Charmless two-body baryonic $B_{u,d,s}$ decays revisited

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We study charmless two-body baryonic B decays using the topological amplitude approach. We extend a previous work to include all ground state octet and decuplet final states with full topological amplitudes. Relations on rates and CP asymmetries are obtained. The number of independent topological amplitudes is significantly reduced in the large m_B asymptotic limit. With the long awaited $\bar{B}^0 \to p\bar{p}$ data, we can finally extract information on the topological amplitudes and predict rates of all other modes. The predicted rates are in general with uncertainties of a factor of 2 by including corrections to the asymptotic relations and from subleading contributions. We point out some modes that will cascadely decay to all charged final states and have large decay rates. For example, $\bar{B}^0_s \to \Omega^-\overline{\Omega^-}$, $B^- \to p\overline{\Delta^{++}}$, $B^- \to \Lambda\bar{p}$ and $\bar{B}^0_s \to \Lambda\bar{\Lambda}$ decays are interesting modes to search for. We find that the $\bar{B}^0 \to p\bar{p}$ mode is the most accessible one among octet-antioctet final states in the $\Delta S = 0$ transition. It is not surprise that it is the first $\bar{B}_q \to \mathcal{B}\bar{\mathcal{B}}$ mode being observed. With the detection of π^0 and/or γ many other unsuppressed modes can be searched for. The predicted $\bar{B}^0_s \to p\bar{p}$ rate is several order smaller than the present experimental result. The central value of the experimental result can be reproduced only with unnaturally scaled up "subleading contributions," which will affect other modes including the $\bar{B}^0 \to p\bar{p}$ decay. We need more data to clarify the situation. The analysis presented in this work can be systematically improved when more measurements on decay rates become available.

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I. INTRODUCTION

Recently, following the observation of $B^- \to \Lambda(1520)\bar{p}$ decay [1], LHCb Collaboration found the evidence for the charmless two-body baryonic mode, $\bar{B}^0 \to p\bar{p}$, with [2]

$$\mathcal{B}(\bar{B}^0 \to p\bar{p}) = 1.47^{+0.62+0.35}_{-0.51-0.14} \times 10^{-8}, \tag{1}$$

and also obtained

$$\mathcal{B}(\bar{B}^0_s \to p\bar{p}) = (2.84^{+2.03+0.85}_{-1.68-0.18}) \times 10^{-8}. \tag{2}$$

The present experimental situation for charmless two-body baryonic decay rates is shown in Table I [1–5]. Many three-body baryonic modes have been observed [6], and show threshold enhancement behavior, with the baryon pair moving collinearly, in their spectra. It has been conjectured that the threshold enhancement is the underlying reason of the large three-body rates from the two-body ones [7]. The rates and threshold enhancement can be understood and reproduced theoretically with factorization approach right after the observations of some of the three-body modes [8–15]. For reviews, see [16,17].

On the other hand, progress on the study of two-body modes is slow and on a smaller scale [16,17]. The two-body baryonic decays are in general nonfactorizable, which makes the theoretical study difficult. In general, one has to resort to model calculations. There are pole model [11,18–20], sum rule [21], diquark model [22,23] and flavor symmetry related [24–27] studies. Predictions from various models usually differ a lot, and explicit calculations usually give too large rates on the charmless modes. For example, all existing predictions on $\bar{B}^0 \to p\bar{p}$ rate are off by several order of magnitude comparing to the LHCb result [2,16,17].

Given that direct computation is not reliable at this moment, it is thus useful to use symmetry related approach to relate modes and make use of the newly measured $B \to p\bar{p}$ rate to give information on other modes. In [9], we use the quark diagram or the so-called topological approach, which was proposed in and has been used extensively in mesonic modes [28–32] (for a recent review, see [16]), to the charmless two-body baryonic decays and obtained predictions on relative rates. In fact, the same approach was also applied to charmful baryonic $\bar{B}^0 \to \Lambda_c^+\bar{p}$

TABLE I. Current experimental status of rates of two-body baryonic modes. Upper limits are at 90% C.L.

Mode	$\mathcal{B}(10^{-8})$	Reference
$B^- \to \Lambda\bar{\Lambda}$	< 32	[3]
$B^- \to \Lambda\bar{p}$	< 32	[3]
$B^- \to \Lambda\overline{\Delta^+}$	< 82	[4]
$B^- \to \Delta^0\bar{p}$	< 138	[5]
$B^- \to p\overline{\Delta^{++}}$	< 14	[5]
$\bar{B}^0 \to p\bar{p}$	$1.47^{+0.62+0.35}_{-0.51-0.14}$	[2]
$\bar{B}^0 \to \Lambda\overline{\Delta^0}$	< 93	[4]
$\bar{B}^0_s \to p\bar{p}$	$2.84^{+2.03+0.85}_{-1.68-0.18}$	[2]

decay [27]. Note that the quark diagram approach is closely related to the SU(3) flavor symmetry [28,31,33]. It is important to stress that the topological approach does not rely on any factorization assumption and, hence, is applicable to the study of nonfactorizable decay modes, such as charmless two-body baryonic modes that we are interested to in this study. With the evidence on the $\bar{B}^0 \to p\bar{p}$ mode, it is timely to revisit the subject. In this work we will extend the previous work to include all topological amplitudes, where only dominant ones were considered previously [9]. We can now make use of the newly observed $\bar{B}^0 \to p\bar{p}$ rate to extract information on decay amplitudes and proceed to provide predictions on rates of all other charmless two-body baryonic modes of ground state octet and decuplet baryons.

As a first step towards numerical study, we use asymptotic relations in the large m_B limit [34] to relate various topological amplitudes [9]. The number of independent amplitudes are significantly reduced. It should be noted that the same technics has been used in the study of the three-body case [11,13,14]. It leads to encouraging results. For example, the experiment finding of $\mathcal{B}(\Lambda\bar{p}\pi^-) > \mathcal{B}(\Sigma^0\bar{p}\pi^-)$ [35] can be understood [14] and three-body decay spectra are consistent with the QCD counting rule [36] expectations. Due to the large energy release, we expect the asymptotic relations to work even better in the two-body case than in the three-body case. The smallness of two-body decay rates may be due to some $1/m_B^2$ suppression as expected from QCD counting rules. We will extract the asymptotic amplitude from the $\bar{B}^0 \to p\bar{p}$ data.

We then try to relax the asymptotic relations and estimate uncertainties on rates. As we shall see, with the present situation, rates can only be predicted or estimated at best within a factor of 2 following the above procedure. However, even order of magnitude estimation on rates is useful, as it can single out several prominent modes that our experimental colleagues may be interested to search for. Furthermore, the results can be systematically improved when the measurements of other modes become available in the future.

The layout of this paper is as following. In Sec. II, we give our formulation for baryonic decays modes, including all ground state decuplet-decuplet, octet-decuplet and octet-octet final states. Full topological amplitudes are given for these charmless two-body baryonic modes. Asymptotic relations are provided at the end of the section. In Sec. III, we discuss the phenomenology of the charmless two-body baryonic decays. Relations on rates and A_{CP} using the full topological amplitudes are obtained. We give predictions on all charmless two-body baryonic modes with the input from the $\bar{B}^0 \to p\bar{p}$ data. Some suggestion on the experimental searching are put forward. In Sec. IV we give the conclusion followed by three appendices on a brief derivation of the asymptotic relations, the decomposition of amplitudes into independent amplitudes and a collection of baryon decay rates.

II. FORMALISM

In this section, we first develop the formalism of topological amplitudes of charmless two-body baryonic $B_{u,d,s}$ decays. The full amplitudes of all ground state octet ($\mathcal{B}$) and decuplet ($\mathcal{D}$) baryon final states are given using the formulas. Simplification can be obtained in the large m_B limit and the asymptotic forms of the amplitudes will be shown before we end this section.

A. Effective Hamiltonian for topological decay amplitudes of charmless two-body baryonic B decays

The effective weak Hamiltonian for charmless B decays is [37]

$$H_{\rm eff} = \frac{G_f}{\sqrt{2}}\left\{\sum_{r=u,c} V_{qb}V_{uq}^*[c_1 O_1^r + c_2 O_2^r] - V_{tb}V_{tq}^*\sum_{i=3}^{10} c_i O_i\right\} + \text{H.c.}, \tag{3}$$

where $q = d$, s, and

$$\begin{aligned}
O_1^r &= (\bar{r}b)_{V-A}(\bar{q}r)_{V-A},\\
O_2^r &= (\bar{r}_\alpha b_\beta)_{V-A}(\bar{q}_\beta r_\alpha)_{V-A},\\
O_{3(5)} &= (\bar{q}b)_{V-A}\sum_{q'}(\bar{q}'q')_{V\mp A},\\
O_{4(6)} &= (\bar{q}_\alpha b_\beta)_{V-A}\sum_{q'}(\bar{q}'_\beta q'_\alpha)_{V\mp A},\\
O_{7(9)} &= \frac{3}{2}(\bar{q}b)_{V-A}\sum_{q'} e_{q'}(\bar{q}'q')_{V\pm A},\\
O_{8(10)} &= \frac{3}{2}(\bar{q}_\alpha b_\beta)_{V-A}\sum_{q'} e_{q'}(\bar{q}'_\beta q'_\alpha)_{V\pm A},
\end{aligned} \tag{4}$$

with $O_{3\text{–}6}$ the QCD penguin operators, $O_{7\text{–}10}$ the electroweak penguin operators, and $(\bar{q}'q)_{V\pm A} \equiv \bar{q}'\gamma_\mu(1+\pm\gamma_5)q$. The next-to-leading order Wilson coefficients,

$$\begin{aligned}
&c_1 = 1.081, \quad c_2 = -0.190, \quad c_3 = 0.014,\\
&c_4 = -0.036, \quad c_5 = 0.009, \quad c_6 = -0.042,\\
&c_7 = -0.011\alpha_{EM}, \quad c_8 = 0.060\alpha_{EM},\\
&c_9 = -1.254\alpha_{EM}, \quad c_{10} = 0.223\alpha_{EM},
\end{aligned} \tag{5}$$

are evaluated in the naive dimensional regularization scheme at scale $\mu = 4.2$ GeV [38].

We will concentrate on the flavor structure of the effective Hamiltonian first. We follow the approach of [9]. As shown in Fig. 1, we have tree (T), penguin (P), electroweak penguin(P_{EW}), W-exchange (E), annihilation (A) and penguin annihilation (PA) amplitudes. It is straightforward to

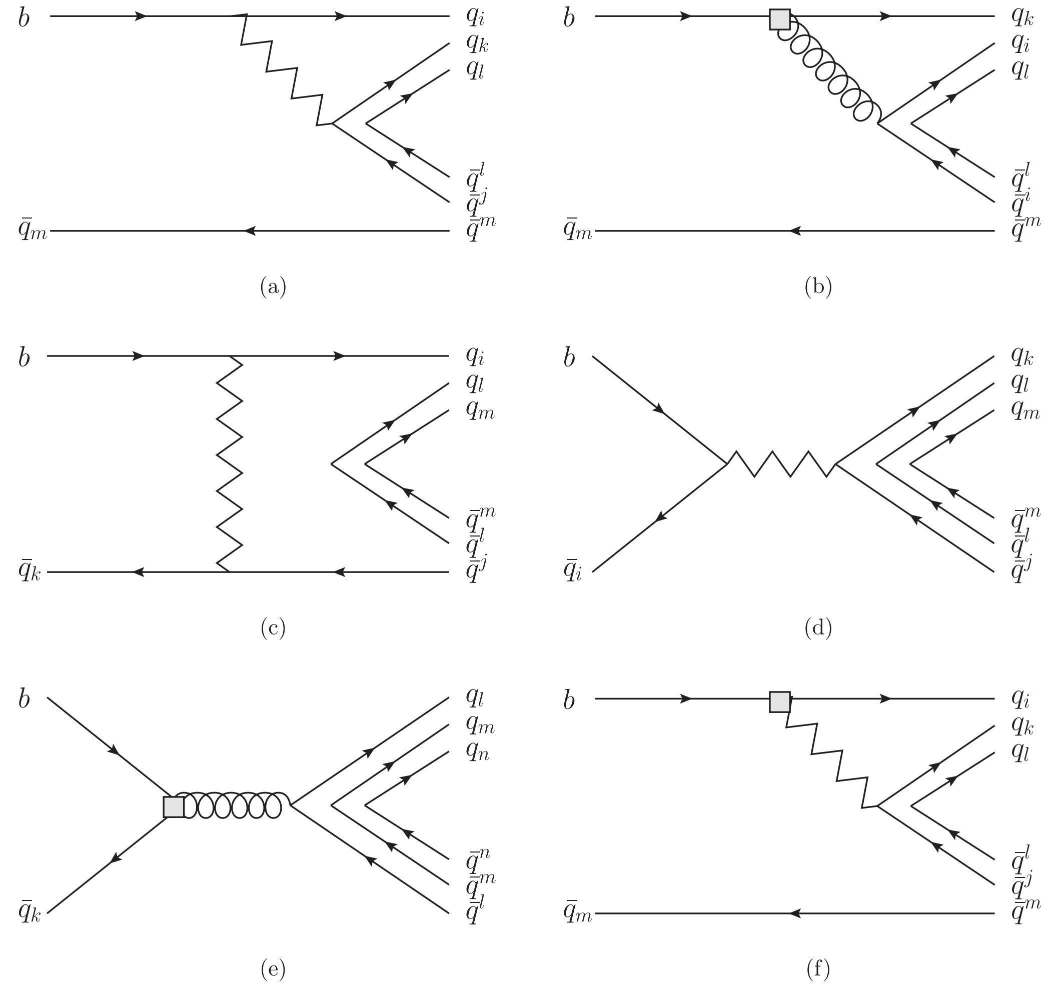

FIG. 1. Pictorial representation of (a) T (tree), (b) P (penguin), (c) E (W-exchange), (d) A (annihilation), (e) PA (penguin annihilation) and (f) P_{EW} (electroweak penguin) amplitudes in $\bar{B}$ to baryon pair decays. These are flavor flow diagrams. We use subscript and superscript according to the field convention. For example, we assign a subscript (superscript) to the initial (final) state antiquark $\bar{q}_m$ ($\bar{q}^m$).

obtain the coefficients of these topological amplitudes. We recall that for the $b \to u\bar{u}d$ and $b \to q\bar{q}d$ processes, the tree ($\mathcal{O}_T = O_{1,2}$), penguin ($\mathcal{O}_P = O_{3\text{–}6}$) and electroweak penguin ($\mathcal{O}_{EWP} = O_{7\text{–}10}$) operators have the following flavor quantum numbers [see Eqs. (3) and (4)]:

$$
\begin{aligned}
\mathcal{O}_T &\sim (\bar{u}b)(\bar{d}u) = H^{ik}_j(\bar{q}_i b)(\bar{q}_k q^j),\\
\mathcal{O}_P &\sim (\bar{d}b)(\bar{q}_i q^i) = H^k(\bar{q}_k b)(\bar{q}_i q^i),\\
\mathcal{O}_{EWP} &\sim Q_j(\bar{d}b)(\bar{q}_j q^j) = H_{EW}{}^{ik}_j(\bar{q}_i b)(\bar{q}_k q^j),\\
H^{12}_1 &= 1 = H^2, \qquad H_{EW}{}^{2k}_j = Q_j \delta^k_j \quad \text{otherwise}\\
H^{ik}_j &= H_{EW}{}^{ik}_j = H^k = 0, \qquad (6)
\end{aligned}
$$

respectively.[1] Note that the above equations also apply to the $|\Delta S| = 1$ case, with d, $H^{12}_1 = 1 = H^2$ and $H_{EW}{}^{2k}_j = Q_j\delta^k_j$ replaced by s, $H^{13}_1 = 1 = H^3$ and $H_{EW}{}^{3k}_j = Q_j\delta^k_j$, respectively.

We are now ready to proceed to $\bar{B}$ to decuplet-antidecuplet decays. A decuplet with $q_k q_i q_l$ flavor as shown in Fig. 1 is produced by a $\bar{\mathcal{D}}_{kil}$ field, while a decuplet with $\bar{q}^l\bar{q}^j\bar{q}^m$ flavor is created by a $\mathcal{D}^{ljm}$ field, where $\mathcal{D}^{ljm}$ is the familiar decuplet field with $\mathcal{D}^{111} = \Delta^{++}$, $\mathcal{D}^{112} = \Delta^+/\sqrt{3}$, $\mathcal{D}^{122} = \Delta^0/\sqrt{3}$, $\mathcal{D}^{222} = \Delta^-$, $\mathcal{D}^{113} = \Sigma^{*-}/\sqrt{3}$, $\mathcal{D}^{123} = \Sigma^{*0}/\sqrt{6}$, $\mathcal{D}^{223} = \Sigma^{*-}/\sqrt{3}$, $\mathcal{D}^{133} = \Xi^{*0}/\sqrt{3}$, $\mathcal{D}^{233} = \Xi^{*-}/\sqrt{3}$ and $\mathcal{D}^{333} = \Omega^-$ (see, for example 39]]). Hence by using the correspondent rule, we have

$$
\begin{aligned}
H_{\rm eff} = {}& 6T_{\mathcal{D}\bar{\mathcal{D}}}\bar{B}_m H^{ik}_j \bar{\mathcal{D}}_{ikl}\mathcal{D}^{ljm} + 2P_{\mathcal{D}\bar{\mathcal{D}}}\bar{B}_m H^k \bar{\mathcal{D}}_{kil}\mathcal{D}^{lim}\\
&+ 6E_{\mathcal{D}\bar{\mathcal{D}}}\bar{B}_k H^{ik}_j \bar{\mathcal{D}}_{ilm}\mathcal{D}^{mlj}\\
&+ 6A_{\mathcal{D}\bar{\mathcal{D}}}\bar{B}_i H^{ik}_j \bar{\mathcal{D}}_{klm}\mathcal{D}^{mlj}\\
&+ 6PA_{\mathcal{D}\bar{\mathcal{D}}}\bar{B}_k H^k \bar{\mathcal{D}}_{lmn}\mathcal{D}^{nml}\\
&+ 6P_{EW\mathcal{D}\bar{\mathcal{D}}}\bar{B}_m H_{EW}{}^{ik}_j \bar{\mathcal{D}}_{ikl}\mathcal{D}^{ljm}, \qquad (7)
\end{aligned}
$$

[1]Note that $H^{ik}_i (= H^k)$ does not lead to any additional term.

with $\bar B_m = (B^-, \bar B^0, \bar B^0_s)$. Without loss of generality, the prefactors before the above terms are assigned for latter purpose.

For $\bar B$ to octet-antidecuplet baryonic decays, the antidecuplet part is as before, while for the octet part, we have [39]

$$\mathcal{B} = \begin{pmatrix} \frac{\Sigma^0}{\sqrt{2}} + \frac{\Lambda}{\sqrt{6}} & \Sigma^+ & p \\ \Sigma^- & -\frac{\Sigma^0}{\sqrt{2}} + \frac{\Lambda}{\sqrt{6}} & n \\ \Xi^- & \Xi^0 & -\sqrt{\frac{2}{3}}\Lambda \end{pmatrix}, \tag{8}$$

and note that the $\mathcal{B}^j_k$ has the flavor structure $q^j q^a q^b \epsilon_{abk} - \frac{1}{3}\delta^j_k q^c q^a q^b \epsilon_{abc}$ [39]. To match the flavor of $q_i q_k q_l$, $\bar q^l \bar q^j \bar q^m$ final states as shown in Fig. 1, we use

$$q_i q_k q_l \to \epsilon_{ika}\bar{\mathcal{B}}^a_l, \qquad \epsilon_{ial}\bar{\mathcal{B}}^a_k, \qquad (\epsilon_{akl}\bar{\mathcal{B}}^a_i),$$
$$\bar q^l \bar q^j \bar q^m \to \epsilon^{ljb}\mathcal{B}^m_b, \qquad \epsilon^{lbm}\mathcal{B}^j_b, \qquad (\epsilon^{bjm}\mathcal{B}^l_b), \tag{9}$$

as corresponding rules in obtaining $H_{\rm eff}$. Since not all terms shown in the above equation are independent, $\epsilon_{ika}\bar{\mathcal{B}}^a_l + \epsilon_{ial}\bar{\mathcal{B}}^a_k + \epsilon_{akl}\bar{\mathcal{B}}^a_i = 0 = \epsilon^{ljb}\mathcal{B}^m_b + \epsilon^{lbm}\bar{\mathcal{B}}^j_b + \epsilon^{bjm}\bar{\mathcal{B}}^l_b$, for each of the $q_k q_j q_l$ and $\bar q^l \bar q^j \bar q^m$ configurations we only need two independent terms. To be specific those in the parentheses in Eq. (9) will not be used.

To obtain the effective Hamiltonian for the $B \to \mathcal{B}\bar{\mathcal{D}}$ decays, we replace $\bar{\mathcal{D}}_{ikl}$ in Eq. (7) by $(\bar{\mathcal{B}}_1)_{ikl} \equiv \epsilon_{ika}\bar{\mathcal{B}}^a_l$ and $(\bar{\mathcal{B}}_2)_{ikl} \equiv \epsilon_{akl}\bar{\mathcal{B}}^a_i$ and get

$$\begin{aligned} H_{\rm eff} = &-\sqrt{6}T_{1\mathcal{B}\bar{\mathcal{D}}}\bar B_m H^{ik}_j \epsilon_{ika}\bar{\mathcal{B}}^a_l \mathcal{D}^{ljm} - 2\sqrt{6}T_{2\mathcal{B}\bar{\mathcal{D}}}\bar B_m H^{ik}_j \epsilon_{akl}\bar{\mathcal{B}}^a_i \mathcal{D}^{ljm} - \sqrt{6}P_{\mathcal{B}\bar{\mathcal{D}}}\bar B_m H^k \epsilon_{kia}\bar{\mathcal{B}}^a_l \mathcal{D}^{lim} - \sqrt{6}E_{\mathcal{B}\bar{\mathcal{D}}}\bar B_k H^{ik}_j \epsilon_{ila}\bar{\mathcal{B}}^a_m \mathcal{D}^{mlj} \\ &- \sqrt{6}A_{\mathcal{B}\bar{\mathcal{D}}}\bar B_i H^{ik}_j \epsilon_{kla}\bar{\mathcal{B}}^a_m \mathcal{D}^{mlj} - \sqrt{6}P_{1EW\mathcal{B}\bar{\mathcal{D}}}\bar B_m H_{EW}{}^{ik}_j \epsilon_{ika}\bar{\mathcal{B}}^a_l \mathcal{D}^{ljm} - 2\sqrt{6}P_{2EW\mathcal{B}\bar{\mathcal{D}}}\bar B_m H_{EW}{}^{ik}_j \epsilon_{akl}\bar{\mathcal{B}}^a_i \mathcal{D}^{ljm}, \end{aligned} \tag{10}$$

where some prefactors are introduced for later purpose. Note that terms obtained with the replacement $\bar{\mathcal{D}} \to \bar{\mathcal{B}}_2$ from penguin, exchange and annihilation topologies of Eq. (7) are vanishing. We have two tree, one penguin, one exchange, one annihilation, two electroweak penguin and no penguin annihilation amplitudes. For example, penguin annihilation amplitude cannot exist in this case as the decuplet is symmetric in flavor index, while the octet part comes in through antisymmetric combination.

For the $\bar B \to \mathcal{D}\bar{\mathcal{B}}$ case, by replacing $\mathcal{D}^{ljm}$ in Eq. (7) by $(\mathcal{B}_1)^{ljm} \equiv \epsilon^{ljb}\mathcal{B}^m_b$ and $(\mathcal{B}_2)^{ljm} \equiv \epsilon^{bjm}\mathcal{B}^l_b$, we have

$$\begin{aligned} H_{\rm eff} = &-\sqrt{6}T_{1\mathcal{D}\bar{\mathcal{B}}}\bar B_m H^{ik}_j \bar{\mathcal{D}}_{ikl}\epsilon^{ljb}\mathcal{B}^m_b + \sqrt{6}T_{2\mathcal{D}\bar{\mathcal{B}}}\bar B_m H^{ik}_j \bar{\mathcal{D}}_{ikl}\epsilon^{bjm}\mathcal{B}^l_b + \sqrt{6}P_{\mathcal{D}\bar{\mathcal{B}}}\bar B_m H^k \bar{\mathcal{D}}_{kil}\epsilon^{bim}\mathcal{B}^l_b + \sqrt{6}E_{\mathcal{D}\bar{\mathcal{B}}}\bar B_k H^{ik}_j \bar{\mathcal{D}}_{ilm}\epsilon^{bli}\mathcal{B}^m_b \\ &+ \sqrt{6}A_{\mathcal{D}\bar{\mathcal{B}}}\bar B_i H^{ik}_j \bar{\mathcal{D}}_{klm}\epsilon^{bli}\mathcal{B}^m_b - \sqrt{6}P_{1EW\mathcal{D}\bar{\mathcal{B}}}\bar B_m H_{EW}{}^{ik}_j \bar{\mathcal{D}}_{ikl}\epsilon^{ljb}\mathcal{B}^m_b + \sqrt{6}P_{2EW\mathcal{D}\bar{\mathcal{B}}}\bar B_m H_{EW}{}^{ik}_j \bar{\mathcal{D}}_{ikl}\epsilon^{bjm}\mathcal{B}^l_b. \end{aligned} \tag{11}$$

Without loss of generality, we introduce some prefactors for later purpose. Note that terms obtained with the replacement $\mathcal{D} \to \mathcal{B}_1$ from penguin, exchange and annihilation topologies of Eq. (7) are vanishing. We have two tree, one penguin, one exchange, one annihilation, two electroweak penguin and no penguin annihilation amplitudes.

To obtain $\bar B \to \mathcal{B}\bar{\mathcal{B}}$ decays effective Hamiltonian, we first replace $\bar{\mathcal{D}}_{ikl}$ and $\mathcal{D}^{ljm}$ in Eq. (7) by $(\bar{\mathcal{B}}_1)_{ikl} \equiv \epsilon_{ika}\bar{\mathcal{B}}^a_l$ and $(\bar{\mathcal{B}}_2)_{ikl} \equiv \epsilon_{akl}\bar{\mathcal{B}}^a_i$, and $(\mathcal{B}_1)^{ljm} \equiv \epsilon^{ljb}\mathcal{B}^m_b$ and $(\mathcal{B}_2)^{ljm} \equiv \epsilon^{bjm}\mathcal{B}^l_b$, respectively, and obtain

$$\begin{aligned} H_{\rm eff} &= (H_{\rm eff})_{11} - (H_{\rm eff})_{12} + 2(H_{\rm eff})_{21} - 2(H_{\rm eff})_{22}, \\ (H_{\rm eff})_{pq} &\equiv T_{pq\mathcal{B}\bar{\mathcal{B}}}\bar B_m H^{ik}_j (\bar{\mathcal{B}}_p)_{ikl}(\mathcal{B}_q)^{ljm} + P_{pq\mathcal{B}\bar{\mathcal{B}}}\bar B_m H^k (\bar{\mathcal{B}}_p)_{kil}(\mathcal{B}_q)^{lim} \\ &\quad + E_{pq\mathcal{B}\bar{\mathcal{B}}}\bar B_k H^{ik}_j (\bar{\mathcal{B}}_p)_{ilm}(\mathcal{B}_q)^{mlj} + A_{pq\mathcal{B}\bar{\mathcal{B}}}\bar B_i H^{ik}_j (\bar{\mathcal{B}}_p)_{klm}(\mathcal{B}_q)^{mlj} \\ &\quad + P_{pqEW\mathcal{B}\bar{\mathcal{B}}}\bar B_m H_{EW}{}^{ik}_j (\bar{\mathcal{B}}_p)_{ikl}(\mathcal{B}_q)^{ljm} + PA_{pq\mathcal{B}\bar{\mathcal{B}}}\bar B_k H^k (\bar{\mathcal{B}}_p)_{lmn}(\mathcal{B}_q)^{nml}, \end{aligned} \tag{12}$$

where without loss of generality the coefficients in front of $(H_{\rm eff})_{pq}$ are assigned for later purpose. Using identities, $-2(\bar{\mathcal{B}}_1)_{kil}(\mathcal{B}_1)^{lim} = (\bar{\mathcal{B}}_2)_{kil}(\mathcal{B}_1)^{lim} = -2(\bar{\mathcal{B}}_2)_{kil}(\mathcal{B}_2)^{lim}$, $-2(\bar{\mathcal{B}}_1)_{lmn}(\mathcal{B}_1)^{nml} = (\bar{\mathcal{B}}_1)_{lmn}(\mathcal{B}_2)^{nml} = (\bar{\mathcal{B}}_2)_{lmn}(\mathcal{B}_1)^{nml} = -2(\bar{\mathcal{B}}_2)_{lmn}(\mathcal{B}_2)^{nml}$, and redefining topological fields,[2] we finally get

[2]Explicitly, we redefine $T_{1\mathcal{B}\bar{\mathcal{B}}} \equiv T_{11\mathcal{B}\bar{\mathcal{B}}}$, $T_{2\mathcal{B}\bar{\mathcal{B}}} \equiv T_{12\mathcal{B}\bar{\mathcal{B}}}$, $T_{3\mathcal{B}\bar{\mathcal{B}}} \equiv T_{21\mathcal{B}\bar{\mathcal{B}}}$, $T_{4\mathcal{B}\bar{\mathcal{B}}} \equiv T_{22\mathcal{B}\bar{\mathcal{B}}}$ (and similarly for $P_{iEW\mathcal{B}\bar{\mathcal{B}}}$), $-5P_{1\mathcal{B}\bar{\mathcal{B}}} \equiv P_{11\mathcal{B}\bar{\mathcal{B}}} - 4P_{21\mathcal{B}\bar{\mathcal{B}}} - 2P_{22\mathcal{B}\bar{\mathcal{B}}}$, $P_{2\mathcal{B}\bar{\mathcal{B}}} \equiv P_{12\mathcal{B}\bar{\mathcal{B}}}$ (and similarly for $A_{i\mathcal{B}\bar{\mathcal{B}}}$ and $E_{i\mathcal{B}\bar{\mathcal{B}}}$) and $-3PA_{\mathcal{B}\bar{\mathcal{B}}} = PA_{11\mathcal{B}\bar{\mathcal{B}}} + 2PA_{12\mathcal{B}\bar{\mathcal{B}}} - 4PA_{21\mathcal{B}\bar{\mathcal{B}}} - 2PA_{22\mathcal{B}\bar{\mathcal{B}}}$.

$$\begin{aligned} H_{\rm eff} = {} & T_{1\mathcal{B}\bar{\mathcal{B}}}\bar{B}_m H^{ik}_j \epsilon_{ika}\bar{\mathcal{B}}^a_l \epsilon^{ljb}\mathcal{B}^m_b - T_{2\mathcal{B}\bar{\mathcal{B}}}\bar{B}_m H^{ik}_j \epsilon_{ika}\bar{\mathcal{B}}^a_l \epsilon^{bjm}\mathcal{B}^l_b + 2T_{3\mathcal{B}\bar{\mathcal{B}}}\bar{B}_m H^{ik}_j \epsilon_{akl}\bar{\mathcal{B}}^a_i \epsilon^{ljb}\mathcal{B}^m_b - 2T_{4\mathcal{B}\bar{\mathcal{B}}}\bar{B}_m H^{ik}_j \epsilon_{akl}\bar{\mathcal{B}}^a_i \epsilon^{bjm}\mathcal{B}^l_b \\ & - 5P_{1\mathcal{B}\bar{\mathcal{B}}}\bar{B}_m H^k \epsilon_{kia}\bar{\mathcal{B}}^a_l \epsilon^{lib}\mathcal{B}^m_b - P_{2\mathcal{B}\bar{\mathcal{B}}}\bar{B}_m H^k \epsilon_{kia}\bar{\mathcal{B}}^a_l \epsilon^{bim}\mathcal{B}^l_b - 5E_{1\mathcal{B}\bar{\mathcal{B}}}\bar{B}_k H^{ik}_j \epsilon_{ila}\bar{\mathcal{B}}^a_m \epsilon^{mlb}\mathcal{B}^j_b - E_{2\mathcal{B}\bar{\mathcal{B}}}\bar{B}_k H^{ik}_j \epsilon_{ila}\bar{\mathcal{B}}^a_m \epsilon^{blj}\mathcal{B}^l_m \\ & - 5A_{1\mathcal{B}\bar{\mathcal{B}}}\bar{B}_i H^{ik}_j \epsilon_{kla}\bar{\mathcal{B}}^a_m \epsilon^{mlb}\mathcal{B}^j_b - A_{2\mathcal{B}\bar{\mathcal{B}}}\bar{B}_i H^{ik}_j \epsilon_{kla}\bar{\mathcal{B}}^a_m \epsilon^{blj}\mathcal{B}^l_m + P_{1EW\mathcal{B}\bar{\mathcal{B}}}\bar{B}_m H_{EW}{}^{ik}_j \epsilon_{ika}\bar{\mathcal{B}}^a_l \epsilon^{ljb}\mathcal{B}^m_b \\ & - P_{2EW\mathcal{B}\bar{\mathcal{B}}}\bar{B}_m H_{EW}{}^{ik}_j \epsilon_{ika}\bar{\mathcal{B}}^a_l \epsilon^{bjm}\mathcal{B}^l_b + 2P_{3EW\mathcal{B}\bar{\mathcal{B}}}\bar{B}_m H_{EW}{}^{ik}_j \epsilon_{akl}\bar{\mathcal{B}}^a_i \epsilon^{ljb}\mathcal{B}^m_b \\ & - 2P_{4EW\mathcal{B}\bar{\mathcal{B}}}\bar{B}_m H_{EW}{}^{ik}_j \epsilon_{akl}\bar{\mathcal{B}}^a_i \epsilon^{bjm}\mathcal{B}^l_b - 3PA_{\mathcal{B}\bar{\mathcal{B}}}\bar{B}_k H^k \epsilon_{lma}\bar{\mathcal{B}}^a_n \epsilon^{nmb}\mathcal{B}^l_b. \end{aligned} \tag{13}$$

We have four tree, two penguin, two exchange, two annihilation, four electroweak penguin and one penguin annihilation amplitudes.

All of the above results are for $\Delta S = 0$ transitions. For $\Delta S = -1$ transitions, we use T', P' and so on for the corresponding topological amplitudes.

B. Topological amplitudes of two-body charmless baryonic B decays

Here we collect all the $\bar{B} \to \mathcal{D}\bar{\mathcal{D}}$, $\mathcal{D}\bar{\mathcal{B}}$, $\mathcal{B}\bar{\mathcal{D}}$, $\mathcal{B}\bar{\mathcal{B}}$ decay amplitudes expressed in term of topological amplitudes as obtained using formulas in the previous subsection. These are some of the main results of this work.

1. $\bar{B}$ to decuplet-antidecuplet baryonic decays

The full $\bar{B} \to \mathcal{D}\bar{\mathcal{D}}$ decay amplitudes for $\Delta S = 0$ processes are given by

$$\begin{aligned} A(B^- \to \Delta^+\overline{\Delta^{++}}) &= 2\sqrt{3}T_{\mathcal{D}\bar{\mathcal{D}}} + 2\sqrt{3}P_{\mathcal{D}\bar{\mathcal{D}}} + \frac{4}{\sqrt{3}}P_{EW\mathcal{D}\bar{\mathcal{D}}} + 2\sqrt{3}A_{\mathcal{D}\bar{\mathcal{D}}}, \\ A(B^- \to \Delta^0\overline{\Delta^{+}}) &= 2T_{\mathcal{D}\bar{\mathcal{D}}} + 4P_{\mathcal{D}\bar{\mathcal{D}}} + \frac{2}{3}P_{EW\mathcal{D}\bar{\mathcal{D}}} + 4A_{\mathcal{D}\bar{\mathcal{D}}}, \\ A(B^- \to \Delta^-\overline{\Delta^{0}}) &= 2\sqrt{3}P_{\mathcal{D}\bar{\mathcal{D}}} - \frac{2}{\sqrt{3}}P_{EW\mathcal{D}\bar{\mathcal{D}}} + 2\sqrt{3}A_{\mathcal{D}\bar{\mathcal{D}}}, \\ A(B^- \to \Sigma^{*0}\overline{\Sigma^{*+}}) &= \sqrt{2}T_{\mathcal{D}\bar{\mathcal{D}}} + 2\sqrt{2}P_{\mathcal{D}\bar{\mathcal{D}}} + \frac{\sqrt{2}}{3}P_{EW\mathcal{D}\bar{\mathcal{D}}} + 2\sqrt{2}A_{\mathcal{D}\bar{\mathcal{D}}}, \\ A(B^- \to \Sigma^{*-}\overline{\Sigma^{*0}}) &= 2\sqrt{2}P_{\mathcal{D}\bar{\mathcal{D}}} - \frac{2\sqrt{2}}{3}P_{EW\mathcal{D}\bar{\mathcal{D}}} + 2\sqrt{2}A_{\mathcal{D}\bar{\mathcal{D}}}, \\ A(B^- \to \Xi^{*-}\overline{\Xi^{*0}}) &= 2P_{\mathcal{D}\bar{\mathcal{D}}} - \frac{2}{3}P_{EW\mathcal{D}\bar{\mathcal{D}}} + 2A_{\mathcal{D}\bar{\mathcal{D}}}, \end{aligned} \tag{14}$$

$$\begin{aligned} A(\bar{B}^0 \to \Delta^{++}\overline{\Delta^{++}}) &= 6E_{\mathcal{D}\bar{\mathcal{D}}} + 18PA_{\mathcal{D}\bar{\mathcal{D}}}, \\ A(\bar{B}^0 \to \Delta^{+}\overline{\Delta^{+}}) &= 2T_{\mathcal{D}\bar{\mathcal{D}}} + 2P_{\mathcal{D}\bar{\mathcal{D}}} + \frac{4}{3}P_{EW\mathcal{D}\bar{\mathcal{D}}} + 4E_{\mathcal{D}\bar{\mathcal{D}}} + 18PA_{\mathcal{D}\bar{\mathcal{D}}}, \\ A(\bar{B}^0 \to \Delta^{0}\overline{\Delta^{0}}) &= 2T_{\mathcal{D}\bar{\mathcal{D}}} + 4P_{\mathcal{D}\bar{\mathcal{D}}} + \frac{2}{3}P_{EW\mathcal{D}\bar{\mathcal{D}}} + 2E_{\mathcal{D}\bar{\mathcal{D}}} + 18PA_{\mathcal{D}\bar{\mathcal{D}}}, \\ A(\bar{B}^0 \to \Delta^{-}\overline{\Delta^{-}}) &= 6P_{\mathcal{D}\bar{\mathcal{D}}} - 2P_{EW\mathcal{D}\bar{\mathcal{D}}} + 18PA_{\mathcal{D}\bar{\mathcal{D}}}, \\ A(\bar{B}^0 \to \Sigma^{*+}\overline{\Sigma^{*+}}) &= 4E_{\mathcal{D}\bar{\mathcal{D}}} + 18PA_{\mathcal{D}\bar{\mathcal{D}}}, \\ A(\bar{B}^0 \to \Sigma^{*0}\overline{\Sigma^{*0}}) &= T_{\mathcal{D}\bar{\mathcal{D}}} + 2P_{\mathcal{D}\bar{\mathcal{D}}} + \frac{1}{3}P_{EW\mathcal{D}\bar{\mathcal{D}}} + 2E_{\mathcal{D}\bar{\mathcal{D}}} + 18PA_{\mathcal{D}\bar{\mathcal{D}}}, \\ A(\bar{B}^0 \to \Sigma^{*-}\overline{\Sigma^{*-}}) &= 4P_{\mathcal{D}\bar{\mathcal{D}}} - \frac{4}{3}P_{EW\mathcal{D}\bar{\mathcal{D}}} + 18PA_{\mathcal{D}\bar{\mathcal{D}}}, \\ A(\bar{B}^0 \to \Xi^{*0}\overline{\Xi^{*0}}) &= \frac{1}{3}E_{\mathcal{D}\bar{\mathcal{D}}} + 18PA_{\mathcal{D}\bar{\mathcal{D}}}, \\ A(\bar{B}^0 \to \Xi^{*-}\overline{\Xi^{*-}}) &= 2P_{\mathcal{D}\bar{\mathcal{D}}} - \frac{2}{3}P_{EW\mathcal{D}\bar{\mathcal{D}}} + 18PA_{\mathcal{D}\bar{\mathcal{D}}}, \\ A(\bar{B}^0 \to \Omega^{-}\overline{\Omega^{-}}) &= 18PA_{\mathcal{D}\bar{\mathcal{D}}}, \end{aligned} \tag{15}$$

and

$$
\begin{aligned}
A(\bar{B}_s^0 \to \Delta^+\overline{\Sigma^{*+}}) &= 2T_{\mathcal{D}\bar{\mathcal{D}}} + 2P_{\mathcal{D}\bar{\mathcal{D}}} + \frac{4}{3}P_{EW\mathcal{D}\bar{\mathcal{D}}},\\
A(\bar{B}_s^0 \to \Delta^0\overline{\Sigma^{*0}}) &= \sqrt{2}T_{\mathcal{D}\bar{\mathcal{D}}} + 2\sqrt{2}P_{\mathcal{D}\bar{\mathcal{D}}} + \frac{\sqrt{2}}{3}P_{EW\mathcal{D}\bar{\mathcal{D}}},\\
A(\bar{B}_s^0 \to \Delta^-\overline{\Sigma^{*-}}) &= 2\sqrt{3}P_{\mathcal{D}\bar{\mathcal{D}}} - \frac{2}{\sqrt{3}}P_{EW\mathcal{D}\bar{\mathcal{D}}},\\
A(\bar{B}_s^0 \to \Sigma^{*0}\overline{\Xi^{*0}}) &= \sqrt{2}T_{\mathcal{D}\bar{\mathcal{D}}} + 2\sqrt{2}P_{\mathcal{D}\bar{\mathcal{D}}} + \frac{\sqrt{2}}{3}P_{EW\mathcal{D}\bar{\mathcal{D}}},\\
A(\bar{B}_s^0 \to \Sigma^{*-}\overline{\Xi^{*-}}) &= 4P_{\mathcal{D}\bar{\mathcal{D}}} - \frac{4}{3}P_{EW\mathcal{D}\bar{\mathcal{D}}},\\
A(\bar{B}_s^0 \to \Xi^{*-}\overline{\Omega^-}) &= 2\sqrt{3}P_{\mathcal{D}\bar{\mathcal{D}}} - \frac{2}{\sqrt{3}}P_{EW\mathcal{D}\bar{\mathcal{D}}},
\end{aligned} \tag{16}
$$

while those for $\Delta S = 1$ transitions are given by

$$
\begin{aligned}
A(B^- \to \Sigma^{*+}\overline{\Delta^{++}}) &= 2\sqrt{3}T'_{\mathcal{D}\bar{\mathcal{D}}} + 2\sqrt{3}P'_{\mathcal{D}\bar{\mathcal{D}}} + \frac{4}{\sqrt{3}}P'_{EW\mathcal{D}\bar{\mathcal{D}}} + 2\sqrt{3}A'_{\mathcal{D}\bar{\mathcal{D}}},\\
A(B^- \to \Sigma^{*0}\overline{\Delta^{+}}) &= \sqrt{2}T'_{\mathcal{D}\bar{\mathcal{D}}} + 2\sqrt{2}P'_{\mathcal{D}\bar{\mathcal{D}}} + \frac{\sqrt{2}}{3}P'_{EW\mathcal{D}\bar{\mathcal{D}}} + 2\sqrt{2}A'_{\mathcal{D}\bar{\mathcal{D}}},\\
A(B^- \to \Sigma^{*-}\overline{\Delta^{0}}) &= 2P'_{\mathcal{D}\bar{\mathcal{D}}} - \frac{2}{3}P'_{EW\mathcal{D}\bar{\mathcal{D}}} + 2A'_{\mathcal{D}\bar{\mathcal{D}}},\\
A(B^- \to \Xi^{*0}\overline{\Sigma^{*+}}) &= 2T'_{\mathcal{D}\bar{\mathcal{D}}} + 4P'_{\mathcal{D}\bar{\mathcal{D}}} + \frac{2}{3}P'_{EW\mathcal{D}\bar{\mathcal{D}}} + 4A'_{\mathcal{D}\bar{\mathcal{D}}},\\
A(B^- \to \Xi^{*-}\overline{\Sigma^{*0}}) &= 2\sqrt{2}P'_{\mathcal{D}\bar{\mathcal{D}}} - \frac{2\sqrt{2}}{3}P'_{EW\mathcal{D}\bar{\mathcal{D}}} + 2\sqrt{2}A'_{\mathcal{D}\bar{\mathcal{D}}},\\
A(B^- \to \Omega^-\overline{\Xi^{*0}}) &= 2\sqrt{3}P'_{\mathcal{D}\bar{\mathcal{D}}} - \frac{2}{\sqrt{3}}P'_{EW\mathcal{D}\bar{\mathcal{D}}} + 2\sqrt{3}A'_{\mathcal{D}\bar{\mathcal{D}}},
\end{aligned} \tag{17}
$$

$$
\begin{aligned}
A(\bar{B}^0 \to \Sigma^{*+}\overline{\Delta^{+}}) &= 2T'_{\mathcal{D}\bar{\mathcal{D}}} + 2P'_{\mathcal{D}\bar{\mathcal{D}}} + \frac{4}{3}P'_{EW\mathcal{D}\bar{\mathcal{D}}},\\
A(\bar{B}^0 \to \Sigma^{*0}\overline{\Delta^{0}}) &= \sqrt{2}T'_{\mathcal{D}\bar{\mathcal{D}}} + 2\sqrt{2}P'_{\mathcal{D}\bar{\mathcal{D}}} + \frac{\sqrt{2}}{3}P'_{EW\mathcal{D}\bar{\mathcal{D}}},\\
A(\bar{B}^0 \to \Sigma^{*-}\overline{\Delta^{-}}) &= 2\sqrt{3}P'_{\mathcal{D}\bar{\mathcal{D}}} - \frac{2}{\sqrt{3}}P'_{EW\mathcal{D}\bar{\mathcal{D}}},\\
A(\bar{B}^0 \to \Xi^{*0}\overline{\Sigma^{*0}}) &= \sqrt{2}T'_{\mathcal{D}\bar{\mathcal{D}}} + 2\sqrt{2}P'_{\mathcal{D}\bar{\mathcal{D}}} + \frac{\sqrt{2}}{3}P'_{EW\mathcal{D}\bar{\mathcal{D}}},\\
A(\bar{B}^0 \to \Xi^{*-}\overline{\Sigma^{*-}}) &= 4P'_{\mathcal{D}\bar{\mathcal{D}}} - \frac{4}{3}P'_{EW\mathcal{D}\bar{\mathcal{D}}},\\
A(\bar{B}^0 \to \Omega^-\overline{\Xi^{*-}}) &= 2\sqrt{3}P'_{\mathcal{D}\bar{\mathcal{D}}} - \frac{2}{\sqrt{3}}P'_{EW\mathcal{D}\bar{\mathcal{D}}},
\end{aligned} \tag{18}
$$

and

$$\begin{aligned}
A(\bar{B}_s^0 \to \Delta^{++}\overline{\Delta^{++}}) &= 6E'_{\mathcal{D}\bar{\mathcal{D}}} + 18PA'_{\mathcal{D}\bar{\mathcal{D}}},\\
A(\bar{B}_s^0 \to \Delta^{+}\overline{\Delta^{+}}) &= 4E'_{\mathcal{D}\bar{\mathcal{D}}} + 18PA'_{\mathcal{D}\bar{\mathcal{D}}},\\
A(\bar{B}_s^0 \to \Delta^{0}\overline{\Delta^{0}}) &= 2E'_{\mathcal{D}\bar{\mathcal{D}}} + 18PA'_{\mathcal{D}\bar{\mathcal{D}}},\\
A(\bar{B}_s^0 \to \Delta^{-}\overline{\Delta^{-}}) &= 18PA'_{\mathcal{D}\bar{\mathcal{D}}},\\
A(\bar{B}_s^0 \to \Sigma^{*+}\overline{\Sigma^{*+}}) &= 2T'_{\mathcal{D}\bar{\mathcal{D}}} + 2P'_{\mathcal{D}\bar{\mathcal{D}}} + \frac{4}{3}P'_{EW\mathcal{D}\bar{\mathcal{D}}} + 4E'_{\mathcal{D}\bar{\mathcal{D}}} + 18PA'_{\mathcal{D}\bar{\mathcal{D}}},\\
A(\bar{B}_s^0 \to \Sigma^{*0}\overline{\Sigma^{*0}}) &= T'_{\mathcal{D}\bar{\mathcal{D}}} + 2P'_{\mathcal{D}\bar{\mathcal{D}}} + \frac{1}{3}P'_{EW\mathcal{D}\bar{\mathcal{D}}} + 2E'_{\mathcal{D}\bar{\mathcal{D}}} + 18PA'_{\mathcal{D}\bar{\mathcal{D}}},\\
A(\bar{B}_s^0 \to \Sigma^{*-}\overline{\Sigma^{*-}}) &= 2P'_{\mathcal{D}\bar{\mathcal{D}}} - \frac{2}{3}P'_{EW\mathcal{D}\bar{\mathcal{D}}} + 18PA'_{\mathcal{D}\bar{\mathcal{D}}},\\
A(\bar{B}_s^0 \to \Xi^{*0}\overline{\Xi^{*0}}) &= 2T'_{\mathcal{D}\bar{\mathcal{D}}} + 4P'_{\mathcal{D}\bar{\mathcal{D}}} + \frac{2}{3}P'_{EW\mathcal{D}\bar{\mathcal{D}}} + 2E'_{\mathcal{D}\bar{\mathcal{D}}} + 18PA'_{\mathcal{D}\bar{\mathcal{D}}},\\
A(\bar{B}_s^0 \to \Xi^{*-}\overline{\Xi^{*-}}) &= 4P'_{\mathcal{D}\bar{\mathcal{D}}} - \frac{4}{3}P'_{EW\mathcal{D}\bar{\mathcal{D}}} + 18PA'_{\mathcal{D}\bar{\mathcal{D}}},\\
A(\bar{B}_s^0 \to \Omega^{-}\overline{\Omega^{-}}) &= 6P_{\mathcal{D}\bar{\mathcal{D}}} - 2P_{EW\mathcal{D}\bar{\mathcal{D}}} + 18PA'_{\mathcal{D}\bar{\mathcal{D}}}.
\end{aligned} \tag{19}$$

2. $\bar{B}$ to octet-antidecuplet baryonic decays

The full $\bar{B} \to \mathcal{B}\bar{\mathcal{D}}$ decay amplitudes for $\Delta S = 0$ processes are given by

$$\begin{aligned}
A(B^- \to p\overline{\Delta^{++}}) &= -\sqrt{6}(T_{1\mathcal{B}\bar{\mathcal{D}}} - 2T_{2\mathcal{B}\bar{\mathcal{D}}}) + \sqrt{6}P_{\mathcal{B}\bar{\mathcal{D}}} + 2\sqrt{\frac{2}{3}}P_{1EW\mathcal{B}\bar{\mathcal{D}}} + \sqrt{6}A_{\mathcal{B}\bar{\mathcal{D}}},\\
A(B^- \to n\overline{\Delta^{+}}) &= -\sqrt{2}T_{1\mathcal{B}\bar{\mathcal{D}}} + \sqrt{2}P_{\mathcal{B}\bar{\mathcal{D}}} + \frac{2\sqrt{2}}{3}(P_{1EW\mathcal{B}\bar{\mathcal{D}}} - 3P_{2EW\mathcal{B}\bar{\mathcal{D}}}) + \sqrt{2}A_{\mathcal{B}\bar{\mathcal{D}}},\\
A(B^- \to \Sigma^0\overline{\Sigma^{*+}}) &= -2T_{2\mathcal{B}\bar{\mathcal{D}}} - P_{\mathcal{B}\bar{\mathcal{D}}} + \frac{1}{3}(P_{1EW\mathcal{B}\bar{\mathcal{D}}} - 6P_{2EW\mathcal{B}\bar{\mathcal{D}}}) - A_{\mathcal{B}\bar{\mathcal{D}}},\\
A(B^- \to \Sigma^-\overline{\Sigma^{*0}}) &= -P_{\mathcal{B}\bar{\mathcal{D}}} + \frac{1}{3}P_{1EW\mathcal{B}\bar{\mathcal{D}}} - A_{\mathcal{B}\bar{\mathcal{D}}},\\
A(B^- \to \Xi^-\overline{\Xi^{*0}}) &= -\sqrt{2}P_{\mathcal{B}\bar{\mathcal{D}}} + \frac{\sqrt{2}}{3}P_{1EW\mathcal{B}\bar{\mathcal{D}}} - \sqrt{2}A_{\mathcal{B}\bar{\mathcal{D}}},\\
A(B^- \to \Lambda\overline{\Sigma^{*+}}) &= \frac{2}{\sqrt{3}}(T_{1\mathcal{B}\bar{\mathcal{D}}} - T_{2\mathcal{B}\bar{\mathcal{D}}}) - \sqrt{3}P_{\mathcal{B}\bar{\mathcal{D}}} - \frac{1}{\sqrt{3}}(P_{1EW\mathcal{B}\bar{\mathcal{D}}} - 2P_{2EW\mathcal{B}\bar{\mathcal{D}}}) - \sqrt{3}A_{\mathcal{B}\bar{\mathcal{D}}},
\end{aligned} \tag{20}$$

$$\begin{aligned}
A(\bar{B}^0 \to p\overline{\Delta^{+}}) &= -\sqrt{2}(T_{1\mathcal{B}\bar{\mathcal{D}}} - 2T_{2\mathcal{B}\bar{\mathcal{D}}}) + \sqrt{2}P_{\mathcal{B}\bar{\mathcal{D}}} + \frac{2\sqrt{2}}{3}P_{1EW\mathcal{B}\bar{\mathcal{D}}} - \sqrt{2}E_{\mathcal{B}\bar{\mathcal{D}}},\\
A(\bar{B}^0 \to n\overline{\Delta^{0}}) &= -\sqrt{2}T_{1\mathcal{B}\bar{\mathcal{D}}} + \sqrt{2}P_{\mathcal{B}\bar{\mathcal{D}}} + \frac{2\sqrt{2}}{3}(P_{1EW\mathcal{B}\bar{\mathcal{D}}} - 3P_{2EW\mathcal{B}\bar{\mathcal{D}}}) - \sqrt{2}E_{\mathcal{B}\bar{\mathcal{D}}},\\
A(\bar{B}^0 \to \Sigma^+\overline{\Sigma^{*+}}) &= \sqrt{2}E_{\mathcal{B}\bar{\mathcal{D}}},\\
A(\bar{B}^0 \to \Sigma^0\overline{\Sigma^{*0}}) &= -\sqrt{2}T_{2\mathcal{B}\bar{\mathcal{D}}} - \frac{1}{\sqrt{2}}P_{\mathcal{B}\bar{\mathcal{D}}} + \frac{1}{3\sqrt{2}}(P_{1EW\mathcal{B}\bar{\mathcal{D}}} - 6P_{2EW\mathcal{B}\bar{\mathcal{D}}}) - \frac{1}{\sqrt{2}}E_{\mathcal{B}\bar{\mathcal{D}}},\\
A(\bar{B}^0 \to \Sigma^-\overline{\Sigma^{*-}}) &= -\sqrt{2}P_{\mathcal{B}\bar{\mathcal{D}}} + \frac{\sqrt{2}}{3}P_{1EW\mathcal{B}\bar{\mathcal{D}}},\\
A(\bar{B}^0 \to \Xi^0\overline{\Xi^{*0}}) &= \sqrt{2}E_{\mathcal{B}\bar{\mathcal{D}}},\\
A(\bar{B}^0 \to \Xi^-\overline{\Xi^{*-}}) &= -\sqrt{2}P_{\mathcal{B}\bar{\mathcal{D}}} + \frac{\sqrt{2}}{3}P_{1EW\mathcal{B}\bar{\mathcal{D}}},\\
A(\bar{B}^0 \to \Lambda\overline{\Sigma^{*0}}) &= \sqrt{\frac{2}{3}}(T_{1\mathcal{B}\bar{\mathcal{D}}} - T_{2\mathcal{B}\bar{\mathcal{D}}}) - \sqrt{\frac{3}{2}}P_{\mathcal{B}\bar{\mathcal{D}}} - \frac{1}{\sqrt{6}}(P_{1EW\mathcal{B}\bar{\mathcal{D}}} - 2P_{2EW\mathcal{B}\bar{\mathcal{D}}}) + \sqrt{\frac{3}{2}}E_{\mathcal{B}\bar{\mathcal{D}}},
\end{aligned} \tag{21}$$

and

$$\begin{aligned}
A(\bar{B}_s^0 \to p\overline{\Sigma^{*+}}) &= -\sqrt{2}(T_{1\mathcal{B}\bar{\mathcal{D}}} - 2T_{2\mathcal{B}\bar{\mathcal{D}}}) + \sqrt{2}P_{\mathcal{B}\bar{\mathcal{D}}} + \frac{2\sqrt{2}}{3}P_{1EW\mathcal{B}\bar{\mathcal{D}}},\\
A(\bar{B}_s^0 \to n\overline{\Sigma^{*0}}) &= -T_{1\mathcal{B}\bar{\mathcal{D}}} + P_{\mathcal{B}\bar{\mathcal{D}}} + \frac{2}{3}(P_{1EW\mathcal{B}\bar{\mathcal{D}}} - 3P_{2EW\mathcal{B}\bar{\mathcal{D}}}),\\
A(\bar{B}_s^0 \to \Sigma^0\overline{\Xi^{*0}}) &= -2T_{2\mathcal{B}\bar{\mathcal{D}}} - P_{\mathcal{B}\bar{\mathcal{D}}} + \frac{1}{3}(P_{1EW\mathcal{B}\bar{\mathcal{D}}} - 6P_{2EW\mathcal{B}\bar{\mathcal{D}}}),\\
A(\bar{B}_s^0 \to \Sigma^-\overline{\Xi^{*-}}) &= -\sqrt{2}P_{\mathcal{B}\bar{\mathcal{D}}} + \frac{\sqrt{2}}{3}P_{1EW\mathcal{B}\bar{\mathcal{D}}},\\
A(\bar{B}_s^0 \to \Xi^-\overline{\Omega^-}) &= -\sqrt{6}P_{\mathcal{B}\bar{\mathcal{D}}} + \sqrt{\frac{2}{3}}P_{1EW\mathcal{B}\bar{\mathcal{D}}},\\
A(\bar{B}_s^0 \to \Lambda\overline{\Xi^{*0}}) &= \frac{2}{\sqrt{3}}(T_{1\mathcal{B}\bar{\mathcal{D}}} - T_{2\mathcal{B}\bar{\mathcal{D}}}) - \sqrt{3}P_{\mathcal{B}\bar{\mathcal{D}}} - \frac{1}{\sqrt{3}}(P_{1EW\mathcal{B}\bar{\mathcal{D}}} - 2P_{2EW\mathcal{B}\bar{\mathcal{D}}}),
\end{aligned} \tag{22}$$

while those for $\Delta S = 1$ transitions are given by

$$\begin{aligned}
A(B^- \to \Sigma^+\overline{\Delta^{++}}) &= \sqrt{6}(T'_{1\mathcal{B}\bar{\mathcal{D}}} - 2T'_{2\mathcal{B}\bar{\mathcal{D}}}) - \sqrt{6}P'_{\mathcal{B}\bar{\mathcal{D}}} - 2\sqrt{\frac{2}{3}}P'_{1EW\mathcal{B}\bar{\mathcal{D}}} - \sqrt{6}A'_{\mathcal{B}\bar{\mathcal{D}}},\\
A(B^- \to \Sigma^0\overline{\Delta^{+}}) &= -T'_{1\mathcal{B}\bar{\mathcal{D}}} + 2T'_{2\mathcal{B}\bar{\mathcal{D}}} + 2P'_{\mathcal{B}\bar{\mathcal{D}}} + \frac{1}{3}P'_{1EW\mathcal{B}\bar{\mathcal{D}}} + 2A'_{\mathcal{B}\bar{\mathcal{D}}},\\
A(B^- \to \Sigma^-\overline{\Delta^{0}}) &= \sqrt{2}P'_{\mathcal{B}\bar{\mathcal{D}}} - \frac{\sqrt{2}}{3}P'_{1EW\mathcal{B}\bar{\mathcal{D}}} + \sqrt{2}A'_{\mathcal{B}\bar{\mathcal{D}}},\\
A(B^- \to \Xi^0\overline{\Sigma^{*+}}) &= \sqrt{2}T'_{1\mathcal{B}\bar{\mathcal{D}}} - \sqrt{2}P'_{\mathcal{B}\bar{\mathcal{D}}} - \frac{2\sqrt{2}}{3}(P'_{1EW\mathcal{B}\bar{\mathcal{D}}} - 3P'_{2EW\mathcal{B}\bar{\mathcal{D}}}) - \sqrt{2}A'_{\mathcal{B}\bar{\mathcal{D}}},\\
A(B^- \to \Xi^-\overline{\Sigma^{*0}}) &= P'_{\mathcal{B}\bar{\mathcal{D}}} - \frac{1}{3}P'_{1EW\mathcal{B}\bar{\mathcal{D}}} + A'_{\mathcal{B}\bar{\mathcal{D}}},\\
A(B^- \to \Lambda\overline{\Delta^{+}}) &= \frac{1}{\sqrt{3}}(T'_{1\mathcal{B}\bar{\mathcal{D}}} + 2T'_{2\mathcal{B}\bar{\mathcal{D}}}) - \frac{1}{\sqrt{3}}(P'_{1EW\mathcal{B}\bar{\mathcal{D}}} - 4P'_{2EW\mathcal{B}\bar{\mathcal{D}}}),
\end{aligned} \tag{23}$$

$$\begin{aligned}
A(\bar{B}^0 \to \Sigma^+\overline{\Delta^{+}}) &= \sqrt{2}(T'_{1\mathcal{B}\bar{\mathcal{D}}} - 2T'_{2\mathcal{B}\bar{\mathcal{D}}}) - \sqrt{2}P'_{\mathcal{B}\bar{\mathcal{D}}} - \frac{2\sqrt{2}}{3}P'_{1EW\mathcal{B}\bar{\mathcal{D}}},\\
A(\bar{B}^0 \to \Sigma^0\overline{\Delta^{0}}) &= -T'_{1\mathcal{B}\bar{\mathcal{D}}} + 2T'_{2\mathcal{B}\bar{\mathcal{D}}} + 2P'_{\mathcal{B}\bar{\mathcal{D}}} + \frac{1}{3}P'_{1EW\mathcal{B}\bar{\mathcal{D}}},\\
A(\bar{B}^0 \to \Sigma^-\overline{\Delta^{-}}) &= \sqrt{6}P'_{\mathcal{B}\bar{\mathcal{D}}} - \sqrt{\frac{2}{3}}P'_{1EW\mathcal{B}\bar{\mathcal{D}}},\\
A(\bar{B}^0 \to \Xi^0\overline{\Sigma^{*0}}) &= T'_{1\mathcal{B}\bar{\mathcal{D}}} - P'_{\mathcal{B}\bar{\mathcal{D}}} - \frac{2}{3}(P'_{1EW\mathcal{B}\bar{\mathcal{D}}} - 3P'_{2EW\mathcal{B}\bar{\mathcal{D}}}),\\
A(\bar{B}^0 \to \Xi^-\overline{\Sigma^{*-}}) &= \sqrt{2}P'_{\mathcal{B}\bar{\mathcal{D}}} - \frac{\sqrt{2}}{3}P'_{1EW\mathcal{B}\bar{\mathcal{D}}},\\
A(\bar{B}^0 \to \Lambda\overline{\Delta^{0}}) &= \frac{1}{\sqrt{3}}(T'_{1\mathcal{B}\bar{\mathcal{D}}} + 2T'_{2\mathcal{B}\bar{\mathcal{D}}}) - \frac{1}{\sqrt{3}}(P'_{1EW\mathcal{B}\bar{\mathcal{D}}} - 4P'_{2EW\mathcal{B}\bar{\mathcal{D}}}),
\end{aligned} \tag{24}$$

and

$$A(\bar{B}^0_s \to p\overline{\Delta^+}) = -\sqrt{2}E'_{\mathcal{B}\bar{\mathcal{D}}},$$
$$A(\bar{B}^0_s \to n\overline{\Delta^0}) = -\sqrt{2}E'_{\mathcal{B}\bar{\mathcal{D}}},$$
$$A(\bar{B}^0_s \to \Sigma^+\overline{\Sigma^{*+}}) = \sqrt{2}(T'_{1\mathcal{B}\bar{\mathcal{D}}} - 2T'_{2\mathcal{B}\bar{\mathcal{D}}}) - \sqrt{2}P'_{\mathcal{B}\bar{\mathcal{D}}} - \frac{2\sqrt{2}}{3}P'_{1EW\mathcal{B}\bar{\mathcal{D}}} + \sqrt{2}E'_{\mathcal{B}\bar{\mathcal{D}}},$$
$$A(\bar{B}^0_s \to \Sigma^0\overline{\Sigma^{*0}}) = -\frac{1}{\sqrt{2}}(T'_{1\mathcal{B}\bar{\mathcal{D}}} - 2T'_{2\mathcal{B}\bar{\mathcal{D}}}) + \sqrt{2}P'_{\mathcal{B}\bar{\mathcal{D}}} + \frac{1}{3\sqrt{2}}P'_{1EW\mathcal{B}\bar{\mathcal{D}}} - \frac{1}{\sqrt{2}}E'_{\mathcal{B}\bar{\mathcal{D}}},$$
$$A(\bar{B}^0_s \to \Sigma^-\overline{\Sigma^{*-}}) = \sqrt{2}P'_{\mathcal{B}\bar{\mathcal{D}}} - \frac{\sqrt{2}}{3}P'_{1EW\mathcal{B}\bar{\mathcal{D}}},$$
$$A(\bar{B}^0_s \to \Xi^0\overline{\Xi^{*0}}) = \sqrt{2}T'_{1\mathcal{B}\bar{\mathcal{D}}} - \sqrt{2}P'_{\mathcal{B}\bar{\mathcal{D}}} - \frac{2\sqrt{2}}{3}(P'_{1EW\mathcal{B}\bar{\mathcal{D}}} - 3P'_{2EW\mathcal{B}\bar{\mathcal{D}}}) + \sqrt{2}E'_{\mathcal{B}\bar{\mathcal{D}}},$$
$$A(\bar{B}^0_s \to \Xi^-\overline{\Xi^{*-}}) = \sqrt{2}P'_{\mathcal{B}\bar{\mathcal{D}}} - \frac{\sqrt{2}}{3}P'_{1EW\mathcal{B}\bar{\mathcal{D}}},$$
$$A(\bar{B}^0_s \to \Lambda\overline{\Sigma^{*0}}) = \frac{1}{\sqrt{6}}(T'_{1\mathcal{B}\bar{\mathcal{D}}} + 2T'_{2\mathcal{B}\bar{\mathcal{D}}}) - \frac{1}{\sqrt{6}}(P'_{1EW\mathcal{B}\bar{\mathcal{D}}} - 4P'_{2EW\mathcal{B}\bar{\mathcal{D}}}) + \sqrt{\frac{3}{2}}E'_{\mathcal{B}\bar{\mathcal{D}}}. \quad (25)$$

3. $\bar{B}$ to decuplet-antioctet baryonic decays

The full $\bar{B} \to \mathcal{D}\bar{\mathcal{B}}$ decay amplitudes for $\Delta S = 0$ processes are given by

$$A(B^- \to \Delta^0\bar{p}) = \sqrt{2}T_{1\mathcal{D}\bar{\mathcal{B}}} - \sqrt{2}P_{\mathcal{D}\bar{\mathcal{B}}} + \frac{\sqrt{2}}{3}(3P_{1EW\mathcal{D}\bar{\mathcal{B}}} + P_{2EW\mathcal{D}\bar{\mathcal{B}}}) - \sqrt{2}A_{\mathcal{D}\bar{\mathcal{B}}},$$
$$A(B^- \to \Delta^-\bar{n}) = -\sqrt{6}P_{\mathcal{D}\bar{\mathcal{B}}} + \sqrt{\frac{2}{3}}P_{2EW\mathcal{D}\bar{\mathcal{B}}} - \sqrt{6}A_{\mathcal{D}\bar{\mathcal{B}}},$$
$$A(B^- \to \Sigma^{*0}\overline{\Sigma^+}) = -T_{1\mathcal{D}\bar{\mathcal{B}}} + P_{\mathcal{D}\bar{\mathcal{B}}} - \frac{1}{3}(3P_{1EW\mathcal{D}\bar{\mathcal{B}}} + P_{2EW\mathcal{D}\bar{\mathcal{B}}}) + A_{\mathcal{D}\bar{\mathcal{B}}},$$
$$A(B^- \to \Sigma^{*-}\overline{\Sigma^0}) = -P_{\mathcal{D}\bar{\mathcal{B}}} + \frac{1}{3}P_{2EW\mathcal{D}\bar{\mathcal{B}}} - A_{\mathcal{D}\bar{\mathcal{B}}},$$
$$A(B^- \to \Xi^{*-}\overline{\Xi^0}) = \sqrt{2}P_{\mathcal{D}\bar{\mathcal{B}}} - \frac{\sqrt{2}}{3}P_{2EW\mathcal{D}\bar{\mathcal{B}}} + \sqrt{2}A_{\mathcal{D}\bar{\mathcal{B}}},$$
$$A(B^- \to \Sigma^{*-}\bar{\Lambda}) = \sqrt{3}P_{\mathcal{D}\bar{\mathcal{B}}} - \frac{1}{\sqrt{3}}P_{2EW\mathcal{D}\bar{\mathcal{B}}} + \sqrt{3}A_{\mathcal{D}\bar{\mathcal{B}}}, \quad (26)$$

$$A(\bar{B}^0 \to \Delta^+\bar{p}) = \sqrt{2}T_{2\mathcal{D}\bar{\mathcal{B}}} + \sqrt{2}P_{\mathcal{D}\bar{\mathcal{B}}} + \frac{2\sqrt{2}}{3}P_{2EW\mathcal{D}\bar{\mathcal{B}}} - \sqrt{2}E_{\mathcal{D}\bar{\mathcal{B}}},$$
$$A(\bar{B}^0 \to \Delta^0\bar{n}) = \sqrt{2}(T_{1\mathcal{D}\bar{\mathcal{B}}} + T_{2\mathcal{D}\bar{\mathcal{B}}}) + \sqrt{2}P_{\mathcal{D}\bar{\mathcal{B}}} + \frac{\sqrt{2}}{3}(3P_{1EW\mathcal{D}\bar{\mathcal{B}}} + 2P_{2EW\mathcal{D}\bar{\mathcal{B}}}) - \sqrt{2}E_{\mathcal{D}\bar{\mathcal{B}}},$$
$$A(\bar{B}^0 \to \Sigma^{*+}\overline{\Sigma^+}) = \sqrt{2}E_{\mathcal{D}\bar{\mathcal{B}}},$$
$$A(\bar{B}^0 \to \Sigma^{*0}\overline{\Sigma^0}) = \frac{1}{\sqrt{2}}T_{1\mathcal{D}\bar{\mathcal{B}}} - \frac{1}{\sqrt{2}}P_{\mathcal{D}\bar{\mathcal{B}}} + \frac{1}{3\sqrt{2}}(3P_{1EW\mathcal{D}\bar{\mathcal{B}}} + P_{2EW\mathcal{D}\bar{\mathcal{B}}}) - \frac{1}{\sqrt{2}}E_{\mathcal{D}\bar{\mathcal{B}}},$$
$$A(\bar{B}^0 \to \Sigma^{*-}\overline{\Sigma^-}) = -\sqrt{2}P_{\mathcal{D}\bar{\mathcal{B}}} + \frac{\sqrt{2}}{3}P_{2EW\mathcal{D}\bar{\mathcal{B}}},$$
$$A(\bar{B}^0 \to \Xi^{*0}\overline{\Xi^0}) = \sqrt{2}E_{\mathcal{D}\bar{\mathcal{B}}},$$
$$A(\bar{B}^0 \to \Xi^{*-}\overline{\Xi^-}) = -\sqrt{2}P_{\mathcal{D}\bar{\mathcal{B}}} + \frac{\sqrt{2}}{3}P_{2EW\mathcal{D}\bar{\mathcal{B}}},$$
$$A(\bar{B}^0 \to \Sigma^{*0}\bar{\Lambda}) = -\frac{1}{\sqrt{6}}(T_{1\mathcal{D}\bar{\mathcal{B}}} + 2T_{2\mathcal{D}\bar{\mathcal{B}}}) - \sqrt{\frac{3}{2}}P_{\mathcal{D}\bar{\mathcal{B}}} - \frac{1}{\sqrt{6}}(P_{1EW\mathcal{D}\bar{\mathcal{B}}} + P_{2EW\mathcal{D}\bar{\mathcal{B}}}) + \sqrt{\frac{3}{2}}E_{\mathcal{D}\bar{\mathcal{B}}}, \quad (27)$$

and

$$
\begin{aligned}
A(\bar{B}_s^0 \to \Delta^+\overline{\Sigma^+}) &= -\sqrt{2}T_{2\mathcal{D}\bar{\mathcal{B}}} - \sqrt{2}P_{\mathcal{D}\bar{\mathcal{B}}} - \frac{2\sqrt{2}}{3}P_{2EW\mathcal{D}\bar{\mathcal{B}}}, \\
A(\bar{B}_s^0 \to \Delta^0\overline{\Sigma^0}) &= T_{2\mathcal{D}\bar{\mathcal{B}}} + 2P_{\mathcal{D}\bar{\mathcal{B}}} + \frac{1}{3}P_{2EW\mathcal{D}\bar{\mathcal{B}}}, \\
A(\bar{B}_s^0 \to \Delta^-\overline{\Sigma^-}) &= \sqrt{6}P_{\mathcal{D}\bar{\mathcal{B}}} - \sqrt{\frac{2}{3}}P_{2EW\mathcal{D}\bar{\mathcal{B}}}, \\
A(\bar{B}_s^0 \to \Sigma^{*0}\overline{\Xi^0}) &= -(T_{1\mathcal{D}\bar{\mathcal{B}}} + T_{2\mathcal{D}\bar{\mathcal{B}}}) - P_{\mathcal{D}\bar{\mathcal{B}}} - \frac{1}{3}(3P_{1EW\mathcal{D}\bar{\mathcal{B}}} + 2P_{2EW\mathcal{D}\bar{\mathcal{B}}}), \\
A(\bar{B}_s^0 \to \Sigma^{*-}\overline{\Xi^-}) &= \sqrt{2}P_{\mathcal{D}\bar{\mathcal{B}}} - \frac{\sqrt{2}}{3}P_{2EW\mathcal{D}\bar{\mathcal{B}}}, \\
A(\bar{B}_s^0 \to \Delta^0\bar{\Lambda}) &= -\frac{1}{\sqrt{3}}(2T_{1\mathcal{D}\bar{\mathcal{B}}} + T_{2\mathcal{D}\bar{\mathcal{B}}}) - \frac{1}{\sqrt{3}}(2P_{1EW\mathcal{D}\bar{\mathcal{B}}} + P_{2EW\mathcal{D}\bar{\mathcal{B}}}),
\end{aligned} \tag{28}
$$

while those for $\Delta S = 1$ transitions are given by

$$
\begin{aligned}
A(B^- \to \Sigma^{*0}\bar{p}) &= T'_{1\mathcal{D}\bar{\mathcal{B}}} - P'_{\mathcal{D}\bar{\mathcal{B}}} + \frac{1}{3}(3P'_{1EW\mathcal{D}\bar{\mathcal{B}}} + P'_{2EW\mathcal{D}\bar{\mathcal{B}}}) - A'_{\mathcal{D}\bar{\mathcal{B}}}, \\
A(B^- \to \Sigma^{*-}\bar{n}) &= -\sqrt{2}P'_{\mathcal{D}\bar{\mathcal{B}}} + \frac{\sqrt{2}}{3}P'_{2EW\mathcal{D}\bar{\mathcal{B}}} - \sqrt{2}A'_{\mathcal{D}\bar{\mathcal{B}}}, \\
A(B^- \to \Xi^{*0}\overline{\Sigma^+}) &= -\sqrt{2}T'_{1\mathcal{D}\bar{\mathcal{B}}} + \sqrt{2}P'_{\mathcal{D}\bar{\mathcal{B}}} - \frac{\sqrt{2}}{3}(3P'_{1EW\mathcal{D}\bar{\mathcal{B}}} + P'_{2EW\mathcal{D}\bar{\mathcal{B}}}) + \sqrt{2}A'_{\mathcal{D}\bar{\mathcal{B}}}, \\
A(B^- \to \Xi^{*-}\overline{\Sigma^0}) &= -P'_{\mathcal{D}\bar{\mathcal{B}}} + \frac{1}{3}P'_{2EW\mathcal{D}\bar{\mathcal{B}}} - A'_{\mathcal{D}\bar{\mathcal{B}}}, \\
A(B^- \to \Omega^-\overline{\Xi^0}) &= \sqrt{6}P'_{\mathcal{D}\bar{\mathcal{B}}} - \sqrt{\frac{2}{3}}P'_{2EW\mathcal{D}\bar{\mathcal{B}}} + \sqrt{6}A'_{\mathcal{D}\bar{\mathcal{B}}}, \\
A(B^- \to \Xi^{*-}\bar{\Lambda}) &= \sqrt{3}P'_{\mathcal{D}\bar{\mathcal{B}}} - \frac{1}{\sqrt{3}}P'_{2EW\mathcal{D}\bar{\mathcal{B}}} + \sqrt{3}A'_{\mathcal{D}\bar{\mathcal{B}}},
\end{aligned} \tag{29}
$$

$$
\begin{aligned}
A(\bar{B}^0 \to \Sigma^{*+}\bar{p}) &= \sqrt{2}T'_{2\mathcal{D}\bar{\mathcal{B}}} + \sqrt{2}P'_{\mathcal{D}\bar{\mathcal{B}}} + \frac{2\sqrt{2}}{3}P'_{2EW\mathcal{D}\bar{\mathcal{B}}}, \\
A(\bar{B}^0 \to \Sigma^{*0}\bar{n}) &= T'_{1\mathcal{D}\bar{\mathcal{B}}} + T'_{2\mathcal{D}\bar{\mathcal{B}}} + P'_{\mathcal{D}\bar{\mathcal{B}}} + \frac{1}{3}(3P'_{1EW\mathcal{D}\bar{\mathcal{B}}} + 2P'_{2EW\mathcal{D}\bar{\mathcal{B}}}), \\
A(\bar{B}^0 \to \Xi^{*0}\overline{\Sigma^0}) &= T'_{1\mathcal{D}\bar{\mathcal{B}}} - P'_{\mathcal{D}\bar{\mathcal{B}}} + \frac{1}{3}(3P'_{1EW\mathcal{D}\bar{\mathcal{B}}} + P'_{2EW\mathcal{D}\bar{\mathcal{B}}}), \\
A(\bar{B}^0 \to \Xi^{*-}\overline{\Sigma^-}) &= -\sqrt{2}P'_{\mathcal{D}\bar{\mathcal{B}}} + \frac{\sqrt{2}}{3}P'_{2EW\mathcal{D}\bar{\mathcal{B}}}, \\
A(\bar{B}^0 \to \Omega^-\overline{\Xi^-}) &= -\sqrt{6}P'_{\mathcal{D}\bar{\mathcal{B}}} + \sqrt{\frac{2}{3}}P_{2EW\mathcal{D}\bar{\mathcal{B}}}, \\
A(\bar{B}^0 \to \Xi^{*0}\bar{\Lambda}) &= -\frac{1}{\sqrt{3}}(T'_{1\mathcal{D}\bar{\mathcal{B}}} + 2T'_{2\mathcal{D}\bar{\mathcal{B}}}) - \sqrt{3}P'_{\mathcal{D}\bar{\mathcal{B}}} - \frac{1}{\sqrt{3}}(P'_{1EW\mathcal{D}\bar{\mathcal{B}}} + P'_{2EW\mathcal{D}\bar{\mathcal{B}}}),
\end{aligned} \tag{30}
$$

and

$$
\begin{aligned}
A(\bar{B}_s^0 \to \Delta^+ \bar{p}) &= -\sqrt{2} E'_{\mathcal{D}\bar{\mathcal{B}}}, \\
A(\bar{B}_s^0 \to \Delta^0 \bar{n}) &= -\sqrt{2} E'_{\mathcal{D}\bar{\mathcal{B}}}, \\
A(\bar{B}_s^0 \to \Sigma^{*+} \overline{\Sigma^+}) &= -\sqrt{2} T'_{2\mathcal{D}\bar{\mathcal{B}}} - \sqrt{2} P'_{\mathcal{D}\bar{\mathcal{B}}} - \frac{2\sqrt{2}}{3} P'_{2EW\mathcal{D}\bar{\mathcal{B}}} + \sqrt{2} E'_{\mathcal{D}\bar{\mathcal{B}}}, \\
A(\bar{B}_s^0 \to \Sigma^{*0} \overline{\Sigma^0}) &= \frac{1}{\sqrt{2}} T'_{2\mathcal{D}\bar{\mathcal{B}}} + \sqrt{2} P'_{\mathcal{D}\bar{\mathcal{B}}} + \frac{1}{3\sqrt{2}} P'_{2EW\mathcal{D}\bar{\mathcal{B}}} - \frac{1}{\sqrt{2}} E'_{\mathcal{D}\bar{\mathcal{B}}}, \\
A(\bar{B}_s^0 \to \Sigma^{*-} \overline{\Sigma^-}) &= \sqrt{2} P'_{\mathcal{D}\bar{\mathcal{B}}} - \frac{\sqrt{2}}{3} P'_{2EW\mathcal{D}\bar{\mathcal{B}}}, \\
A(\bar{B}_s^0 \to \Xi^{*0} \overline{\Xi^0}) &= -\sqrt{2}(T'_{1\mathcal{D}\bar{\mathcal{B}}} + T'_{2\mathcal{D}\bar{\mathcal{B}}}) - \sqrt{2} P'_{\mathcal{D}\bar{\mathcal{B}}} - \frac{\sqrt{2}}{3}(3P'_{1EW\mathcal{D}\bar{\mathcal{B}}} + 2P'_{2EW\mathcal{D}\bar{\mathcal{B}}}) + \sqrt{2} E'_{\mathcal{D}\bar{\mathcal{B}}}, \\
A(\bar{B}_s^0 \to \Xi^{*-} \overline{\Xi^-}) &= \sqrt{2} P'_{\mathcal{D}\bar{\mathcal{B}}} - \frac{\sqrt{2}}{3} P'_{2EW\mathcal{D}\bar{\mathcal{B}}}, \\
A(\bar{B}_s^0 \to \Sigma^{*0} \bar{\Lambda}) &= -\frac{1}{\sqrt{6}}(2T'_{1\mathcal{D}\bar{\mathcal{B}}} + T'_{2\mathcal{D}\bar{\mathcal{B}}}) - \frac{1}{\sqrt{6}}(2P'_{1EW\mathcal{D}\bar{\mathcal{B}}} + P'_{2EW\mathcal{D}\bar{\mathcal{B}}}) + \sqrt{\frac{3}{2}} E'_{\mathcal{D}\bar{\mathcal{B}}}.
\end{aligned} \tag{31}
$$

4. $\bar{B}$ to octet-antioctet baryonic decays

The full $\bar{B} \to \mathcal{B}\bar{\mathcal{B}}$ decay amplitudes for $\Delta S = 0$ processes are given by

$$
\begin{aligned}
A(B^- \to n\bar{p}) &= -T_{1\mathcal{B}\bar{\mathcal{B}}} - 5P_{1\mathcal{B}\bar{\mathcal{B}}} + \frac{2}{3}(P_{1EW\mathcal{B}\bar{\mathcal{B}}} - P_{3EW\mathcal{B}\bar{\mathcal{B}}} + P_{4EW\mathcal{B}\bar{\mathcal{B}}}) - 5A_{1\mathcal{B}\bar{\mathcal{B}}}, \\
A(B^- \to \Sigma^0 \overline{\Sigma^+}) &= \sqrt{2} T_{3\mathcal{B}\bar{\mathcal{B}}} + \frac{1}{\sqrt{2}}(5P_{1\mathcal{B}\bar{\mathcal{B}}} - P_{2\mathcal{B}\bar{\mathcal{B}}}) + \frac{1}{3\sqrt{2}}(P_{1EW\mathcal{B}\bar{\mathcal{B}}} + P_{2EW\mathcal{B}\bar{\mathcal{B}}} + 2P_{3EW\mathcal{B}\bar{\mathcal{B}}} - 2P_{4EW\mathcal{B}\bar{\mathcal{B}}}) + \frac{1}{\sqrt{2}}(5A_{1\mathcal{B}\bar{\mathcal{B}}} - A_{2\mathcal{B}\bar{\mathcal{B}}}), \\
A(B^- \to \Sigma^- \overline{\Sigma^0}) &= -\frac{1}{\sqrt{2}}(5P_{1\mathcal{B}\bar{\mathcal{B}}} - P_{2\mathcal{B}\bar{\mathcal{B}}}) - \frac{1}{3\sqrt{2}}(P_{1EW\mathcal{B}\bar{\mathcal{B}}} + P_{2EW\mathcal{B}\bar{\mathcal{B}}} - 4P_{3EW\mathcal{B}\bar{\mathcal{B}}} - 2P_{4EW\mathcal{B}\bar{\mathcal{B}}}) - \frac{1}{\sqrt{2}}(5A_{1\mathcal{B}\bar{\mathcal{B}}} - A_{2\mathcal{B}\bar{\mathcal{B}}}), \\
A(B^- \to \Sigma^- \bar{\Lambda}) &= -\frac{1}{\sqrt{6}}(5P_{1\mathcal{B}\bar{\mathcal{B}}} + P_{2\mathcal{B}\bar{\mathcal{B}}}) - \frac{1}{3\sqrt{6}}(P_{1EW\mathcal{B}\bar{\mathcal{B}}} - P_{2EW\mathcal{B}\bar{\mathcal{B}}} - 4P_{3EW\mathcal{B}\bar{\mathcal{B}}} - 2P_{4EW\mathcal{B}\bar{\mathcal{B}}}) - \frac{1}{\sqrt{6}}(5A_{1\mathcal{B}\bar{\mathcal{B}}} + A_{2\mathcal{B}\bar{\mathcal{B}}}), \\
A(B^- \to \Xi^- \overline{\Xi^0}) &= -P_{2\mathcal{B}\bar{\mathcal{B}}} + \frac{1}{3} P_{2EW\mathcal{B}\bar{\mathcal{B}}} - A_{2\mathcal{B}\bar{\mathcal{B}}}, \\
A(B^- \to \Lambda \overline{\Sigma^+}) &= -\sqrt{\frac{2}{3}}(T_{1\mathcal{B}\bar{\mathcal{B}}} - T_{3\mathcal{B}\bar{\mathcal{B}}}) - \frac{1}{\sqrt{6}}(5P_{1\mathcal{B}\bar{\mathcal{B}}} + P_{2\mathcal{B}\bar{\mathcal{B}}}) + \frac{1}{3\sqrt{6}}(5P_{1EW\mathcal{B}\bar{\mathcal{B}}} + P_{2EW\mathcal{B}\bar{\mathcal{B}}} - 4P_{3EW\mathcal{B}\bar{\mathcal{B}}} + 2P_{4EW\mathcal{B}\bar{\mathcal{B}}}) \\
&\quad - \frac{1}{\sqrt{6}}(5A_{1\mathcal{B}\bar{\mathcal{B}}} + A_{2\mathcal{B}\bar{\mathcal{B}}}),
\end{aligned} \tag{32}
$$

$$
\begin{aligned}
A(\bar{B}^0 \to p\bar{p}) &= -T_{2\mathcal{B}\bar{\mathcal{B}}} + 2T_{4\mathcal{B}\bar{\mathcal{B}}} + P_{2\mathcal{B}\bar{\mathcal{B}}} + \frac{2}{3} P_{2EW\mathcal{B}\bar{\mathcal{B}}} - 5E_{1\mathcal{B}\bar{\mathcal{B}}} + E_{2\mathcal{B}\bar{\mathcal{B}}} - 9PA_{\mathcal{B}\bar{\mathcal{B}}}, \\
A(\bar{B}^0 \to n\bar{n}) &= -(T_{1\mathcal{B}\bar{\mathcal{B}}} + T_{2\mathcal{B}\bar{\mathcal{B}}}) - (5P_{1\mathcal{B}\bar{\mathcal{B}}} - P_{2\mathcal{B}\bar{\mathcal{B}}}) + \frac{2}{3}(P_{1EW\mathcal{B}\bar{\mathcal{B}}} + P_{2EW\mathcal{B}\bar{\mathcal{B}}} - P_{3EW\mathcal{B}\bar{\mathcal{B}}} - 2P_{4EW\mathcal{B}\bar{\mathcal{B}}}) + E_{2\mathcal{B}\bar{\mathcal{B}}} - 9PA_{\mathcal{B}\bar{\mathcal{B}}}, \\
A(\bar{B}^0 \to \Sigma^+ \overline{\Sigma^+}) &= -5E_{1\mathcal{B}\bar{\mathcal{B}}} + E_{2\mathcal{B}\bar{\mathcal{B}}} - 9PA_{\mathcal{B}\bar{\mathcal{B}}}, \\
A(\bar{B}^0 \to \Sigma^0 \overline{\Sigma^0}) &= -T_{3\mathcal{B}\bar{\mathcal{B}}} - \frac{1}{2}(5P_{1\mathcal{B}\bar{\mathcal{B}}} - P_{2\mathcal{B}\bar{\mathcal{B}}}) - \frac{1}{6}(P_{1EW\mathcal{B}\bar{\mathcal{B}}} + P_{2EW\mathcal{B}\bar{\mathcal{B}}} + 2P_{3EW\mathcal{B}\bar{\mathcal{B}}} - 2P_{4EW\mathcal{B}\bar{\mathcal{B}}}) \\
&\quad - \frac{1}{2}(5E_{1\mathcal{B}\bar{\mathcal{B}}} - E_{2\mathcal{B}\bar{\mathcal{B}}}) - 9PA_{\mathcal{B}\bar{\mathcal{B}}},
\end{aligned}
$$

$$\begin{aligned}
A(\bar{B}^0\to\Sigma^0\bar{\Lambda}) &= \frac{1}{\sqrt{3}}(T_{3\mathcal{B}\bar{\mathcal{B}}}+2T_{4\mathcal{B}\bar{\mathcal{B}}})+\frac{1}{2\sqrt{3}}(5P_{1\mathcal{B}\bar{\mathcal{B}}}+P_{2\mathcal{B}\bar{\mathcal{B}}})+\frac{1}{6\sqrt{3}}(P_{1EW\mathcal{B}\bar{\mathcal{B}}}-P_{2EW\mathcal{B}\bar{\mathcal{B}}}+2P_{3EW\mathcal{B}\bar{\mathcal{B}}}+10P_{4EW\mathcal{B}\bar{\mathcal{B}}})\\
&\quad -\frac{1}{2\sqrt{3}}(5E_{1\mathcal{B}\bar{\mathcal{B}}}+E_{2\mathcal{B}\bar{\mathcal{B}}}),\\
A(\bar{B}^0\to\Sigma^-\overline{\Sigma^-}) &= -(5P_{1\mathcal{B}\bar{\mathcal{B}}}-P_{2\mathcal{B}\bar{\mathcal{B}}})-\frac{1}{3}(P_{1EW\mathcal{B}\bar{\mathcal{B}}}+P_{2EW\mathcal{B}\bar{\mathcal{B}}}-4P_{3EW\mathcal{B}\bar{\mathcal{B}}}-2P_{4EW\mathcal{B}\bar{\mathcal{B}}})-9PA_{\mathcal{B}\bar{\mathcal{B}}},\\
A(\bar{B}^0\to\Xi^0\overline{\Xi^0}) &= E_{2\mathcal{B}\bar{\mathcal{B}}}-9PA_{\mathcal{B}\bar{\mathcal{B}}},\quad A(\bar{B}^0\to\Xi^-\overline{\Xi^-})=P_{2\mathcal{B}\bar{\mathcal{B}}}-\frac{1}{3}P_{2EW\mathcal{B}\bar{\mathcal{B}}}-9PA_{\mathcal{B}\bar{\mathcal{B}}},\\
A(\bar{B}^0\to\Lambda\overline{\Sigma^0}) &= \frac{1}{\sqrt{3}}(T_{1\mathcal{B}\bar{\mathcal{B}}}-T_{3\mathcal{B}\bar{\mathcal{B}}})+\frac{1}{2\sqrt{3}}(5P_{1\mathcal{B}\bar{\mathcal{B}}}+P_{2\mathcal{B}\bar{\mathcal{B}}})-\frac{1}{6\sqrt{3}}(5P_{1EW\mathcal{B}\bar{\mathcal{B}}}+P_{2EW\mathcal{B}\bar{\mathcal{B}}}-2P_{3EW\mathcal{B}\bar{\mathcal{B}}}+2P_{4EW\mathcal{B}\bar{\mathcal{B}}})\\
&\quad -\frac{1}{2\sqrt{3}}(5E_{1\mathcal{B}\bar{\mathcal{B}}}+E_{2\mathcal{B}\bar{\mathcal{B}}}),\\
A(\bar{B}^0\to\Lambda\bar{\Lambda}) &= -\frac{1}{3}(T_{1\mathcal{B}\bar{\mathcal{B}}}+2T_{2\mathcal{B}\bar{\mathcal{B}}}-T_{3\mathcal{B}\bar{\mathcal{B}}}-2T_{4\mathcal{B}\bar{\mathcal{B}}})-\frac{5}{6}(P_{1\mathcal{B}\bar{\mathcal{B}}}-P_{2\mathcal{B}\bar{\mathcal{B}}})\\
&\quad +\frac{1}{18}(5P_{1EW\mathcal{B}\bar{\mathcal{B}}}+7P_{2EW\mathcal{B}\bar{\mathcal{B}}}-2P_{3EW\mathcal{B}\bar{\mathcal{B}}}-10P_{4EW\mathcal{B}\bar{\mathcal{B}}})-\frac{5}{6}(E_{1\mathcal{B}\bar{\mathcal{B}}}-E_{2\mathcal{B}\bar{\mathcal{B}}})-9PA_{\mathcal{B}\bar{\mathcal{B}}},
\end{aligned}\tag{33}$$

and

$$\begin{aligned}
A(\bar{B}^0_s\to p\overline{\Sigma^+}) &= T_{2\mathcal{B}\bar{\mathcal{B}}}-2T_{4\mathcal{B}\bar{\mathcal{B}}}-P_{2\mathcal{B}\bar{\mathcal{B}}}-\frac{2}{3}P_{2EW\mathcal{B}\bar{\mathcal{B}}},\\
A(\bar{B}^0_s\to n\overline{\Sigma^0}) &= -\frac{1}{\sqrt{2}}T_{2\mathcal{B}\bar{\mathcal{B}}}+\frac{1}{\sqrt{2}}P_{2\mathcal{B}\bar{\mathcal{B}}}+\frac{\sqrt{2}}{3}(P_{2EW\mathcal{B}\bar{\mathcal{B}}}-3P_{4EW\mathcal{B}\bar{\mathcal{B}}}),\\
A(\bar{B}^0_s\to n\bar{\Lambda}) &= \frac{1}{\sqrt{6}}(2T_{1\mathcal{B}\bar{\mathcal{B}}}+T_{2\mathcal{B}\bar{\mathcal{B}}})+\frac{1}{\sqrt{6}}(10P_{1\mathcal{B}\bar{\mathcal{B}}}-P_{2\mathcal{B}\bar{\mathcal{B}}})-\frac{1}{3}\sqrt{\frac{2}{3}}(2P_{1EW\mathcal{B}\bar{\mathcal{B}}}+P_{2EW\mathcal{B}\bar{\mathcal{B}}}-2P_{3EW\mathcal{B}\bar{\mathcal{B}}}-P_{4EW\mathcal{B}\bar{\mathcal{B}}}),\\
A(\bar{B}^0_s\to\Sigma^0\overline{\Xi^0}) &= \sqrt{2}(T_{3\mathcal{B}\bar{\mathcal{B}}}+T_{4\mathcal{B}\bar{\mathcal{B}}})+\frac{5}{\sqrt{2}}P_{1\mathcal{B}\bar{\mathcal{B}}}+\frac{1}{3\sqrt{2}}(P_{1EW\mathcal{B}\bar{\mathcal{B}}}+2P_{3EW\mathcal{B}\bar{\mathcal{B}}}+4P_{4EW\mathcal{B}\bar{\mathcal{B}}}),\\
A(\bar{B}^0_s\to\Sigma^-\overline{\Xi^-}) &= -5P_{1\mathcal{B}\bar{\mathcal{B}}}+\frac{1}{3}(-P_{1EW\mathcal{B}\bar{\mathcal{B}}}+4P_{3EW\mathcal{B}\bar{\mathcal{B}}}+2P_{4EW\mathcal{B}\bar{\mathcal{B}}}),\\
A(\bar{B}^0_s\to\Lambda\overline{\Xi^0}) &= -\sqrt{\frac{2}{3}}(T_{1\mathcal{B}\bar{\mathcal{B}}}+T_{2\mathcal{B}\bar{\mathcal{B}}}-T_{3\mathcal{B}\bar{\mathcal{B}}}-T_{4\mathcal{B}\bar{\mathcal{B}}})-\frac{1}{\sqrt{6}}(5P_{1\mathcal{B}\bar{\mathcal{B}}}-2P_{2\mathcal{B}\bar{\mathcal{B}}})\\
&\quad +\frac{1}{3\sqrt{6}}(5P_{1EW\mathcal{B}\bar{\mathcal{B}}}+4P_{2EW\mathcal{B}\bar{\mathcal{B}}}-2P_{3EW\mathcal{B}\bar{\mathcal{B}}}-4P_{4EW\mathcal{B}\bar{\mathcal{B}}}),
\end{aligned}\tag{34}$$

while those for $\Delta S=1$ transitions are given by

$$\begin{aligned}
A(B^-\to\Sigma^0\bar{p}) &= -\frac{1}{\sqrt{2}}(T'_{1\mathcal{B}\bar{\mathcal{B}}}-2T'_{3\mathcal{B}\bar{\mathcal{B}}})-\frac{1}{\sqrt{2}}P'_{2\mathcal{B}\bar{\mathcal{B}}}+\frac{1}{3\sqrt{2}}(3P'_{1EW\mathcal{B}\bar{\mathcal{B}}}+P'_{2EW\mathcal{B}\bar{\mathcal{B}}})-\frac{1}{\sqrt{2}}A'_{2\mathcal{B}\bar{\mathcal{B}}},\\
A(B^-\to\Sigma^-\bar{n}) &= -P'_{2\mathcal{B}\bar{\mathcal{B}}}+\frac{1}{3}P'_{2EW\mathcal{B}\bar{\mathcal{B}}}-A'_{2\mathcal{B}\bar{\mathcal{B}}},\\
A(B^-\to\Xi^0\overline{\Sigma^+}) &= -T'_{1\mathcal{B}\bar{\mathcal{B}}}-5P'_{1\mathcal{B}\bar{\mathcal{B}}}+\frac{2}{3}(P'_{1EW\mathcal{B}\bar{\mathcal{B}}}-P'_{3EW\mathcal{B}\bar{\mathcal{B}}}+P'_{4EW\mathcal{B}\bar{\mathcal{B}}})-5A'_{1\mathcal{B}\bar{\mathcal{B}}},\\
A(B^-\to\Xi^-\overline{\Sigma^0}) &= -\frac{5}{\sqrt{2}}P'_{1\mathcal{B}\bar{\mathcal{B}}}-\frac{1}{3\sqrt{2}}(P'_{1EW\mathcal{B}\bar{\mathcal{B}}}-4P'_{3EW\mathcal{B}\bar{\mathcal{B}}}-2P'_{4EW\mathcal{B}\bar{\mathcal{B}}})-\frac{5}{\sqrt{2}}A'_{1\mathcal{B}\bar{\mathcal{B}}},
\end{aligned}$$

$$A(B^-\to\Xi^-\bar\Lambda)=-\frac{1}{\sqrt6}(5P'_{1\mathcal{B}\bar{\mathcal{B}}}-2P'_{2\mathcal{B}\bar{\mathcal{B}}})-\frac{1}{3\sqrt6}(P'_{1EW\mathcal{B}\bar{\mathcal{B}}}+2P'_{2EW\mathcal{B}\bar{\mathcal{B}}}-4P'_{3EW\mathcal{B}\bar{\mathcal{B}}}-2P'_{4EW\mathcal{B}\bar{\mathcal{B}}})-\frac{1}{\sqrt6}(5A'_{1\mathcal{B}\bar{\mathcal{B}}}-2A'_{2\mathcal{B}\bar{\mathcal{B}}}),$$

$$\begin{aligned}A(B^-\to\Lambda\bar p)={}&\frac{1}{\sqrt6}(T'_{1\mathcal{B}\bar{\mathcal{B}}}+2T'_{3\mathcal{B}\bar{\mathcal{B}}})+\frac{1}{\sqrt6}(10P'_{1\mathcal{B}\bar{\mathcal{B}}}-P'_{2\mathcal{B}\bar{\mathcal{B}}})-\frac{1}{3\sqrt6}(P'_{1EW\mathcal{B}\bar{\mathcal{B}}}-P'_{2EW\mathcal{B}\bar{\mathcal{B}}}-4P'_{3EW\mathcal{B}\bar{\mathcal{B}}}+4P'_{4EW\mathcal{B}\bar{\mathcal{B}}})\\&+\frac{1}{\sqrt6}(10A'_{1\mathcal{B}\bar{\mathcal{B}}}-A'_{2\mathcal{B}\bar{\mathcal{B}}}),\end{aligned}\tag{35}$$

$$\begin{aligned}A(\bar B^0\to\Sigma^+\bar p)&=T'_{2\mathcal{B}\bar{\mathcal{B}}}-2T'_{4\mathcal{B}\bar{\mathcal{B}}}-P'_{2\mathcal{B}\bar{\mathcal{B}}}-\frac23P'_{2EW\mathcal{B}\bar{\mathcal{B}}},\\
A(\bar B^0\to\Sigma^0\bar n)&=-\frac{1}{\sqrt2}(T'_{1\mathcal{B}\bar{\mathcal{B}}}+T'_{2\mathcal{B}\bar{\mathcal{B}}}-2T'_{3\mathcal{B}\bar{\mathcal{B}}}-2T'_{4\mathcal{B}\bar{\mathcal{B}}})+\frac{1}{\sqrt2}P'_{2\mathcal{B}\bar{\mathcal{B}}}+\frac{1}{3\sqrt2}(3P'_{1EW\mathcal{B}\bar{\mathcal{B}}}+2P'_{2EW\mathcal{B}\bar{\mathcal{B}}}),\\
A(\bar B^0\to\Xi^0\overline{\Sigma^0})&=\frac{1}{\sqrt2}T'_{1\mathcal{B}\bar{\mathcal{B}}}+\frac{5}{\sqrt2}P'_{1\mathcal{B}\bar{\mathcal{B}}}-\frac{\sqrt2}{3}(P'_{1EW\mathcal{B}\bar{\mathcal{B}}}-P'_{3EW\mathcal{B}\bar{\mathcal{B}}}+P'_{4EW\mathcal{B}\bar{\mathcal{B}}}),\\
A(\bar B^0\to\Xi^0\bar\Lambda)&=-\frac{1}{\sqrt6}(T'_{1\mathcal{B}\bar{\mathcal{B}}}+2T'_{2\mathcal{B}\bar{\mathcal{B}}})-\frac{1}{\sqrt6}(5P'_{1\mathcal{B}\bar{\mathcal{B}}}-2P'_{2\mathcal{B}\bar{\mathcal{B}}})+\frac13\sqrt{\frac23}(P'_{1EW\mathcal{B}\bar{\mathcal{B}}}+2P'_{2EW\mathcal{B}\bar{\mathcal{B}}}-P'_{3EW\mathcal{B}\bar{\mathcal{B}}}-5P'_{4EW\mathcal{B}\bar{\mathcal{B}}}),\\
A(\bar B^0\to\Xi^-\overline{\Sigma^-})&=-5P'_{1\mathcal{B}\bar{\mathcal{B}}}-\frac13(P'_{1EW\mathcal{B}\bar{\mathcal{B}}}-4P'_{3EW\mathcal{B}\bar{\mathcal{B}}}-2P'_{4EW\mathcal{B}\bar{\mathcal{B}}}),\\
A(\bar B^0\to\Lambda\bar n)&=\frac{1}{\sqrt6}(T'_{1\mathcal{B}\bar{\mathcal{B}}}+T'_{2\mathcal{B}\bar{\mathcal{B}}}+2T'_{3\mathcal{B}\bar{\mathcal{B}}}+2T'_{4\mathcal{B}\bar{\mathcal{B}}})+\frac{1}{\sqrt6}(10P'_{1\mathcal{B}\bar{\mathcal{B}}}-P'_{2\mathcal{B}\bar{\mathcal{B}}})\\
&\quad-\frac{1}{3\sqrt6}(P'_{1EW\mathcal{B}\bar{\mathcal{B}}}+2P'_{2EW\mathcal{B}\bar{\mathcal{B}}}-4P'_{3EW\mathcal{B}\bar{\mathcal{B}}}-8P'_{4EW\mathcal{B}\bar{\mathcal{B}}}),\end{aligned}\tag{36}$$

and

$$\begin{aligned}A(\bar B^0_s\to p\bar p)&=-5E'_{1\mathcal{B}\bar{\mathcal{B}}}+E'_{2\mathcal{B}\bar{\mathcal{B}}}-9PA'_{\mathcal{B}\bar{\mathcal{B}}},\\
A(\bar B^0_s\to n\bar n)&=E'_{2\mathcal{B}\bar{\mathcal{B}}}-9PA'_{\mathcal{B}\bar{\mathcal{B}}},\\
A(\bar B^0_s\to\Sigma^+\overline{\Sigma^+})&=-T'_{2\mathcal{B}\bar{\mathcal{B}}}+2T'_{4\mathcal{B}\bar{\mathcal{B}}}+P'_{2\mathcal{B}\bar{\mathcal{B}}}+\frac23P'_{2EW\mathcal{B}\bar{\mathcal{B}}}-5E'_{1\mathcal{B}\bar{\mathcal{B}}}+E'_{2\mathcal{B}\bar{\mathcal{B}}}-9PA'_{\mathcal{B}\bar{\mathcal{B}}},\\
A(\bar B^0_s\to\Sigma^0\overline{\Sigma^0})&=-\frac12(T'_{2\mathcal{B}\bar{\mathcal{B}}}-2T'_{4\mathcal{B}\bar{\mathcal{B}}})+P'_{2\mathcal{B}\bar{\mathcal{B}}}+\frac16P'_{2EW\mathcal{B}\bar{\mathcal{B}}}-\frac12(5E'_{1\mathcal{B}\bar{\mathcal{B}}}-E'_{2\mathcal{B}\bar{\mathcal{B}}})-9PA'_{\mathcal{B}\bar{\mathcal{B}}},\\
A(\bar B^0_s\to\Sigma^0\bar\Lambda)&=\frac{1}{2\sqrt3}(2T'_{1\mathcal{B}\bar{\mathcal{B}}}+T'_{2\mathcal{B}\bar{\mathcal{B}}}-4T'_{3\mathcal{B}\bar{\mathcal{B}}}-2T'_{4\mathcal{B}\bar{\mathcal{B}}})-\frac{1}{2\sqrt3}(2P'_{1EW\mathcal{B}\bar{\mathcal{B}}}+P'_{2EW\mathcal{B}\bar{\mathcal{B}}})-\frac{1}{2\sqrt3}(5E'_{1\mathcal{B}\bar{\mathcal{B}}}+E'_{2\mathcal{B}\bar{\mathcal{B}}}),\\
A(\bar B^0_s\to\Sigma^-\overline{\Sigma^-})&=P'_{2\mathcal{B}\bar{\mathcal{B}}}-\frac13P'_{2EW\mathcal{B}\bar{\mathcal{B}}}-9PA'_{\mathcal{B}\bar{\mathcal{B}}},\\
A(\bar B^0_s\to\Xi^0\overline{\Xi^0})&=-T'_{1\mathcal{B}\bar{\mathcal{B}}}-T'_{2\mathcal{B}\bar{\mathcal{B}}}-(5P'_{1\mathcal{B}\bar{\mathcal{B}}}-P'_{2\mathcal{B}\bar{\mathcal{B}}})+\frac23(P'_{1EW\mathcal{B}\bar{\mathcal{B}}}+P'_{2EW\mathcal{B}\bar{\mathcal{B}}}-P'_{3EW\mathcal{B}\bar{\mathcal{B}}}-2P'_{4EW\mathcal{B}\bar{\mathcal{B}}})+E'_{2\mathcal{B}\bar{\mathcal{B}}}-9PA'_{\mathcal{B}\bar{\mathcal{B}}},\\
A(\bar B^0_s\to\Xi^-\overline{\Xi^-})&=-(5P'_{1\mathcal{B}\bar{\mathcal{B}}}-P'_{2\mathcal{B}\bar{\mathcal{B}}})-\frac13(P'_{1EW\mathcal{B}\bar{\mathcal{B}}}+P'_{2EW\mathcal{B}\bar{\mathcal{B}}}-4P'_{3EW\mathcal{B}\bar{\mathcal{B}}}-2P'_{4EW\mathcal{B}\bar{\mathcal{B}}})-9PA'_{\mathcal{B}\bar{\mathcal{B}}},\\
A(\bar B^0_s\to\Lambda\overline{\Sigma^0})&=\frac{1}{2\sqrt3}(T'_{2\mathcal{B}\bar{\mathcal{B}}}+2T'_{4\mathcal{B}\bar{\mathcal{B}}})+\frac{1}{2\sqrt3}(-P'_{2EW\mathcal{B}\bar{\mathcal{B}}}+4P'_{4EW\mathcal{B}\bar{\mathcal{B}}})-\frac{1}{2\sqrt3}(5E'_{1\mathcal{B}\bar{\mathcal{B}}}+E'_{2\mathcal{B}\bar{\mathcal{B}}}),\\
A(\bar B^0_s\to\Lambda\bar\Lambda)&=-\frac16(2T'_{1\mathcal{B}\bar{\mathcal{B}}}+T'_{2\mathcal{B}\bar{\mathcal{B}}}+4T'_{3\mathcal{B}\bar{\mathcal{B}}}+2T'_{4\mathcal{B}\bar{\mathcal{B}}})-\frac13(10P'_{1\mathcal{B}\bar{\mathcal{B}}}-P'_{2\mathcal{B}\bar{\mathcal{B}}})\\
&\quad+\frac{1}{18}(2P'_{1EW\mathcal{B}\bar{\mathcal{B}}}+P'_{2EW\mathcal{B}\bar{\mathcal{B}}}-8P'_{3EW\mathcal{B}\bar{\mathcal{B}}}-4P'_{4EW\mathcal{B}\bar{\mathcal{B}}})-\frac56(E'_{1\mathcal{B}\bar{\mathcal{B}}}-E'_{2\mathcal{B}\bar{\mathcal{B}}})-9PA'_{\mathcal{B}\bar{\mathcal{B}}}.\end{aligned}\tag{37}$$

C. Large m_B limit

Using the chirality structure of $H_{\rm eff}$ in Eq. (3) and large m_B limit, topological amplitudes are related [9,34]. As shown in the Appendix A we have

$$\begin{aligned}
T^{(\prime)} &\equiv T^{(\prime)}_{\mathcal{D}\bar{\mathcal{D}}} = T^{(\prime)}_{1\mathcal{B}\bar{\mathcal{D}},2\mathcal{B}\bar{\mathcal{D}}} = T^{(\prime)}_{1\mathcal{D}\bar{\mathcal{B}},2\mathcal{D}\bar{\mathcal{B}}} = T^{(\prime)}_{1\mathcal{B}\bar{\mathcal{B}},2\mathcal{B}\bar{\mathcal{B}},3\mathcal{B}\bar{\mathcal{B}},4\mathcal{B}\bar{\mathcal{B}}},\\
P^{(\prime)} &\equiv P^{(\prime)}_{\mathcal{D}\bar{\mathcal{D}}} = P^{(\prime)}_{\mathcal{B}\bar{\mathcal{D}}} = P^{(\prime)}_{\mathcal{D}\bar{\mathcal{B}}} = P^{(\prime)}_{1\mathcal{B}\bar{\mathcal{B}},2\mathcal{B}\bar{\mathcal{B}}},\\
P^{(\prime)}_{EW} &\equiv P^{(\prime)}_{EW\mathcal{D}\bar{\mathcal{D}}} = P^{(\prime)}_{1EW\mathcal{B}\bar{\mathcal{D}},2EW\mathcal{B}\bar{\mathcal{D}}} = P^{(\prime)}_{1EW\mathcal{D}\bar{\mathcal{B}},2EW\mathcal{D}\bar{\mathcal{B}}}\\
&= P^{(\prime)}_{1EW\mathcal{B}\bar{\mathcal{B}},2EW\mathcal{B}\bar{\mathcal{B}},3EW\mathcal{B}\bar{\mathcal{B}},4EW\mathcal{B}\bar{\mathcal{B}}},\\
&E_{\mathcal{D}\bar{\mathcal{D}},\mathcal{B}\bar{\mathcal{D}},\mathcal{D}\bar{\mathcal{B}},1\mathcal{B}\bar{\mathcal{B}},2\mathcal{B}\bar{\mathcal{B}}}, A_{\mathcal{D}\bar{\mathcal{D}},\mathcal{B}\bar{\mathcal{D}},\mathcal{D}\bar{\mathcal{B}},1\mathcal{B}\bar{\mathcal{B}},2\mathcal{B}\bar{\mathcal{B}}},\\
&PA_{\mathcal{D}\bar{\mathcal{D}},\mathcal{B}\bar{\mathcal{B}}} \to 0, \qquad (38)
\end{aligned}$$

in the large m_B asymptotic limit. In that limit, we need only one tree, one penguin and one electroweak penguin amplitudes for all four classes of charmless two-body baryonic modes. The asymptotic decay amplitudes can be easily read out using the results shown in the previous subsection and Eq. (38).

Using Eq. (3) these amplitudes are estimated to be

$$\begin{aligned}
T^{(\prime)} &= V_{ub}V^*_{ud(s)}\frac{G_f}{\sqrt{2}}(c_1-c_2)\chi\bar{u}'(1-\gamma_5)v,\\
P^{(\prime)} &= -V_{tb}V^*_{td(s)}\frac{G_f}{\sqrt{2}}[c_3-c_4+c_5-c_6]\chi\bar{u}'(1-\gamma_5)v,\\
P^{(\prime)}_{EW} &= -\frac{3}{2}V_{tb}V^*_{td(s)}\frac{G_f}{\sqrt{2}}[c_9-c_{10}+c_7-c_8]\chi\bar{u}'(1-\gamma_5)v. \qquad (39)
\end{aligned}$$

The minus signs between Wilson coefficients are from the color structure. Note that $O_{1,3,9}$, and similarly $O_{2,4,10}$, are only different on the flavor structure, their contributions are related in the large m_B limit (see e_T, e_{P_L}, $e_{P_{EWL}}$ in Appendix A). Similarly contributions from $O_{5,6}$ and $O_{7,8}$ are related.

The unknown amplitude χ will be fitted from the recent $\bar{B}^0\to p\bar{p}$ data.

III. PHENOMENOLOGY

A. Relations on rates and A_{CP}

From the full topological amplitude expressions of decay amplitudes, we can obtain relation on averaged rates and rate differences, as the number of modes are greater than the number of the independent amplitudes (see Appendix B).

For decuplet-antidecuplet modes, we have

$$\begin{aligned}
2\mathcal{B}(B^-\to\Delta^-\overline{\Delta^0}) &= 3\mathcal{B}(B^-\to\Sigma^{*-}\overline{\Sigma^{*0}})\\
&= 6\mathcal{B}(B^-\to\Xi^{*-}\overline{\Xi^{*0}}),\\
\mathcal{B}(B^-\to\Delta^0\overline{\Delta^+}) &= 2\mathcal{B}(B^-\to\Sigma^{*0}\overline{\Sigma^{*+}}),\\
6\mathcal{B}(B^-\to\Sigma^{*-}\overline{\Delta^0}) &= 2\mathcal{B}(B^-\to\Omega^-\overline{\Xi^{*0}})\\
&= 3\mathcal{B}(B^-\to\Xi^{*-}\overline{\Sigma^{*0}}),\\
2\mathcal{B}(B^-\to\Sigma^{*0}\overline{\Delta^+}) &= \mathcal{B}(B^-\to\Xi^{*0}\overline{\Sigma^{*+}}),\\
\mathcal{B}(\bar{B}^0_s\to\Delta^0\overline{\Sigma^{*0}}) &= \mathcal{B}(\overline{B^0_s}\to\Sigma^{*0}\overline{\Xi^{*0}}),\\
4\mathcal{B}(\bar{B}^0_s\to\Delta^-\overline{\Sigma^{*-}}) &= 4\mathcal{B}(\overline{B^0_s}\to\Xi^{*-}\overline{\Omega^-})\\
&= 3\mathcal{B}(\overline{B^0_s}\to\Sigma^{*-}\overline{\Xi^{*-}}),\\
\mathcal{B}(\bar{B}^0\to\Sigma^{*0}\overline{\Delta^0}) &= \mathcal{B}(\bar{B}^0\to\Xi^{*0}\overline{\Sigma^{*0}}),\\
4\mathcal{B}(\bar{B}^0\to\Sigma^{*-}\overline{\Delta^-}) &= 4\mathcal{B}(\bar{B}^0\to\Xi^{*-}\overline{\Sigma^{*-}})\\
&= 3\mathcal{B}(\bar{B}^0\to\Omega^-\overline{\Xi^{*-}}). \qquad (40)
\end{aligned}$$

Under U-spin symmetry, [40], using $\mathrm{Im}(V_{ub}V^*_{ud}V^*_{tb}V_{td}) = -\mathrm{Im}(V_{ub}V^*_{us}V^*_{tb}V_{ts})$ and the expressions of amplitudes, we obtain

$$\begin{aligned}
2\Delta_{CP}(B^-\to\Delta^-\overline{\Delta^0}) &= 3\Delta_{CP}(B^-\to\Sigma^{*-}\overline{\Sigma^{*0}}) = 6\Delta_{CP}(B^-\to\Xi^{*-}\overline{\Xi^{*0}})\\
&= -6\Delta_{CP}(B^-\to\Sigma^{*-}\overline{\Delta^0}) = -2\Delta_{CP}(B^-\to\Omega^-\overline{\Xi^{*0}})\\
&= -3\Delta_{CP}(B^-\to\Xi^{*-}\overline{\Sigma^{*0}}),\\
\Delta_{CP}(B^-\to\Delta^0\overline{\Delta^+}) &= 2\Delta_{CP}(B^-\to\Sigma^{*0}\overline{\Sigma^{*+}}) = -2\Delta_{CP}(B^-\to\Sigma^{*0}\overline{\Delta^+})\\
&= -\Delta_{CP}(B^-\to\Xi^{*0}\overline{\Sigma^{*+}}),\\
\Delta_{CP}(B^-\to\Delta^+\overline{\Delta^{++}}) &= -\Delta_{CP}(B^-\to\Sigma^{*+}\overline{\Delta^{++}}),\\
\Delta_{CP}(\overline{B^0_s}\to\Delta^0\overline{\Sigma^{*0}}) &= \Delta_{CP}(\overline{B^0_s}\to\Sigma^{*0}\overline{\Xi^{*0}}) = -\Delta_{CP}(\bar{B}^0\to\Sigma^{*0}\overline{\Delta^0})\\
&= -\Delta_{CP}(\bar{B}^0\to\Xi^{*0}\overline{\Sigma^{*0}}),\\
4\Delta_{CP}(\overline{B^0_s}\to\Delta^-\overline{\Sigma^{*-}}) &= 4\Delta_{CP}(\overline{B^0_s}\to\Xi^{*-}\overline{\Omega^-}) = 3\Delta_{CP}(\overline{B^0_s}\to\Sigma^{*-}\overline{\Xi^{*-}})\\
&= -4\Delta_{CP}(\bar{B}^0\to\Sigma^{*-}\overline{\Delta^-}) = -4\Delta_{CP}(\bar{B}^0\to\Xi^{*-}\overline{\Sigma^{*-}})\\
&= -3\Delta_{CP}(\bar{B}^0\to\Omega^-\overline{\Xi^{*-}}),
\end{aligned}$$

$$
\begin{aligned}
\Delta_{CP}(\overline{B_s^0}\to\Delta^+\overline{\Sigma^{*+}}) &= -\Delta_{CP}(\bar B^0\to\Sigma^{*+}\overline{\Delta^+}),\\
\Delta_{CP}(\overline{B^0}\to\Xi^{*0}\overline{\Xi^{*0}}) &= -\Delta_{CP}(\bar B_s^0\to\Delta^0\overline{\Delta^0}),\\
\Delta_{CP}(\overline{B^0}\to\Xi^{*-}\overline{\Xi^{*-}}) &= -\Delta_{CP}(\bar B_s^0\to\Sigma^{*-}\overline{\Sigma^{*-}}),\\
\Delta_{CP}(\overline{B^0}\to\Sigma^{*0}\overline{\Sigma^{*0}}) &= -\Delta_{CP}(\bar B_s^0\to\Sigma^{*0}\overline{\Sigma^{*0}}),\\
\Delta_{CP}(\overline{B^0}\to\Omega^-\overline{\Omega^-}) &= -\Delta_{CP}(\bar B_s^0\to\Delta^-\overline{\Delta^-}),\\
\Delta_{CP}(\overline{B^0}\to\Delta^{++}\overline{\Delta^{++}}) &= -\Delta_{CP}(\bar B_s^0\to\Delta^{++}\overline{\Delta^{++}}),\\
\Delta_{CP}(\overline{B^0}\to\Sigma^{*+}\overline{\Sigma^{*+}}) &= -\Delta_{CP}(\bar B_s^0\to\Delta^+\overline{\Delta^+}),\\
\Delta_{CP}(\overline{B^0}\to\Delta^-\overline{\Delta^-}) &= -\Delta_{CP}(\bar B_s^0\to\Omega^-\overline{\Omega^-}),\\
\Delta_{CP}(\overline{B^0}\to\Sigma^{*-}\overline{\Sigma^{*-}}) &= -\Delta_{CP}(\bar B_s^0\to\Xi^{*-}\overline{\Xi^{*-}}),\\
\Delta_{CP}(\overline{B^0}\to\Delta^+\overline{\Delta^+}) &= -\Delta_{CP}(\bar B_s^0\to\Sigma^{*+}\overline{\Sigma^{*+}}),\\
\Delta_{CP}(\overline{B^0}\to\Delta^0\overline{\Delta^0}) &= -\Delta_{CP}(\bar B_s^0\to\Xi^{*0}\overline{\Xi^{*0}}),
\end{aligned}
\tag{41}
$$

where Δ_{CP} is defined as the $\bar B_q$ decay rate subtracted by the rate of the CP conjugated mode.

For octet-antidecuplet modes, we have

$$
\begin{aligned}
\mathcal{B}(B^-\to\Xi^-\overline{\Xi^{*0}}) &= 2\mathcal{B}(B^-\to\Sigma^-\overline{\Sigma^{*0}}),\\
2\mathcal{B}(B^-\to\Xi^-\overline{\Sigma^{*0}}) &= \mathcal{B}(B^-\to\Sigma^-\overline{\Delta^0}),\\
3\tau_{B_d}\mathcal{B}(\bar B^0\to\Sigma^-\overline{\Sigma^{*-}}) &= 3\tau_{B_d}\mathcal{B}(\bar B^0\to\Xi^-\overline{\Xi^{*-}}) = 3\tau_{B_s}\mathcal{B}(\bar B_s^0\to\Sigma^-\overline{\Xi^{*-}}) = \tau_{B_s}\mathcal{B}(\bar B_s^0\to\Xi^-\overline{\Omega^-}),\\
3\tau_{B_s}\mathcal{B}(\bar B_s^0\to\Sigma^-\overline{\Sigma^{*-}}) &= 3\tau_{B_s}\mathcal{B}(\bar B_s^0\to\Xi^-\overline{\Xi^{*-}}) = 3\tau_{B_d}\mathcal{B}(\bar B^0\to\Xi^-\overline{\Sigma^{*-}}) = \tau_{B_d}\mathcal{B}(\bar B^0\to\Sigma^-\overline{\Delta^-}),\\
\mathcal{B}(\bar B^0\to\Sigma^+\overline{\Sigma^{*+}}) &= \mathcal{B}(\bar B^0\to\Xi^0\overline{\Xi^{*0}}),\\
\mathcal{B}(\bar B_s^0\to p\overline{\Delta^+}) &= \mathcal{B}(\bar B_s^0\to n\overline{\Delta^0}),
\end{aligned}
\tag{42}
$$

and

$$
\begin{aligned}
\Delta_{CP}(B^-\to n\overline{\Delta^+}) &= -\Delta_{CP}(B^-\to\Xi^0\overline{\Sigma^{*+}}),\\
\Delta_{CP}(B^-\to\Xi^-\overline{\Xi^{*0}}) &= 2\Delta_{CP}(B^-\to\Sigma^-\overline{\Sigma^{*0}}) = -2\Delta_{CP}(B^-\to\Xi^-\overline{\Sigma^{*0}}) = -\Delta_{CP}(B^-\to\Sigma^-\overline{\Delta^0}),\\
\Delta_{CP}(B^-\to p\overline{\Delta^{++}}) &= -\Delta_{CP}(B^-\to\Sigma^+\overline{\Delta^{++}}),\\
\Delta_{CP}(\bar B^0\to n\overline{\Delta^0}) &= -\Delta_{CP}(\bar B_s^0\to\Xi^0\overline{\Xi^{*0}}),\\
3\Delta_{CP}(\bar B^0\to\Sigma^-\overline{\Sigma^{*-}}) &= 3\Delta_{CP}(\bar B^0\to\Xi^-\overline{\Xi^{*-}}) = 3\Delta_{CP}(\bar B_s^0\to\Sigma^-\overline{\Xi^{*-}}) = \Delta_{CP}(\bar B_s^0\to\Xi^-\overline{\Omega^-}) = -3\Delta_{CP}(\bar B_s^0\to\Sigma^-\overline{\Sigma^{*-}})\\
&= -3\Delta_{CP}(\bar B_s^0\to\Xi^-\overline{\Xi^{*-}}) = -3\Delta_{CP}(\bar B^0\to\Xi^-\overline{\Sigma^{*-}}) = -\Delta_{CP}(\bar B^0\to\Sigma^-\overline{\Delta^-}),\\
\Delta_{CP}(\bar B^0\to\Sigma^+\overline{\Sigma^{*+}}) &= \Delta_{CP}(\bar B^0\to\Xi^0\overline{\Xi^{*0}}) = -\Delta_{CP}(\bar B_s^0\to p\overline{\Delta^+}) = -\Delta_{CP}(\bar B_s^0\to n\overline{\Delta^0}),\\
\Delta_{CP}(\bar B^0\to p\overline{\Delta^+}) &= -\Delta_{CP}(\bar B_s^0\to\Sigma^+\overline{\Sigma^{*+}}),\\
\Delta_{CP}(\bar B_s^0\to n\overline{\Sigma^{*0}}) &= -\Delta_{CP}(\bar B^0\to\Xi^0\overline{\Sigma^{*0}})\\
\Delta_{CP}(\bar B_s^0\to p\overline{\Sigma^{*+}}) &= -\Delta_{CP}(\bar B^0\to\Sigma^+\overline{\Delta^+}).
\end{aligned}
\tag{43}
$$

For decuplet-antioctet modes, we have

$$\begin{aligned}
3\tau_{B_d}\mathcal{B}(\bar{B}^0 \to \Sigma^{*-}\overline{\Sigma^-}) &= 3\tau_{B_d}\mathcal{B}(\bar{B}^0 \to \Xi^{*-}\overline{\Xi^-}) = \tau_{B_s}\mathcal{B}(\bar{B}_s^0 \to \Delta^-\overline{\Sigma^-}) = 3\tau_{B_s}\mathcal{B}(\bar{B}_s^0 \to \Sigma^{*-}\overline{\Xi^-}),\\
3\tau_{B_s}\mathcal{B}(\bar{B}_s^0 \to \Sigma^{*-}\overline{\Sigma^-}) &= 3\tau_{B_s}\mathcal{B}(\bar{B}_s^0 \to \Xi^{*-}\overline{\Xi^-}) = 3\tau_{B_d}\mathcal{B}(\bar{B}^0 \to \Xi^{*-}\overline{\Sigma^-}) = \tau_{B_d}\mathcal{B}(\bar{B}^0 \to \Omega^-\overline{\Xi^-}),\\
\mathcal{B}(\bar{B}^0 \to \Sigma^{*+}\overline{\Sigma^+}) &= \mathcal{B}(\bar{B}^0 \to \Xi^{*0}\overline{\Xi^0}),\\
\mathcal{B}(\bar{B}_s^0 \to \Delta^+\bar{p}) &= \mathcal{B}(\bar{B}_s^0 \to \Delta^0\bar{n}),
\end{aligned} \tag{44}$$

and

$$\begin{aligned}
\Delta_{CP}(B^- \to \Delta^0\bar{p}) &= 2\Delta_{CP}(B^- \to \Sigma^{*0}\overline{\Sigma^+}) = -2\Delta_{CP}(B^- \to \Sigma^{*0}\bar{p}) = -\Delta_{CP}(B^- \to \Xi^{*0}\overline{\Sigma^+}),\\
\Delta_{CP}(B^- \to \Delta^-\bar{n}) &= 3\Delta_{CP}(B^- \to \Xi^{*-}\overline{\Xi^0}) = 6\Delta_{CP}(B^- \to \Sigma^{*-}\overline{\Sigma^0}) = 2\Delta_{CP}(B^- \to \Sigma^{*-}\bar{\Lambda}) = -3\Delta_{CP}(B^- \to \Sigma^{*-}\bar{n})\\
&= -6\Delta_{CP}(B^- \to \Xi^{*-}\overline{\Sigma^0}) = -\Delta_{CP}(B^- \to \Omega^-\overline{\Xi^0}) = -2\Delta_{CP}(B^- \to \Xi^{*-}\bar{\Lambda}),\\
\Delta_{CP}(\bar{B}^0 \to \Delta^+\bar{p}) &= -\Delta_{CP}(\bar{B}_s^0 \to \Sigma^{*+}\overline{\Sigma^+}),\\
3\Delta_{CP}(\bar{B}^0 \to \Sigma^{*-}\overline{\Sigma^-}) &= 3\Delta_{CP}(\bar{B}^0 \to \Xi^{*-}\overline{\Xi^-}) = \Delta_{CP}(\bar{B}_s^0 \to \Delta^-\overline{\Sigma^-}) = 3\Delta_{CP}(\bar{B}_s^0 \to \Sigma^{*-}\overline{\Xi^-}) = -3\Delta_{CP}(\bar{B}_s^0 \to \Sigma^{*-}\overline{\Sigma^-})\\
&= -3\Delta_{CP}(\bar{B}_s^0 \to \Xi^{*-}\overline{\Xi^-}) = -3\Delta_{CP}(\bar{B}^0 \to \Xi^{*-}\overline{\Sigma^-}) = -\Delta_{CP}(\bar{B}^0 \to \Omega^-\overline{\Xi^-}),\\
\Delta_{CP}(\bar{B}^0 \to \Sigma^{*+}\overline{\Sigma^+}) &= \Delta_{CP}(\bar{B}^0 \to \Xi^{*0}\overline{\Xi^0}) = -\Delta_{CP}(\bar{B}_s^0 \to \Delta^+\bar{p}) = -\Delta_{CP}(\bar{B}_s^0 \to \Delta^0\bar{n}),\\
\Delta_{CP}(\bar{B}^0 \to \Delta^0\bar{n}) &= -\Delta_{CP}(\bar{B}_s^0 \to \Xi^{*0}\overline{\Xi^0}),\\
\Delta_{CP}(\bar{B}_s^0 \to \Delta^+\overline{\Sigma^+}) &= -\Delta_{CP}(\bar{B}^0 \to \Sigma^{*+}\bar{p}),\\
\Delta_{CP}(\bar{B}_s^0 \to \Sigma^{*0}\overline{\Xi^0}) &= -\Delta_{CP}(\bar{B}^0 \to \Sigma^{*0}\bar{n}).
\end{aligned} \tag{45}$$

For octet-octet modes, there are no relations for the averaged branching ratios, when the full topological amplitudes are used (see Appendix B).[3] However for Δ_{CP}, we have

$$\begin{aligned}
\Delta_{CP}(B^- \to n\bar{p}) &= -\Delta_{CP}(B^- \to \Xi^0\overline{\Sigma^+}),\\
\Delta_{CP}(B^- \to \Xi^-\overline{\Xi^0}) &= -\Delta_{CP}(B^- \to \Sigma^-\bar{n}),\\
\Delta_{CP}(\bar{B}^0 \to p\bar{p}) &= -\Delta_{CP}(\bar{B}_s^0 \to \Sigma^+\overline{\Sigma^+}),\\
\Delta_{CP}(\bar{B}^0 \to n\bar{n}) &= -\Delta_{CP}(\bar{B}_s^0 \to \Xi^0\overline{\Xi^0}),\\
\Delta_{CP}(\bar{B}^0 \to \Sigma^+\overline{\Sigma^+}) &= -\Delta_{CP}(\bar{B}_s^0 \to p\bar{p}),\\
\Delta_{CP}(\bar{B}^0 \to \Sigma^-\overline{\Sigma^-}) &= -\Delta_{CP}(\bar{B}_s^0 \to \Xi^-\overline{\Xi^-}),\\
\Delta_{CP}(\bar{B}^0 \to \Xi^0\overline{\Xi^0}) &= -\Delta_{CP}(\bar{B}_s^0 \to n\bar{n}),\\
\Delta_{CP}(\bar{B}^0 \to \Xi^-\overline{\Xi^-}) &= -\Delta_{CP}(\bar{B}_s^0 \to \Sigma^-\overline{\Sigma^-}),\\
\Delta_{CP}(\bar{B}_s^0 \to p\overline{\Sigma^+}) &= -\Delta_{CP}(\bar{B}^0 \to \Sigma^+\bar{p}),\\
\Delta_{CP}(\bar{B}_s^0 \to \Sigma^-\overline{\Xi^-}) &= -\Delta_{CP}(\bar{B}^0 \to \Xi^-\overline{\Sigma^-}).
\end{aligned} \tag{46}$$

[3]For approximated relations, using only the dominating terms in the amplitudes, one is referred to [9].

All of the above relations are obtained without using the large m_B limits and are ready to be checked experimentally.

B. Triangle relations on amplitudes

In the previous subsection we only make use of some of the relations on amplitudes. There are, in fact, much more relations on amplitudes. For example, for $\Delta S = 0$, $\bar{B}_q$ to decuplet-antidecuplet decay, we can have isospin relations,

$$\begin{aligned}
&\sqrt{2}A(B^- \to \Delta^+\overline{\Delta^{++}})\\
&\quad = \sqrt{6}A(B^- \to \Delta^0\overline{\Delta^+}) - \sqrt{2}A(B^- \to \Delta^-\overline{\Delta^0}),\\
&\sqrt{3}A(\overline{B_s^0} \to \Delta^+\overline{\Sigma^{*+}})\\
&\quad = \sqrt{6}A(\overline{B_s^0} \to \Delta^0\overline{\Sigma^{*0}}) - A(\overline{B_s^0} \to \Delta^-\overline{\Sigma^{*-}}),\\
&A(\overline{B^0} \to \Delta^{++}\overline{\Delta^{++}}) - 3A(\overline{B^0} \to \Delta^+\overline{\Delta^+})\\
&\quad + 3A(\overline{B^0} \to \Delta^0\overline{\Delta^0}) - A(\overline{B^0} \to \Delta^-\overline{\Delta^-}) = 0,
\end{aligned} \tag{47}$$

and

$$
\begin{aligned}
2A(\overline{B^0}\to\Xi^{*-}\overline{\Xi^{*-}})&=A(\overline{B^0_s}\to\Sigma^{*-}\overline{\Xi^{*-}})+2A(\overline{B^0}\to\Omega^-\overline{\Omega^-}),\\
2A(\overline{B^0}\to\Sigma^{*0}\overline{\Sigma^{*0}})&=\sqrt{2}A(\overline{B^0_s}\to\Sigma^{*0}\overline{\Xi^{*0}})+A(\overline{B^0}\to\Xi^{*0}\overline{\Xi^{*0}}),\\
A(\overline{B^0}\to\Delta^{++}\overline{\Delta^{++}})&=3A(\overline{B^0}\to\Xi^{*0}\overline{\Xi^{*0}})-2A(\overline{B^0}\to\Omega^-\overline{\Omega^-}),\\
A(\overline{B^0}\to\Sigma^{*+}\overline{\Sigma^{*+}})&=2A(\overline{B^0}\to\Xi^{*0}\overline{\Xi^{*0}})-A(\overline{B^0}\to\Omega^-\overline{\Omega^-}),\\
A(\overline{B^0}\to\Delta^{-}\overline{\Delta^{-}})&=3A(\overline{B^0}\to\Xi^{*-}\overline{\Xi^{*-}})-2A(\overline{B^0}\to\Omega^-\overline{\Omega^-}),\\
A(\bar{B}^0\to\Sigma^{*-}\overline{\Sigma^{*-}})&=2A(\bar{B}^0\to\Xi^{*-}\overline{\Xi^{*-}})-A(\overline{B^0}\to\Omega^-\overline{\Omega^-}),\\
A(\overline{B^0}\to\Delta^{+}\overline{\Delta^{+}})&=A(\bar{B}^0_s\to\Delta^{+}\overline{\Sigma^{*+}})+A(\overline{B^0}\to\Sigma^{*+}\overline{\Sigma^{*+}}),\\
A(\bar{B}^0\to\Delta^{0}\overline{\Delta^{0}})&=\sqrt{2}A(\overline{B^0_s}\to\Delta^{0}\overline{\Sigma^{*0}})+A(\overline{B^0}\to\Xi^{*0}\overline{\Xi^{*0}}).
\end{aligned}
\tag{48}
$$

These can be easily obtained by using the full decay amplitudes given in the previous section or in Appendix B.

There are many similar relations for amplitudes within decuplet-antidecuplet, octet-antidecuplet, decuplet-antioctet and octet-antioctet modes. The interested reader can work them out using formulas in Appendix B. In below we only give two examples of the relations on octet-antioctet amplitudes:

$$A(\bar{B}^0\to p\bar{p})=-A(\bar{B}^0_s\to p\overline{\Sigma^+})+A(\bar{B}^0\to\Sigma^+\overline{\Sigma^+}),\tag{49}$$

and

$$A(\bar{B}^0_s\to p\bar{p})=A(\bar{B}^0_s\to\Sigma^+\overline{\Sigma^+})+A(\bar{B}^0\to\Sigma^+\bar{p}).\tag{50}$$

For more relations on amplitudes in various limits, one is referred to [9].

C. Numerical results on rates

In our numerical analysis, masses and lifetimes of hadrons are taken from [6], while values of Wolfenstein parameters for the CKM matrix are from [41]. Our strategy is to fit the asymptotic amplitude using the experimental $\bar{B}^0\to p\bar{p}$ rate, and try to predict rates on other baryonic modes with estimations on the corrections to the asymptotic relations and contributions from subleading terms. In principle, we can extract the full topological amplitudes directly from data, but at the moment since only one mode is found, we can only start from the asymptotic limit, as the number of parameters is highly reduced, and consider reasonable corrections to it. As we shall see, the prediction on rates are within a factor of 2. The accuracy can be systematically improved when more modes are observed.

Fitting to the experimental result on $\bar{B}^0\to p\bar{p}$ rate using the topological amplitude, Eq. (33), but in the asymptotic forms, Eqs. (38) and (39), we obtain

$$\chi=(3.57^{+0.78}_{-0.71})\times10^{-3}\ \mathrm{GeV}^2.\tag{51}$$

Rates on other modes in the asymptotic limit can be obtained by using formulas in Sec. II. B and Eqs. (38) and (39).

In reality the topological amplitudes are, however, not in the asymptotic limit. Corrections are expected and can be estimated as following. (i) The correction on $T_i^{(\prime)}$, $P_i^{(\prime)}$ and $P_{EWi}^{(\prime)}$ are estimated to be of order $m_{\mathcal{B}}/m_B$ (the baryon and B meson mass ratio), which is roughly, 0.2, hence, we have

$$
\begin{aligned}
&T_i^{(\prime)}=(1+t_i^{(\prime)})T^{(\prime)},\qquad P_i^{(\prime)}=(1+p_i^{(\prime)})P^{(\prime)},\\
&P_{EWi}^{(\prime)}=(1+p_{ewi}^{(\prime)})P_{EW}^{(\prime)},
\end{aligned}
\tag{52}
$$

with

$$-0.2\le t_i^{(\prime)},\qquad p_i^{(\prime)},\qquad p_{ewi}^{(\prime)}\le0.2,\tag{53}$$

which parametrize the correction. (ii) Furthermore, since the Fierz transformation of $O_{5,6,7,8}$ is different from $O_{1,2,3,4}$, the relation of the contributions from these two sets of operators may be distorted when we move away from the asymptotic limit. We assign a coefficient κ in front of c_5–c_6 and c_7–c_8 in Eq. (39) with κ having a 100% uncertainty:

$$\kappa=1\pm1,\tag{54}$$

to model the correction. (iii) For subleading terms, such as annihilation, penguin annihilation, exchange amplitude, we have

$$
\begin{aligned}
&E_i^{(\prime)}\equiv\eta_i\frac{f_B}{m_B}\frac{m_{\mathcal{B}}}{m_B}T^{(\prime)},\qquad A_j^{(\prime)}\equiv\eta_j\frac{f_B}{m_B}\frac{m_{\mathcal{B}}}{m_B}T^{(\prime)},\\
&PA_k^{(\prime)}\equiv\eta_k\frac{f_B}{m_B}\frac{m_{\mathcal{B}}}{m_B}P^{(\prime)},
\end{aligned}
\tag{55}
$$

where the ratio f_B/m_B is from the usual estimation [32], the factor $m_{\mathcal{B}}/m_B$ is from the chirality structure, and $|\eta_{i,j,k}|$ are estimated to be of order 1. Explicitly, we take

$$0\le|\eta_{i,j,k}|\le|\eta|=1,\tag{56}$$

where we set the bound $|\eta|$ to 1 in our numerical results. We will return to this point later when confronting the $\bar{B}^0_S\to p\bar{p}$ data. Note that some SU(3) breaking effects in rates are included, as the physical hadron masses [6] are used in the numerical analysis.

Before we show our results, we comment on the detectability of baryonic final states. As shown in Appendix C, we note that, (i) $\Delta^{++,0}$, Λ, Ξ^-, $\Sigma^{*\pm}$, Ξ^{*0} and Ω^- have nonsuppressed decay modes of final states with all charged particles, (ii) Δ^+, $\Sigma^{+,0}$, Ξ^0, Σ^{*0} and Ξ^{*-} can be detected by detecting a π^0 or γ, (iii) while one needs to deal with n in detecting Δ^- and Σ^-. Modes with final states from the first group or even the second group and

TABLE II. Decay rates for $\Delta S = 0$, $\bar{B}_q \to \mathcal{D}\bar{\mathcal{D}}$ modes. The first uncertainty is from the uncertainty of the asymptotic amplitude, χ, and from relaxing the asymptotic relations, by varying t_i, p_i, p_{ewi} [see Eqs. (51) and (53)], the second uncertainty is from $\delta\kappa$ [see Eq. (54)], and the last uncertainty is from subleading contributions, terms with $\eta_{i,j,k}$ [see Eq. (56)]. Occasionally the last uncertainty is shown to larger decimal place.

Mode	$\mathcal{B}(10^{-8})$	Mode	$\mathcal{B}(10^{-8})$
$B^- \to \Delta^+\overline{\Delta^{++}}$	$17.15^{+19.62+0.81}_{-10.15-0.47} \pm 0.22$	$\bar{B}^0_s \to \Delta^+\overline{\Sigma^{*+}}$	$5.18^{+5.92+0.24}_{-3.07-0.14} \pm 0$
$B^- \to \Delta^0\overline{\Delta^{+}}$	$6.42^{+7.34+1.13}_{-3.80-0.68} \pm 0.15$	$\bar{B}^0_s \to \Delta^0\overline{\Sigma^{*0}}$	$2.91^{+3.32+0.51}_{-1.72-0.31} \pm 0$
$B^- \to \Delta^-\overline{\Delta^{0}}$	$0.75^{+0.85+0.89}_{-0.44-0.55} \pm 0.05$	$\bar{B}^0_s \to \Delta^-\overline{\Sigma^{*-}}$	$0.68^{+0.77+0.81}_{-0.40-0.49} \pm 0$
$B^- \to \Sigma^{*0}\overline{\Sigma^{*+}}$	$2.99^{+3.42+0.53}_{-1.77-0.32} \pm 0.07$	$\bar{B}^0_s \to \Sigma^{*0}\overline{\Xi^{*0}}$	$2.70^{+3.09+0.48}_{-1.60-0.29} \pm 0$
$B^- \to \Sigma^{*-}\overline{\Sigma^{*0}}$	$0.47^{+0.53+0.55}_{-0.27-0.34} \pm 0.03$	$\bar{B}^0_s \to \Sigma^{*-}\overline{\Xi^{*-}}$	$0.84^{+0.96+1.00}_{-0.50-0.61} \pm 0$
$B^- \to \Xi^{*-}\overline{\Xi^{*0}}$	$0.21^{+0.24+0.25}_{-0.13-0.16} \pm 0.01$	$\bar{B}^0_s \to \Xi^{*-}\overline{\Omega^{-}}$	$0.58^{+0.66+0.69}_{-0.34-0.42} \pm 0$
$\bar{B}^0 \to \Delta^{++}\overline{\Delta^{++}}$	$0 \pm 0 \pm 0^{+0.0053}_{-0}$	$\bar{B}^0 \to \Sigma^{*+}\overline{\Sigma^{*+}}$	$0 \pm 0 \pm 0^{+0.0031}_{-0}$
$\bar{B}^0 \to \Delta^+\overline{\Delta^{+}}$	$5.29^{+6.05+0.25+0.27}_{-3.13-0.15-0.26}$	$\bar{B}^0 \to \Sigma^{*0}\overline{\Sigma^{*0}}$	$1.39^{+1.58+0.24}_{-0.82-0.15} \pm 0.09$
$\bar{B}^0 \to \Delta^0\overline{\Delta^{0}}$	$5.94^{+6.79+1.05+0.20}_{-3.52-0.63-0.19}$	$\bar{B}^0 \to \Sigma^{*-}\overline{\Sigma^{*-}}$	$0.86^{+0.98+1.02}_{-0.51-0.63} \pm 0.05$
$\bar{B}^0 \to \Delta^-\overline{\Delta^{-}}$	$2.08^{+2.37+2.47}_{-1.23-1.52} \pm 0.08$	$\bar{B}^0 \to \Xi^{*0}\overline{\Xi^{*0}}$	$0 \pm 0 \pm 0^{+0.0016}_{-0}$
$\bar{B}^0 \to \Omega^-\overline{\Omega^{-}}$	$0 \pm 0 \pm 0^{+0.0006}_{-0}$	$\bar{B}^0 \to \Xi^{*-}\overline{\Xi^{*-}}$	$0.20^{+0.22+0.24}_{-0.12-0.14} \pm 0.02$

with unsuppressed B decay rates should be experimentally accessible.

We are now ready to discuss our numerical results. Predictions on $\Delta S = 0$, $\bar{B}_q \to \mathcal{D}\bar{\mathcal{D}}$ decay rates are shown in Table II. The first uncertainty is from the uncertainty of the asymptotic amplitude, χ, and from relaxing the asymptotic relations, by varying t_i, p_i, p_{ewi} [see Eqs. (51) and (53)], the second uncertainty is from $\delta\kappa$ [see Eq. (54)], and the last uncertainty is from subleading contributions, terms with $\eta_{i,j,k}$ [see Eq. (56)]. Occasionally the last uncertainty is shown to larger decimal place.

There are modes that will cascadely decay to all charged final states, such as $p\bar{p}$ with one or more charge pions or kaons (see Appendix C). These include $\bar{B}^0 \to \Delta^{++}\overline{\Delta^{++}}$, $\Delta^0\overline{\Delta^0}$, $\Omega^-\overline{\Omega^-}$, $\Sigma^{*+}\overline{\Sigma^{*+}}$, $\Sigma^{*-}\overline{\Sigma^{*-}}$ and $\Xi^{*0}\overline{\Xi^{*0}}$ decays. Among them, we note that $\bar{B}^0 \to \Delta^0\overline{\Delta^0}$ and $\bar{B}^0 \to \Sigma^{*-}\overline{\Sigma^{*-}}$ rates are at 10^{-8} level. These two modes are relatively easy to be detected, while other modes are suppressed.

Modes need one π^0 or one γ for detections are $B^- \to \Delta^+\overline{\Delta^{++}}$, $\Delta^0\overline{\Delta^+}$, $\Sigma^{*0}\overline{\Sigma^{*+}}$, $\Sigma^{*-}\overline{\Sigma^{*0}}$, $\Xi^{*-}\overline{\Xi^{*0}}$, $\bar{B}^0_s \to \Delta^+\overline{\Sigma^{*+}}$, $\Delta^0\overline{\Sigma^{*0}}$, $\Sigma^{*0}\overline{\Xi^{*0}}$, $\Sigma^{*-}\overline{\Xi^{*-}}$ and $\Xi^{*-}\overline{\Omega^-}$ decays. Among them, we have $\mathcal{B}(B^- \to \Delta^+\overline{\Delta^{++}}) \simeq 2 \times 10^{-7}$ and it reduces ~30% in producing $p\pi^0\bar{p}\pi^-$ final state.

Modes with more than one π^0 or γ are more difficult to detect. They are $\bar{B}^0 \to \Delta^+\overline{\Delta^+}$, $\Sigma^{*0}\overline{\Sigma^{*0}}$, $\Xi^{*-}\overline{\Xi^{*-}}$ decays. The

TABLE III. Same as Table II, but with $\Delta S = -1$, $\bar{B}_q \to \mathcal{D}\bar{\mathcal{D}}$ modes.

Mode	$\mathcal{B}(10^{-8})$	Mode	$\mathcal{B}(10^{-8})$
$B^- \to \Sigma^{*+}\overline{\Delta^{++}}$	$13.94^{+18.20+17.08}_{-8.87\ -10.09} \pm 0.038$	$\bar{B}^0 \to \Sigma^{*+}\overline{\Delta^{+}}$	$4.30^{+5.62+5.27}_{-2.74-3.11} \pm 0$
$B^- \to \Sigma^{*0}\overline{\Delta^{+}}$	$9.74^{+11.49+11.92}_{-5.87\ -7.18} \pm 0.028$	$\bar{B}^0 \to \Sigma^{*0}\overline{\Delta^{0}}$	$9.02^{+10.64+11.03}_{-5.43\ -6.64} \pm 0$
$B^- \to \Sigma^{*-}\overline{\Delta^{0}}$	$5.24^{+5.96+6.22}_{-3.09-3.82} \pm 0.015$	$\bar{B}^0 \to \Sigma^{*-}\overline{\Delta^{-}}$	$14.54^{+16.54+17.28}_{-8.58\ -10.60} \pm 0$
$B^- \to \Xi^{*0}\overline{\Sigma^{*+}}$	$18.07^{+21.31+22.10}_{-10.88-13.31} \pm 0.052$	$\bar{B}^0 \to \Xi^{*0}\overline{\Sigma^{*0}}$	$8.37^{+9.86+10.23}_{-5.04-6.16} \pm 0$
$B^- \to \Xi^{*-}\overline{\Sigma^{*0}}$	$9.71^{+11.05+11.54}_{-5.73\ -7.08} \pm 0.028$	$\bar{B}^0 \to \Xi^{*-}\overline{\Sigma^{*-}}$	$17.96^{+20.43+21.34}_{-10.60-13.09} \pm 0$
$B^- \to \Omega^-\overline{\Xi^{*0}}$	$13.38^{+15.21+15.89}_{-7.90\ -9.75} \pm 0.039$	$\bar{B}^0 \to \Omega^-\overline{\Xi^{*-}}$	$12.37^{+14.07+14.70}_{-7.30\ -9.02} \pm 0$
$\bar{B}^0_s \to \Delta^{++}\overline{\Delta^{++}}$	$0 \pm 0 \pm 0^{+0.019}_{-0}$	$\bar{B}^0_s \to \Sigma^{*+}\overline{\Sigma^{*+}}$	$4.21^{+5.50+5.16+0.54}_{-2.68-3.05-0.50}$
$\bar{B}^0_s \to \Delta^+\overline{\Delta^{+}}$	$0 \pm 0 \pm 0^{+0.018}_{-0}$	$\bar{B}^0_s \to \Sigma^{*0}\overline{\Sigma^{*0}}$	$4.42^{+5.20+5.40+0.55}_{-2.66-3.25-0.52}$
$\bar{B}^0_s \to \Delta^0\overline{\Delta^{0}}$	$0 \pm 0 \pm 0^{+0.017}_{-0}$	$\bar{B}^0_s \to \Sigma^{*-}\overline{\Sigma^{*-}}$	$4.74^{+5.39+5.63+0.56}_{-2.80-3.45-0.53}$
$\bar{B}^0_s \to \Delta^-\overline{\Delta^{-}}$	$0 \pm 0 \pm 0^{+0.017}_{-0}$	$\bar{B}^0_s \to \Xi^{*0}\overline{\Xi^{*0}}$	$16.33^{+19.25+19.97+1.00}_{-9.83\ -12.03-0.97}$
$\bar{B}^0_s \to \Omega^-\overline{\Omega^{-}}$	$36.24^{+41.22+43.06+1.40}_{-21.39-26.41-1.37}$	$\bar{B}^0_s \to \Xi^{*-}\overline{\Xi^{*-}}$	$17.53^{+19.94+20.83+1.02}_{-10.35-12.78-0.99}$

TABLE IV. Same as Table II, but with $\Delta S = 0$, $\bar{B}_q \to \mathcal{B}\bar{\mathcal{D}}$ modes. The latest experimental result is given in the parenthesis.

Mode	$\mathcal{B}(10^{-8})$	Mode	$\mathcal{B}(10^{-8})$
$B^- \to p\overline{\Delta^{++}}$	$7.50^{+20.63+0.35}_{-6.67\ -0.21} \pm 0.10$ (< 14) [5]	$\bar{B}^0_s \to p\overline{\Sigma^{*+}}$	$2.28^{+6.28+0.11}_{-2.03-0.06} \pm 0$
$B^- \to n\overline{\Delta^{+}}$	$2.54^{+2.91+0.14}_{-1.50-0.09} \pm 0.03$	$\bar{B}^0_s \to n\overline{\Sigma^{*0}}$	$1.16^{+1.33+0.07}_{-0.69-0.04} \pm 0$
$B^- \to \Sigma^0\overline{\Sigma^{*+}}$	$4.12^{+4.70+0.04}_{-2.44-0.02} \pm 0.03$	$\bar{B}^0_s \to \Sigma^0\overline{\Xi^{*0}}$	$3.74^{+4.27+0.04}_{-2.21-0.02} \pm 0$
$B^- \to \Sigma^-\overline{\Sigma^{*0}}$	$0.05^{+0.05+0.05}_{-0.03-0.03} \pm 0.003$	$\bar{B}^0_s \to \Sigma^-\overline{\Xi^{*-}}$	$0.08^{+0.10+0.10}_{-0.05-0.06} \pm 0$
$B^- \to \Xi^-\overline{\Xi^{*0}}$	$0.08^{+0.09+0.10}_{-0.05-0.06} \pm 0.005$	$\bar{B}^0_s \to \Xi^-\overline{\Omega^-}$	$0.22^{+0.25+0.25}_{-0.13-0.16} \pm 0$
$B^- \to \Lambda\overline{\Sigma^{*+}}$	$0.14^{+0.52+0.17}_{-0.09-0.10} \pm 0.009$	$\bar{B}^0_s \to \Lambda\overline{\Xi^{*0}}$	$0.13^{+0.47+0.15}_{-0.08-0.10} \pm 0$
$\bar{B}^0 \to p\overline{\Delta^{+}}$	$2.31^{+6.37+0.11}_{-2.06-0.06} \pm 0.03$	$\bar{B}^0 \to \Sigma^+\overline{\Sigma^{*+}}$	$0 \pm 0 \pm 0^{+0.0001}_{-0}$
$\bar{B}^0 \to n\overline{\Delta^{0}}$	$2.35^{+2.69+0.13}_{-1.39-0.08} \pm 0.03$	$\bar{B}^0 \to \Sigma^0\overline{\Sigma^{*0}}$	$1.91^{+2.18+0.02}_{-1.13-0.01} \pm 0.01$
$\bar{B}^0 \to \Xi^0\overline{\Xi^{*0}}$	$0 \pm 0 \pm 0^{+0.0001}_{-0}$	$\bar{B}^0 \to \Sigma^-\overline{\Sigma^{*-}}$	$0.09^{+0.10+0.10}_{-0.05-0.06} \pm 0$
$\bar{B}^0 \to \Xi^-\overline{\Xi^{*-}}$	$0.07^{+0.08+0.09}_{-0.04-0.05} \pm 0$	$\bar{B}^0 \to \Lambda\overline{\Sigma^{*0}}$	$0.07^{+0.24+0.08}_{-0.04-0.05} \pm 0.004$

first two have rates of order 10^{-8}. Some modes need n for detection and they are very difficult to be observed. They are $B^- \to \Delta^-\overline{\Delta^0}$, $\bar{B}^0 \to \Delta^-\overline{\Delta^-}$ and $\bar{B}^0_s \to \Delta^-\overline{\Sigma^{*-}}$ decays.

Predictions on $\Delta S = -1$, $\bar{B}_q \to \mathcal{D}\bar{\mathcal{D}}$ decay rates are shown in Table III. From the table we see that: (i) Modes having all charge final states in cascade decays with rates ranging from 10^{-8} to 10^{-7} are $B^- \to \Sigma^{*+}\overline{\Delta^{++}}$, $\Sigma^{*-}\overline{\Delta^0}$, $\Omega^-\overline{\Xi^{*0}}$, $\bar{B}^0_s \to \Omega^-\overline{\Omega^-}$, $\Xi^{*0}\overline{\Xi^{*0}}$, $\Sigma^{*-}\overline{\Sigma^{*-}}$ and $\Sigma^{*+}\overline{\Sigma^{*+}}$ decays. Note that $\bar{B}^0_s \to \Omega^-\overline{\Omega^-}$ decay has the largest rate. (ii) With one π^0 or γ for detection, we have $B^- \to \Xi^{*-}\overline{\Sigma^{*0}}$, $\bar{B}^0 \to \Xi^{*-}\overline{\Sigma^{*-}}$, $\Omega^-\overline{\Xi^{*-}}$ with rate at 10^{-7}. (iii) All other modes are either too small in rates or need more than one π^0 or one γ or even n for detection.

Predictions on rates of $\Delta S = 0$, $\bar{B}_q \to \mathcal{B}\bar{\mathcal{D}}$ decays are shown in Table IV. We note that for modes having all charge final states in cascade decays, the central value of the $B^- \to p\overline{\Delta^{++}}$ predicted rate is only half of the experimental upper bound. It should be searchable in the near future. Furthermore, the measurement of this mode will be useful to reduce the theoretical uncertainty. Another all charge cascade decay final state mode $\bar{B}^0_s \to p\overline{\Sigma^{*+}}$ has rate at 10^{-8} order, while all other states with similar cascade decay final states are suppressed. With one π^0 or γ, one may search for $B^- \to \Sigma^0\overline{\Sigma^{*+}}$, $\bar{B}^0 \to p\overline{\Delta^+}$ and $\bar{B}^0_s \to \Sigma^0\overline{\Xi^{*0}}$. All other modes are either suppressed or are more difficult to be detected.

Predictions on $\Delta S = -1$, $\bar{B}_q \to \mathcal{B}\bar{\mathcal{D}}$ decay rates are shown in Table V. There are only two modes having all charge final states in cascade decays, namely $\bar{B}^0 \to \Xi^-\overline{\Sigma^{*-}}$ and $\Lambda\overline{\Delta^0}$. The former has rate of 10^{-8} order, while the latter is of order 10^{-9} and is 2 order of magnitude smaller than the experimental upper limit. With one π^0 or γ one may search

TABLE V. Same as Table II, but with $\Delta S = -1$, $\bar{B}_q \to \mathcal{B}\bar{\mathcal{D}}$ modes. The latest experimental results are given in parentheses.

Mode	$\mathcal{B}(10^{-8})$	Mode	$\mathcal{B}(10^{-8})$
$B^- \to \Sigma^+\overline{\Delta^{++}}$	$5.75^{+8.76+7.04}_{-3.94-4.16} \pm 0.02$	$\bar{B}^0 \to \Sigma^+\overline{\Delta^{+}}$	$1.77^{+2.70+2.17}_{-1.22-1.28} \pm 0$
$B^- \to \Sigma^0\overline{\Delta^{+}}$	$4.01^{+5.07+4.91}_{-2.50-2.96} \pm 0.01$	$\bar{B}^0 \to \Sigma^0\overline{\Delta^{0}}$	$3.71^{+4.69+4.54}_{-2.32-2.74} \pm 0$
$B^- \to \Sigma^-\overline{\Delta^{0}}$	$2.15^{+2.45+2.56}_{-1.27-1.57} \pm 0.006$	$\bar{B}^0 \to \Sigma^-\overline{\Delta^{-}}$	$5.98^{+6.80+7.11}_{-3.53-4.36} \pm 0$
$B^- \to \Xi^0\overline{\Sigma^{*+}}$	$2.32^{+3.13+2.46}_{-1.48-1.55} \pm 0.006$	$\bar{B}^0 \to \Xi^0\overline{\Sigma^{*0}}$	$1.07^{+1.45+1.14}_{-0.69-0.72} \pm 0$
$B^- \to \Xi^-\overline{\Sigma^{*0}}$	$0.95^{+1.08+1.12}_{-0.56-0.69} \pm 0.003$	$\bar{B}^0 \to \Xi^-\overline{\Sigma^{*-}}$	$1.75^{+1.99+2.08}_{-1.03-1.27} \pm 0$
$B^- \to \Lambda\overline{\Delta^{+}}$	$0.18^{+0.23}_{-0.11} \pm 0.005 \pm 0$ (< 82) [4]	$\bar{B}^0 \to \Lambda\overline{\Delta^{0}}$	$0.17^{+0.21}_{-0.10} \pm 0.004 \pm 0$ (< 93) [4]
$\bar{B}^0_s \to p\overline{\Delta^{+}}$	$0 \pm 0 \pm 0^{+0.00001}_{-0}$	$\bar{B}^0_s \to \Sigma^+\overline{\Sigma^{*+}}$	$1.75^{+2.67+2.14}_{-1.20-1.27} \pm 0.005$
$\bar{B}^0_s \to n\overline{\Delta^{0}}$	$0 \pm 0 \pm 0^{+0.00001}_{-0}$	$\bar{B}^0_s \to \Sigma^0\overline{\Sigma^{*0}}$	$1.83^{+2.31+2.24}_{-1.14-1.35} \pm 0.003$
$\bar{B}^0_s \to \Xi^0\overline{\Xi^{*0}}$	$2.11^{+2.84+2.23}_{-1.35-1.41} \pm 0.006$	$\bar{B}^0_s \to \Sigma^-\overline{\Sigma^{*-}}$	$1.96^{+2.23+2.33}_{-1.16-1.43} \pm 0$
$\bar{B}^0_s \to \Xi^-\overline{\Xi^{*-}}$	$1.72^{+1.95+2.04}_{-1.01-1.25} \pm 0$	$\bar{B}^0_s \to \Lambda\overline{\Sigma^{*0}}$	$0.08^{+0.10}_{-0.05} \pm 0.002 \pm 0.0008$

TABLE VI. Same as Table II, but with $\Delta S = 0$, $\bar{B}_q \to \mathcal{D}\bar{\mathcal{B}}$ modes. The latest experimental result is given in the parenthesis.

Mode	$\mathcal{B}(10^{-8})$	Mode	$\mathcal{B}(10^{-8})$
$B^- \to \Delta^0 \bar{p}$	$2.54^{+2.90+0.14}_{-1.50-0.09} \pm 0.03$ (<138) [5]	$\bar{B}^0_s \to \Delta^+ \overline{\Sigma^+}$	$2.13^{+2.44+0.10}_{-1.26-0.06} \pm 0$
$B^- \to \Delta^- \bar{n}$	$0.33^{+0.37+0.39}_{-0.19-0.24} \pm 0.02$	$\bar{B}^0_s \to \Delta^0 \overline{\Sigma^0}$	$1.19^{+1.37+0.21}_{-0.71-0.13} \pm 0$
$B^- \to \Sigma^{*0} \overline{\Sigma^+}$	$1.08^{+1.22+0.06}_{-0.64-0.04} \pm 0.013$	$\bar{B}^0_s \to \Delta^- \overline{\Sigma^-}$	$0.28^{+0.32+0.33}_{-0.16-0.20} \pm 0$
$B^- \to \Sigma^{*-} \overline{\Sigma^0}$	$0.05^{+0.05+0.05}_{-0.03-0.03} \pm 0.003$	$\bar{B}^0_s \to \Sigma^{*0} \overline{\Xi^0}$	$3.65^{+4.16+0.04}_{-2.16-0.02} \pm 0$
$B^- \to \Xi^{*-} \overline{\Xi^0}$	$0.08^{+0.09+0.10}_{-0.05-0.06} \pm 0.005$	$\bar{B}^0_s \to \Sigma^{*-} \overline{\Xi^-}$	$0.08^{+0.09+0.10}_{-0.05-0.06} \pm 0$
$B^- \to \Sigma^{*-} \bar{\Lambda}$	$0.14^{+0.16+0.17}_{-0.08-0.10} \pm 0.01$	$\bar{B}^0_s \to \Delta^0 \bar{\Lambda}$	$3.17^{+3.61+0.00}_{-1.87-0.00} \pm 0$
$\bar{B}^0 \to \Delta^+ \bar{p}$	$2.31^{+2.65+0.11}_{-1.37-0.06} \pm 0.03$	$\bar{B}^0 \to \Sigma^{*+} \overline{\Sigma^+}$	$0 \pm 0 \pm 0^{+0.0001}_{-0}$
$\bar{B}^0 \to \Delta^0 \bar{n}$	$8.99^{+10.25+0.10}_{-5.31\ -0.06} \pm 0.06$	$\bar{B}^0 \to \Sigma^{*0} \overline{\Sigma^0}$	$0.50^{+0.57+0.03}_{-0.29-0.02} \pm 0.006$
$\bar{B}^0 \to \Xi^{*0} \overline{\Xi^0}$	$0 \pm 0 \pm 0^{+0.0001}_{-0}$	$\bar{B}^0 \to \Sigma^{*-} \overline{\Sigma^-}$	$0.09^{+0.10+0.10}_{-0.05-0.06} \pm 0$
$\bar{B}^0 \to \Xi^{*-} \overline{\Xi^-}$	$0.07^{+0.08+0.09}_{-0.04-0.05} \pm 0$	$\bar{B}^0 \to \Sigma^{*0} \bar{\Lambda}$	$1.52^{+1.74+0.07}_{-0.90-0.04} \pm 0.02$

for $B^- \to \Sigma^+ \overline{\Delta^{++}}$ and $\bar{B}^0 \to \Sigma^0 \overline{\Delta^0}$. Note that $B^- \to \Lambda \overline{\Delta^+}$ is lower than the experimental upper limit by one to two orders of magnitudes.

Predictions on $\Delta S = 0$, $\bar{B}_q \to \mathcal{D}\bar{\mathcal{B}}$ decay rates are shown in Table VI. Note that $B^- \to \Delta^0 \bar{p}$ and $\bar{B}^0_s \to \Delta^0 \bar{\Lambda}$ decays are modes that having all charge final states in cascade decays and with rates of order 10^{-8}. The former is one to two orders of magnitudes below the present experimental limit.

Predictions on $\Delta S = -1$, $\bar{B}_q \to \mathcal{D}\bar{\mathcal{B}}$ decay rates are shown in Table VII. Note that $\bar{B}^0 \to \Sigma^{*+} \bar{p}$, $\Omega^- \overline{\Xi^-}$ and $\Xi^{*0} \bar{\Lambda}$ are modes that have all charge final states in cascade decays and have rates of order 10^{-8}.

Predictions on $\Delta S = 0$, $\bar{B}_q \to \mathcal{B}\bar{\mathcal{B}}$ decay rates are shown in Table VIII. We see from the table that the $\bar{B}^0 \to p\bar{p}$ decay has the highest rate among modes that have all charge final states in cascade decays. Although there are rates higher than it, they require detection of π^0 and/or γ for observations. For example, the $\bar{B}^0_s \to \Sigma^0 \overline{\Xi^0}$ decay rate is of the order of 10^{-7}, but one needs γ and π^0 for detection. For $\Delta S = 0$, $\bar{B}_q \to \mathcal{B}\bar{\mathcal{B}}$ decays, the $\bar{B}^0 \to p\bar{p}$ decay is the most accessible mode among them. Therefore, it is not surprise that it is the first $\bar{B}_q \to \mathcal{B}\bar{\mathcal{B}}$ mode being found. Furthermore, we note that $\bar{B}^0 \to \Xi^- \overline{\Xi^-}$ and $\Lambda\bar{\Lambda}$ decays having all charge final states in cascade decays are predicted to be highly suppressed. In fact, the latter is several orders of magnitudes below the present experimental limit. These predictions can be checked experimentally.

Predictions on $\Delta S = -1$, $\bar{B}_q \to \mathcal{B}\bar{\mathcal{B}}$ decay rates are shown in Table IX. The results can be summarized as following. (i) $B^- \to \Lambda\bar{p}$, $\Xi^- \bar{\Lambda}$ and $\bar{B}^0_s \to \Lambda\bar{\Lambda}$, $\Xi^- \overline{\Xi^-}$ decays are unsuppressed modes having all charge final states in cascade decays. (ii) In fact, since $B^- \to \Lambda\bar{p}$ and $\bar{B}^0_s \to \Lambda\bar{\Lambda}$ decays having rates at 10^{-7} level and do not lose much in producing $p\bar{p}\pi^-$ (reduced 26%) and $p\bar{p}\pi^+\pi^-$ (reduced 60%) final states, respectively, they are interesting modes to search for. Indeed the predicted $B^- \to \Lambda\bar{p}$ rate is

TABLE VII. Same as Table II, but with $\Delta S = -1$, $\bar{B}_q \to \mathcal{D}\bar{\mathcal{B}}$ modes.

Mode	$\mathcal{B}(10^{-8})$	Mode	$\mathcal{B}(10^{-8})$
$B^- \to \Sigma^{*0} \bar{p}$	$1.36^{+1.63+1.43}_{-0.81-0.91} \pm 0.004$	$\bar{B}^0 \to \Sigma^{*+} \bar{p}$	$1.82^{+2.38+2.23}_{-1.16-1.32} \pm 0$
$B^- \to \Sigma^{*-} \bar{n}$	$2.21^{+2.52+2.63}_{-1.31-1.61} \pm 0.006$	$\bar{B}^0 \to \Sigma^{*0} \bar{n}$	$0.90^{+1.39+1.01}_{-0.62-0.57} \pm 0$
$B^- \to \Xi^{*0} \overline{\Sigma^+}$	$2.27^{+2.73+2.41}_{-1.37-1.52} \pm 0.006$	$\bar{B}^0 \to \Xi^{*0} \overline{\Sigma^0}$	$1.05^{+1.26+1.11}_{-0.63-0.70} \pm 0$
$B^- \to \Xi^{*-} \overline{\Sigma^0}$	$0.93^{+1.06+1.10}_{-0.55-0.68} \pm 0.003$	$\bar{B}^0 \to \Xi^{*-} \overline{\Sigma^-}$	$1.71^{+1.95+2.04}_{-1.01-1.25} \pm 0$
$B^- \to \Omega^- \overline{\Xi^0}$	$4.81^{+5.47+5.72}_{-2.84-3.51} \pm 0.014$	$\bar{B}^0 \to \Omega^- \overline{\Xi^-}$	$4.44^{+5.05+5.27}_{-2.62-3.24} \pm 0$
$B^- \to \Xi^{*-} \bar{\Lambda}$	$2.88^{+3.28+3.42}_{-1.70-2.10} \pm 0.008$	$\bar{B}^0 \to \Xi^{*0} \bar{\Lambda}$	$2.37^{+3.09+2.90}_{-1.51-1.71} \pm 0$
$\bar{B}^0_s \to \Delta^+ \bar{p}$	$0 \pm 0 \pm 0^{+0.00001}_{-0}$	$\bar{B}^0_s \to \Sigma^{*+} \overline{\Sigma^+}$	$1.67^{+2.18+2.05}_{-1.06-1.21} \pm 0.005$
$\bar{B}^0_s \to \Delta^0 \bar{n}$	$0 \pm 0 \pm 0^{+0.00001}_{-0}$	$\bar{B}^0_s \to \Sigma^{*0} \overline{\Sigma^0}$	$1.75^{+2.07+2.14}_{-1.05-1.29} \pm 0.003$
$\bar{B}^0_s \to \Xi^{*0} \overline{\Xi^0}$	$1.45^{+2.22+1.62}_{-1.00-0.92} \pm 0.004$	$\bar{B}^0_s \to \Sigma^{*-} \overline{\Sigma^-}$	$1.88^{+2.13+2.23}_{-1.11-1.37} \pm 0$
$\bar{B}^0_s \to \Xi^{*-} \overline{\Xi^-}$	$1.64^{+1.86+1.94}_{-0.97-1.19} \pm 0$	$\bar{B}^0_s \to \Sigma^{*0} \bar{\Lambda}$	$0.08^{+0.09+0.00}_{-0.05-0.00} \pm 0.001$

TABLE VIII. Same as Table II, but with $\Delta S = 0$, $\bar{B}_q \to \mathcal{B}\bar{\mathcal{B}}$ modes. The latest experimental results are given in parentheses under the theoretical results.

Mode	$\mathcal{B}(10^{-8})$	Mode	$\mathcal{B}(10^{-8})$
$B^- \to n\bar{p}$	$3.20^{+3.69+2.02+0.11}_{-1.90-1.23-0.10}$	$\bar{B}^0_s \to p\overline{\Sigma^+}$	$1.42^{+3.91+0.07}_{-1.26-0.04} \pm 0$
$B^- \to \Sigma^0\overline{\Sigma^+}$	$3.26^{+3.92+0.57+0.12}_{-1.98-0.35-0.11}$	$\bar{B}^0_s \to n\overline{\Sigma^0}$	$0.72^{+0.83+0.04}_{-0.43-0.03} \pm 0$
$B^- \to \Sigma^-\overline{\Sigma^0}$	$0.51^{+0.78+0.60+0.05}_{-0.35-0.37-0.05}$	$\bar{B}^0_s \to n\bar{\Lambda}$	$2.88^{+3.44+0.98}_{-1.74-0.59} \pm 0$
$B^- \to \Sigma^-\bar{\Lambda}$	$0.39^{+0.44+0.46+0.02}_{-0.23-0.28-0.02}$	$\bar{B}^0_s \to \Sigma^0\overline{\Xi^0}$	$10.84^{+12.40+0.79}_{-6.42-0.47} \pm 0$
$B^- \to \Xi^-\overline{\Xi^0}$	$0.06^{+0.07+0.07+0.004}_{-0.04-0.04-0.004}$	$\bar{B}^0_s \to \Sigma^-\overline{\Xi^-}$	$1.44^{+1.67+1.72}_{-0.86-1.05} \pm 0$
$B^- \to \Lambda\overline{\Sigma^+}$	$0.39^{+0.69+0.46+0.02}_{-0.23-0.28-0.02}$	$\bar{B}^0_s \to \Lambda\overline{\Xi^0}$	$0.09^{+1.04+0.10}_{-0.07-0.06} \pm 0$
$\bar{B}^0 \to p\bar{p}$	$1.47^{+4.04+0.07+0.15}_{-1.31-0.04-0.15}$	$\bar{B}^0 \to \Sigma^+\overline{\Sigma^+}$	$0 \pm 0 \pm 0^{+0.004}_{-0}$
	$(1.47^{+0.62+0.35}_{-0.51-0.14})^{\text{a}}$ [2]		
$\bar{B}^0 \to n\bar{n}$	$6.60^{+7.98+1.16+0.11}_{-4.01-0.70-0.11}$	$\bar{B}^0 \to \Sigma^0\overline{\Sigma^0}$	$1.51^{+1.82+0.27+0.09}_{-0.92-0.16-0.09}$
$\bar{B}^0 \to \Xi^0\overline{\Xi^0}$	$0 \pm 0 \pm 0^{+0.0004}_{-0}$	$\bar{B}^0 \to \Sigma^-\overline{\Sigma^-}$	$0.94^{+1.44+1.11+0.03}_{-0.65-0.68-0.03}$
$\bar{B}^0 \to \Xi^-\overline{\Xi^-}$	$0.06^{+0.06+0.07+0.01}_{-0.03-0.04-0.01}$	$\bar{B}^0 \to \Sigma^0\bar{\Lambda}$	$4.10^{+4.68+0.19+0.05}_{-2.42-0.11-0.05}$
$\bar{B}^0 \to \Lambda\bar{\Lambda}$	$0^{+0.33}_{-0} \pm 0^{+0.0007}_{-0}$	$\bar{B}^0 \to \Lambda\overline{\Sigma^0}$	$0.18^{+0.32+0.21+0.01}_{-0.11-0.13-0.01}$
	(< 32) [3]		

[a]Taken as the input of our numerical analysis.

TABLE IX. Same as Table II, but with $\Delta S = -1$, $\bar{B}_q \to \mathcal{B}\bar{\mathcal{B}}$ modes. The latest experimental result is given in the parenthesis under the theoretical results.

Mode	$\mathcal{B}(10^{-8})$	Mode	$\mathcal{B}(10^{-8})$
$B^- \to \Sigma^0\bar{p}$	$0.88^{+1.13+0.93+0.002}_{-0.53-0.59-0.002}$	$\bar{B}^0 \to \Sigma^+\bar{p}$	$1.18^{+1.81+1.45}_{-0.81-0.86} \pm 0$
$B^- \to \Sigma^-\bar{n}$	$1.44^{+1.64+1.71+0.004}_{-0.85-1.05-0.004}$	$\bar{B}^0 \to \Sigma^0\bar{n}$	$0.59^{+1.26+0.66}_{-0.47-0.37} \pm 0$
$B^- \to \Xi^0\overline{\Sigma^+}$	$32.54^{+38.07+39.22+0.09}_{-19.51-23.89-0.09}$	$\bar{B}^0 \to \Xi^0\overline{\Sigma^0}$	$15.05^{+17.61+18.14}_{-9.02\ -11.05} \pm 0$
$B^- \to \Xi^-\overline{\Sigma^0}$	$16.76^{+19.33+19.91+0.05}_{-9.97-12.21-0.05}$	$\bar{B}^0 \to \Xi^0\bar{\Lambda}$	$1.68^{+4.35+2.06}_{-1.46-1.22} \pm 0$
$B^- \to \Xi^-\bar{\Lambda}$	$2.04^{+4.55+2.43+0.01}_{-1.68-1.49-0.01}$	$\bar{B}^0 \to \Xi^-\overline{\Sigma^-}$	$31.00^{+35.75+36.83}_{-18.44-22.59} \pm 0$
$B^- \to \Lambda\bar{p}$	$18.78^{+25.16+22.80+0.07}_{-12.11-13.82-0.07}$	$\bar{B}^0 \to \Lambda\bar{n}$	$16.68^{+23.54+20.48}_{-11.06-12.26} \pm 0$
	(< 32) [3]		
$\bar{B}^0_s \to p\bar{p}$	$0 \pm 0 \pm 0^{+0.006}_{-0}$	$\bar{B}^0_s \to \Sigma^+\overline{\Sigma^+}$	$1.14^{+1.75+1.40+0.16}_{-0.78-0.83-0.15}$
	$(2.84^{+2.03+0.85}_{-1.68-0.18})$ [2]		
$\bar{B}^0_s \to n\bar{n}$	$0 \pm 0 \pm 0^{+0.005}_{-0}$	$\bar{B}^0_s \to \Sigma^0\overline{\Sigma^0}$	$1.20^{+1.51+1.47+0.16}_{-0.75-0.88-0.15}$
$\bar{B}^0_s \to \Xi^0\overline{\Xi^0}$	$18.23^{+29.78+22.29+0.55}_{-13.02-13.43-0.55}$	$\bar{B}^0_s \to \Sigma^-\overline{\Sigma^-}$	$1.29^{+1.46+1.53+0.15}_{-0.76-0.94-0.14}$
$\bar{B}^0_s \to \Xi^-\overline{\Xi^-}$	$19.55^{+29.91+23.22+0.56}_{-13.51-14.24-0.55}$	$\bar{B}^0_s \to \Sigma^0\bar{\Lambda}$	$0.05^{+0.13+0.00+0.001}_{-0.04-0.00-0.001}$
$\bar{B}^0_s \to \Lambda\bar{\Lambda}$	$11.10^{+15.01+13.58+0.46}_{-7.20\ -8.18\ -0.45}$	$\bar{B}^0_s \to \Lambda\overline{\Sigma^0}$	$0.05^{+0.07+0.00+0.001}_{-0.03-0.00-0.001}$

close to the present experimental upper limit. It could be the second $\bar{B} \to \mathcal{B}\bar{\mathcal{B}}$ mode to be observed. (iii) Although $B^- \to \Xi^-\overline{\Sigma^0}$ has rate of the order of 10^{-7}, it needs γ for detection.

We now comment on the $\bar{B}^0_s \to p\bar{p}$ mode. The predicted rate is several order smaller than the present experimental result, which, however, has large uncertainty. To accommodate the central value of the experimental result on $B_s \to p\bar{p}$ rate, one need to scale $|\eta|$ from 1 [see Eq. (56)] up to 20.54. Although it is unlikely that for $|\eta|$ to be enhanced by factor 20, some enhancement is possible if final state rescattering is present [42]. Note that the last entries of rates for modes with vanishing central values in Tables VIII and IX, scale with $|\eta|^2$, while those with nonvanishing central values, roughly scale with $|\eta|$. By naively scaling up $|\eta|$ by a factor of 20.54, we find that the contribution of the "subleading terms" (term with η) will give rate five time of the tree contribution in $\bar{B}^0 \to p\bar{p}$ rate.[4] This is highly unnatural and unlikely. We certainly need more data to clarify the situation.

We give a summary of our suggestions before ending this section. We shall concentrate on modes that will cascadely decay to all charged final states and have large decay rates. (i) For $\bar{B}_q \to \mathcal{D}\bar{\mathcal{D}}$, $\Delta S = 0$ decays, we have $\bar{B}^0 \to \Delta^0\overline{\Delta^0}$ and $\bar{B}^0 \to \Sigma^{*-}\overline{\Sigma^{*-}}$ having rates at 10^{-8} level. (ii) For $\Delta S = -1$, $\bar{B}_q \to \mathcal{D}\bar{\mathcal{D}}$ decays, $B^- \to \Sigma^{*+}\overline{\Delta^{++}}$, $\Sigma^{*-}\overline{\Delta^0}$, $\Omega^-\overline{\Xi^{*0}}$ and $\bar{B}^0_s \to \Omega^-\overline{\Omega^-}$, $\Xi^{*0}\overline{\Xi^{*0}}$, $\Sigma^{*-}\overline{\Sigma^{*-}}$, $\Sigma^{*+}\overline{\Sigma^{*+}}$ decays have rates ranging from 10^{-8} to 10^{-7}, where the $\bar{B}^0_s \to \Omega^-\overline{\Omega^-}$ decay has the largest rate. (iii) For $\Delta S = 0$, $\bar{B}_q \to \mathcal{B}\bar{\mathcal{D}}$ decays, the central value of the $B^- \to p\overline{\Delta^{++}}$ rate is only half of the experimental upper bound and should be searchable in the near future, while another all charge final state $\bar{B}^0_s \to p\overline{\Sigma^{*+}}$ has rate at 10^{-8} order. (iv) For $\Delta S = -1$, $\bar{B}_q \to \mathcal{B}\bar{\mathcal{D}}$ decays, $\bar{B}^0 \to \Xi^-\overline{\Sigma^{*-}}$ decay rate is at 10^{-8} order. (v) For $\Delta S = 0$, $\bar{B}_q \to \mathcal{D}\bar{\mathcal{B}}$ decays, $B^- \to \Delta^0\bar{p}$ and $\bar{B}^0_s \to \Delta^0\bar{\Lambda}$ decays have rates of order 10^{-8}. (vi) For $\Delta S = -1$, $\bar{B}_q \to \mathcal{D}\bar{\mathcal{B}}$ decays, $\bar{B}^0 \to \Sigma^{*-}\bar{p}$, $\Omega^-\overline{\Xi^-}$ and $\Xi^{*0}\bar{\Lambda}$ rates are at the order of 10^{-8}. (vii) For $\Delta S = 0$, $\bar{B}_q \to \mathcal{B}\bar{\mathcal{B}}$ decays, $\bar{B}^0 \to p\bar{p}$ is the most accessible mode. It is not surprise that it is the first $\bar{B}_q \to \mathcal{B}\bar{\mathcal{B}}$ mode being observed. (viii) For $\Delta S = -1$, $\bar{B}_q \to \mathcal{B}\bar{\mathcal{B}}$ decays, $B^- \to \Lambda\bar{p}$ and $\bar{B}^0_s \to \Lambda\bar{\Lambda}$ have rates at 10^{-7} level and do not lose much in producing $p\bar{p}\pi^-$ and $p\bar{p}\pi^+\pi^-$ final states, respectively. They are interesting modes to search for. The $B^- \to \Lambda\bar{p}$ decay could be the second $\bar{B} \to \mathcal{B}\bar{\mathcal{B}}$ mode to be observed as its rate is close to the present experimental upper limit. (ix) The predicted $\bar{B}^0_s \to p\bar{p}$ rate is several order smaller than the present experimental result. The central value of the experimental result can be reproduced only with an unnaturally scaled up $|\eta|$. By naively scaling up $|\eta|$, we find that the contribution of the subleading terms (term with η) will give rate five time of the tree contribution in $\bar{B}^0 \to p\bar{p}$ rate. We need more data to clarify the situation.

IV. CONCLUSION

In this work, we study charmless two-body baryonic $B_{u,d,s}$ decays using the topological amplitude approach. We extend previous work [9] to include all ground state octet and decuplet final states with full topological amplitudes. Relations on rates and CP asymmetries are obtained using these amplitudes.

There are in general more than one tree and one penguin amplitudes in the baryonic decays. However, by considering the chirality nature of weak interaction and asymptotic relations [34], the number of independent amplitudes is significantly reduced [9].

With the long awaited $\bar{B}^0 \to p\bar{p}$ data [2], we can finally extract information on the topological amplitudes. Using ratio of the Wilson coefficients, we estimate the penguin to tree amplitude ratio and are able to predict rates of all other modes in the asymptotic limit. Corrections to the amplitudes by relaxing the asymptotic relations and including subleading contributions are estimated. The predicted rates on decay rates are in general with uncertainties of a factor of 2.

We point out some modes that will cascadely decay to all charged final states and have large decay rates. (i) For $\bar{B}_q \to \mathcal{D}\bar{\mathcal{D}}$, $\Delta S = 0$ decays, we have $\bar{B}^0 \to \Delta^0\overline{\Delta^0}$ and $\bar{B}^0 \to \Sigma^{*-}\overline{\Sigma^{*-}}$ having rates at 10^{-8} level. (ii) For $\Delta S = -1$, $\bar{B}_q \to \mathcal{D}\bar{\mathcal{D}}$ decays, $B^- \to \Sigma^{*+}\overline{\Delta^{++}}$, $\Sigma^{*-}\overline{\Delta^0}$, $\Omega^-\overline{\Xi^{*0}}$ and $\bar{B}^0_s \to \Omega^-\overline{\Omega^-}$, $\Xi^{*0}\overline{\Xi^{*0}}$, $\Sigma^{*-}\overline{\Sigma^{*-}}$, $\Sigma^{*+}\overline{\Sigma^{*+}}$ decays have rates ranging from 10^{-8} to 10^{-7}, where the $\bar{B}^0_s \to \Omega^-\overline{\Omega^-}$ decay has the largest rate. (iii) For $\Delta S = 0$, $\bar{B}_q \to \mathcal{B}\bar{\mathcal{D}}$ decays, $\bar{B}^0_s \to p\overline{\Sigma^{*+}}$ has rate at 10^{-8} order, while the predicted $B^- \to p\overline{\Delta^{++}}$ rate is close to the experimental upper bound and should be searchable in the near future. (iv) For $\Delta S = -1$, $\bar{B}_q \to \mathcal{B}\bar{\mathcal{D}}$ decays, $\bar{B}^0 \to \Xi^-\overline{\Sigma^{*-}}$ decay rate is at 10^{-8} order. (v) For $\Delta S = 0$, $\bar{B}_q \to \mathcal{D}\bar{\mathcal{B}}$ decays, $B^- \to \Delta^0\bar{p}$ and $\bar{B}^0_s \to \Delta^0\bar{\Lambda}$ decays have rates of order 10^{-8}. (vi) For $\Delta S = -1$, $\bar{B}_q \to \mathcal{D}\bar{\mathcal{B}}$ decays, $\bar{B}^0 \to \Sigma^{*-}\bar{p}$, $\Omega^-\overline{\Xi^-}$ and $\Xi^{*0}\bar{\Lambda}$ rates are at the order of 10^{-8}. (vii) For $\Delta S = 0$, $\bar{B}_q \to \mathcal{B}\bar{\mathcal{B}}$ decays, $\bar{B}^0 \to p\bar{p}$ is the most accessible mode. It is not surprise that it is the first $\bar{B}_q \to \mathcal{B}\bar{\mathcal{B}}$ mode being found. (viii) For $\Delta S = -1$, $\bar{B}_q \to \mathcal{B}\bar{\mathcal{B}}$ decays, $B^- \to \Lambda\bar{p}$ and $\bar{B}^0_s \to \Lambda\bar{\Lambda}$ have rates at 10^{-7} level and do not lost much in cascade decays. They are interesting modes to search for. In fact, the $B^- \to \Lambda\bar{p}$ decay could be the second $\bar{B} \to \mathcal{B}\bar{\mathcal{B}}$ mode to be observed as its rate is close to the present experimental upper limit.

With the detection of π^0 and/or γ many other unsuppressed modes can be searched for.

The predicted $\bar{B}^0_s \to p\bar{p}$ rate is several order smaller than the present experimental result. The central value of the experimental result can be reproduced only with an unnaturally scaled up $|\eta|$. By naively scaling up $|\eta|$, we find that the contribution of the subleading terms (term with η) will give rate five time of the tree contribution in $\bar{B}^0 \to p\bar{p}$ rate. We need more data to clarify the situation.

The analysis presented in this work can be systematically improved when more measurements on decay rates become available.

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[4]The last uncertainty in the $\bar{B}^0 \to p\bar{p}$ rate (in the unit of 10^{-8}) in Table VIII changes from $^{+0.15}_{-0.15}$ to $^{+5.03}_{-1.47}$.

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APPENDIX A: ASYMPTOTIC RELATIONS IN THE LARGE m_B LIMIT

In this appendix we summarize the main procedures to obtain asymptotic relations as in Ref. [14] and further extend it to include discussion on electroweak penguins. In general the decay amplitudes of $\bar{B}$ to final states with octet baryon ($\mathcal{B}$) and decuplet baryons ($\mathcal{D}$) can be expressed as [19]

$$\begin{aligned}
A(\bar{B}\to\mathcal{B}_1\bar{\mathcal{B}}_2) &= \bar{u}_1(A_{\mathcal{B}\bar{\mathcal{B}}}+\gamma_5 B_{\mathcal{B}\bar{\mathcal{B}}})v_2,\\
A(\bar{B}\to\mathcal{D}_1\bar{\mathcal{B}}_2) &= i\frac{q^\mu}{m_B}\bar{u}_1^\mu(A_{\mathcal{D}\bar{\mathcal{B}}}+\gamma_5 B_{\mathcal{D}\bar{\mathcal{B}}})v_2,\\
A(\bar{B}\to\mathcal{B}_1\bar{\mathcal{D}}_2) &= i\frac{q^\mu}{m_B}\bar{u}_1(A_{\mathcal{B}\bar{\mathcal{D}}}+\gamma_5 B_{\mathcal{B}\bar{\mathcal{D}}})v_2^\mu,\\
A(\bar{B}\to\mathcal{D}_1\bar{\mathcal{D}}_2) &= \bar{u}_1^\mu(A_{\mathcal{D}\bar{\mathcal{D}}}+\gamma_5 B_{\mathcal{D}\bar{\mathcal{D}}})v_{2\mu}\\
&\quad+\frac{q^\mu q^\nu}{m_B^2}\bar{u}_1^\mu(C_{\mathcal{D}\bar{\mathcal{D}}}+\gamma_5 D_{\mathcal{D}\bar{\mathcal{D}}})v_{2\nu}, \qquad \text{(A1)}
\end{aligned}$$

where $q=p_1-p_2$ and u^μ, v^μ are the Rarita-Schwinger vector spinors for a spin-$\frac{3}{2}$ particle. The vector spinor can be expressed as [43] $u_\mu(\pm\frac{3}{2})=\epsilon_\mu(\pm1)u(\pm\frac{1}{2})$ and $u_\mu(\pm\frac{1}{2})=(\epsilon_\mu(\pm1)u(\mp\frac{1}{2})+\sqrt{2}\epsilon_\mu(0)u(\pm\frac{1}{2}))/\sqrt{3}$, where $\epsilon_\mu(\lambda)$ and $u(s)$ are the usual polarization vector and spinor, respectively. By using $q\cdot\epsilon(\lambda)_{1,2}=\mp\delta_{\lambda,0}m_B p_c/m_{1,2}$, where p_c is the baryon momentum in the B rest frame and the fact that $\epsilon_1^*(0)\cdot\epsilon_2(0)=(m_B^2-m_1^2-m_2^2)/2m_1m_2$ is the largest product among $\epsilon_1^*(\lambda_1)\cdot\epsilon_2(\lambda_2)$, we have

$$\begin{aligned}
A(\bar{B}\to\mathcal{D}_1\bar{\mathcal{B}}_2) &= -i\sqrt{\frac{2}{3}}\frac{p_c}{m_1}\bar{u}_1(A_{\mathcal{D}\bar{\mathcal{B}}}+\gamma_5 B_{\mathcal{D}\bar{\mathcal{B}}})v_2,\\
A(\bar{B}\to\mathcal{B}_1\bar{\mathcal{D}}_2) &= i\sqrt{\frac{2}{3}}\frac{p_c}{m_2}\bar{u}_1(A_{\mathcal{B}\bar{\mathcal{D}}}+\gamma_5 B_{\mathcal{B}\bar{\mathcal{D}}})v_2,\\
A(\bar{B}\to\mathcal{D}_1\bar{\mathcal{D}}_2) &\simeq \frac{m_B^2}{3m_1m_2}\bar{u}_1(A'_{\mathcal{D}\bar{\mathcal{D}}}+\gamma_5 B'_{\mathcal{D}\bar{\mathcal{D}}})v_2, \qquad \text{(A2)}
\end{aligned}$$

where $A'_{\mathcal{D}\bar{\mathcal{D}}}=A_{\mathcal{D}\bar{\mathcal{D}}}-2(p_c/m_B)^2C_{\mathcal{D}\bar{\mathcal{D}}}$ and $B'_{\mathcal{D}\bar{\mathcal{D}}}=B_{\mathcal{D}\bar{\mathcal{D}}}-2(p_c/m_B)^2D_{\mathcal{D}\bar{\mathcal{D}}}$ and decuplets can only be in $\pm\frac{1}{2}$-helicity states. All four $\bar{B}\to\mathbf{B}_1\bar{\mathbf{B}}_2$ ($\mathbf{B}\bar{\mathbf{B}}=\mathcal{B}\bar{\mathcal{B}}$, $\mathcal{D}\bar{\mathcal{B}}$, $\mathcal{B}\bar{\mathcal{D}}$, $\mathcal{D}\bar{\mathcal{D}}$) decays can be effectively expressed as

$$A(\bar{B}\to\mathbf{B}_1\bar{\mathbf{B}}_2)=\bar{u}_1(A+\gamma_5 B)v_2. \qquad \text{(A3)}$$

The chiral structure of weak interaction provides further information on A and B. For example, in the $\Delta S=0$ processes, we have either $b\to u_L\bar{u}_R d_L$ or $b\to q_{L(R)}\bar{q}_{R(L)}d_L$ decays, therefore the produced d_L quark is left handed. Furthermore, as strong interaction is chirality conserving, the pop up quark pair $q'\bar{q}'$ should have $q'_{L(R)}\bar{q}'_{R(L)}$. From the conservation of helicity, the produced baryon must be in a left-helicity state and the produced antibaryon must be in a right-helicity state. In large m_B limit, as the spinor helicity identify to chirality, we should have $B\to -A$ in above equations.

We follow Refs. [14,34] to obtain the asymptotic relations for these coefficients (A and B). As noted we only need to consider helicity $\pm\frac{1}{2}$ states. The wave function of a right-handed (helicity $=\frac{1}{2}$) baryon can be expressed as

$$|\mathbf{B};\uparrow\rangle\sim\frac{1}{\sqrt{3}}(|\mathbf{B};\uparrow\downarrow\uparrow\rangle+|\mathbf{B};\uparrow\uparrow\downarrow\rangle+|\mathbf{B};\downarrow\uparrow\uparrow\rangle), \qquad \text{(A4)}$$

i.e. composed of 13-, 12- and 23-symmetric terms, respectively. For $\mathbf{B}=p$, n, Σ^0, Λ, we have

$$\begin{aligned}
&|\Delta^{++};\uparrow\downarrow\uparrow\rangle=u(1)u(2)u(3)|\uparrow\downarrow\uparrow\rangle, \qquad |\Delta^{-};\uparrow\downarrow\uparrow\rangle=d(1)d(2)d(3)|\uparrow\downarrow\uparrow\rangle,\\
&|\Delta^{+};\uparrow\downarrow\uparrow\rangle=\frac{1}{\sqrt{3}}[u(1)u(2)d(3)+u(1)d(2)u(3)+d(1)u(2)u(3)]|\uparrow\downarrow\uparrow\rangle,\\
&|\Delta^{0};\uparrow\downarrow\uparrow\rangle=(|\Delta^{+};\uparrow\downarrow\uparrow\rangle \quad \text{with} \quad u\leftrightarrow d), \qquad |\Sigma^{*+};\uparrow\downarrow\uparrow\rangle=(|\Delta^{+};\uparrow\downarrow\uparrow\rangle \quad \text{with} \quad d\leftrightarrow s),\\
&|\Sigma^{*0};\uparrow\downarrow\uparrow\rangle=\frac{1}{\sqrt{6}}[u(1)d(2)s(3)+\text{permutation}]|\uparrow\downarrow\uparrow\rangle,\\
&|p;\uparrow\downarrow\uparrow\rangle=\left[\frac{d(1)u(3)+u(1)d(3)}{\sqrt{6}}u(2)-\sqrt{\frac{2}{3}}u(1)d(2)u(3)\right]|\uparrow\downarrow\uparrow\rangle,\\
&|n;\uparrow\downarrow\uparrow\rangle=(-|p;\uparrow\downarrow\uparrow\rangle \quad \text{with} \quad u\leftrightarrow d),\\
&|\Sigma^{0};\uparrow\downarrow\uparrow\rangle=\left[-\frac{u(1)d(3)+d(1)u(3)}{\sqrt{3}}s(2)+\frac{u(2)d(3)+d(2)u(3)}{2\sqrt{3}}s(1)+\frac{u(1)d(2)+d(1)u(2)}{2\sqrt{3}}s(3)\right]|\uparrow\downarrow\uparrow\rangle,\\
&|\Lambda;\uparrow\downarrow\uparrow\rangle=\left[\frac{d(2)u(3)-u(2)d(3)}{2}s(1)+\frac{u(1)d(2)-d(1)u(2)}{2}s(3)\right]|\uparrow\downarrow\uparrow\rangle, \qquad \text{(A5)}
\end{aligned}$$

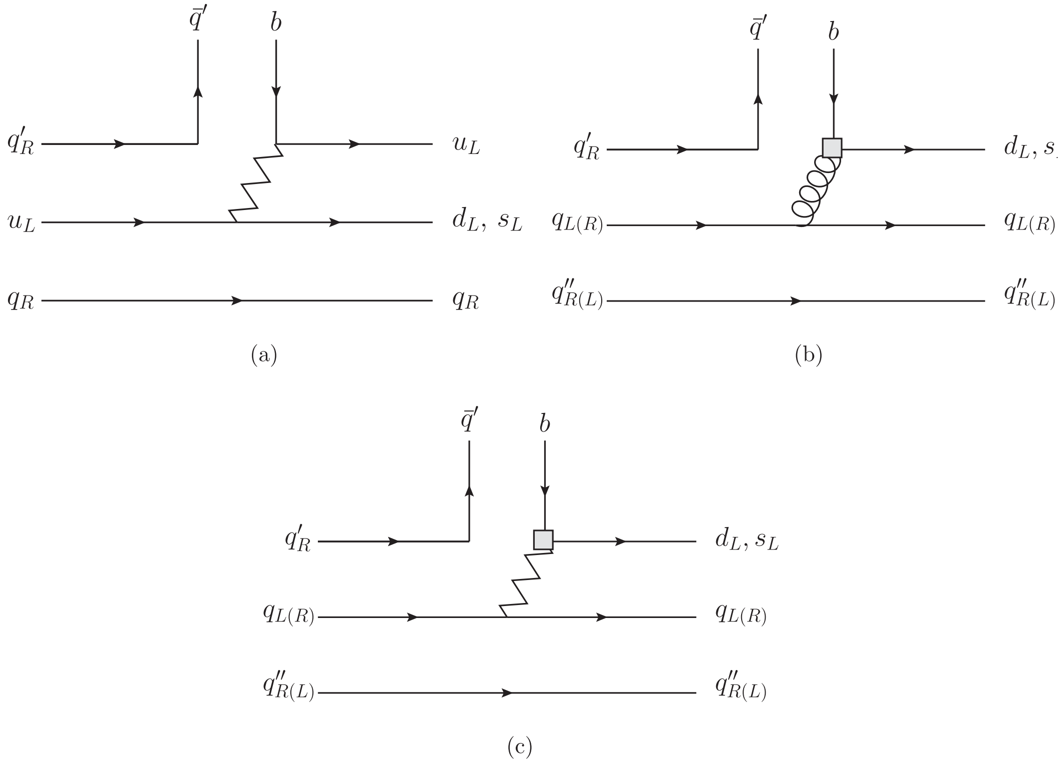

FIG. 2. (a) Tree, (b) penguin, and (c) electroweak penguin $\mathbf{B}'-\bar{B}-\mathbf{B}$ diagrams in the asymptotic limit.

for the corresponding $|\mathbf{B};\uparrow\downarrow\uparrow\rangle$ parts, while the 12- and 23-symmetric parts can be obtained by permutation.

Following Ref. [34] and using the above helicity argument, asymptotically we have

$$\langle\mathbf{B}(p_1)|\mathcal{O}|\bar{B}\mathbf{B}'(p_2)\rangle=\bar{u}(p_1)\left[\frac{1-\gamma_5}{2}F(t)\right]u(p_2),$$
$$F(t)=\sum_{i=T,P_L,P_R}e_i(\mathbf{B}'-B-\mathbf{B})F_i(t), \tag{A6}$$

where $\mathcal{O}$ are the operators in $H_{\rm eff}$. For simplicity, we illustrate with the spacelike case. Note that the above equation is obtained in the large $t(=(p_1-p_2)^2)$ limit, where we may take a large m_B limit. Quark mass dependent terms are subleading and are neglected.

As shown in Fig. 2(a) the $\mathbf{B}'(q'_R u_L q_R)-\bar{B}(\bar{q}'_L b)-\mathbf{B}(u_L d_L q_R)$ coupling is governed by the the tree operator $(\bar{u}b)_{V-A}(\bar{d}u)_{V-A}$. The corresponding coefficient $e_T(\mathbf{B}'-\bar{B}-\mathbf{B})$ is given by

$$\begin{aligned}e_T(\mathbf{B}'-\bar{B}-\mathbf{B})&\\=\langle\mathbf{B};\downarrow\downarrow\uparrow|\mathcal{Q}[q'_R(1)\to u_L(1);u_L(2)\to d_L(2)]|\mathbf{B}';\uparrow\downarrow\uparrow\rangle&\\+\langle\mathbf{B};\uparrow\downarrow\downarrow|\mathcal{Q}[q'_R(3)\to u_L(3);u_L(2)\to d_L(2)]|\mathbf{B}';\uparrow\downarrow\uparrow\rangle,&\end{aligned} \tag{A7}$$

where $\mathcal{Q}[q'_R(1(3))\to u_L(1,3);u_L(2)\to d_L(2)]$ changes the parallel spin $q'(1(3))|\uparrow\rangle\otimes u(2)|\downarrow\rangle$ part of $|\mathbf{B}';\uparrow\downarrow\uparrow\rangle$ to the $u(1(3))|\downarrow\rangle\otimes d(2)|\downarrow\rangle$ part.

Similarly coefficients $e_{P_L,P_R}(\mathbf{B}'-\bar{B}-\mathbf{B})$ for the $\mathbf{B}'(q'_R q_L q''_R)-\bar{B}(\bar{q}'_L b)-\mathbf{B}(d_L q_L q''_R)$ and $\mathbf{B}'(q'_R q_R q''_L)-\bar{B}(\bar{q}'_L b)-\mathbf{B}(d_L q_R q''_L)$ couplings governed respectively by the penguin operators $(\bar{d}b)_{V-A}(\bar{q}q)_{V\mp A}$ are given by

$$\begin{aligned}e_{P_L}(\mathbf{B}'-\bar{B}-\mathbf{B})&=\langle\mathbf{B};\downarrow\downarrow\uparrow|\mathcal{Q}[q'_R(1)\to d_L(1);q_L(2)\\&\quad\to q_L(2)]|\mathbf{B}';\uparrow\downarrow\uparrow\rangle\\&\quad+\langle\mathbf{B};\uparrow\downarrow\downarrow|\mathcal{Q}[q'_R(3)\to d_L(3);q_L(2)\\&\quad\to q_L(2)]|\mathbf{B}';\uparrow\downarrow\uparrow\rangle,\\e_P(\mathbf{B}'-\bar{B}-\mathbf{B})&\equiv e_{P_L}(\mathbf{B}'-\bar{B}-\mathbf{B})=e_{P_R}(\mathbf{B}'-\bar{B}-\mathbf{B}).\end{aligned} \tag{A8}$$

The corresponding diagram is shown in Fig. 2(b). Note that that e_{P_L} is similar to e_T with the $q'_R(1,3)\to u_L(1,3)$ and $u_L(2)\to d_L(2)$ operations replaced by the $q'_R(1,3)\to d_L(1,3)$ and $q_L(2)\to q_L(2)$ operations, respectively. The equality of e_{P_R} and e_{P_L} can be understood by inter changing $q\leftrightarrow q''$ in $\mathbf{B}'(q'_R q_L q''_R)-\bar{B}(\bar{q}'_L b)-\mathbf{B}(d_L q_L q''_R)$ and $\mathbf{B}'(q'_R q_R q''_L)-\bar{B}(\bar{q}'_L b)-\mathbf{B}(d_L q_R q''_L)$. The coefficients for the $|\Delta S|=1$ case can be obtained by the suitable replacement of $d_L\to s_L$ in the $\mathbf{B}$ content in Eqs. (A7), (A8). Similarly for electroweak penguin, we have

TABLE X. The coefficients $e_{T,P}(\mathbf{B}'-\bar{B}-\mathbf{B})$ for various modes obtained from Eqs. (A7), (A8) and (A9).

$\mathbf{B}'-\bar{B}-\mathbf{B}$	e_T	e_P	e_{EWP}	$\mathbf{B}'-\bar{B}-\mathbf{B}$	e_T	e_P	e_{EWP}
$\Sigma^{*0}-\bar{B}^0-\Sigma^{*0}$	$1/3$	$2/3$	$1/9$	$\Delta^0-B^--\Delta^-$	0	$2/\sqrt{3}$	$-2/3\sqrt{3}$
$\Delta^+-B^--\Delta^0$	$2/3$	$4/3$	$2/9$	$\Delta^+-B^--\Sigma^{*0}$	$\sqrt{2}/3$	$2\sqrt{2}/3$	$\sqrt{2}/9$
$\Delta^{++}-B^--p$	$\sqrt{2/3}$	$\sqrt{2/3}$	$2\sqrt{2}/3\sqrt{3}$	$\Sigma^{*0}-\bar{B}^0-\Lambda$	0	$-1/\sqrt{6}$	$1/3\sqrt{6}$
$\Delta^+-\bar{B}^0-p$	$\sqrt{2}/3$	$\sqrt{2}/3$	$2\sqrt{2}/9$	Δ^+-B^--n	$-\sqrt{2}/3$	$\sqrt{2}/3$	$-4\sqrt{2}/9$
$\Sigma^{*+}-\bar{B}^0_s-p$	$\sqrt{2}/3$	$\sqrt{2}/3$	$2\sqrt{2}/9$	$\Delta^+-B^--\Sigma^0$	$1/3$	$2/3$	$1/9$
$p-B^--\Delta^0$	$\sqrt{2}/3$	$-\sqrt{2}/3$	$4\sqrt{2}/9$	$p-\bar{B}^0-\Delta^+$	$\sqrt{2}/3$	$\sqrt{2}/3$	$2\sqrt{2}/9$
$n-B^--\Delta^-$	0	$-\sqrt{2/3}$	$\sqrt{2}/3\sqrt{3}$	$\Lambda-\bar{B}^0-\Sigma^{*0}$	$-1/\sqrt{6}$	$-1/\sqrt{6}$	$-\sqrt{2}/3\sqrt{3}$
$p-B^--\Sigma^{*0}$	$1/3$	$-1/3$	$4/9$	$n-\bar{B}^0-\Sigma^{*0}$	$2/3$	$1/3$	$5/9$
$p-\bar{B}^0-p$	$1/3$	$1/3$	$2/9$	$p-B^--n$	$-1/3$	$-5/3$	$2/9$
$n-\bar{B}^0-n$	$-2/3$	$-4/3$	$-2/9$	$\Lambda-\bar{B}^0-\Sigma^0$	$1/\sqrt{3}$	$1/\sqrt{3}$	$2/3\sqrt{3}$
$\Sigma^0-\bar{B}^0-\Sigma^0$	$-1/3$	$-2/3$	$-1/9$	$\Sigma^0-\bar{B}^0-\Lambda$	0	$1/\sqrt{3}$	$-1/3\sqrt{3}$
$\Lambda-\bar{B}^0-\Lambda$	0	0	0	$n-\bar{B}^0-\Lambda$	$\sqrt{2/3}$	$\sqrt{3/2}$	$1/\sqrt{6}$
$p-B^--\Sigma^0$	$1/3\sqrt{2}$	$-1/3\sqrt{2}$	$2\sqrt{2}/9$	$p-B^--\Lambda$	$1/\sqrt{6}$	$\sqrt{3/2}$	0

$$\begin{aligned}
&e_{EWP_L}(\mathbf{B}'-\bar{B}-\mathbf{B})\\
&=Q(q)[\langle\mathbf{B};\downarrow\downarrow\uparrow|\mathcal{Q}[q'_R(1)\to d_L(1);q_L(2)\to q_L(2)]|\mathbf{B}';\uparrow\downarrow\uparrow\rangle\\
&\quad+\langle\mathbf{B};\uparrow\downarrow\downarrow|\mathcal{Q}[q'_R(3)\to d_L(3);q_L(2)\to q_L(2)]|\mathbf{B}';\uparrow\downarrow\uparrow\rangle],\\
&e_{EWP}(\mathbf{B}'-\bar{B}-\mathbf{B})\\
&\equiv e_{EWP_L}(\mathbf{B}'-\bar{B}-\mathbf{B})=e_{EWP_R}(\mathbf{B}'-\bar{B}-\mathbf{B}),
\end{aligned}\tag{A9}$$

where $Q(q)$ is the electric charge of quark q. Note that we do not include factor $3/2$ in the above formulas. The corresponding diagram is shown in Fig. 2(c).

By using the above equations, it is straightforward to obtain the coefficients of various modes as shown in Table X. Comparing these results to the decay amplitudes in terms of topological amplitudes, we obtain the asymptotic amplitudes shown in Eqs. (38) and (39).

APPENDIX B: INDEPENDENT AMPLITUDES

The number of independent amplitudes are in general less then the one of topological amplitudes. In this appendix we express decay amplitudes in terms of independent amplitudes. Although the physical interpretations and size estimations of these independent amplitudes are not as clear as the topological amplitudes, they are useful in finding relations of decay amplitudes, where some examples are given in Sec. III. A. Readers can use the following expressions to work out additional relations.

For $\bar{B}_q\to\mathcal{D}\bar{\mathcal{D}}$ decays, we have

$$\begin{aligned}
\sqrt{2}A(B^-\to\Delta^-\overline{\Delta^0})&=\sqrt{3}A(B^-\to\Sigma^{*-}\overline{\Sigma^{*0}})\\
&=\sqrt{6}A(B^-\to\Xi^{*-}\overline{\Xi^{*0}})\equiv\sqrt{6}A_A,\\
A(B^-\to\Delta^0\overline{\Delta^+})&=\sqrt{2}A(B^-\to\Sigma^{*0}\overline{\Sigma^{*+}})\\
&=A_T-A_P+2A_A,\\
A(B^-\to\Delta^+\overline{\Delta^{++}})&=\sqrt{3}(A_T-A_P+A_A),
\end{aligned}\tag{B1}$$

$$\begin{aligned}
A(\overline{B^0}\to\Xi^{*0}\overline{\Xi^{*0}})&\equiv A_E,\\
A(\overline{B^0}\to\Xi^{*-}\overline{\Xi^{*-}})&=A_P+A_{PA},\\
2A(\overline{B^0}\to\Sigma^{*0}\overline{\Sigma^{*0}})&=A_T+A_P+2A_E,\\
A(\overline{B^0}\to\Omega^-\overline{\Omega^-})&\equiv A_{PA},\\
A(\overline{B^0}\to\Delta^{++}\overline{\Delta^{++}})&=3A_E-2A_{PA},\\
A(\overline{B^0}\to\Sigma^{*+}\overline{\Sigma^{*+}})&=2A_E-A_{PA},\\
A(\overline{B^0}\to\Delta^-\overline{\Delta^-})&=3A_P+A_{PA},\\
A(\overline{B^0}\to\Sigma^{*-}\overline{\Sigma^{*-}})&=2A_P+A_{PA},\\
A(\overline{B^0}\to\Delta^+\overline{\Delta^+})&=A_T+2A_E-A_{PA},\\
A(\overline{B^0}\to\Delta^0\overline{\Delta^0})&=A_T+A_P+A_E,
\end{aligned}\tag{B2}$$

and

$$\begin{aligned}
\sqrt{2}A(\overline{B^0_s}\to\Delta^0\overline{\Sigma^{*0}})&=\sqrt{2}A(\overline{B^0_s}\to\Sigma^{*0}\overline{\Xi^{*0}})=A_T+A_P,\\
2A(\overline{B^0_s}\to\Delta^-\overline{\Sigma^{*-}})&=2A(\overline{B^0_s}\to\Xi^{*-}\overline{\Omega^-})\\
&=\sqrt{3}A(\overline{B^0_s}\to\Sigma^{*-}\overline{\Xi^{*-}})\equiv2\sqrt{3}A_P,\\
A(\overline{B^0_s}\to\Delta^+\overline{\Sigma^{*+}})&\equiv A_T,
\end{aligned}\tag{B3}$$

where these $A_{T,P,A,E,PA}$ can be easily read out by comparing the decay amplitudes to those shown in Sec. II. B. It is important to stress that the labels T, P, A, E, PA of these As are for the purpose of bookkeeping, they not necessarily correspond to tree, penguin, annihilation, exchange and penguin annihilation amplitudes. These remarks are also true for the following discussion. Note that there are only five independent amplitudes for these modes.

Similarly for $\Delta S = -1$ transition, we have

$$\begin{aligned}\sqrt{2}A(B^- \to \Sigma^{*0}\overline{\Delta^+}) &= A(B^- \to \Xi^{*0}\overline{\Sigma^{*+}}) \\ &= A'_T - A'_P + 2A'_A, \\ \sqrt{6}A(B^- \to \Sigma^{*-}\overline{\Delta^0}) &= \sqrt{2}A(B^- \to \Omega^-\overline{\Xi^{*0}}) \\ &= \sqrt{3}A(B^- \to \Xi^{*-}\overline{\Sigma^{*0}}) = \sqrt{6}A'_A, \\ A(B^- \to \Sigma^{*+}\overline{\Delta^{++}}) &= \sqrt{3}(A'_T - A'_P + A'_A), \end{aligned} \tag{B4}$$

$$\begin{aligned}\sqrt{2}A(\bar{B}^0 \to \Sigma^{*0}\overline{\Delta^0}) &= \sqrt{2}A(\bar{B}^0 \to \Xi^{*0}\overline{\Sigma^{*0}}) = (A'_T + A'_P), \\ 2A(\bar{B}^0 \to \Sigma^{*-}\overline{\Delta^-}) &= 2A(\bar{B}^0 \to \Xi^{*-}\overline{\Sigma^{*-}}) \\ &= \sqrt{3}A(\bar{B}^0 \to \Omega^-\overline{\Xi^{*-}}) = 2\sqrt{3}A'_P, \\ A(\bar{B}^0 \to \Sigma^{*+}\overline{\Delta^+}) &= A'_T, \end{aligned} \tag{B5}$$

and

$$\begin{aligned} A(\bar{B}^0_s \to \Delta^0\overline{\Delta^0}) &= A'_E, \quad A(\bar{B}^0_s \to \Delta^-\overline{\Delta^-}) = A'_{PA}, \\ 2A(\bar{B}^0_s \to \Sigma^{*0}\overline{\Sigma^{*0}}) &= A'_T + A'_P + 2A'_E, \\ A(\bar{B}^0_s \to \Sigma^{*-}\overline{\Sigma^{*-}}) &= A'_P + A'_{PA}, \\ A(\bar{B}^0_s \to \Delta^{++}\overline{\Delta^{++}}) &= 3A'_E - 2A'_{PA}, \\ A(\bar{B}^0_s \to \Delta^+\overline{\Delta^+}) &= 2A'_E - A'_{PA}, \\ A(\bar{B}^0_s \to \Sigma^{*+}\overline{\Sigma^{*+}}) &= A'_T + 2A'_E - A'_{PA}, \\ A(\bar{B}^0_s \to \Xi^{*0}\overline{\Xi^{*0}}) &= A'_T + A'_P + A'_E, \\ A(\bar{B}^0_s \to \Xi^{*-}\overline{\Xi^{*-}}) &= 2A'_P + A'_{PA}, \\ A(\bar{B}^0_s \to \Omega^-\overline{\Omega^-}) &= 3A'_P + A'_{PA}. \end{aligned} \tag{B6}$$

There are five independent amplitudes.

For $\bar{B}_q \to \mathcal{B}\bar{\mathcal{D}}$ decays, we have

$$\begin{aligned} A(B^- \to n\overline{\Delta^+}) &= \sqrt{2}(B_{1T} + B_P - B_A), \\ A(B^- \to \Sigma^0\overline{\Sigma^{*+}}) &= B_{2T} - B_P, \\ \sqrt{2}B_A &\equiv A(B^- \to \Xi^-\overline{\Xi^{*0}}) \\ &= \sqrt{2}A(B^- \to \Sigma^-\overline{\Sigma^{*0}}), \\ \sqrt{3}A(B^- \to \Lambda\overline{\Sigma^{*+}}) &= -2B_{1T} + B_{2T} - 3B_P + 3B_A, \\ A(B^- \to p\overline{\Delta^{++}}) &= \sqrt{6}(B_{1T} - B_{2T} + 2B_P - B_A), \end{aligned} \tag{B7}$$

$$\begin{aligned} A(\bar{B}^0 \to n\overline{\Delta^0}) &= \sqrt{2}(B_{1T} - B_E), \\ \sqrt{2}A(\bar{B}^0 \to \Sigma^0\overline{\Sigma^{*0}}) &= B_{2T} - B_E, \\ \sqrt{2}B_P &\equiv A(\bar{B}^0 \to \Sigma^-\overline{\Sigma^{*-}}) = A(\bar{B}^0 \to \Xi^-\overline{\Xi^{*-}}), \\ \sqrt{2}B_E &\equiv A(\bar{B}^0 \to \Sigma^+\overline{\Sigma^{*+}}) = A(\bar{B}^0 \to \Xi^0\overline{\Xi^{*0}}), \\ A(\bar{B}^0 \to p\overline{\Delta^+}) &= \sqrt{2}(B_{1T} - B_{2T} + B_P - B_E), \\ \sqrt{6}A(\bar{B}^0 \to \Lambda\overline{\Sigma^{*0}}) &= -2B_{1T} + B_{2T} + 3B_E, \end{aligned} \tag{B8}$$

and

$$\begin{aligned} B_{1T} &\equiv A(\bar{B}^0_s \to n\overline{\Sigma^{*0}}), \\ B_{2T} &\equiv A(\bar{B}^0_s \to \Sigma^0\overline{\Xi^{*0}}), \\ \sqrt{3}A(\bar{B}^0_s \to \Sigma^-\overline{\Xi^{*-}}) &= A(\bar{B}^0_s \to \Xi^-\overline{\Omega^-}) = \sqrt{6}B_P, \\ A(\bar{B}^0_s \to p\overline{\Sigma^{*+}}) &= \sqrt{2}(B_{1T} - B_{2T} + B_P), \\ \sqrt{3}A(\bar{B}^0_s \to \Lambda\overline{\Xi^{*0}}) &= -2B_{1T} + B_{2T}, \end{aligned} \tag{B9}$$

where we have five independent amplitudes for these modes. Those for $|\Delta S| = 1$ transitions are given by

$$\begin{aligned} A(B^- \to \Sigma^+\overline{\Delta^{++}}) &= -\sqrt{6}(B'_{1T} - B'_{2T} + 2B'_P - B'_A), \\ \sqrt{2}A(B^- \to \Sigma^0\overline{\Delta^+}) &= B'_{1T} - B'_{2T} + 2B'_P - 2B'_A, \\ A(B^- \to \Xi^0\overline{\Sigma^{*+}}) &= -\sqrt{2}(B'_{1T} + B'_P - B'_A), \\ \sqrt{2}A(B^- \to \Xi^-\overline{\Sigma^{*0}}) &= A(B^- \to \Sigma^-\overline{\Delta^0}) = -\sqrt{2}B'_A, \\ \sqrt{3}A(B^- \to \Lambda\overline{\Delta^+}) &= -B'_{1T} - B'_{2T}, \end{aligned} \tag{B10}$$

$$\begin{aligned} A(\bar{B}^0 \to \Sigma^+\overline{\Delta^+}) &= -\sqrt{2}(B'_{1T} - B'_{2T} + B'_P), \\ A(\bar{B}^0 \to \Sigma^0\overline{\Delta^0}) &= B'_{1T} - B'_{2T}, \\ A(\bar{B}^0 \to \Xi^0\overline{\Sigma^{*0}}) &= -B'_{1T}, \\ \sqrt{3}A(\bar{B}^0 \to \Xi^-\overline{\Sigma^{*-}}) &= A(\bar{B}^0 \to \Sigma^-\overline{\Delta^-}) = -\sqrt{6}B'_P, \\ \sqrt{3}A(\bar{B}^0 \to \Lambda\overline{\Delta^0}) &= -B'_{1T} - B'_{2T}, \end{aligned} \tag{B11}$$

and

$$\begin{aligned} A(\bar{B}^0_s \to p\overline{\Delta^+}) &= A(\bar{B}^0_s \to n\overline{\Delta^0}) = -\sqrt{2}B'_E, \\ A(\bar{B}^0_s \to \Sigma^+\overline{\Sigma^{*+}}) &= -\sqrt{2}(B'_{1T} - B'_{2T} + B'_P - B'_E), \\ \sqrt{2}A(\bar{B}^0_s \to \Sigma^0\overline{\Sigma^{*0}}) &= B'_{1T} - 2B'_{2T} - B'_E, \\ A(\bar{B}^0_s \to \Sigma^-\overline{\Sigma^{*-}}) &= A(\bar{B}^0_s \to \Xi^-\overline{\Xi^{*-}}) = -\sqrt{2}B'_P, \\ A(\bar{B}^0_s \to \Xi^0\overline{\Xi^{*0}}) &= -\sqrt{2}(B'_{1T} - B'_E), \\ \sqrt{6}A(\bar{B}^0_s \to \Lambda\overline{\Sigma^{*0}}) &= -B'_{1T} - B'_{2T} + 3B'_E. \end{aligned} \tag{B12}$$

For $\bar{B}_q \to \mathcal{D}\bar{\mathcal{B}}$ decays, we have

$$\begin{aligned}
A(B^- \to \Delta^0 \bar{p}) &= -\sqrt{2}A(B^- \to \Sigma^{*0}\overline{\Sigma^+}) \\
&= \sqrt{2}(C_{1T} - C_P + C_A), \\
A(B^- \to \Delta^- \bar{n}) &= -\sqrt{3}A(B^- \to \Xi^{*-}\overline{\Xi^0}) \\
&= \sqrt{6}A(B^- \to \Sigma^{*-}\overline{\Sigma^0}) \\
&= -\sqrt{2}A(B^- \to \Sigma^{*-}\bar{\Lambda}) = \sqrt{6}C_A, \quad \text{(B13)}
\end{aligned}$$

$$\begin{aligned}
A(\bar{B}^0 \to \Delta^+ \bar{p}) &= \sqrt{2}(C_{2T} + C_P - C_E), \\
\sqrt{2}A(\bar{B}^0 \to \Sigma^{*0}\overline{\Sigma^0}) &= C_{1T} - C_E, \\
\sqrt{3}A(\bar{B}^0 \to \Sigma^{*-}\overline{\Sigma^-}) &= \sqrt{3}A(\bar{B}^0 \to \Xi^{*-}\overline{\Xi^-}) \\
&= -A(\bar{B}^0_s \to \Delta^-\overline{\Sigma^-}) \\
&= -\sqrt{3}A(\bar{B}^0_s \to \Sigma^{*-}\overline{\Xi^-}) = \sqrt{6}C_P, \\
A(\bar{B}^0 \to \Sigma^{*+}\overline{\Sigma^+}) &= A(\bar{B}^0 \to \Xi^{*0}\overline{\Xi^0}) = \sqrt{2}C_E, \\
A(\bar{B}^0 \to \Delta^0 \bar{n}) &= \sqrt{2}(C_{1T} + C_{2T} - C_E), \\
\sqrt{6}A(\bar{B}^0 \to \Sigma^{*0}\bar{\Lambda}) &= C_{1T} + 2C_{2T} - 3C_E, \quad \text{(B14)}
\end{aligned}$$

and

$$\begin{aligned}
A(\bar{B}^0_s \to \Delta^+\overline{\Sigma^+}) &= -\sqrt{2}(C_{2T} + C_P), \\
A(\bar{B}^0_s \to \Delta^0\overline{\Sigma^0}) &= C_{2T}, \\
A(\bar{B}^0_s \to \Sigma^{*0}\overline{\Xi^0}) &= -(C_{1T} + C_{2T}), \\
\sqrt{3}A(\bar{B}^0_s \to \Delta^0\bar{\Lambda}) &= -(2C_{1T} + C_{2T}), \quad \text{(B15)}
\end{aligned}$$

where we have five independent amplitudes. Similarly, the amplitudes for $|\Delta S| = 1$ transitions are given by

$$\begin{aligned}
\sqrt{2}A(B^- \to \Sigma^{*0}\bar{p}) &= -A(B^- \to \Xi^{*0}\overline{\Sigma^+}) \\
&= \sqrt{2}(C'_{1T} - C'_P + C'_A), \\
\sqrt{3}A(B^- \to \Sigma^{*-}\bar{n}) &= \sqrt{6}A(B^- \to \Xi^{*-}\overline{\Sigma^0}) \\
&= -A(B^- \to \Omega^-\overline{\Xi^0}) \\
&= -\sqrt{2}A(B^- \to \Xi^{*-}\bar{\Lambda}) = \sqrt{6}C'_A, \quad \text{(B16)}
\end{aligned}$$

$$\begin{aligned}
A(\bar{B}^0 \to \Sigma^{*+}\bar{p}) &= \sqrt{2}(C'_{2T} + C'_P), \\
A(\bar{B}^0 \to \Sigma^{*0}\bar{n}) &= C'_{1T} + C'_{2T}, \\
A(\bar{B}^0 \to \Xi^{*0}\overline{\Sigma^0}) &= C'_{1T}, \\
\sqrt{3}A(\bar{B}^0 \to \Xi^{*-}\overline{\Sigma^-}) &= A(\bar{B}^0 \to \Omega^-\overline{\Xi^-}) \\
&= -\sqrt{3}A(\bar{B}^0_s \to \Sigma^{*-}\overline{\Sigma^-}) \\
&= -\sqrt{3}A(\bar{B}^0_s \to \Xi^{*-}\overline{\Xi^-}) = \sqrt{6}C'_P, \\
\sqrt{3}A(\bar{B}^0 \to \Xi^{*0}\bar{\Lambda}) &= -(C'_{1T} + 2C'_{2T}), \quad \text{(B17)}
\end{aligned}$$

and

$$\begin{aligned}
A(\bar{B}^0_s \to \Delta^+\bar{p}) &= A(\bar{B}^0_s \to \Delta^0\bar{n}) = -\sqrt{2}C'_E, \\
A(\bar{B}^0_s \to \Sigma^{*+}\overline{\Sigma^+}) &= -\sqrt{2}(C'_{2T} + C'_P - C'_E), \\
\sqrt{2}A(\bar{B}^0_s \to \Sigma^{*0}\overline{\Sigma^0}) &= C'_{2T} - C'_E, \\
A(\bar{B}^0_s \to \Xi^{*0}\overline{\Xi^0}) &= -\sqrt{2}(C'_{1T} + C'_{2T} - C'_E), \\
\sqrt{6}A(\bar{B}^0_s \to \Sigma^{*0}\bar{\Lambda}) &= -(2C'_{1T} + C'_{2T} - 3C'_E). \quad \text{(B18)}
\end{aligned}$$

For $\bar{B}_q \to \mathcal{B}\bar{\mathcal{B}}$ decays, we have

$$\begin{aligned}
A(B^- \to n\bar{p}) &= -D_{1T} + D_P + D_{1A}, \\
\sqrt{2}A(B^- \to \Sigma^0\overline{\Sigma^+}) &= 2D_{3T} - D_P - D_{1A} + D_{2A}, \\
\sqrt{2}A(B^- \to \Sigma^-\overline{\Sigma^0}) &= D_{1A} - D_{2A}, \\
\sqrt{6}A(B^- \to \Sigma^-\bar{\Lambda}) &= D_{1A} + D_{2A}, \\
A(B^- \to \Xi^-\overline{\Xi^0}) &= D_{2A}, \\
\sqrt{6}A(B^- \to \Lambda\overline{\Sigma^+}) &= -2D_{1T} + 2D_{3T} \\
&\quad + D_P + D_{1A} + D_{2A}, \quad \text{(B19)}
\end{aligned}$$

$$\begin{aligned}
A(\bar{B}^0 \to p\bar{p}) &= -D_{2T} + 2D_{4T} + D_{1E} + D_{2E}, \\
A(\bar{B}^0 \to n\bar{n}) &= -D_{1T} - D_{2T} + D_{2E}, \\
A(\bar{B}^0 \to \Sigma^+\overline{\Sigma^+}) &= D_{1E} + D_{2E}, \\
2A(\bar{B}^0 \to \Sigma^0\overline{\Sigma^0}) &= -2D_{3T} + D_{1E} + D_{2E} + D_{PA}, \\
2\sqrt{3}A(\bar{B}^0 \to \Sigma^0\bar{\Lambda}) &= 2D_{3T} + 4D_{4T} + D_{1E} - D_{2E} + D_{PA}, \\
A(\bar{B}^0 \to \Sigma^-\overline{\Sigma^-}) &= -D_P + D_{PA}, \\
A(\bar{B}^0 \to \Xi^0\overline{\Xi^0}) &= D_{2E}, \\
A(\bar{B}^0 \to \Xi^-\overline{\Xi^-}) &= D_{PA}, \\
2\sqrt{3}A(\bar{B}^0 \to \Lambda\overline{\Sigma^0}) &= 2D_{1T} - 2D_{3T} + D_{1E} - D_{2E} + D_{PA}, \\
6A(\bar{B}^0 \to \Lambda\bar{\Lambda}) &= -2D_{1T} - 4D_{2T} + 2D_{3T} \\
&\quad + 4D_{4T} + D_{1E} + 5D_{2E} + D_{PA}, \quad \text{(B20)}
\end{aligned}$$

and

$$\begin{aligned}
A(\bar{B}^0_s \to p\overline{\Sigma^+}) &= D_{2T} - 2D_{4T}, \\
\sqrt{2}A(\bar{B}^0_s \to n\overline{\Sigma^0}) &= -D_{2T}, \\
\sqrt{6}A(\bar{B}^0_s \to n\bar{\Lambda}) &= 2D_{1T} + D_{2T}, \\
A(\bar{B}^0_s \to \Sigma^0\overline{\Xi^0}) &= \sqrt{2}(D_{3T} + D_{4T}), \\
A(\bar{B}^0_s \to \Sigma^-\overline{\Xi^-}) &= -D_P, \\
\sqrt{3}A(\bar{B}^0_s \to \Lambda\overline{\Xi^0}) &= \sqrt{2}(-D_{1T} - D_{2T} + D_{3T} + D_{4T}), \quad \text{(B21)}
\end{aligned}$$

where we need ten independent amplitudes for these modes. Similarly the amplitudes for $|\Delta S| = 1$ transitions are given by

$$\begin{aligned}
\sqrt{2}A(B^- \to \Sigma^0 \bar{p}) &= -D'_{1T} + 2D'_{3T} + D'_{2A},\\
A(B^- \to \Sigma^- \bar{n}) &= D'_{2A},\\
A(B^- \to \Xi^0 \overline{\Sigma^+}) &= -D'_{1T} + D'_P + D'_{1A},\\
\sqrt{2}A(B^- \to \Xi^- \overline{\Sigma^0}) &= D'_{1A},\\
\sqrt{6}A(B^- \to \Xi^- \bar{\Lambda}) &= D'_{1A} - 2D'_{2A},\\
\sqrt{6}A(B^- \to \Lambda \bar{p}) &= D'_{1T} + 2D'_{3T} - 2D'_P - 2D'_{1A} + D'_{2A},
\end{aligned} \tag{B22}$$

$$\begin{aligned}
A(\bar{B}^0 \to \Sigma^+ \bar{p}) &= D'_{2T} - 2D'_{4T},\\
\sqrt{2}A(\bar{B}^0 \to \Sigma^0 \bar{n}) &= -D'_{1T} - D'_{2T} + 2D'_{3T} + 2D'_{4T},\\
\sqrt{2}A(\bar{B}^0 \to \Xi^0 \overline{\Sigma^0}) &= D'_{1T},\\
\sqrt{6}A(\bar{B}^0 \to \Xi^0 \bar{\Lambda}) &= -D'_{1T} - 2D'_{2T},\\
A(\bar{B}^0 \to \Xi^- \overline{\Sigma^-}) &= -D'_P,\\
\sqrt{6}A(\bar{B}^0 \to \Lambda \bar{n}) &= D'_{1T} + D'_{2T} + 2D'_{3T} + 2D'_{4T},
\end{aligned} \tag{B23}$$

and

$$\begin{aligned}
A(\bar{B}^0_s \to p\bar{p}) &= D'_{1E} + D'_{2E},\\
A(\bar{B}^0_s \to n\bar{n}) &= D'_{2E},\\
A(\bar{B}^0_s \to \Sigma^+ \overline{\Sigma^+}) &= -D'_{2T} + 2D'_{4T} + D'_{1E} + D'_{2E},\\
2A(\bar{B}^0_s \to \Sigma^0 \overline{\Sigma^0}) &= -D'_{2T} + 2D'_{4T} + D'_{1E} + D'_{2E} + D'_{PA},\\
2\sqrt{3}A(\bar{B}^0_s \to \Sigma^0 \bar{\Lambda}) &= 2D'_{1T} + D'_{2T} - 4D'_{3T} - 2D'_{4T}\\
&\quad + D'_{1E} - D'_{2E} + D'_{PA},\\
A(\bar{B}^0_s \to \Sigma^- \overline{\Sigma^-}) &= D'_{PA},\\
A(\bar{B}^0_s \to \Xi^0 \overline{\Xi^0}) &= -D'_{1T} - D'_{2T} + D'_{2E},\\
A(\bar{B}^0_s \to \Xi^- \overline{\Xi^-}) &= -D'_P + D'_{PA},\\
2\sqrt{3}A(\bar{B}^0_s \to \Lambda \overline{\Sigma^0}) &= D'_{2T} + 2D'_{4T} + D'_{1E} - D'_{2E} + D'_{PA},\\
6A(\bar{B}^0_s \to \Lambda \bar{\Lambda}) &= -2D'_{1T} - D'_{2T} - 4D'_{3T} - 2D'_{4T}\\
&\quad + D'_{1E} + 5D'_{2E} + D'_{PA}.
\end{aligned} \tag{B24}$$

APPENDIX C: BRANCHING RATIONS OF BARYON DOMINANT DECAY MODES

In this appendix we collect dominant decay branching ratios of ground state octet and decuplet baryons. The information is shown in Table XI. They will be useful in the discussions of the accessibility of searching of the charmless two-body baryonic modes. We note that (i) $\Delta^{++,0}$, Λ, Ξ^-, $\Sigma^{*\pm}$, Ξ^{*0} and Ω^- have nonsuppressed decay modes of final states with all charged particles, (ii) Δ^+, $\Sigma^{+,0}$, Ξ^0, Σ^{*0} and Ξ^{*-} can be detected by detecting a π^0 or γ, (iii) while one needs to deal with n in detecting Δ^- and Σ^-.

TABLE XI. Branching ratios of baryon dominant decay modes [6]. The n in $\pi^{n,n\pm1}$ follows the charge of the decaying baryon.

	$p\pi^+$	$p\pi^0$	$p\pi^-$	$n\pi^+$	$n\pi^0$	$n\pi^-$
Δ^{++}	100%					
Δ^+		2/3		1/3		
Δ^0			1/3		2/3	
Δ^-						100%
Λ			$(63.9 \pm 0.5)\%$		$(48.31 \pm 0.30)\%$	
Σ^+		$(51.57 \pm 0.30)\%$		$(48.31 \pm 0.30)\%$		
Σ^-						$(99.848 \pm 0.005)\%$
	$\Lambda\pi^n$	$\Lambda\gamma$	$\Sigma^+\pi^{n-1}$	$\Sigma^0\pi^n$	$\Sigma^-\pi^{n+1}$	
Σ^0		100%				
Ξ^0	$(99.525 \pm 0.012)\%$					
Ξ^-	$(99.887 \pm 0.035)\%$					
Σ^{*+}	$(87.0 \pm 1.5)\%$		$(5.8 \pm 0.8)\%$	$(5.8 \pm 0.8)\%$		
Σ^{*0}	$(87.0 \pm 1.5)\%$	$(1.25^{+0.13}_{-0.12})\%$	$(5.8 \pm 0.8)\%$		$(5.8 \pm 0.8)\%$	
Σ^{*-}	$(87.0 \pm 1.5)\%$			$(5.8 \pm 0.8)\%$	$(5.8 \pm 0.8)\%$	
	ΛK^-	$\Xi^0\pi^0$	$\Xi^0\pi^-$	$\Xi^-\pi^+$	$\Xi^-\pi^0$	
Ξ^{*0}		1/3		2/3		
Ξ^{*-}			2/3		1/3	
Ω^-	$(67.8 \pm 0.7)\%$		$(23.6 \pm 0.6)\%$		$(8.6 \pm 0.4)\%$	

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