Baryonic B decays

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Introduction

- $m_B > m_{\mathbf{B}} + m_{\bar{\mathbf{B}}'}$ **for $\mathbf{B\bar{B}'}$**

1. $B \to \mathbf{B\bar{B}'}M$

$\mathcal{B}(\bar{B}^0 \to n\bar{p}D^{*+}) \simeq 10^{-3}$ observed in 2001 (CLEO)

$\mathcal{B}(B^- \to p\bar{p}K^-) \simeq 10^{-6}$ observed in 2002 (BELLE)

2. $B \to \mathbf{B\bar{B}'}$, LHCb

$\mathcal{B}(B^- \to \Lambda(1520)\bar{p}) = (3.15 \pm 0.48 \pm 0.27) \times 10^{-7}$ (2014)

$\mathcal{B}(B^- \to \Lambda\bar{p}) = (2.4^{+1.0}_{-0.8} \pm 0.3) \times 10^{-7}$ (2017)

$\mathcal{B}(\bar{B}^0 \to p\bar{p}) = (1.25 \pm 0.27 \pm 0.18) \times 10^{-8}$ (2017)

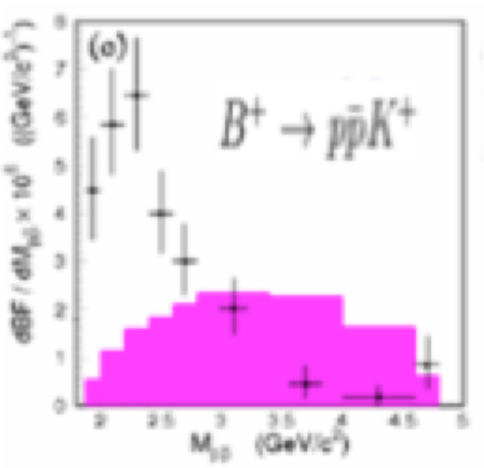
$\mathcal{B}(\bar{B}^0_s \to p\bar{p}) < 1.5 \times 10^{-8}$ (2017)

Introduction

- **The threshold effect in the $m_{\mathbf{B\bar{B}'}}$ spectrum**

Peak near the threshold area of $m_{\mathbf{B\bar{B}'}} \simeq m_{\mathbf{B}} + m_{\mathbf{\bar{B}'}}$

Smallness of $\mathcal{B}(\bar{B}^0_{(s)} \to p\bar{p}, \Lambda\bar{\Lambda},\, B^- \to \Lambda\bar{p})$
Hou and Soni, PRL86, 4247 (2001)



Introduction

3. 1st observation of a baryonic $\bar{B}_s^0$ decay (LHCb, 2017)

$$\mathcal{B}(\bar{B}_s^0 \to \Lambda\bar{p}K^+ + \bar{\Lambda}pK^-)$$
$$= (5.46 \pm 0.61 \pm 0.57 \pm 0.50 \pm 0.32) \times 10^{-6}$$

4. $B_{(s)} \to \mathbf{B}\bar{\mathbf{B}}' M M'$

$\mathcal{B}(B^- \to \Lambda\bar{p}\pi^+\pi^-) = (5.92^{+0.88}_{-0.84} \pm 0.69) \times 10^{-6}$ (BELLE, 2009)

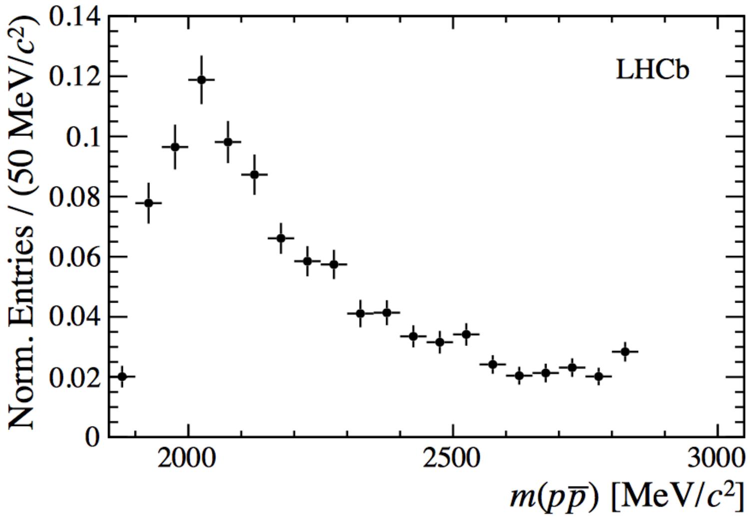
$\mathcal{B}(\bar{B}^0 \to p\bar{p}\pi^+\pi^-) = (3.0 \pm 0.2 \pm 0.2 \pm 0.1) \times 10^{-6}$ (LHCb, 2017)

$\mathcal{B}(\bar{B}^0 \to p\bar{p}K^\mp\pi^\pm) = (6.6 \pm 0.3 \pm 0.3 \pm 0.3) \times 10^{-6}$ (LHCb, 2017)

5. radiative and semileptonic

$B^- \to \Lambda\bar{p}\gamma$ (2005, BELLE)

$B^- \to p\bar{p}\ell^-\bar{\nu}_\ell$ (2014, BELLE)



- Angular distribution asymmetries

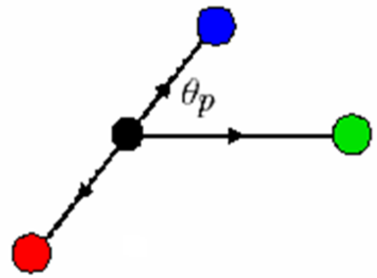
$\mathcal{A}_\theta$ for $B^+ \to p\bar{p}K^+$, $B^+ \to p\bar{p}\pi^+$, $B^0 \to p\bar{\Lambda}\pi^-$

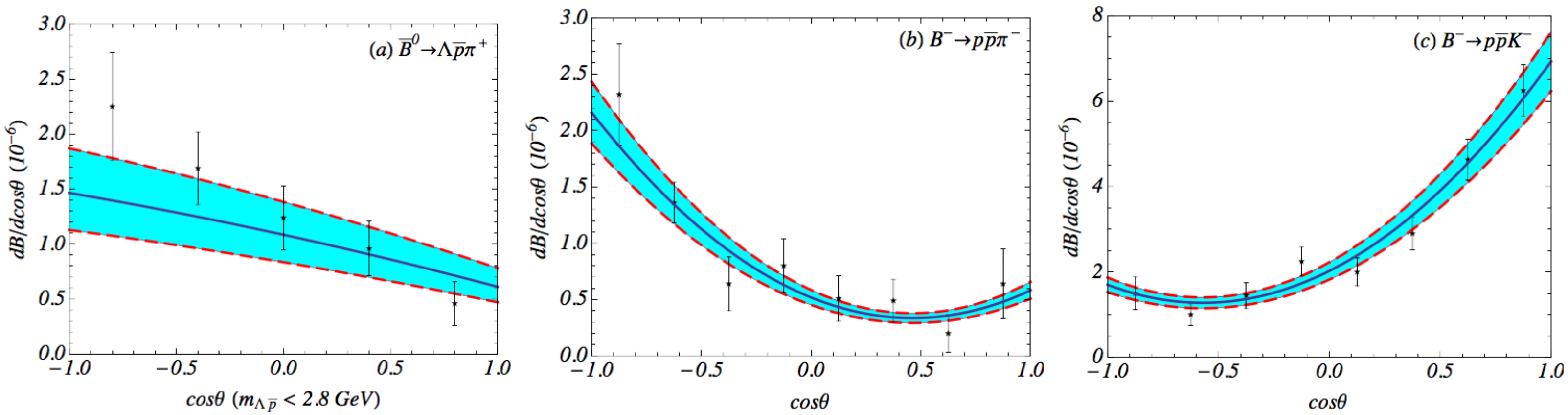
0.45 ± 0.06, -0.47 ± 0.12, -0.41 ± 0.11,

measured by BELLE

large and unexpected.

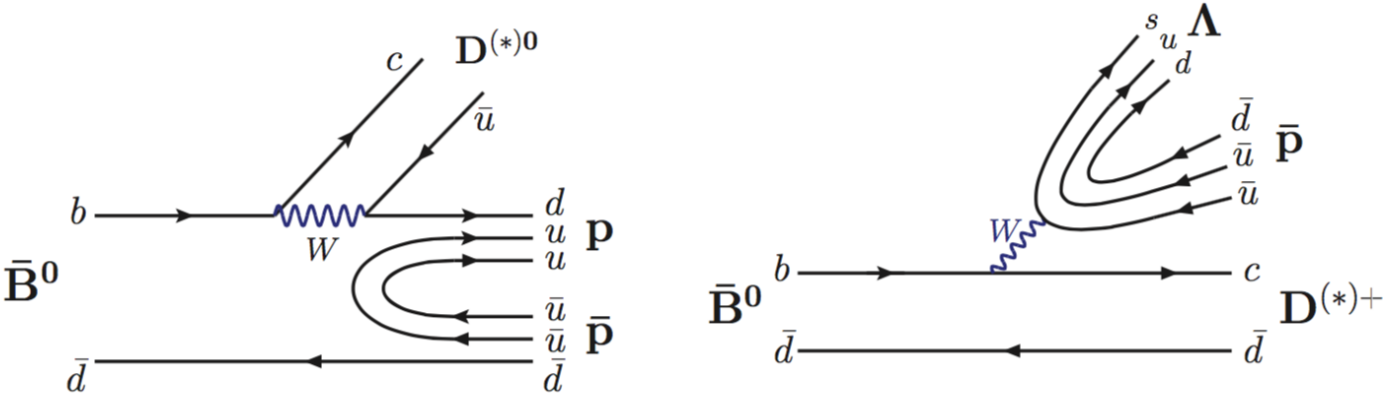
[PRD76, 052004 (2007), PLB659, 80 (2008)]





• Factorization

$$\mathcal{A}_{\mathcal{T}} \propto \langle M|(\bar{q}_1 q_2)|0\rangle\langle \mathbf{B}\bar{\mathbf{B}}'|(\bar{q}_3 b)|\bar{B}\rangle \qquad \mathcal{A}_{\mathcal{C}} \propto \langle \mathbf{B}\bar{\mathbf{B}}'|(\bar{q}_1 q_2)|0\rangle\langle M|(\bar{q}_3 b)|\bar{B}\rangle$$



(a) (b)

Matrix elements of the $\mathbf{B}\bar{\mathbf{B}}'$ formation

$0 \to \mathbf{B}\bar{\mathbf{B}}'$, timelike baryonic form factors

$B \to \mathbf{B}\bar{\mathbf{B}}'$ transition form factors (Chua, Hou, Tsai, 2002)

Extractions of the baryonic form factors

1. Timelike baryonic form factors:

$$\langle \mathbf{B}\bar{\mathbf{B}}'|(\bar{q}q')_V|0\rangle = \bar{u}\left[F_1\gamma_\mu + \frac{F_2}{m_{\mathbf{B}}+m_{\bar{\mathbf{B}}'}}i\sigma_{\mu\nu}q^\nu\right]v$$

$$\langle \mathbf{B}\bar{\mathbf{B}}'|(\bar{q}q')_A|0\rangle = \bar{u}\left[g_A\gamma_\mu + \frac{h_A}{m_{\mathbf{B}}+m_{\bar{\mathbf{B}}'}}q_\mu\right]\gamma_5 v$$

$$\langle \mathbf{B}\bar{\mathbf{B}}'|(\bar{q}q')_S|0\rangle = f_S\bar{u}v$$

$$\langle \mathbf{B}\bar{\mathbf{B}}'|(\bar{q}q')_P|0\rangle = g_P\bar{u}\gamma_5 v$$

$$F_1 = \frac{\bar{C}_{F_1}}{t^2}\,,\ g_A = \frac{\bar{C}_{g_A}}{t^2}\,,\ f_S = \frac{\bar{C}_{f_S}}{t^2}\,,\ g_P = \frac{\bar{C}_{g_P}}{t^2}$$

$\bar{C}_i = C_i[\ln(t/\Lambda_0^2)]^{-\gamma}$ with $\gamma = 2.148$ and $\Lambda_0 = 0.3$ GeV.

$(C_{F_1}, C_{g_A}, C_{f_S}, C_{g_P}) = \sqrt{\frac{3}{2}}(C_{||}, C^*_{||}, -\bar{C}_{||}, -\bar{C}^*_{||})$ (for $\langle\Lambda\bar{p}|(\bar{s}u)_{V,A,S,P}|0\rangle$)

with $C^*_{||(\overline{||})} \equiv C_{||(\overline{||})} + \delta C_{||(\overline{||})}$ and $\bar{C}^*_{||} \equiv \bar{C}_{||} + \delta\bar{C}_{||}$.

$\chi^2/d.o.f \simeq 2.3$ (20 data points)

$(C_{||},\ \delta C_{||}) = (154.4 \pm 12.1,\ 19.3 \pm 21.6)$ GeV^4

$(C_{\overline{||}},\ \delta C_{\overline{||}}) = (18.1 \pm 72.2,\ -477.4 \pm 99.0)$ GeV^4

$(\bar{C}_{||},\ \delta\bar{C}_{||}) = (537.6 \pm 28.7,\ -342.3 \pm 61.4)$ GeV^4

2. $B \to \mathbf{B}\bar{\mathbf{B}}'$ transition form factors:

$$\langle \mathbf{B}\bar{\mathbf{B}}'|(\bar{s}b)_V|B\rangle = i\bar{u}[g_1\gamma_\mu + g_2 i\sigma_{\mu\nu}p^\nu + g_3 p_\mu + g_4 q_\mu + g_5(p_{\bar{\mathbf{B}}'} - p_{\mathbf{B}})_\mu]\gamma_5 v$$

$$\langle \mathbf{B}\bar{\mathbf{B}}'|(\bar{s}b)_A|B\rangle = i\bar{u}[f_1\gamma_\mu + f_2 i\sigma_{\mu\nu}p^\nu + f_3 p_\mu + f_4 q_\mu + f_5(p_{\bar{\mathbf{B}}'} - p_{\mathbf{B}})_\mu]v$$

$$\langle \mathbf{B}\bar{\mathbf{B}}'|(\bar{s}b)_S|B\rangle = i\bar{u}[\bar{g}_1 \not{p} + \bar{g}_2(E_{\bar{\mathbf{B}}_2} + E_{\mathbf{B}_1}) + \bar{g}_3(E_{\bar{\mathbf{B}}_2} - E_{\mathbf{B}_1})]\gamma_5 v$$

$$\langle \mathbf{B}\bar{\mathbf{B}}'|(\bar{s}b)_P|B\rangle = i\bar{u}[\bar{f}_1 \not{p} + \bar{f}_2(E_{\bar{\mathbf{B}}'} + E_{\mathbf{B}}) + \bar{f}_3(E_{\bar{\mathbf{B}}'} - E_{\mathbf{B}})]v$$

$$f_i = \frac{D_{f_i}}{t^3}\,,\ g_i = \frac{D_{g_i}}{t^3}\,,\ \bar{f}_i = \frac{D_{\bar{f}_i}}{t^3}\,,\ \bar{g}_i = \frac{D_{\bar{g}_i}}{t^3}$$

$\langle \Lambda\bar{p}|(\bar{s}b)_{V,A}|B^-\rangle$:

$$D_{g_1} = D_{f_1} = \sqrt{\frac{3}{2}}D_{||}\,,\ D_{g_{4,5}} = -D_{f_{4,5}} = -\sqrt{\frac{3}{2}}D_{||}^{4,5}$$

$\chi^2/d.o.f \simeq 0.8$ (28 data points)

$$D_{||} = (45.7 \pm 33.8)\ \text{GeV}^5\,, (D_{||}^4, D_{||}^5) = (6.5 \pm 18.1, -147.1 \pm 29.3)\ \text{GeV}^4$$

$$(\bar{D}_{||}, \bar{D}_{||}^2, \bar{D}_{||}^3) = (35.2 \pm 4.8, -22.3 \pm 10.2, 504.5 \pm 32.4)\ \text{GeV}^4$$

$$C_{F_1} = \frac{5}{3}C_{||} + \frac{1}{3}C_{\overline{||}}\,,\ C_{g_A} = \frac{5}{3}C^*_{||} - \frac{1}{3}C^*_{\overline{||}}\,,\quad (\text{for } \langle p\bar{p}|\bar{u}\gamma_\mu(\gamma_5)u|0\rangle)$$

$$C_{F_1} = \frac{1}{3}C_{||} + \frac{2}{3}C_{\overline{||}}\,,\ C_{g_A} = \frac{1}{3}C^*_{||} - \frac{2}{3}C^*_{\overline{||}}\,,\quad (\text{for } \langle p\bar{p}|\bar{d}\gamma_\mu(\gamma_5)d|0\rangle)$$

$$C_{f_S} = \frac{1}{3}\bar{C}_{||}\,,\ C_{g_P} = \frac{1}{3}\bar{C}^*_{||}\,,\quad (\text{for } \langle p\bar{p}|\bar{d}(\gamma_5)d|0\rangle)$$

$$C_{F_1} = \sqrt{\frac{3}{2}}C_{||}\,,\ C_{g_A} = \sqrt{\frac{3}{2}}C^*_{||}\,,\quad (\text{for } \langle \Lambda\bar{p}|\bar{s}\gamma_\mu(\gamma_5)u|0\rangle)$$

$$C_{f_S} = -\sqrt{\frac{3}{2}}\bar{C}_{||}\,, C_{g_P} = -\sqrt{\frac{3}{2}}\bar{C}^*_{||}\,,\quad (\text{for } \langle \Lambda\bar{p}|\bar{s}(\gamma_5)u|0\rangle)$$

- Predictions, approved by data.

decay modes	predictions	data
$10^6\mathcal{B}(B^- \to \Lambda\bar{\Lambda}K^-)$	2.8 ± 0.2	$3.38^{+0.41}_{-0.36} \pm 0.41$
$10^6\mathcal{B}(\bar{B}^0 \to \Lambda\bar{\Lambda}\bar{K}^0)$	2.5 ± 0.3	$4.76^{+0.84}_{-0.68} \pm 0.61$
$10^7\mathcal{B}(B^- \to \Lambda\bar{\Lambda}\pi^-)$	1.7 ± 0.7	< 9.4
$10^5\mathcal{B}(B^- \to \Lambda\bar{p}D^0)$	1.14 ± 0.26	$1.43^{+0.28}_{-0.25} \pm 0.18$
$10^5\mathcal{B}(B^- \to \Lambda\bar{p}D^{*0})$	3.23 ± 0.32	$1.53^{+1.12}_{-0.85} \pm 0.47\ (< 4.8)$
$10^5\mathcal{B}(\bar{B}^0 \to \Sigma^0\bar{\Lambda}D^0)$	1.8 ± 0.5	$1.5^{+0.9}_{-0.8}$
$10^6\mathcal{B}(\bar{B}^0 \to \Lambda\bar{p}\phi)$	1.5 ± 0.3	$0.818 \pm 0.215 \pm 0.078$

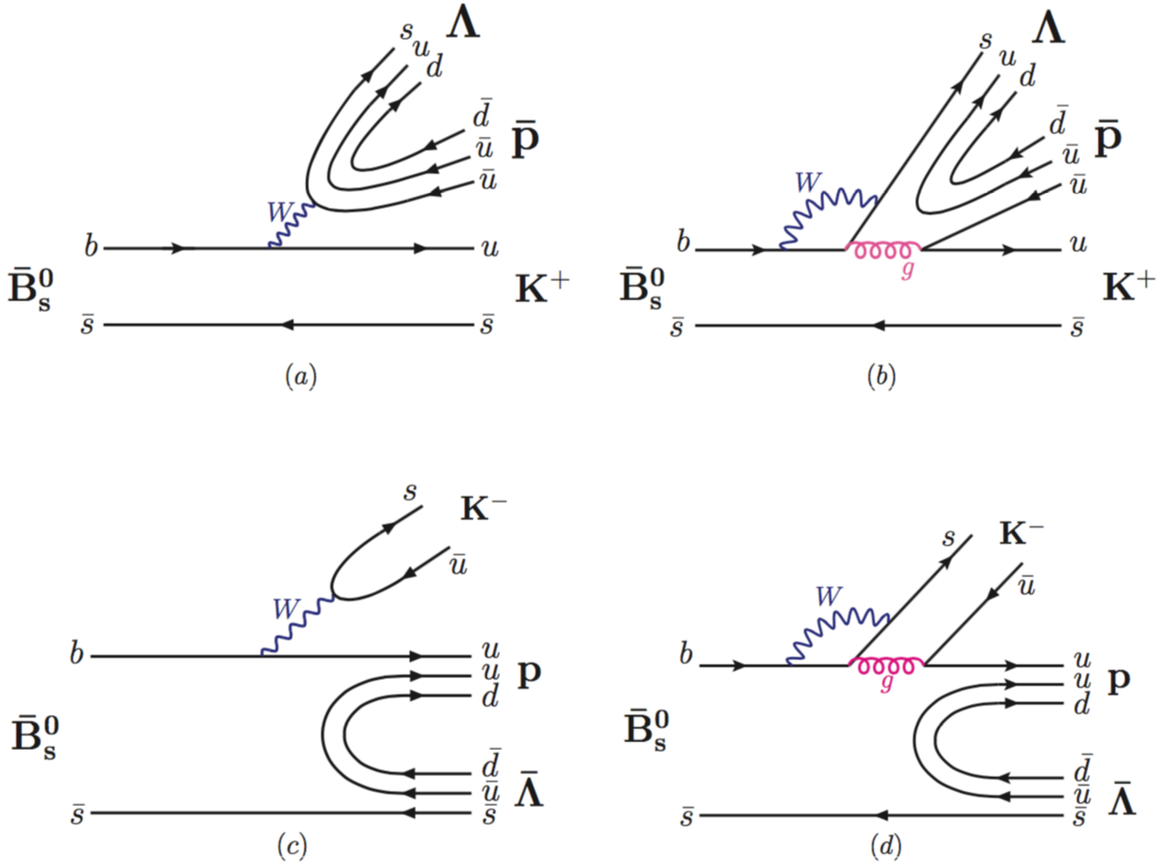
- Baryonic $\bar{B}_s^0$ decay

First observation of a baryonic $\bar{B}_s^0$ decay (LHCb)

$\mathcal{B}(\bar{B}_s^0 \to \Lambda \bar{p} K^+ + \bar{\Lambda} p K^-)$

$= (5.46 \pm 0.61 \pm 0.57 \pm 0.50 \pm 0.32) \times 10^{-6}$

[PRL119, 232001 (2017)]



• our results [PLB767, 205 (2017)]

$$\mathcal{B}(\bar{B}^0_s \to \bar{p}\Lambda K^+) = (3.75 \pm 0.81^{+0.67}_{-0.31} \pm 0.01) \times 10^{-6}$$

$$\mathcal{B}(\bar{B}^0_s \to p\bar{\Lambda} K^-) = (1.31 \pm 0.32^{+0.22}_{-0.10} \pm 0.01) \times 10^{-6}$$

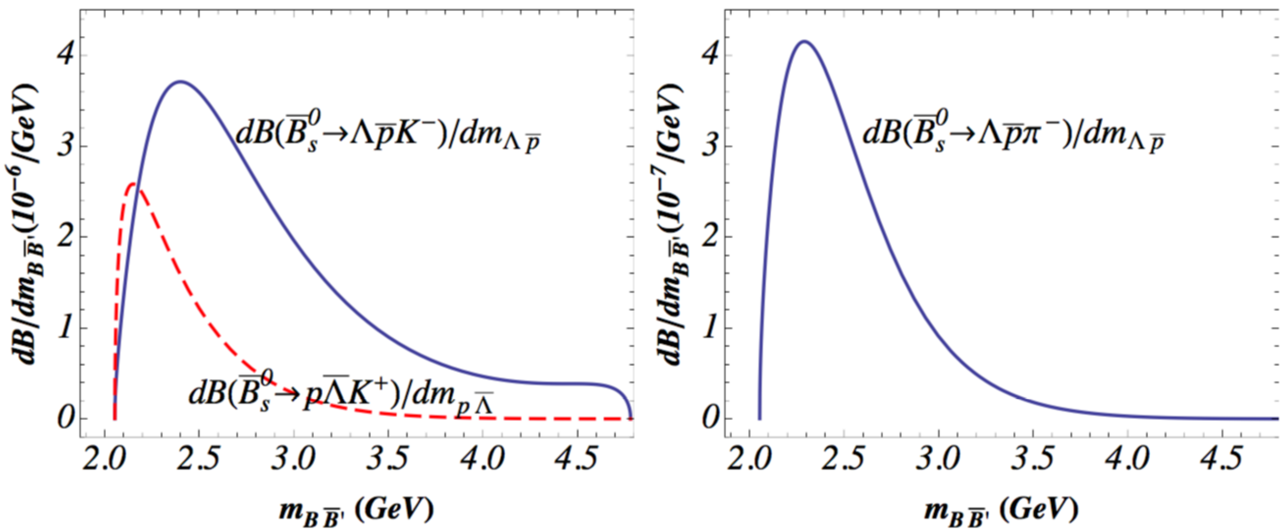
$$\mathcal{B}(\bar{B}^0_s \to p\bar{\Lambda} \pi^-) = (2.79 \pm 1.37^{+0.64}_{-0.30} \pm 0.17) \times 10^{-7}$$

errors: form factors, non-factorizable effects, CKM matrix elements.

$$\mathcal{B}(\bar{B}^0_s \to \bar{p}\Lambda K^+ + p\bar{\Lambda} K^-) = (5.1 \pm 1.1) \times 10^{-6},$$

to agree with the data of

$$(5.46 \pm 0.61 \pm 0.57 \pm 0.50 \pm 0.32) \times 10^{-6}.$$

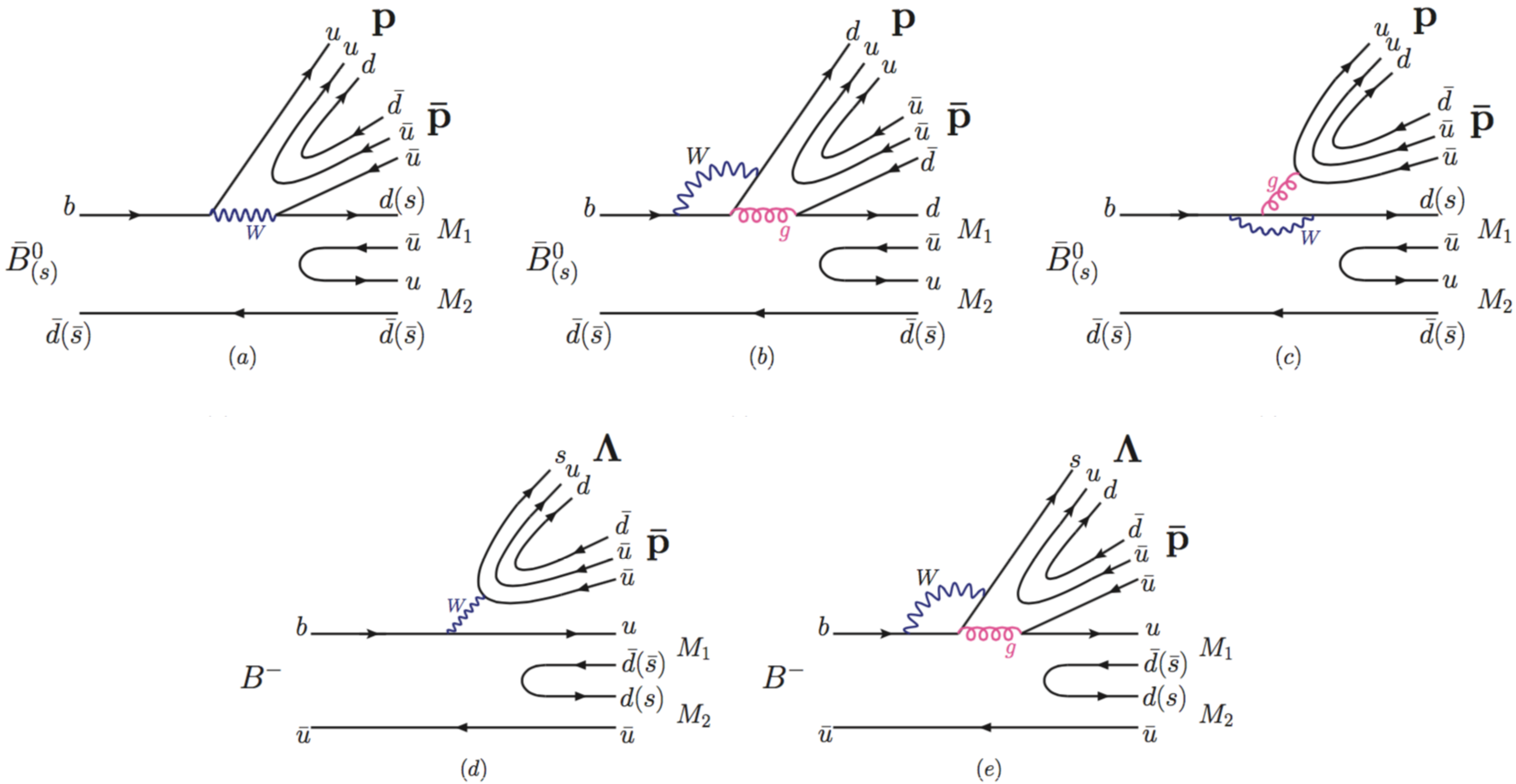


• Four-body Baryonic $B_{(s)}$ decays

$$\mathcal{B}(B^- \to \Lambda\bar{p}\pi^+\pi^-) = (5.92^{+0.88}_{-0.84} \pm 0.69) \times 10^{-6} \text{ (BELLE, 2009)}$$

$$\mathcal{B}(\bar{B}^0 \to p\bar{p}\pi^+\pi^-) = (3.0 \pm 0.2 \pm 0.2 \pm 0.1) \times 10^{-6} \text{ (LHCb, 2017)}$$

$$\mathcal{B}(\bar{B}^0 \to p\bar{p}K^\mp\pi^\pm) = (6.6 \pm 0.3 \pm 0.3 \pm 0.3) \times 10^{-6} \text{ (LHCb, 2017)}$$



• $B \to M_1 M_2$ transition form factors

$\langle M_1 M_2 | \bar{q}_1 \gamma_\mu (1-\gamma_5) b | B \rangle =$

$h \epsilon_{\mu\nu\alpha\beta} p_B^\nu p^\alpha (p_{M_2} - p_{M_1})^\beta + i r q_\mu + i w_+ p_\mu + i w_- (p_{M_2} - p_{M_1})$

$h = \frac{C_h}{t^2}$, $w_- = \frac{D_{w_-}}{t^2}$

Chua, Hou, Shiau and Tsai,

"Evidence for factorization in three-body anti-$B \to D^{(*)} K^- K^0$ decays,"

PRD67, 034012 (2003); EPJC33, S253 (2004).

$(C_h, C_{w_-})|_{B\to\pi\pi} = (3.6 \pm 0.3, 0.7 \pm 0.2)\,\mathrm{GeV}^3$

$(C_h, C_{w_-})|_{B\to KK(K\pi)} = (-38.9 \pm 3.3, 14.2 \pm 2.3)\,\mathrm{GeV}^3$

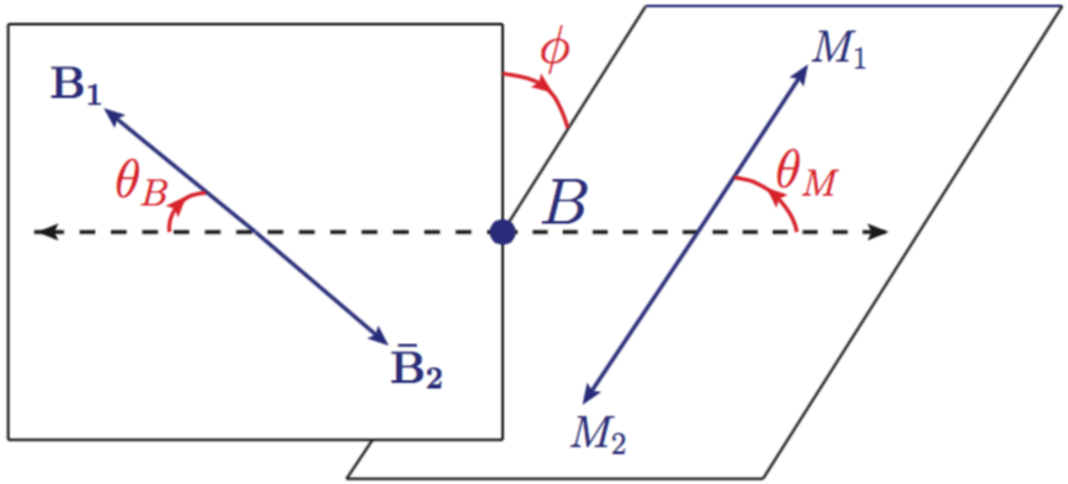
phase space

$$d\Gamma = \frac{|\bar{\mathcal{A}}|^2}{4(4\pi)^6 m_B^3} X \alpha_{\mathbf{B}} \alpha_{\mathbf{M}}\, ds\, dt\, d\cos\theta_{\mathbf{B}}\, d\cos\theta_{\mathbf{M}}\, d\phi$$

$$X = \left[\frac{1}{4}(m_B^2 - s - t)^2 - st\right]^{1/2},$$

$$\alpha_{\mathbf{B}} = \frac{1}{t}\lambda^{1/2}(t, m^2_{\mathbf{B_1}}, m^2_{\bar{\mathbf{B}}_2}),$$

$$\alpha_{\mathbf{M}} = \frac{1}{s}\lambda^{1/2}(s, m^2_{M_1}, m^2_{M_2}),$$

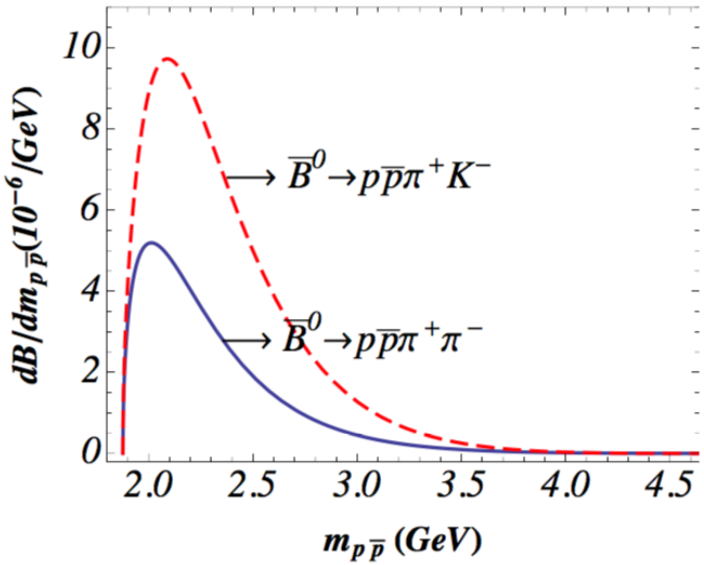


$$\lambda(a, b, c) = a^2 + b^2 + c^2 - 2ab - 2bc - 2ca,$$

$$(m_{M_1} + m_{M_2})^2 \leq s \leq (m_B - \sqrt{t})^2, \quad (m_{\mathbf{B_1}} + m_{\bar{\mathbf{B}}_2})^2 \leq t \leq (m_B - m_{M_1} - m_{M_2})^2,$$

$$0 \leq \theta_{\mathbf{B}}, \theta_{\mathbf{M}} \leq \pi, \quad 0 \leq \phi \leq 2\pi.$$

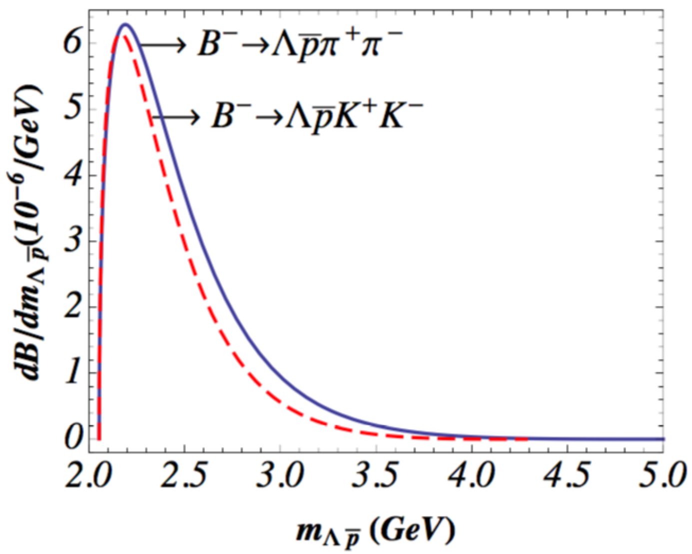
branching ratios	our results	data
$10^6\mathcal{B}(B^- \to \Lambda\bar{p}\pi^+\pi^-)$	$3.7^{+1.2}_{-0.5} \pm 0.1 \pm 0.9$	5.9 ± 1.1
$10^6\mathcal{B}(B^- \to \Lambda\bar{p}K^+K^-)$	$3.0^{+1.1}_{-0.5} \pm 0.1 \pm 0.7$	—
$10^6\mathcal{B}(\bar{B}^0 \to p\bar{p}\pi^+\pi^-)$	$3.0^{+0.5}_{-0.3} \pm 0.3 \pm 0.7$	3.0 ± 0.3
$10^6\mathcal{B}(\bar{B}^0 \to p\bar{p}\pi^\pm K^\mp)$	$6.6 \pm 0.5 \pm 0.0 \pm 2.3$	6.6 ± 0.5



The errors come from the non-factorizable effects, CKM matrix elements, and form factors, respectively.

Phys.Rev. D99 (2019) no.3, 032003

$$\mathcal{B}(B^+ \to p\bar{\Lambda}K^+K^-)$$
$$= (4.22^{+0.45}_{-0.44} \pm 0.51) \times 10^{-6}$$

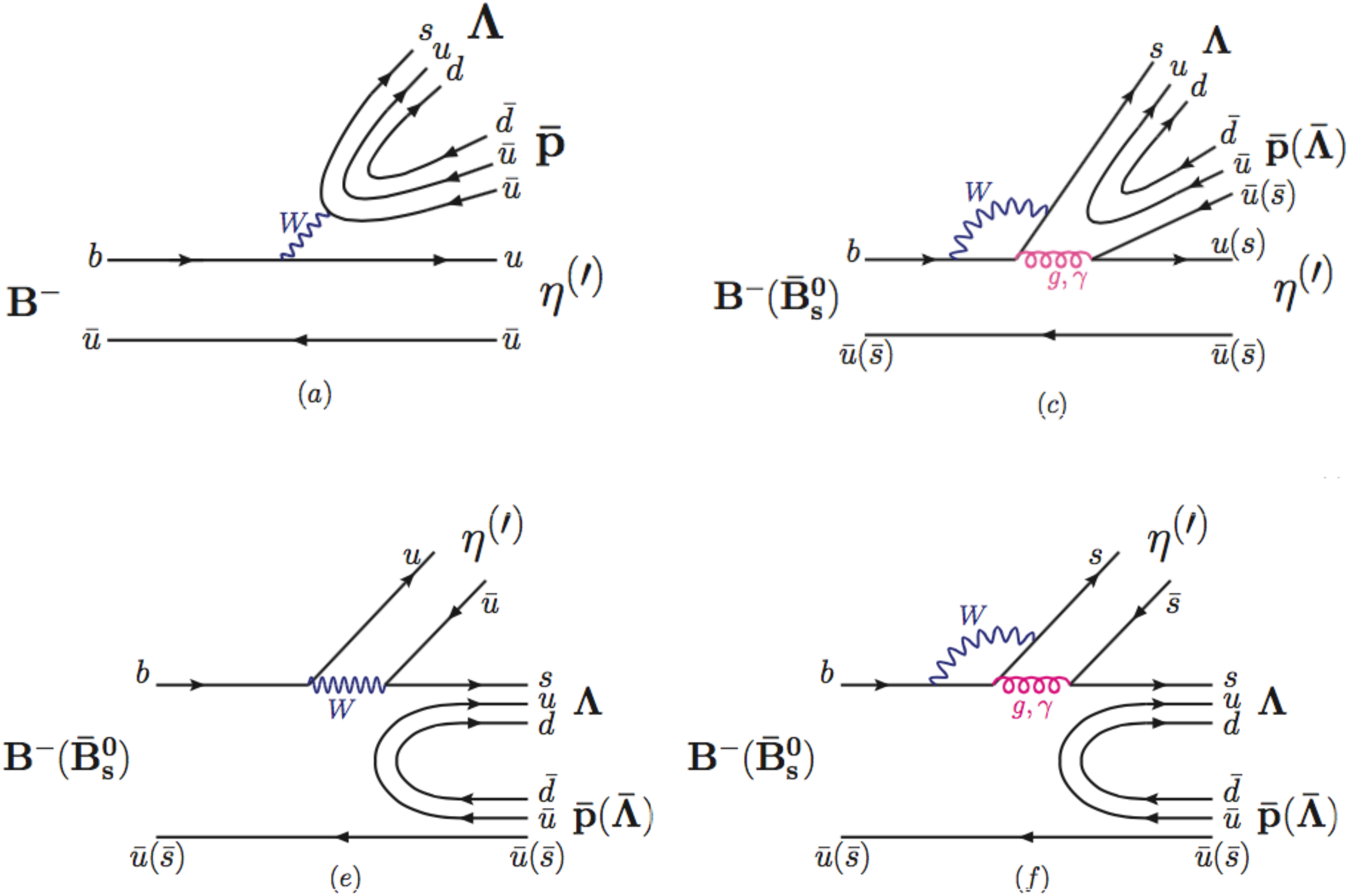


$B^- \to \Lambda\bar{p}\eta^{(\prime)}$ and $\bar{B}^0_s \to \Lambda\bar{\Lambda}\eta^{(\prime)}$

• $b \to sn\bar{n} \to s\eta_n$ $(n = u$ or $d)$ and $b \to s\bar{s}s \to s\eta_s$
$\mathcal{B}(B \to K\eta) \ll \mathcal{B}(B \to K\eta')$
$\mathcal{B}(B \to K^*\eta) \gg \mathcal{B}(B \to K^*\eta')$
large interference effects, η-η' mixing, QCD anomaly

• $B \to \mathbf{B}\bar{\mathbf{B}}'\eta^{(\prime)}$,

Hou, Soni, PRL86, 4247 (2001); Cheng,Yang, PRD66, 014020 (2002).


s u d Λ
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b s u d Λ
W
B⁻(B̄s0)
d̄ ū p̄(Λ̄)
ū(s̄) ū(s̄)
(e)
s s̄ η(′)
W
b s u d Λ
g, γ
B⁻(B̄s0)
d̄ ū p̄(Λ̄)
ū(s̄) ū(s̄)
(f)

$$
\begin{aligned}
\mathcal{A}(B^- \to \Lambda\bar{p}\eta^{(\prime)}) &= \mathcal{A}_1(B^- \to \Lambda\bar{p}\eta^{(\prime)}) + \mathcal{A}_2(B^- \to \Lambda\bar{p}\eta^{(\prime)})\,, \\
\mathcal{A}_1(B^- \to \Lambda\bar{p}\eta^{(\prime)}) &= \frac{G_F}{\sqrt{2}}\Big\{\alpha_1\langle\Lambda\bar{p}|(\bar{s}\gamma_\mu(1-\gamma_5)u|0\rangle\langle\eta^{(\prime)}|\bar{u}\gamma_\mu(1-\gamma_5)b|B^-\rangle \\
&\quad + \alpha_6\langle\Lambda\bar{p}|\bar{s}(1+\gamma_5)u|0\rangle\langle\eta^{(\prime)}|\bar{u}(1-\gamma_5)b|B^-\rangle\Big\}\,,
\end{aligned}
$$

$$
\begin{aligned}
\mathcal{A}_2(B^- \to \Lambda\bar{p}\eta^{(\prime)}) &= \frac{G_F}{\sqrt{2}}\Big\{\Big[\beta_2\langle\eta^{(\prime)}|\bar{n}\gamma_\mu\gamma_5 n|0\rangle + \beta_3\langle\eta^{(\prime)}|\bar{s}\gamma_\mu\gamma_5 s|0\rangle\Big]\langle\Lambda\bar{p}|\bar{s}\gamma_\mu(1-\gamma_5)b|B^-\rangle \\
&\quad + \beta_6\langle\eta^{(\prime)}|\bar{s}\gamma_5 s|0\rangle\langle\Lambda\bar{p}|\bar{s}(1-\gamma_5)b|B^-\rangle\Big\}\,,
\end{aligned}
$$

- η-η' mixing (FKS):

$|\eta_n\rangle = (|u\bar{u} + d\bar{d}\rangle)/\sqrt{2},\ |\eta_s\rangle = |s\bar{s}\rangle$

$$\begin{pmatrix} \eta \\ \eta' \end{pmatrix} = \begin{pmatrix} \cos\phi & -\sin\phi \\ \sin\phi & \cos\phi \end{pmatrix} \begin{pmatrix} \eta_n \\ \eta_s \end{pmatrix}$$

- decay constant:

$$\langle \eta^{(\prime)} | \bar{n}\gamma_\mu\gamma_5 n | 0 \rangle = -\frac{i}{\sqrt{2}} f^n_{\eta^{(\prime)}} q_\mu$$

$$\langle \eta^{(\prime)} | \bar{s}\gamma_\mu\gamma_5 s | 0 \rangle = -i f^s_{\eta^{(\prime)}} q_\mu$$

$$2m_s \langle \eta^{(\prime)} | \bar{s}\gamma_5 s | 0 \rangle = -i h^s_{\eta^{(\prime)}}$$

- QCD anomaly:

$$2m_s \langle \eta^{(\prime)} | \bar{s} i\gamma_5 s | 0 \rangle = \partial^\mu \langle \eta^{(\prime)} | \bar{s}\gamma_\mu\gamma_5 s | 0 \rangle + \langle \eta^{(\prime)} | \frac{\alpha_s}{4\pi} G\tilde{G} | 0 \rangle$$

$$\partial^\mu \langle \eta^{(\prime)} | \bar{s}\gamma_\mu\gamma_5 s | 0 \rangle = f_{\eta^{(\prime)}} m^2_{\eta^{(\prime)}},\ \langle \eta^{(\prime)} | \alpha_s G\tilde{G} | 0 \rangle \equiv 4\pi a_{\eta^{(\prime)}}$$

$$h^s_{\eta^{(\prime)}} = a_{\eta^{(\prime)}} + f^s_{\eta^{(\prime)}} m^2_{\eta^{(\prime)}}$$

• $B \to \eta^{(\prime)}$ transition

$$\langle \eta^{(\prime)} | \bar{q}\gamma^\mu b | B\rangle = \left[(p_B + p_{\eta^{(\prime)}})^\mu - \frac{m_B^2 - m_{\eta^{(\prime)}}^2}{t} q^\mu \right] F_1^{B\eta^{(\prime)}}(t) + \frac{m_B^2 - m_{\eta^{(\prime)}}^2}{t} q^\mu F_0^{B\eta^{(\prime)}}(t)$$

$$F_1^{B\eta^{(\prime)}}(t) = \frac{F_1^{B\eta^{(\prime)}}(0)}{(1-\frac{t}{M_V^2})(1-\frac{\sigma_{11}t}{M_V^2}+\frac{\sigma_{12}t^2}{M_V^4})},\ F_0^{B\eta^{(\prime)}}(t) = \frac{F_0^{B\eta^{(\prime)}}(0)}{1-\frac{\sigma_{01}t}{M_V^2}+\frac{\sigma_{02}t^2}{M_V^4}}$$

$$(F^{B\eta}, F^{B\eta'}) = (F^{B\eta_n}\cos\phi, F^{B\eta_n}\sin\phi),$$

$$(F^{B_s\eta}, F^{B_s\eta'}) = (-F^{B_s\eta_s}\sin\phi, F^{B_s\eta_s}\cos\phi)$$

$$(f_\eta^n, f_{\eta'}^n, f_\eta^s, f_{\eta'}^s) = (0.108,\ 0.089\ , -0.111,\ 0.136)\,\mathrm{GeV}\,,$$

$$(h_\eta^s, h_{\eta'}^s) = (-0.055,\ 0.068)\,\mathrm{GeV}^3\,,$$

$$(F^{B\eta_n}, \sigma_{11}, \sigma_{12}, \sigma_{01}, \sigma_{02}) = (0.33,\ 0.48,\ 0,\ 0.76,\ 0.28)\,,$$

$$(F^{B_s\eta_s}, \sigma_{11}, \sigma_{12}, \sigma_{01}, \sigma_{02}) = (0.36,\ 0.60,\ 0.20,\ 0.80,\ 0.40)\,,$$

$B^- \to \Lambda\bar{p}\eta$:

$$(\mathcal{B}_1, \mathcal{B}_2, \mathcal{B}_{1\cdot 2}) = (2.92, 1.73, 0.65) \times 10^{-6}$$

$B^- \to \Lambda\bar{p}\eta'$:

$$(\mathcal{B}'_1, \mathcal{B}'_2, \mathcal{B}'_{1\cdot 2}) = (1.71, 2.24, -0.61) \times 10^{-6}$$

branching ratios	$\mathcal{B}_+$
$10^6\mathcal{B}(B^- \to \Lambda\bar{p}\eta)$	$5.3 \pm 0.7 \pm 1.2$
$10^6\mathcal{B}(B^- \to \Lambda\bar{p}\eta')$	$3.3 \pm 0.6 \pm 0.4$
$10^6\mathcal{B}(\bar{B}^0_s \to \Lambda\bar{\Lambda}\eta)$	$1.2 \pm 0.2 \pm 0.2$
$10^6\mathcal{B}(\bar{B}^0_s \to \Lambda\bar{\Lambda}\eta')$	$2.6 \pm 0.5 \pm 0.6$

Summary

• In factorization, together with the baryonic form factors, we can study baryonic B decays.

• Particularly, we have explained $\bar{B}_s^0 \to \bar{p}\Lambda K^+ + p\bar{\Lambda}K^-$, $B \to p\bar{p}MM'$, and predicted $B \to \mathbf{B}\bar{\mathbf{B}}'\eta^{(\prime)}$.

Thank You