

Baryonic B Decays

This content has been downloaded from IOPscience. Please scroll down to see the full text.

2016 J. Phys.: Conf. Ser. 675 022007

(<http://iopscience.iop.org/1742-6596/675/2/022007>)

View [the table of contents for this issue](#), or go to the [journal homepage](#) for more

Download details:

IP Address: 131.169.5.251

This content was downloaded on 21/02/2016 at 20:47

Please note that [terms and conditions apply](#).

Baryonic B Decays

R Chistov

National Research Nuclear University MEPhI (Moscow Engineering Physics Institute),
Kashirskoe highway 31, Moscow, 115409, Russia

E-mail: chistov@itep.ru

Abstract. In this talk the decays of B-mesons into baryons are discussed. Large mass of B-meson makes possible the decays of the type $B \rightarrow \text{baryon} \overline{\text{baryon}} (+\text{mesons})$. Experimental observations and measurements of these decays at B-factories Belle and BaBar have stimulate the development of theoretical models in this field. We briefly review the experimental results together with the current theoretical models which describe baryonic B decays.

1. Introduction

Due to large B meson mass, its decays to baryons are possible. The only example of baryonic decay of charm meson is $D_s^+ \rightarrow p\bar{n}$. The thing is that baryons should be produced in pairs in the Standard Model and the sum of 2 protons or proton and neutron masses (thresholds) is larger than the D^0 or D^+ masses, respectively.

First observations and studies of baryonic B decays were done by ARGUS [1] and CLEO [2]. During last decade, B-factories Belle and BaBar dominate in this field. Belle and BaBar observed many new baryonic B decay modes [3] and connected with them new phenomena. In this talk we summarize and discuss important features of baryonic B decays, mostly with one or two charm baryons in the final state. For the reference, the discussed baryonic B decay modes are quoted in table 1.

2. New phenomena in baryonic B decays

Below we provide the list of newly found phenomena.

- Hierarchy of branching fractions for multi-body modes: $\mathcal{B}(\bar{B}^0 \rightarrow \Lambda_c^+ \bar{p} \pi^+ \pi^-) \gg \mathcal{B}(B^- \rightarrow \Lambda_c^+ \bar{p} \pi^-) \gg \mathcal{B}(\bar{B}^0 \rightarrow \Lambda_c^+ \bar{p})$ and $\mathcal{B}(\bar{B}^0 \rightarrow D^{*+} p \bar{p} \pi^-) \gg \mathcal{B}(\bar{B}^0 \rightarrow D^{*0} p \bar{p})$. It means that 3-body decays have substantially larger branching fractions than their 2-body counterparts and 4-body decays are usually more frequent than the 3-body modes.
- It was observed that in many 3- and 4-body decay modes the invariant mass of baryon-antibaryon pair is peaking near threshold. This feature is called threshold enhancement.
- Belle observed [4, 5] hierarchy of branching fractions for two-body modes: the decays to two charm baryons have larger branching fraction than the decays to one charm baryon plus light baryon and the latter have larger branching fraction than the decays into two light baryons: $\mathcal{B}(B \rightarrow \text{Baryon}_{c1} \overline{\text{Baryon}}_{c2}) \sim 10^{-3} \gg \mathcal{B}(B \rightarrow \text{Baryon}_c \overline{\text{Baryon}}) \sim 10^{-5} \gg \mathcal{B}(B \rightarrow \text{Baryon} \overline{\text{Baryon}}) < 10^{-6}$ (see table 1).



Table 1: B decay modes considered in this talk and their world average branching fractions.

Decay	\mathcal{B}
$B^- \rightarrow \Xi_c^0 \Lambda_c^-$	$(2.16 \pm 0.54) \times 10^{-3}$
$B^0 \rightarrow p \bar{\Lambda}_c^-$	$(1.9 \pm 0.2) \times 10^{-5}$
$B^0 \rightarrow p \bar{p}$	$< 1.1 \times 10^{-7}$
$B^- \rightarrow \Lambda_c^+ \bar{p} \pi^-$	$(2.92 \pm 0.14) \times 10^{-4}$
$\bar{B}^0 \rightarrow \Lambda_c^+ \bar{p} \pi^+ \pi^-$	$(12.35 \pm 0.72) \times 10^{-4}$

3. Phenomenological explanation of new phenomena

All these phenomena can be understood in the framework of the following dynamical picture [6, 7].

To produce baryon-antibaryon pair in two body B decay, one energetic $q\bar{q}$ pair must be emitted at high invariant mass by a hard gluon (high q^2). So, the 2-body decay amplitude is suppressed by a factor of order α_s/q^2 . In the 3-body baryonic $B \rightarrow \text{Baryon} \overline{\text{Baryon}} + \text{meson}$ decay, it is possible that the baryon-antibaryon pair is emitted collinearly against the meson. The $q\bar{q}$ pair emitted from a gluon is moving in nearly the same direction, i.e. this gluon is soft and is not suppressed by $1/q^2$. Therefore, the branching fraction of $B \rightarrow \text{Baryon} \overline{\text{Baryon}} + \text{meson}$ decay is larger than $B \rightarrow \text{Baryon} \overline{\text{Baryon}}$ decay. It also explains that the baryon-antibaryon mass is peaking near threshold in multi-body modes. Indeed, the baryon-antibaryon pair against the fast meson tends to populate low invariant masses, close to the corresponding baryon-antibaryon threshold.

If we return to the 2-body baryonic B decay modes, we can see the same dynamics which can be understood as follows. In an energetic charm baryon, the momentum is carried by the constituent charm quark. Thus, in $b \rightarrow c\bar{c}s$ decays, the energetic c quark will fragment into Baryon_{c1} and \bar{c} into $\overline{\text{Baryon}}_{c2}$. Consequently, no hard gluon is needed to produce the energetic $\text{Baryon}_{c1} \overline{\text{Baryon}}_{c2}$ pair in B decay. But in $B \rightarrow \text{Baryon}_c \overline{\text{Baryon}}$ decay two hard gluons are needed to produce an energetic $\overline{\text{Baryon}}$: one hard gluon to kick the spectator quark of the B meson to make it energetic and the other to produce the $q\bar{q}$ pair. Therefore, the decay $B \rightarrow \text{Baryon}_c \overline{\text{Baryon}}$ is suppressed with respect to $B \rightarrow \text{Baryon}_{c1} \overline{\text{Baryon}}_{c2}$ by a factor $\approx \alpha_s^4 10^{-2}$. These qualitative statements have been supported by calculations of the decay rates for $\bar{B} \rightarrow \Xi_c \bar{\Lambda}_c$ [8] and $\bar{B}^0 \rightarrow \Lambda_c^+ \bar{p}$ [9]. From the phenomenological side of view, this dynamical suppression can be translated in terms of the thresholds: the invariant mass of two charm baryons in $B \rightarrow \text{Baryon}_{c1} \overline{\text{Baryon}}_{c2}$ is a B mass, but their threshold, i.e. the sum of their masses, is much closer to B meson mass than in B decay to charm baryon and light (anti-)baryon. It explains the $\mathcal{B}(B \rightarrow \text{Baryon}_{c1} \overline{\text{Baryon}}_{c2}) \gg \mathcal{B}(B \rightarrow \text{Baryon}_c \overline{\text{Baryon}})$ inequality. The same consideration could be used to explain the $\mathcal{B}(B \rightarrow \text{Baryon}_{c1} \overline{\text{Baryon}}) \gg \mathcal{B}(B \rightarrow \text{Baryon} \overline{\text{Baryon}})$ inequality.

The common feature is that the baryon form factor $1/(M_{12}^2 - (m_1 + m_2)^2)$ works in each of three mentioned above phenomena. Here M_{12} is the invariant mass of baryon-antibaryon pair and $(m_1 + m_2)$ is its threshold [10, 11].

4. Summary

In conclusion, the baryonic beauty meson decays into (charm) baryons observed and studied at B-factories Belle and BaBar have enriched our understanding of realization of QCD at middle energies ($\sim 5 \text{ GeV} \sim M_B$). Hopefully, this field of flavour physics will develop further with new experimental data at LHCb and Belle II.

Acknowledgments

This work was performed within the framework of the Center of Nanostructured Electronics supported by MEPhI Academic Excellence Project (contract No. 02.a03.21.0005, 27.08.2013) and is supported by the Russian Ministry of Education and Science contracts 14.A12.31.0006.

References

- [1] Albrecht H *et al.* (ARGUS Collaboration) 1989 *Z. Phys.* **C42** 519
- [2] Crawford G D *et al.* (CLEO Collaboration) 1992 *Phys. Rev.* **D45** 752-70
- [3] Olive K A *et al.* (Particle Data Group) 2014 *Chin. Phys.* **C38** 090001
- [4] Gabyshev N *et al.* (Belle Collaboration) 2003 *Phys. Rev. Lett.* **90** 121802
- [5] Chistov R *et al.* (Belle Collaboration) 2006 *Phys. Rev.* **D74** 111105(R)
- [6] Hou W-S and Soni A 2001 *Phys. Rev. Lett.* **86** 4247-50
- [7] Suzuki M 2007 *J. Phys.* **G34** 283-298
- [8] Cheng H-Y, Chua C-K and Hsiao Y-K 2009 *Phys. Rev.* **D79** 114004
- [9] He X-G *et al.* 2007 *Phys. Rev.* **D75** 034011
- [10] Chua C-K and Hou W-S 2003 *Eur. Phys. J.* **C29** 27-35
- [11] C-K Chua *et al.* 2002 *Phys. Rev.* **D66** 054004