BESIII 粲强子物理研讨会

The study of the singly anti-charmed pentaquark production in b-factory

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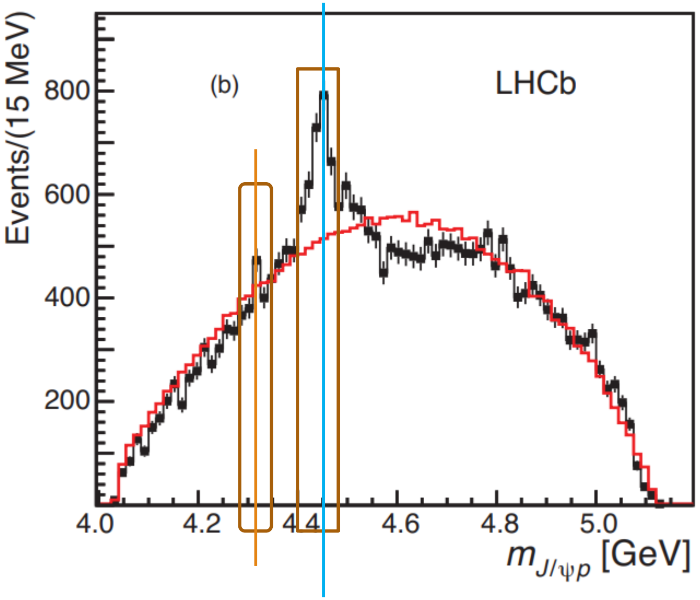
Outline

1. Introduction
2. Pentaquark $\bar{c}$qqqq
3. Decay and Production of pentaquark ground states
4. Results
5. Summary

Production from b-baryon

$$\Lambda_b^0 \to J/\psi K^- p$$

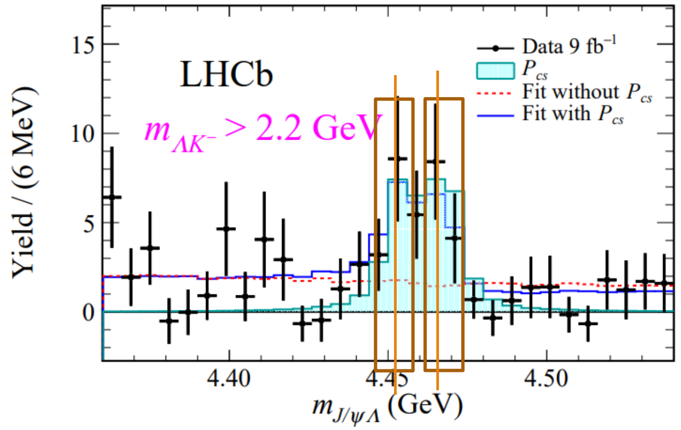


mass =4380 ± 8 ± 29 MeV,
width =205 ± 18 ± 86 MeV.

mass =4449.8 ± 1.7 ± 2.5 MeV,
width =39 ± 5 ± 19 MeV.

https://arxiv.org/pdf/1507.03414.pdf

$$\Xi_b^- \to J/\psi \Lambda K^-$$



Mass= 4454.9 ± 2.7 or 4467.8 ± 3.7 MeV

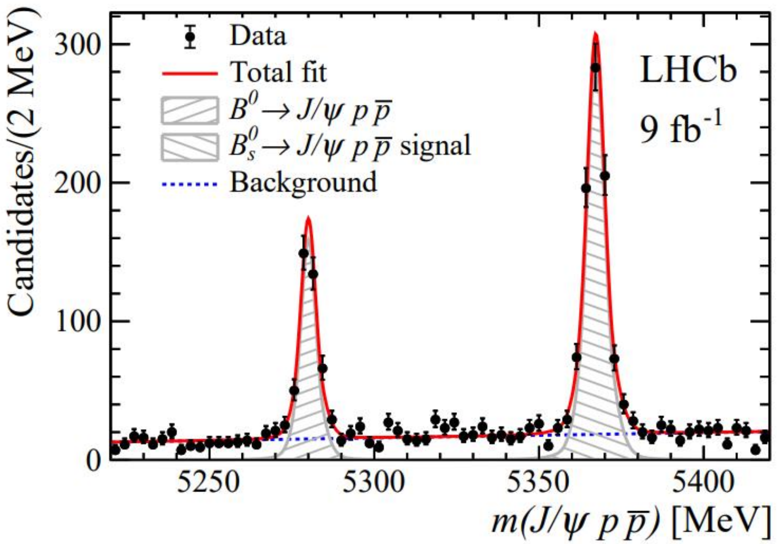
$$P_{cs}(4459)^0 : M = 4458.8 \pm 2.9^{+4.7}_{-1.1}\ \mathrm{MeV}\,,$$
$$\Gamma = 17.3 \pm 6.5^{+8.0}_{-5.7}\ \mathrm{MeV}\,.$$

https://arxiv.org/pdf/1904.03947.pdf

https://arxiv.org/pdf/2012.10380.pdf

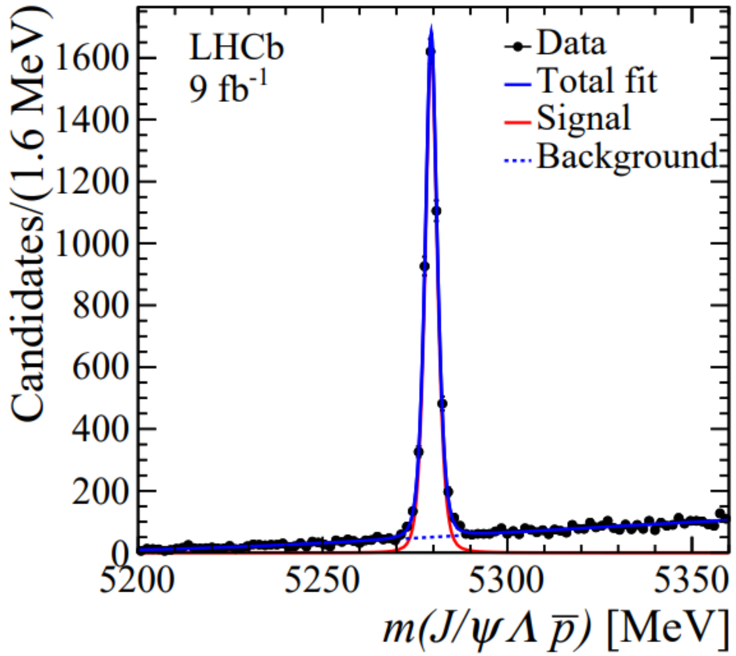
Production from b-meson

$$B_s^0 \to J/\psi p\bar{p}$$



$$M_{P_c} = 4337 \,{}^{+7}_{-4}\,{}^{+2}_{-2}\text{ MeV},$$
$$\Gamma_{P_c} = 29 \,{}^{+26}_{-12}\,{}^{+14}_{-14}\text{ MeV},$$

$$B^- \to J/\psi \Lambda \bar{p}$$



Mass =4338.2 ± 0.7 ± 0.4 MeV,
width = 7.0 ± 1.2 ± 1.3 MeV

https://arxiv.org/pdf/2108.04720.pdf

https://arxiv.org/pdf/2210.10346.pdf

Introduction

Table 1: Available charm dataset at some experiments at different kinds of colliders.

Experiment	Machine	C.M $\sqrt{s}$	Luminosity	charm sample	efficiency	☺advantage/☹disadvantage
CLEOc	CESR (e^+e^-)	3.77 GeV	0.8 fb^{-1}	$2.9\times10^6(D^0)$ $2.3\times10^6(D^+)$	~10-30%	☺ extremely clean enviroment ☺ pure D-beam, almost no bkg ☺ quantum coherence ☹ no CM boost, no T-dep analyses
		4.17 GeV	0.6 fb^{-1}	$0.6\times10^6(D_s^+)$		
BESIII	BEPC-II (e^+e^-)	3.77 GeV	2.9 fb^{-1}	$10.5\times10^6(D^0)$ $8.4\times10^6(D^+)$		
		4.18 GeV	3.0 fb^{-1}	$3\times10^6(D_s^+)$		
		4.6 GeV	0.6 fb^{-1}	$1\times10^5(\Lambda_c^+)$		
				★	★★★	
BELLE	KEKB (e^+e^-)	10.58 GeV	~~1 ab^{-1}~~ 988 fb^{-1}	$1.3\times10^9(D^0)$ $7.7\times10^8(D^+)$ $2.5\times10^8(D_s^+)$ $1.5\times10^8(\Lambda_c^+)$	~5-10%	☺ clear event environment ☺ high trigger efficiency ☺ high-efficiency detection of neutrals ☺ many high-statistics control samples ☺ time-dependent analysis ☹ smaller cross-section than pp collid.
	PEP-II (e^+e^-)	10.58 GeV	~~0.5 ab^{-1}~~ 518 fb^{-1}	$6.5\times10^8(D^0)$ $3.8\times10^8(D^+)$ $1.2\times10^8(D_s^+)$ $0.7\times10^8(\Lambda_c^+)$		
				★★	★★	
CDF	Tevatron ($p\bar{p}$)	1.96 TeV	9.6 fb^{-1}	1.3×10^{11}	$<0.5\%$	☺ large production cross-section ☺ large boost ☺ excellent time resolution ☹ dedicated trigger required ☹ hard to do with neutrals/neutrinos
LHCb	LHC (pp)	7 TeV 8 TeV	1.0 fb^{-1} 2.0 fb^{-1}	5.0×10^{12}		
				★★★	★	

the $\Upsilon(4S)$ resonance

↓

decays to $B\bar{B}$ pairs

↓

the *pentaquark state*

E. Kou et al. [Belle-II], PTEP 2019, no.12, 123C01 (2019)

L. K. Li [Belle], PoS BEAUTY2018, 023 (2018)

Expected yields of b-hadrons at Belle II, LHCb Upgrade II, and Tera-Z

b-hadrons	Belle II	LHCb $(300\,\mathrm{fb}^{-1})$	Tera-Z
B^0, $\bar{B}^0$	5.4×10^{10} $(50\ \mathrm{ab}^{-1}$ on $\Upsilon(4S))$	3×10^{13}	1.2×10^{11}
$B^{\pm}$	5.7×10^{10} $(50\ \mathrm{ab}^{-1}$ on $\Upsilon(4S))$	3×10^{13}	1.2×10^{11}
B_s^0, $\bar{B}_s^0$	6.0×10^{8} $(5\ \mathrm{ab}^{-1}$ on $\Upsilon(5S))$	1×10^{13}	3.1×10^{10}
$B_c^{\pm}$	-	1×10^{11}	1.8×10^{8}
Λ_b^0, $\bar{\Lambda}_b^0$	-	2×10^{13}	2.5×10^{10}

It is expected that the branching ratio of the exotic state generated by the $B\bar{B}$ pairs is large enough, in the order of 10^{-8}, there is a great chance to find it.

L. Aggarwal et al. [Belle-II], [arXiv:2207.06307 [hep-ex]]

https://arxiv.org/pdf/2208.08327.pdf

Theoretical study

1. H.-X. Chen, L.-S. Geng, W.-H. Liang, E. Oset, E. Wang, J.-J. Xie, Looking for a hidden-charm pentaquark state with strangeness S = -1 from Ξ_b^- decay into $J/\psi K^- \Lambda$, Phys. Rev. C 93 (6) (2016) 065203.

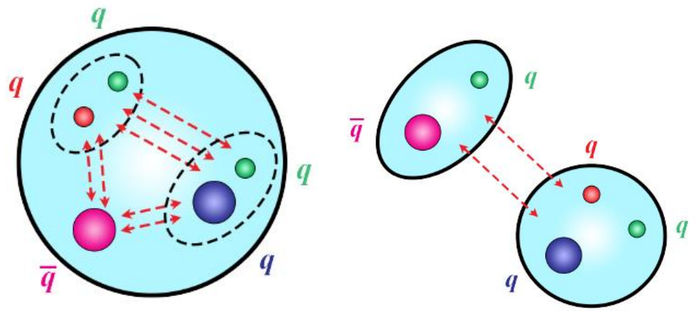
2. H.-Y. Cheng, C.-K. Chua, Bottom baryon decays to pseudoscalar meson and pentaquark, Phys. Rev. D 92 (9) (2015) 096009.

3. E. Santopinto, A. Giachino, Compact pentaquark structures, Phys. Rev. D 96 (1) (2017) 014014.

4. C.-W. Shen, H.-J. Jing, F.-K. Guo, J.-J. Wu, Exploring Possible Triangle Singularities in the $\Xi_b^- \to K^- J/\psi \Lambda$ decay, Symmetry 12 (10) (2020) 1611.

It was suggested in to search for the P_{cs} state in the $J/\psi\Lambda$ invariant mass spectrum of the $\Xi_b^- \to J/\psi K^- \Lambda$ decay.

The pentaquark state was investigated in Ref. [1] as a molecular state.



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5. F. -Z. Peng, M. -J. Yan, M. Sanchez, M. P. Valderrama, The Pcs(4459) pentaquark from a combined effective field theory and phenomenological perspective, Eur. Phys. J. C 81 (7) (2021) 666.

6. J.-T. Zhu, L.-Q. Song, J. He, Pcs(4459) and other possible molecular states from $\Xi_c^{(*)}\overline{D}^{(*)}$ and $\Xi_c'\overline{D}^{(*)}$ interactions, Phys. Rev. D 103 (7) (2021) 074007. (the quasipotential Bethe-Salpeter equation approach)

7. X. Hu, J. Ping, Investigation of hidden-charm pentaquarks with strangeness $S = -1$, Eur. Phys. J. C 82 (2) (2022) 118. (the chiral quark model)

8. M.-L. Du, Z.-H. Guo, J. A. Oller, Insights into the nature of the Pcs(4459), Phys. Rev. D 104 (11) (2021) 114034. (the molecular picture)

9. U. Özdem, Magnetic dipole moments of the hidden-charm pentaquark states: Pc(4440), Pc(4457) and Pcs(4459), Eur. Phys. J. C 81 (4) (2021) 277. (the light-cone QCD sum rule)

10. F. Gao, H.-S. Li, The magnetic moments of hidden-charm strange pentaquark, Chin.Phys.C 46 (2022) 12, 123111. (within the meson-baryon, diquark-diquark-antiquark, and diquark-triquark pictures)

11. C. W. Xiao, J. J. Wu, B. S. Zou, Molecular nature of Pcs(4459) and its heavy quark spin partners, Phys. Rev. D 103 (5) (2021) 054016. (the coupled-channel unitary approach combined with the heavy quark spin and local hidden-gauge symmetries)

12. H.-X. Chen, W. Chen, X. Liu, X.-H. Liu, Establishing the rst hidden-charm pentaquark with strangeness, Eur. Phys. J. C 81 (5) (2021) 409. (QCD sum rule method)

These works may be useful in determining the quantum numbers and the internal structure of the pentaquak states.

Pentaquark $\bar{c}$qqqq

1. The wave function

symmetric — antisymmetric — symmetric

$$\psi_{\text{flavor}}(S) = \bar{c}\Big\{[qq]_A[qq]_A\Big\}_S,\quad \psi_{\text{color}}(A) = \bar{c}_{\bar{3}}\Big[(qq)(qq)\Big]_3,\quad \psi_{\text{spin}}(S) = \bar{c}_{\frac{1}{2}}\Big\{[qq]_A[qq]_A\Big\}_S$$

2. The tensor representation

the pentaquark states $\bar{c}$qqqq → SU(3) → $\bar{6}$, 15, 15'

$$S_0^0 \to I_3(0), Y(0), \qquad S_{\frac{1}{2}}^0 \to I_3(\frac{1}{2}), Y(-1)$$

$$S_{-\frac{1}{2}}^- \to I_3(-\tfrac{1}{2}), Y(-1), \qquad S_1^0 \to I_3(1), Y(-2)$$

$$S_0^- \to I_3(0), Y(-2), \qquad S_{-1}^{--} \to I_3(-1), Y(-2)$$

15, 15': strong decay directly into the ground states $\bar{6}$

Pentaquark $\bar{c}qqqq$

hyper-charge

isospin

States	Name	Tensor	I_3	Y	Name	Tensor	I_3	Y	Name	Tensor	I_3	Y
6 state	S_0^0	$T_{\{33\}}$	0	0	$S^0_{\frac{1}{2}}$	$T_{\{23\}}$	$\frac{1}{2}$	-1	$S^-_{-\frac{1}{2}}$	$T_{\{13\}}$	$-\frac{1}{2}$	-1
	S_1^0	$T_{\{22\}}$	1	-2	S^-_0	$T_{\{12\}}$	0	-2	S^{--}_{-1}	$T_{\{11\}}$	-1	-2
15 state	F_1^+	$T_3^{\{11\}}$	1	0	F_0^0	$T_3^{\{12\}}$	0	0	F^-_{-1}	$T_3^{\{22\}}$	-1	0
	$F^+_{\frac{3}{2}}$	$T_2^{\{11\}}$	$\frac{3}{2}$	-1	$F^0_{\frac{1}{2}}, F'^0_{\frac{1}{2}}$	$T_2^{\{12\}}, T_3^{\{13\}}$	$\frac{1}{2}$	-1	$F^-_{-\frac{1}{2}}, F'^-_{-\frac{1}{2}}$	$T_1^{\{12\}}, T_3^{\{23\}}$	$-\frac{1}{2}$	-1
	$F^{--}_{-\frac{3}{2}}$	$T_1^{\{22\}}$	$-\frac{3}{2}$	-1	F_1^0	$T_2^{\{13\}}$	1	-2	F_0^-, F'^-_0	$T_1^{\{13\}}, T_2^{\{23\}}$	0	-2
	F^{--}_{-1}	$T_1^{\{23\}}$	-1	-2	$F^-_{\frac{1}{2}}$	$T_2^{\{33\}}$	$\frac{1}{2}$	-3	$F^{--}_{-\frac{1}{2}}$	$T_1^{\{33\}}$	$-\frac{1}{2}$	-3
15' state	T_2^{++}	$T^{\{1111\}}$	2	0	T_1^+	$T^{\{1112\}}$	1	0	T_0^0	$T^{\{1122\}}$	0	0
	T^-_{-1}	$T^{\{1222\}}$	-1	0	T^{--}_{-2}	$T^{\{2222\}}$	-2	0	$T^+_{\frac{3}{2}}$	$T^{\{1113\}}$	$\frac{3}{2}$	-1
	$T^0_{\frac{1}{2}}$	$T^{\{1123\}}$	$\frac{1}{2}$	-1	$T^-_{-\frac{1}{2}}$	$T^{\{1223\}}$	$-\frac{1}{2}$	-1	$T^{--}_{-\frac{3}{2}}$	$T^{\{2223\}}$	$-\frac{3}{2}$	-1
	T_1^0	$T^{\{1133\}}$	1	-2	T_0^-	$T^{\{1233\}}$	0	-2	T^{--}_{-1}	$T^{\{2233\}}$	-1	-2
	$T^-_{\frac{1}{2}}$	$T^{\{1333\}}$	$\frac{1}{2}$	-3	$T^{--}_{-\frac{1}{2}}$	$T^{\{2333\}}$	$-\frac{1}{2}$	-3	T_0^{--}	$T^{\{3333\}}$	0	-4

The possible representations of pentaquark

$$(T_{\bar{6}})_{\{11\}} = \bar{b}dsds - \bar{c}dssd - \bar{c}sdds + \bar{c}sdsd, \quad (T_{\bar{6}})_{\{12\}} = \bar{c}dssu - \bar{c}dsus - \bar{c}sdsu + \bar{c}sdus,$$

$$(T_{\bar{6}})_{\{13\}} = -\bar{c}dsdu + \bar{c}dsud + \bar{c}sddu - \bar{c}sdud, \quad (T_{\bar{6}})_{\{22\}} = \bar{c}susu - \bar{c}suus - \bar{c}ussu + \bar{c}usus,$$

$$(T_{\bar{6}})_{\{23\}} = -\bar{c}sudu + \bar{c}suud + \bar{c}usdu - \bar{c}usud, \quad (T_{\bar{6}})_{\{33\}} = \bar{c}dudu - \bar{c}duud - \bar{c}uddu + \bar{c}udud,$$

The quark constituent of pentaquark

Ref: Ye Xing, Wan-Liang Liu, Yi-Hua Xiao, Eur. Phys. J. C82: 1105 (2022)

Pentaquark $\bar{c}$qqqq

3. The mass

Above the strong decay threshold DN: 66 MeV

below the threshold about 94 MeV

mass/GeV	S_0^0	$S_{1/2}^0$	$S_{-1/2}^-$	S_0^-	S_1^0	S_{-1}^{--}
Quark model	2.71 [24]	2.580[15]	2.580[15]	2.77[15]	-	-
Constituent model [18, 27]	2.895 [27]	2.958 [18]	2.958 [18]	3.116 [18]	-	-
Chromomagnetic Interaction model [20]	2.87	2.831	2.831	3.026	3.22	3.22
QCD sum rules [25]	< 3.0					

If the pentaquark states *S* are below their corresponding strong decay threshold, then they will decay weakly. Otherwise, they will undergo by strong decays.

4. The lifetime

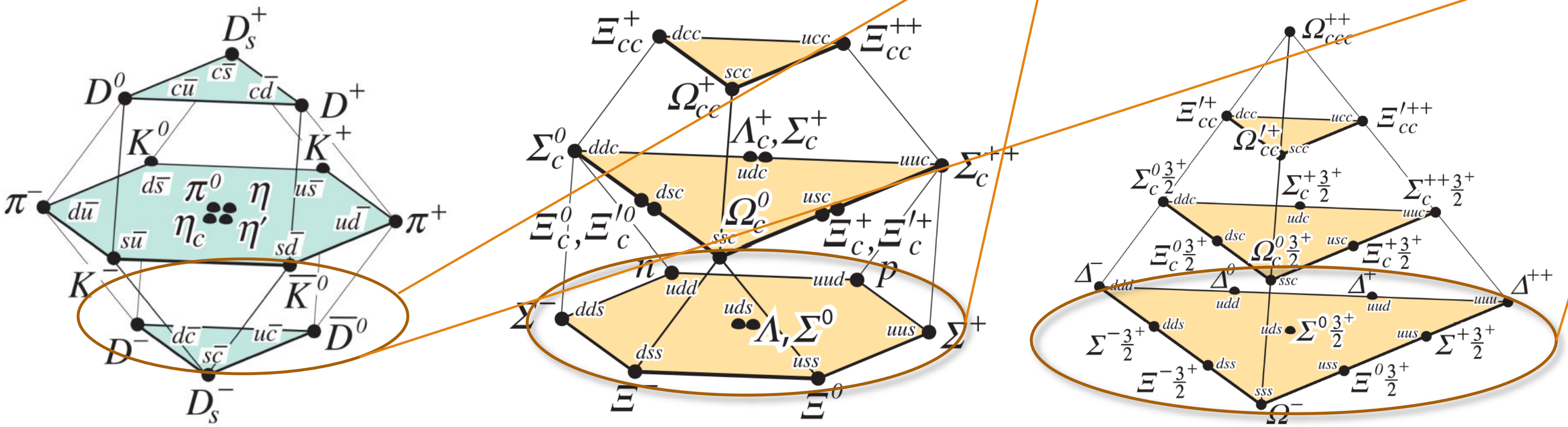
$$\tau(\bar{c}qqqq(\frac{1}{2}^-)) = 9.30 \times 10^{-13} s.$$

OPE method *Eur. Phys. J. C* 82 (2022) 12

Strongly decay of pentaquark ground states

1. The Hamiltonian

$$\mathcal{H} = A_1 (T_6)_{\{\alpha k\}} (D)_i (P_8)^k_j \varepsilon^{\alpha i j} + B_1 (T_6)_{\{ij\}} (D)_k (P_{10})^{ijk},$$



2. Considering the CKM and detection efficiency, the good channels can be chose.

$$S^0_0 \to D^- p,\ S^0_{1/2} \to D_s^- p,\ (S^0_{1/2} \to \overline{D}^0 \Lambda^0,\ S^0_{1/2} \to \overline{D}^0 \Sigma^0),$$

$$S^-_{-1/2} \to D^- \Lambda^0,\ (S^-_{-1/2} \to D^- \Sigma^0),\ S^-_0 \to D_s^- \Sigma^0,\ (S^-_0 \to \overline{D}^0 \Xi^-),\ S^{--}_{-1} \to D^- \Xi^-.$$

https://arxiv.org/pdf/2208.13874.pdf

Weakly decay of pentaquark ground states

1. The Hamiltonian

$$H = A_1 S^{\{ij\}}(H_6)_{\{ij\}} M_l^k (P_8)_k^l + A_2 S^{\{ij\}}(H_6)_{\{ik\}} M_l^k (P_8)_j^l$$
$$+A_3 S^{\{ij\}}(H_6)_{\{il\}} M_j^k (P_8)_k^l + A_4 S^{\{ij\}}(H_6)_{\{kl\}} M_i^k (P_8)_j^k + \bar{A}_1 S^{\{\alpha i\}}(H_{15})_i^{\{jk\}} M_j^l (P_8)_k^m \varepsilon_{\alpha lm}$$
$$+[\bar{A}_2 S^{\{\alpha i\}}(H_{15})_i^{\{jk\}} M_j^l (P_8)_l^m + \bar{A}_4 S^{\{\alpha i\}}(H_{15})_l^{\{jk\}} M_i^l (P_8)_j^m + \bar{A}_5 S^{\{\alpha i\}}(H_{15})_l^{\{jk\}} M_j^l (P_8)_i^m]\varepsilon_{\alpha km}$$
$$+[\bar{A}_3 S^{\{\alpha i\}}(H_{15})_i^{\{jk\}} M_m^l (P_8)_j^m + \bar{A}_6 S^{\{\alpha i\}}(H_{15})_m^{\{jk\}} M_i^l (P_8)_j^m + \bar{A}_7 S^{\{\alpha i\}}(H_{15})_m^{\{jk\}} M_j^l (P_8)_i^m]\varepsilon_{\alpha kl}.$$

2. The transition operator $\bar{c}q_1\bar{q}_2q_3$, which can be composed as $3 \otimes 3 \otimes \bar{3} = \bar{3} \oplus \bar{3} \oplus 6 \oplus 15$.

Cabibbo allowed nonzero tensor components

$$(H_6)_2^{31} = -(H_6)_2^{13} = 1, \ (H_{15})_2^{31} = (H_{15})_2^{13} = 1.$$

3. The golden channels

$$S_{1/2}^0 \to \pi^- p, \ S_1^0 \to K^- p, \ (S_1^0 \to K^+\Xi^-), \ S_0^- \to \pi^-\Lambda^0, \ (S_0^- \to \pi^-\Sigma^0).$$

Production of pentaquark via B decays

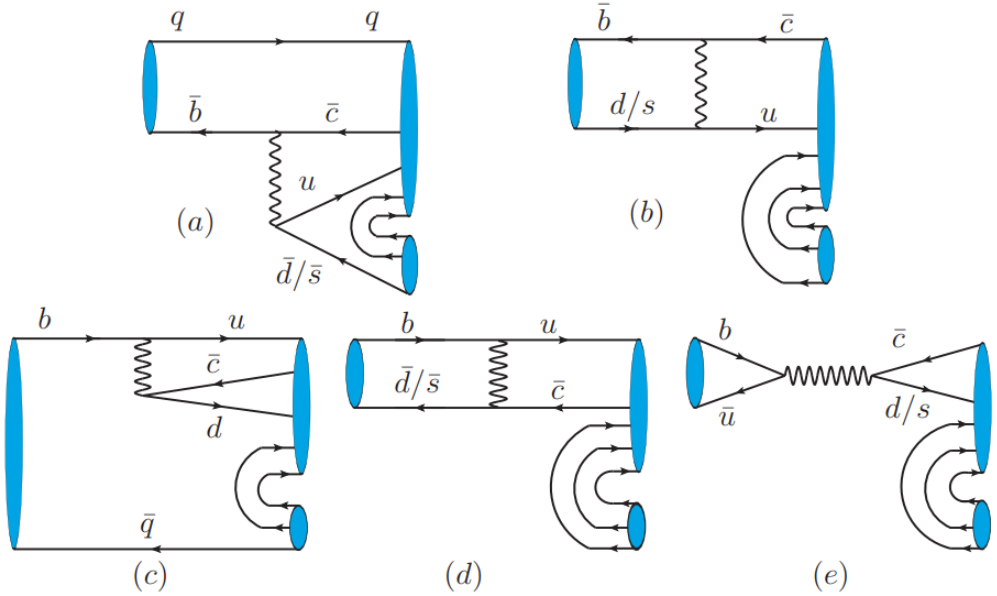
1. The Hamiltonian

$$
\begin{aligned}
\mathcal{H}_6 \quad &= e_1 B_{[ij]}(H_8)^i_k(\overline{T}_6)^{\{jl\}}(P_{\overline{8}})^k_l + e_2 B_{[ij]}(H_8)^i_k(\overline{T}_6)^{\{kl\}}(P_{\overline{8}})^j_l + e_3 B_{[ij]}(H_8)^l_k(\overline{T}_6)^{\{ik\}}(P_{\overline{8}})^j_l \\
&+ a_1 \overline{B}_i (H_{\overline{3}})_j (\overline{T}_6)^{\{ik\}}(P_{\overline{8}})^j_k + a_2 \overline{B}_i (H_{\overline{3}})_j (\overline{T}_6)^{\{jk\}}(P_{\overline{8}})^i_k + a_3 \overline{B}_i (H_6)^{\{ij\}}(\overline{T}_6)^{\{\alpha k\}}(P_{\overline{8}})^l_k \ \varepsilon_{\alpha j l}.
\end{aligned}
$$

The operators $H_8 : \bar{b} \to \bar{c} u \bar{d}/\bar{s}$, $H_{\overline{3}}$ and 6 :$b \to u \bar{c} d/s$.

2. the golden channels for each ground states

$$
\begin{aligned}
CA: \quad & B_s^0 \to S_1^0 \overline{\Lambda}^0/\Sigma^0, (B^+ \to S_1^0 \overline{\Xi}^+), B^0 \to S_0^0 \overline{n}, B_s^0 \to S_{1/2}^0 \overline{n}, (B^0 \to S_{1/2}^0 \overline{\Lambda}^0, B^0 \to S_{1/2}^0 \overline{\Sigma}^0), \\
& B^0 \to S_{-1/2}^- \overline{\Sigma}^+, B^0 \to S_0^- \Xi^+. \\
CS: \quad & \overline{B}_s^0 \to S_0^0 \overline{n},\ B^- \to S_{1/2}^0 \overline{p},\ B^- \to S_{-1/2}^- \overline{n}, B^- \to S_0^- \overline{\Lambda}^0,\ \overline{B}^0 \to S_1^0 \overline{\Lambda}^0,\ B^- \to S_{-1}^{--} \overline{\Sigma}^+.
\end{aligned}
$$



Results

1. The rates of different decay widths

Cabibbo allowed

$$\Gamma_{B^+\to S_0^0\overline{\Sigma}^+}:\Gamma_{B^+\to S^0_{1/2}\overline{\Sigma}^+}:\Gamma_{B^+\to S^0_{1/2}\overline{\Xi}^+}:\Gamma_{B^+\to S^0_{1}\overline{\Xi}^+}:\Gamma_{B^0\to S^0_{0}\overline{\Sigma}^0}=1:18:1:15:0.5,$$

$$\Gamma_{B^0\to S^0_{1/2}\overline{\Xi}^0}:\Gamma_{B_s^0\to S^0_{1/2}\overline{n}}=1:21,\ \Gamma_{B^0\to S^-_{-1/2}\overline{\Xi}^+}:\Gamma_{B_s^0\to S^0_{1}\overline{\Sigma}^0}:\Gamma_{B_s^0\to S^-_{0}\overline{\Sigma}^+}=1:9:18,$$

$$\Gamma_{B_s^0\to S^0_{1}\overline{\Xi}^0}:\Gamma_{B_s^0\to S^-_{0}\overline{\Xi}^+}:\Gamma_{B^0\to S^0_{0}\overline{n}}:\Gamma_{B^0\to S^-_{-1/2}\overline{\Sigma}^+}=1:1:25:23,$$

$$\Gamma_{B_s^0\to S^0_{0}\overline{n}}:\Gamma_{B^0\to S^0_{1}\overline{\Xi}^0}=14:1,\ \Gamma_{B_s^0\to S^0_{1/2}\overline{\Sigma}^0}:\Gamma_{B_s^0\to S^-_{-1/2}\overline{\Sigma}^+}=1:2.$$

Cabibbo suppressed

$$\Gamma_{B^-\to S^-_{-1/2}\overline{\Sigma}^0}:\Gamma_{B^-\to S^0_{1/2}\overline{p}}:\Gamma_{B^-\to S^0_{0}\overline{p}}:\Gamma_{B^-\to S^0_{1/2}\overline{\Sigma}^-}:\Gamma_{B^-\to S^0_{1}\overline{\Sigma}^-}=1:39:2:2:30,$$

$$\Gamma_{B^-\to S^-_{0}\overline{\Xi}^0}:\Gamma_{B^-\to S^-_{-1/2}\overline{n}}:\Gamma_{B^-\to S^{--}_{-1}\overline{\Sigma}^+}:\Gamma_{B^-\to S^{--}_{-1}\overline{\Xi}^+}=1:25:19:1,$$

The difference between the decay widths of different production processes from B mesons is relatively large, but they are interrelated.

Once anyone decay channel will be detected in the future, we can give other decay widths.

Results

2. The branching ratio of different decay widths

$$\Gamma_{BS\bar{P}} = \frac{G_{BS\bar{P}}^2}{8\pi}|V_{CKM}|^2\frac{|\mathbf{q}|}{m_B^2}|F(\mathbf{q}^2)|^2,$$

state	mode	width	branching ratio	state	mode	width	branching ratio
S_1^0	$B_s^0 \to S_1^0\overline{\Lambda}^0$	3.88×10^{-21}	8.96×10^{-9}	$S_{1/2}^0$	$B_s^0 \to S_{1/2}^0\overline{n}$	3.28×10^{-21}	7.58×10^{-9}
	$B_s^0 \to S_1^0\overline{\Sigma}^0$	4.13×10^{-21}	9.95×10^{-9}		$B^0 \to S_{1/2}^0\overline{\Lambda}^0$	4.30×10^{-21}	9.92×10^{-9}
	$B^+ \to S_1^0\overline{\Xi}^+$	5.56×10^{-21}	1.39×10^{-8}		$B^0 \to S_{1/2}^0\overline{\Sigma}^0$	4.59×10^{-21}	1.06×10^{-8}
	$\overline{B}^0 \to S_1^0\overline{\Lambda}^0$	3.59×10^{-23}	8.30×10^{-11}		$B^- \to S_{1/2}^0\bar{p}$	3.00×10^{-23}	7.47×10^{-11}
S_0^0	$B^0 \to S_0^0\overline{n}$	3.44×10^{-21}	7.93×10^{-9}	$S_{-1/2}^-$	$B^0 \to S_{-1/2}^-\overline{\Sigma}^+$	4.57×10^{-21}	1.06×10^{-8}
	$\overline{B}_s^0 \to S_0^0\bar{n}$	2.38×10^{-23}	5.49×10^{-11}		$B^- \to S_{-1/2}^-\bar{n}$	3.00×10^{-23}	7.47×10^{-11}
S_0^-	$B^0 \to S_0^-\overline{\Xi}^+$	6.70×10^{-21}	1.55×10^{-8}	S_{-1}^{--}	$B^- \to S_{-1}^{--}\overline{\Sigma}^+$	5.38×10^{-23}	1.34×10^{-10}
	$B^- \to S_0^-\bar{\Lambda}^0$	4.22×10^{-23}	1.05×10^{-10}				

Results

the reconstruction through strong decays

the reconstruction through weak decays

3. The production events

S.1				S.2			
state	production mode	experimental signatures	events	state	production mode	experimental signature	events
S_0^0	$B^0 \to S_0^0(\to D^- p)\bar{n}$	$M(D^- p)$	424	S_1^0	$B_s^0 \to S_1^0(\to K^- p)\bar{\Lambda}$	$M(K^- p)$	698
	$\overline{B}_s^0 \to S_0^0(\to D^- p)\bar{n}$	$M(D^- p)$	3		$B_s^0 \to S_1^0(\to K^- p)\overline{\Sigma}^0$	$M(K^- p)$	744
S_0^-	$B^0 \to S_0^-(\to D_s^- \Sigma^0)\overline{\Xi}^+$	$M(D_s^- \Sigma^0)$	347		$B^+ \to S_1^0(\to K^- p)\overline{\Xi}^+$	$M(K^- p)$	1079
	$B^- \to S_0^-(\to D_s^- \Sigma^0)\bar{\Lambda}$	$M(D_s^- \Sigma^0)$	2		$\overline{B}^0 \to S_1^0(\to K^- p)\bar{\Lambda}$	$M(K^- p)$	7
$S_{1/2}^0$	$B_s^0 \to S_{1/2}^0(\to D_s^- p)\bar{n}$	$M(D_s^- p)$	380	$S_{1/2}^0$	$B_s^0 \to S_{1/2}^0(\to \pi^- p)\bar{n}$	$M(\pi^- p)$	8
	$B^0 \to S_{1/2}^0(\to D_s^- p)\bar{\Lambda}$	$M(D_s^- p)$	497		$B^0 \to S_{1/2}^0(\to \pi^- p)\bar{\Lambda}$	$M(\pi^- p)$	10
	$B^0 \to S_{1/2}^0(\to D_s^- p)\overline{\Sigma}^0$	$M(D_s^- p)$	531		$B^0 \to S_{1/2}^0(\to \pi^- p)\overline{\Sigma}^0$	$M(\pi^- p)$	10
	$B^- \to S_{1/2}^0(\to D_s^- p)\bar{p}$	$M(D_s^- p)$	4		$B^- \to S_{1/2}^0(\to \pi^- p)\bar{p}$	$M(\pi^- p)$	0
$S_{-1/2}^-$	$B^0 \to S_{-1/2}^-(\to D^- \Lambda)\overline{\Sigma}^+$	$M(D^- \Lambda)$	253	S_0^-	$B^0 \to S_0^-(\to \pi^- \Lambda^0)\overline{\Sigma}^+$	$M(\pi^- \Lambda^0)$	267
	$B^- \to S_{-1/2}^-(\to D^- \Lambda)\bar{n}$	$M(D^- \Lambda)$	2		$B^- \to S_0^-(\to \pi^- \Lambda^0)\bar{\Lambda}$	$M(\pi^- \Lambda^0)$	2
S_{-1}^{--}	$B^- \to S_{-1}^{--}(\to D^- \Xi^-)\overline{\Sigma}^+$	$M(D^- \Xi^-)$	2				

$$(10^{13}) \cdot (1.06 \times 10^{-8}) \cdot (1.46 \times 10^{-2}) \cdot (63.9 \times 10^{-2}) \cdot (0.7)^3 \simeq 531 \text{ events.}$$

$$(10^{13}) \cdot (1.39 \times 10^{-8}) \cdot (1.59 \times 10^{-2}) \cdot (0.7)^2 \simeq 1079 \text{ events.}$$

Pentaquark production via b baryon decays

1. Pentaquark signatures in b baryon decays

the reconstruction through strong decays

the reconstruction through weak decays

	S states	production mode	experimental signatures
S.1	S_0^0	$\Lambda_b^0 \to S_0^0(\to D^- p)\bar{K}^0$	$\mathrm{M}(D^- p)$
	$S_{1/2}^0$	$\Lambda_b^0 \to S_{1/2}^0(\to D_s^- p)K^-$	$\mathrm{M}(D_s^- p)$
	$S_{-1/2}^-$	$\Lambda_b^0 \to S_{-1/2}^-(\to D^- \Lambda)\pi^+$	$\mathrm{M}(D^- \Lambda)$
	S_0^-	$\Xi_b^0 \to S_0^-(\to D_s^- \Sigma^0)\pi^+$	$\mathrm{M}(D_s^- \Sigma^0)$
	S_{-1}^{--}	$\Xi_b^- \to S_{-1}^{--}(\to D^- \Xi^-)\pi^+$	$\mathrm{M}(D^- \Xi^-)$
S.2	$S_{1/2}^0$	$\Lambda_b^0 \to S_{1/2}^0(\to \pi^- p)K^-$	$\mathrm{M}(\pi^- p)$
	S_0^-	$\Xi_b^0 \to S_0^-(\to \pi^- \Lambda^0)\pi^+$	$\mathrm{M}(\pi^- \Lambda^0)$
	S_1^0	$\Xi_b^- \to S_1^0(\to K^- p)\pi^-$	$\mathrm{M}(K^- p)$

2. The golden channels

$$\Lambda_b^0 \to S_0^0 \bar{K}^0,\ \Lambda_b^0 \to S_{1/2}^0 K^-,\ \Lambda_b^0 \to S_{-1/2}^- \pi^+,\ \Xi_b^0 \to S_0^- \pi^+,\ \Xi_b^- \to S_{-1}^{--} \pi^+,\ \Xi_b^- \to S_1^0 \pi^-.$$

Summary

1. The production of pentaquark $\bar{c}qqqq$ via B meson decays have been discussed under the strategy of light quark SU(3) symmetry.

2. The possible Hamiltonian of the strong decay, weak decay and production for the ground states S_6 have been constructed by the representations of initial and final states.

3. The amplitude of different channels and the relations of different channels have been obtained.

4. We suggest several dominant channels for searching the pentaquark S_6 at b-factory experiments.

$$B_s^0 \to S_1^0\overline{\Lambda}^0/\Sigma^0, (B^+ \to S_1^0\Xi^+), B^0 \to S_0^0\overline{n}, B_s^0 \to S_{1/2}^0\overline{n}, (B^0 \to S_{1/2}^0\overline{\Lambda}^0, B^0 \to S_{1/2}^0\overline{\Sigma}^0),$$

$$B^0 \to S_{-1/2}^{-}\overline{\Sigma}^+, B^0 \to S_0^- \Xi^+,\ B^- \to S_{-1}^{--}\overline{\Sigma}^+.$$

$$\Lambda_b^0 \to S_0^0\bar{K}^0,\ \Lambda_b^0 \to S_{1/2}^0 K^-,\ \Lambda_b^0 \to S_{-1/2}^-\pi^+,\ \Xi_b^0 \to S_0^-\pi^+,\ \Xi_b^- \to S_{-1}^{--}\pi^+,\ \Xi_b^- \to S_1^0\pi^-.$$

5. Combining the integrated luminosity and the reconstruction efficiency, we consider both strong and weak decays of the S states to calculate the production events in the experiments.

It is expected that in the future work, the three body weak decay process of b meson and baryon will be studied, and more results about the production and detection of S will be given for experimental reference.