{M}{\sqrt{2}}(1-f^-)x'_2, \mathbf{k}'_{2\mathrm{T}}\right), \quad k'_3 = \left(0, \frac{M}{\sqrt{2}}(1-f^-)x'_3, \mathbf{k}'_{3\mathrm{T}}\right).$$

$$f^\pm = \frac{1}{2}\left(1 + r^2 - \bar{r}^2 \pm \sqrt{(1 + r^2 - \bar{r}^2)^2 - 4r^2}\right),$$

Numerical results

$$\mathcal{A} = i\bar{u}_p(p_p)(P + S\gamma_5)v_{\bar{\Lambda}}(p_{\bar{\Lambda}})$$

$$S = \lambda_{\mathcal{T}}|S_{\mathcal{T}}|e^{i\delta^S_{\mathcal{T}}} + \lambda_{\mathcal{P}}|S_{\mathcal{P}}|e^{i\delta^S_{\mathcal{P}}},$$
$$P = \lambda_{\mathcal{T}}|P_{\mathcal{T}}|e^{i\delta^P_{\mathcal{T}}} + \lambda_{\mathcal{P}}|P_{\mathcal{P}}|e^{i\delta^P_{\mathcal{P}}},$$

$$\Gamma = \frac{p_c}{4\pi m_B^2}\left\{M_+^2|S|^2 + M_-^2|P|^2\right\} = \frac{p_c}{8\pi m_B^2}\left(|H_{1/2,1/2}|^2 + |H_{-1/2,-1/2}|^2\right),$$

$$A_{CP}^{dir}(B^+ \to p\bar{\Lambda}) \equiv \frac{\Gamma(B^+ \to p\bar{\Lambda}) - \bar{\Gamma}(B^- \to \bar{p}\Lambda)}{\Gamma(B^+ \to p\bar{\Lambda}) + \bar{\Gamma}(B^- \to \bar{p}\Lambda)}$$

$$A_{CP}^{dir} = \frac{M_+^2(|S|^2 - |\bar{S}|^2) + M_-^2(|P|^2 - |\bar{P}|^2)}{M_+^2(|S|^2 + |\bar{S}|^2) + M_-^2(|P|^2 + |\bar{P}|^2)} = \kappa_S A_{CP}^S + \kappa_P A_{CP}^P$$

$$\alpha = \frac{|H_{1/2,1/2}|^2 - |H_{-1/2,-1/2}|^2}{|H_{1/2,1/2}|^2 + |H_{-1/2,-1/2}|^2}, \quad \beta = \frac{2\mathrm{Im}(H_{1/2,1/2}H^*_{-1/2,-1/2})}{|H_{1/2,1/2}|^2 + |H_{-1/2,-1/2}|^2}, \quad \gamma = \frac{2\mathrm{Re}(H_{1/2,1/2}H^*_{-1/2,-1/2})}{|H_{1/2,1/2}|^2 + |H_{-1/2,-1/2}|^2}.$$

$$A_{CP}^{\alpha} = \frac{\alpha + \bar{\alpha}}{2}, \quad A_{CP}^{\beta} = \frac{\beta + \bar{\beta}}{2}, \quad A_{CP}^{\gamma} = \frac{\gamma - \bar{\gamma}}{2},$$

PQCD predictions of $B \longrightarrow \mathcal{B}_c\mathcal{B}_c$ JHEP12(2024)159

Mode	PQCD	SU(3)	Data
$B^- \to \Xi_c^0\overline{\Lambda_c^-}$	$9.5^{+3.0+2.6+1.7+1.2}_{-2.3-3.5-1.4-1.1}\times10^{-4}$	$7.8^{+2.3}_{-2.0}\times10^{-4}$	$(9.5 \pm 2.3)\times10^{-4}$
$\overline{B^0} \to \Xi_c^+\overline{\Lambda_c^-}$	$8.8^{+2.7+2.6+1.5+1.1}_{-2.1-3.1-1.2-1.0}\times10^{-4}$	$7.2^{+2.1}_{-1.9}\times10^{-4}$	$(12 \pm 8)\times10^{-4}$
$\bar{B}_s^0 \to \Lambda_c^+\overline{\Lambda_c^-}$	$4.0^{+0.7+0.2+0.9+1.0}_{-0.3-0.1-0.7-0.8}\times10^{-5}$	$8.1^{+1.7}_{-1.5}\times10^{-5}$	$(5.0 \pm 1.6)\times10^{-5}$
$\overline{B^0} \to \Lambda_c^+\overline{\Lambda_c^-}$	$8.8^{+4.4+3.5+1.1+1.0}_{-2.8-3.6-0.9-0.6}\times10^{-6}$	$2.1^{+1.0}_{-0.8}\times10^{-5}$	$(1.01 \pm 0.33)\times10^{-5}$

PRL136 (2026) 061802

- The predicted branching fractions of $\bar{B}^0, \bar{B}_s^0 \to \Lambda_c^+\overline{\Lambda_c^-}$ decays match very well with the subsequent experimental measurements conducted by LHCb.

- The observed significant SU(3) breaking effect and the destructive interference between the W-exchange and W-emission contributions are also confirmed by the LHCb measurements.

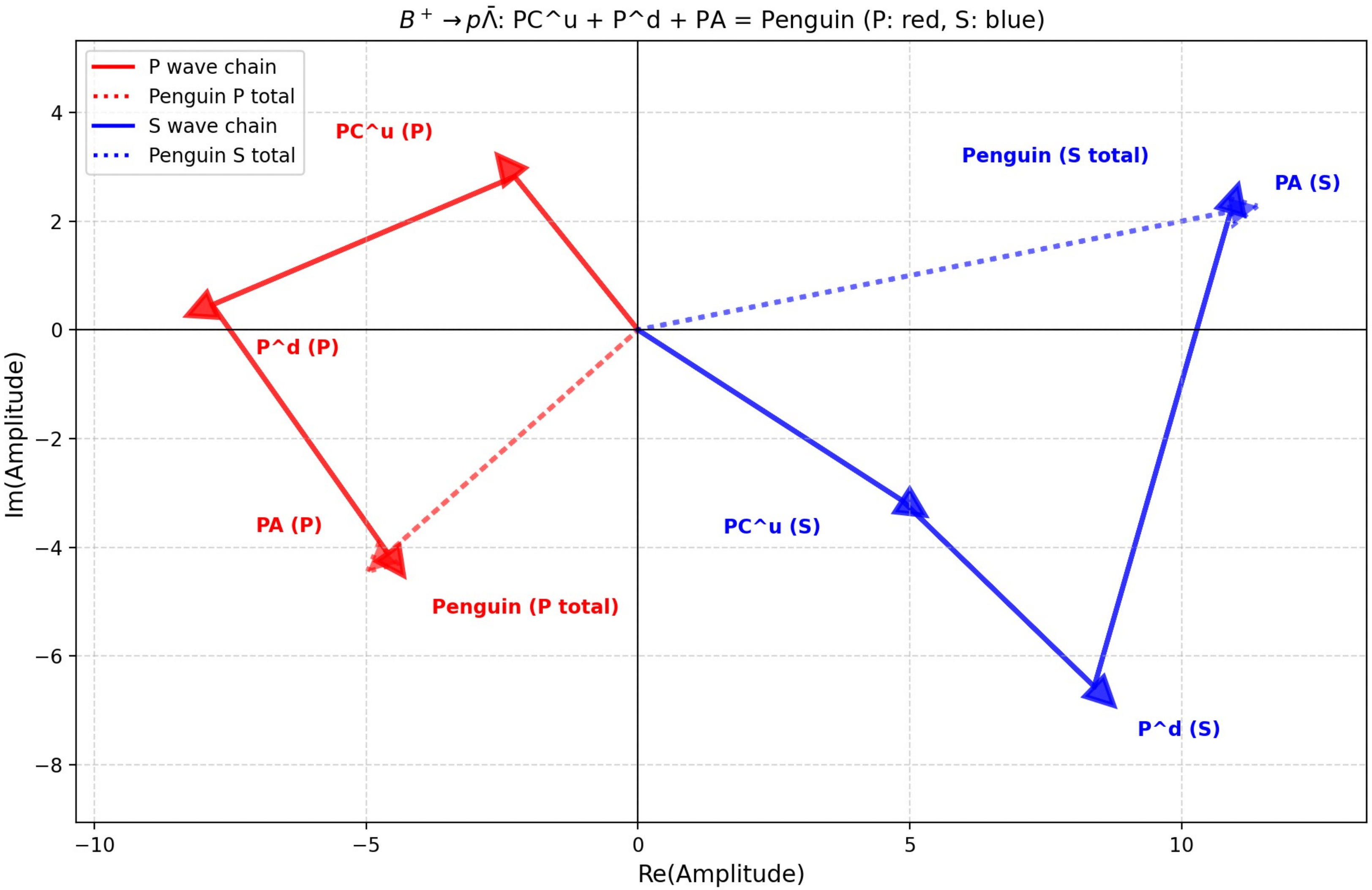
PQCD predictions of $B^+ \to p\bar{\Lambda}$

Results of the topological amplitudes for the $B^+ \to p\bar{\Lambda}$ decays, without the CKM matrix elements.

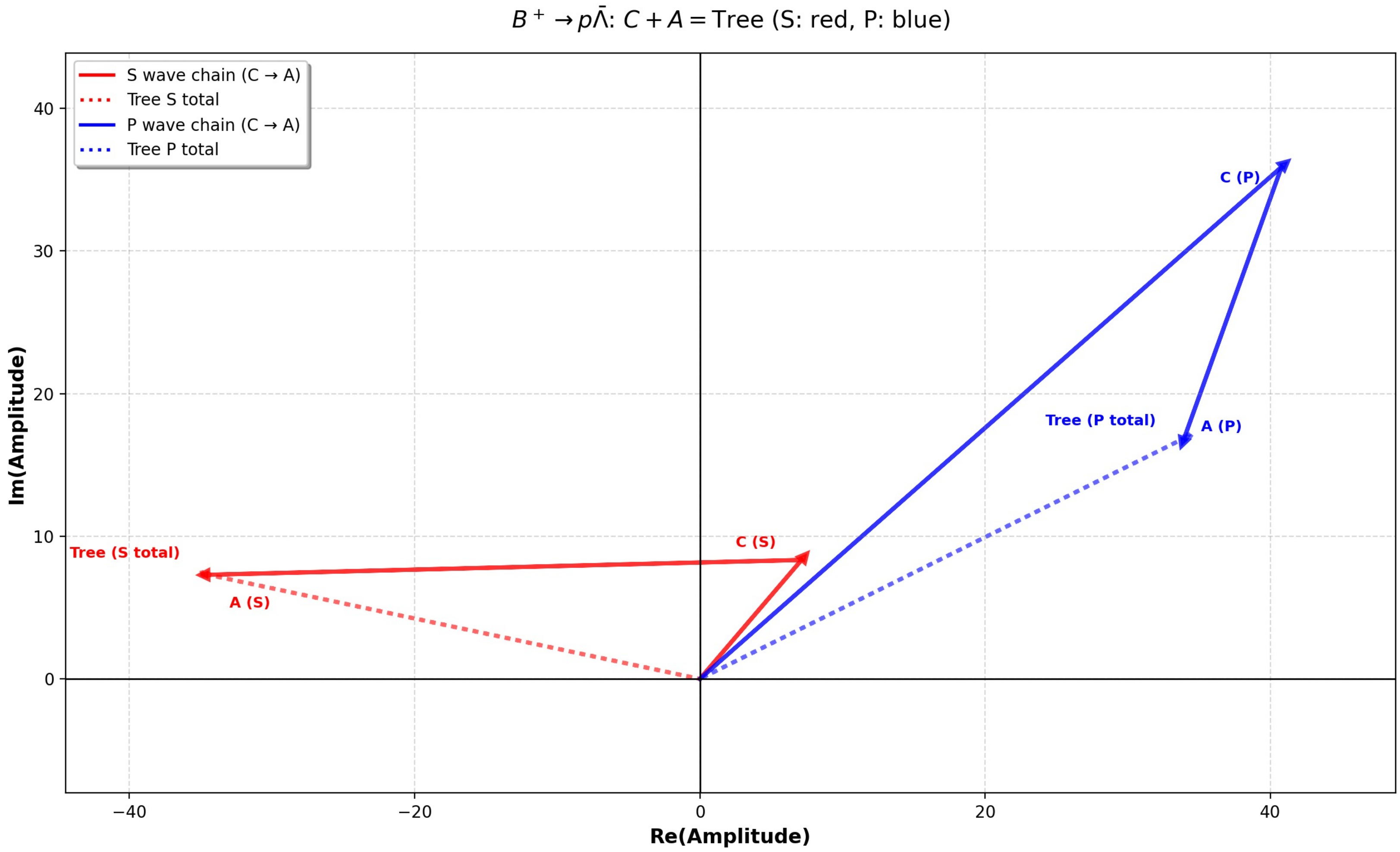
$$\mathcal{A} = i\bar{u}_p(p_p)(P + S\gamma_5)v_{\bar{\Lambda}}(p_{\bar{\Lambda}})$$

Amplitudes	$\|P\|$	$\delta^P(^\circ)$	Re(P)	Im(P)	$\|S\|$	$\delta^S(^\circ)$	Re(S)	Im(S)
C	54.33	41.34	40.79	35.89	10.98	49.45	7.13	8.34
A	20.21	-109.76	-6.83	-19.02	41.61	-178.56	-41.60	-1.04
Tree	37.92	26.42	33.96	16.87	35.23	168.05	-34.46	7.30
PC^u	3.62	128.74	-2.27	2.82	5.79	-32.90	4.86	-3.14
P^d	6.04	-157.01	-5.56	-2.36	4.92	-44.13	3.53	-3.42
PA	5.60	-54.74	3.23	-4.57	9.10	74.00	2.51	8.74
Penguin	6.16	-138.20	-4.59	-4.11	11.11	11.29	10.90	2.18

PQCD predictions of $B^+ \to p\bar{\Lambda}$



PQCD predictions of $B^+ \to p\bar{\Lambda}$



PQCD predictions of $B^+ \to p\bar{\Lambda}$

Penguin-dominant decay mode

with CKM matrix elements

Amplitudes	Re(P)	Im(P)	Re(S)	Im(S)
C	-0.01	0.04	-0.00	0.01
A	0.01	-0.01	-0.01	-0.03
Tree	-0.00	0.03	-0.02	-0.02
PC^u	0.09	-0.11	-0.20	0.13
P^d	0.23	0.10	-0.14	0.14
PA	-0.13	0.19	-0.10	-0.35
Penguin	0.19	0.17	-0.44	-0.09

PQCD=1.358×10^{-7} LHCb=$(1.24 \pm 0.17 \pm 0.05 \pm 0.03)\times10^{-7}$

CPV observables of $B^+ \to p\bar{\Lambda}$ decay

weight coefficients

PQCD

A_{CP}^{dir}	$A_{CP}^{P\text{-wave}}(\kappa_P)$	$A_{CP}^{S\text{-wave}}(\kappa_S)$	α	A_{CP}^{α}	β	A_{CP}^{β}	γ	A_{CP}^{γ}
0.05	0.05(21.56%)	0.04(78.44%)	0.69	-0.019	0.45	0.04	0.56	0.00

Mode	$\phi = 0$	$\phi = \pm\pi/4$	$\phi = \pm\pi/2$
$B^- \to \Lambda\bar{p}$	0 ± 4.8	$\pm(9.6^{+5.9}_{-4.0})$	$\pm(13.2^{+6.5}_{-4.3})$

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channels	$\mathcal{B}_{av}$	A_{dir}%	α_s	β_s	γ_s	α_w	β_w	γ_w	
$B^+ \to p\overline{\Lambda}$	2.31	−3.1	62.7	6.2	−77.3	3.1	−1.5	6.4	positive strong phases
	2.31	4.2	59.7	−8.4	−79.3	−4.2	2.0	−8.7	negative strong phases

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Our results indicate that CPV originating from tree-penguin interference is difficult to be significant in baryonic processes within the Standard Model (SM):

- **the suppressed penguin-to-tree amplitude ratio**
- **cancellations among partial waves**

Summary

- The QCD dynamics of baryonic B decay processes are more complicated than those of mesonic ones and poorly understood theoretically.
- We have made a first step to calculate the two-body charmless baryonic B decays in PQCD.
- Some higher-power corrections arise from the nonperturbative hadronic LCDAs are taken into account in our numerical analysis.
- Branching ratios, CPAs and asymmetry parameters are obtained and compared with other predictions and data.
- PQCD is a powerful tool to analyze the baryonic B decays. The applications of the PQCD formalism extension to other baryonic B decays are in progress. We will focus on the CPV in these decays.

Thank you !