通过衰变对重子激发态性质的探讨

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LY, XH, PRD87,094002(2013)   KL, LY, XH, QZ, PRD95,016010(2017)

LY, XH, PRD98,034004(2018)   KL, YX, XH, QZ, PRD96,016016(2017)

ZY, LC, QF , LY, XH, PRD98,114023(2018)

KL, QF, XH, PRD99,014011(2019)

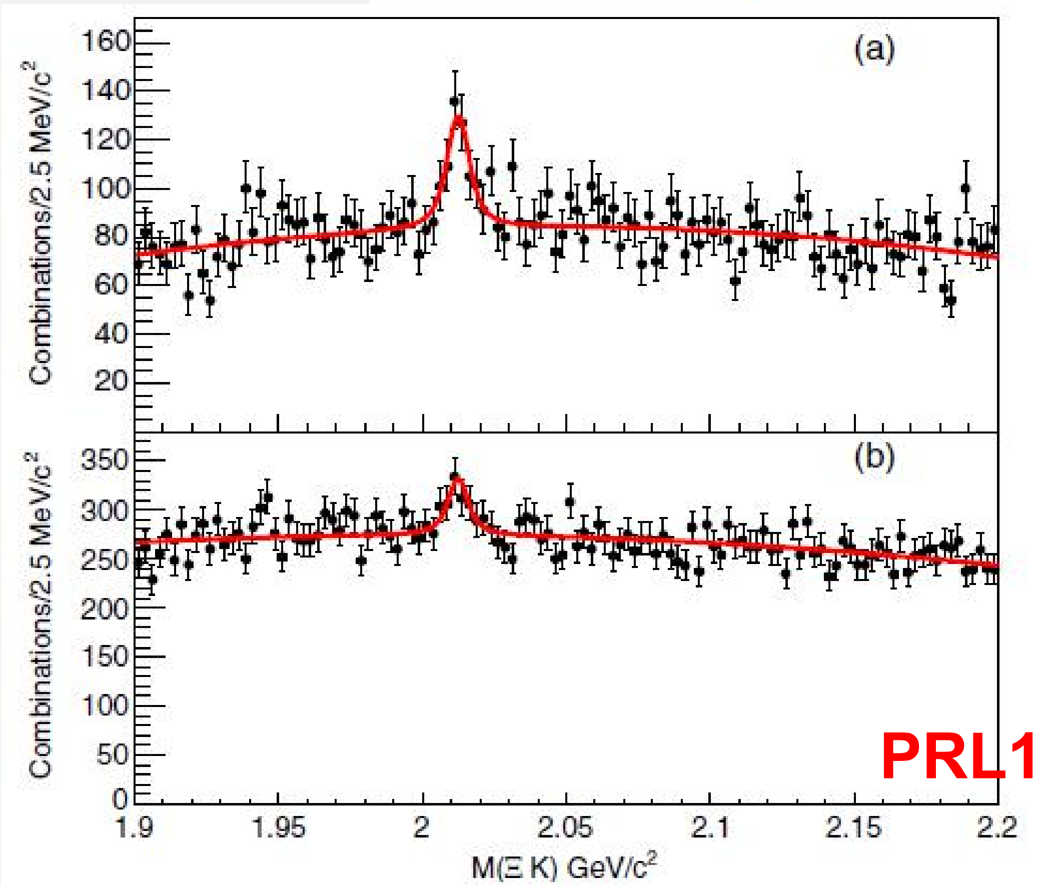
Ω超子激发态

LY, XH, PRD98,034004(2018)

ZY, LC, QF , LY, XH, PRD98,114023(2018)

新发现的Ω(2012) @Belle

Observation of an Excited Ω^- Baryon



M=2012 MeV

Γ=6.4 MeV

PRL121,052003（2018）

Ω谱的夸克模型预言

State	Experiment [1]	[5]	[4]	[3]	[8]
$\|56, {}^4 10, 0, 0, \frac{3}{2}^+\rangle$	1672.45	1678	1635	1694	1675
$\|70, {}^2 10, 1, 1, \frac{1}{2}^-\rangle$	…	1941	1950	1837	2020
$\|70, {}^2 10, 1, 1, \frac{3}{2}^-\rangle$	…	2038	2000	1978	2020
$\|70, {}^2 10, 2, 0, \frac{1}{2}^+\rangle$	…	2301	2220	2140	2190
$\|56, {}^4 10, 2, 2, \frac{1}{2}^+\rangle$	…		2255		2210
$\|56, {}^4 10, 2, 0, \frac{3}{2}^+\rangle$	…	2173/2304	2165	2282	2065
$\|56, {}^4 10, 2, 2, \frac{3}{2}^+\rangle$	…		2280		2215
$\|70, {}^2 10, 2, 2, \frac{3}{2}^+\rangle$	…		2345		2265
$\|56, {}^4 10, 2, 2, \frac{5}{2}^+\rangle$	…	2401	2280	…	2225
$\|70, {}^2 10, 2, 2, \frac{5}{2}^+\rangle$	…		2345	…	2265
$\|56, {}^4 10, 2, 2, \frac{7}{2}^+\rangle$	…	2332	2295	…	2210

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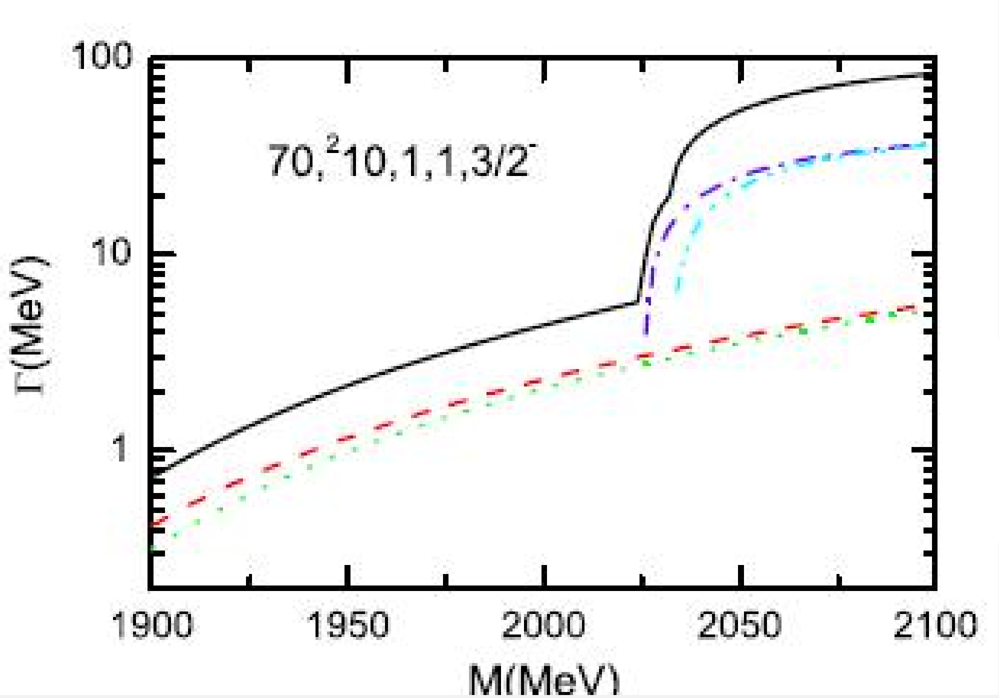
$\Omega(2012)$作为$J^P=3/2^-$的态

实验测量的衰变性质与手征夸克模型的解释一致



$$\Gamma^{\rm th}_{\rm total}[\Omega(2012)] = 5.03\ \mathrm{MeV},$$

$$\mathcal{R} = \frac{\mathcal{B}[\Omega(2012) \to \Xi^0 K^-]}{\mathcal{B}[\Omega(2012) \to \Xi^- \bar{K}^0]} \simeq 1.10,$$

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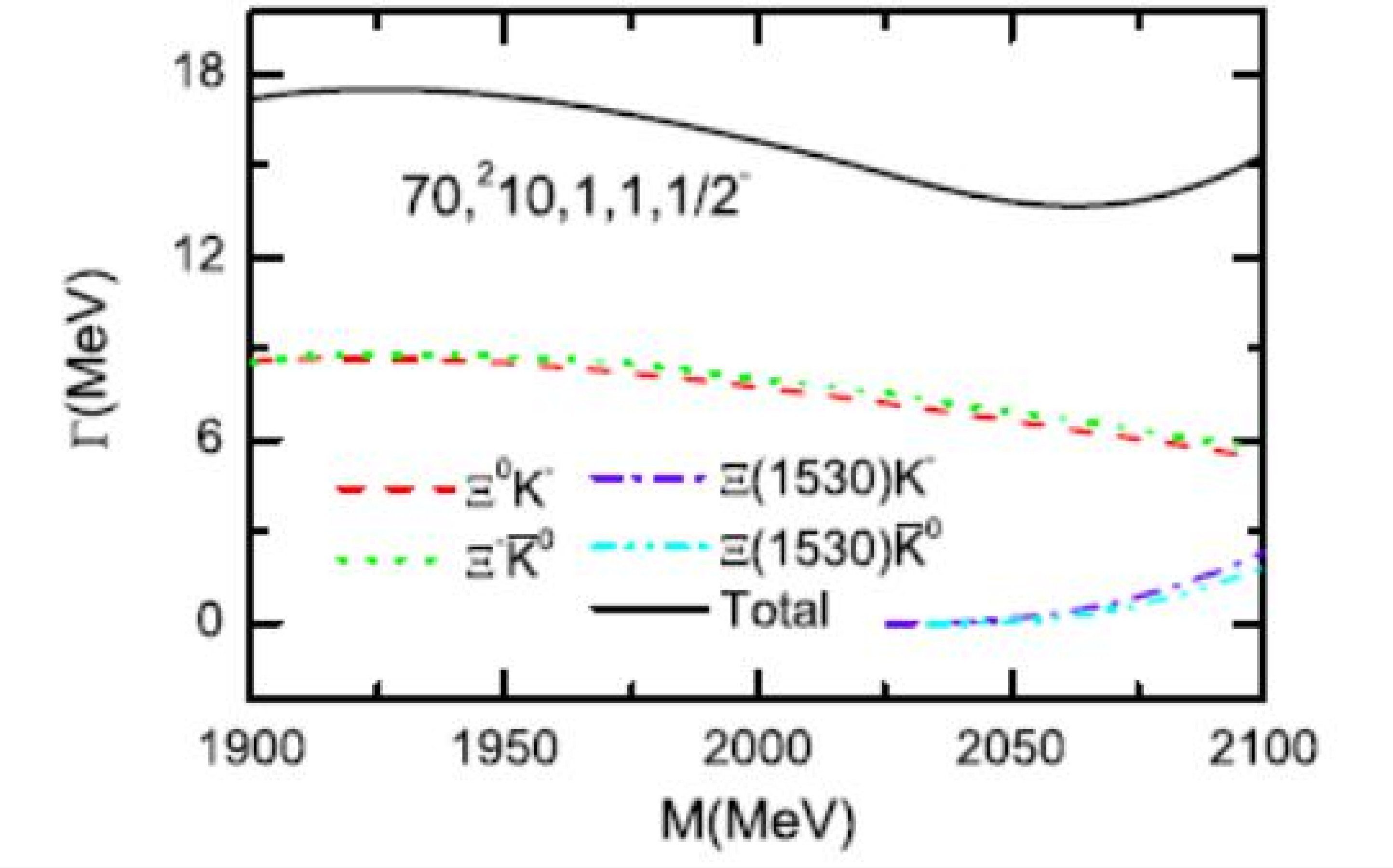
其它Ω激发态的强衰变性质

$J^P=1/2^-$的态的衰变性质：宽度 15-18 MeV



主要衰变到 ΞK, 期待实验观测！

其它Ω激发态的强衰变性质

其它的较高激发态的衰变性质

States	Mass [8]	$\Gamma[\Xi K]$	$\Gamma[\Xi(1530)K]$	$\Gamma[\Omega\eta]$	$\Gamma^{\mathrm{th}}_{\mathrm{total}}$
$\lvert 70, {}^2 10, 2, 0, 1/2^+\rangle$	2190	0.01	2.39	…	2.40
$\lvert 56, {}^4 10, 2, 0, 3/2^+\rangle$	2065	1.48	0.94	…	2.42
$\lvert 56, {}^4 10, 2, 2, 1/2^+\rangle$	2210	48.8	4.09	…	52.9
$\lvert 56, {}^4 10, 2, 2, 3/2^+\rangle$	2215	24.4	14.0	…	38.4
$\lvert 56, {}^4 10, 2, 2, 5/2^+\rangle$	2225	3.19	20.0	0.11	23.3
$\lvert 56, {}^4 10, 2, 2, 7/2^+\rangle$	2210	13.0	1.16	…	14.2
$\lvert 70, {}^2 10, 2, 2, 3/2^+\rangle$	2265	3.82	10.8	1.56	16.2
$\lvert 70, {}^2 10, 2, 2, 5/2^+\rangle$	2265	1.30	9.56	0.81	11.7

我们也用3P0模型研究了Ω激发态的衰变性质

WANG, GUI, LÜ, XIAO, and ZHONG   PHYS. REV. D **98**, 114023 (2018)

Ξ 超子激发态

LY, XH, PRD87,094002(2013)

三超子谱的理论预言

TABLE XI. Comparison of theoretical predictions and experimental data for the masses of the Ξ states (in MeV).

	Experiment [1]			Theory					
J^P	State	Status	Mass	Our	[20]	[21]	[22]	[23]	[24]
$\frac{1}{2}^+$	Ξ	****	1321.71 ± 0.07	1330	1305	1310	1348	1317	1303 ± 13
				1886	1840	1876	1805	1772	2178 ± 48
				1993	2040	2062		1868	2231 ± 44
				2012	2100	2131		1874	2408 ± 45
				2091	2130	2176			
				2142	2150	2215			
				2367	2230	2249			
$\frac{3}{2}^+$	Ξ(1530)	****	1531.80 ± 0.32	1518	1505	1539	1528	1552	1553 ± 18
				1966	2045	1988		1653	2228 ± 44
				2100	2065	2076			2398 ± 52
				2121	2115	2128			2574 ± 52
				2122	2165	2170			
				2144	2170	2175			
				2149	2210	2219			
				2421	2230	2257			
$\frac{5}{2}^+$				2108	2045	2013			
				2147	2165	2141			
				2213	2230	2197			
$\frac{7}{2}^+$				2189	2180	2169			

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PHYSICAL REVIEW D 92, 054005 (2015)

TABLE XI. Comparison of theoretical predictions and experimental data for the masses of the Ξ states (in MeV).

	Experiment [1]			Theory					
J^P	State	Status	Mass	Our	[20]	[21]	[22]	[23]	[24]
$\frac{1}{2}^-$				1682	1755	1770			1716 ± 43
				1758	1810	1922			1837 ± 28
				1839	1835	1938			1844 ± 43
				2160	2225	2241			2758 ± 78
				2210	2285	2266			
				2233	2300	2387			
				2261	2320	2411			
$\frac{3}{2}^-$				1764	1785	1780	1792	1861	1894 ± 38
	Ξ(1820)	***	1823 ± 5	1798	1880	1873		1971	1906 ± 29
				1904	1895	1924			2426 ± 73
				2245	2240	2246			2497 ± 61
				2252	2305	2284			
				2350	2330	2353			
				2352	2340	2384			
$\frac{5}{2}^-$				1853	1900	1955	1881		
				2333	2345	2292			
				2411	2350	2409			
$\frac{7}{2}^-$				2460	2355	2320			
				2474		2425			
$\frac{9}{2}^-$				2502		2505			

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PHYSICAL REVIEW D **92**, 054005 (2015)

实验已确认的Ξ超子态

用Ξ（1530）作为输入，确定参数

TABLE II. The partial and total decay widths (MeV) of the well-established baryons $\Xi(1530)$, $\Sigma(1385)$, and $\Delta(1232)$, which correspond to the same representation $|56,^4 10, 0, 0, \frac{3}{2}^+\rangle$. The experimental data are obtained from PDG.

State	Channel	Γ_i^{th}	Γ_{total}^{th}	Γ_{total}^{exp}
$\Xi(1530)^0$	$\Xi^- \pi^+$	5.6	9.1 (input)	9.1 ± 0.5
	$\Xi^0 \pi^0$	3.5		
$\Xi(1530)^-$	$\Xi^0 \pi^-$	7.1	10.3	$9.9^{+1.7}_{-1.9}$
	$\Xi^- \pi^0$	3.2		
$\Sigma(1385)^+$	$\Sigma^+ \pi^0$	1.9	27.1	36 ± 0.7
	$\Sigma^0 \pi^+$	1.5		
	$\Lambda^0 \pi^+$	23.7		
$\Sigma(1385)^0$	$\Sigma^+ \pi^-$	1.8	27.9	36 ± 5
	$\Sigma^- \pi^+$	1.3		
	$\Lambda^0 \pi^0$	24.8		
$\Sigma(1385)^-$	$\Sigma^- \pi^0$	1.7	28.7	39.4 ± 2.1
	$\Sigma^0 \pi^-$	1.8		
	$\Lambda^0 \pi^-$	25.2		

Li-Ye Xiao, XH Zhong, PRD87,094002

Ξ (1690) J^P=1/2$^-$

$\Xi(1690)^0$ WIDTH

VALUE (MeV)	*EVTS*
10 ± 6	1400
44 ± 23	175
20 ± 4	183

$\Xi(1690)^-$ WIDTH

VALUE (MeV)	*CL%*	*EVTS*
< 8	90	104
47 ± 14		150
26 ± 6		45

$\Xi(1690)$ DECAY MODES

	Mode	Fraction (Γ_i/Γ)
Γ_1	$\Lambda \overline{K}$	seen
Γ_2	$\Sigma \overline{K}$	seen
Γ_3	$\Xi \pi$	seen
Γ_4	$\Xi^- \pi^+ \pi^0$	
Γ_5	$\Xi^- \pi^+ \pi^-$	possibly seen
Γ_6	$\Xi(1530)\pi$	

TABLE III. The total and partial decay widths (MeV) of $\Xi(1690)$ with different $J^P = 1/2^-$ assignments.

Assignment	$\Xi\pi$	$\Sigma\bar{K}$	$\Lambda\bar{K}$	$\Xi(1530)\pi$	Γ_{total}
$\lvert 70, ^2 8, 1, 1, \frac{1}{2}^- \rangle$	3.69	22.30	22.15	0.005	48.14
$\lvert 70, ^4 8, 1, 1, \frac{1}{2}^- \rangle$	59.05	5.58	22.15	0.001	86.78
$\lvert 70, ^2 10, 1, 1, \frac{1}{2}^- \rangle$	3.69	1.39	5.54	0.005	10.63

$\Xi(1820)\ 3/2^-$

$I(J^P) = \frac{1}{2}(\frac{3}{2}^-)$ Status: ∗∗∗

The clearest evidence is an 8-standard-deviation peak in ΛK^- seen by GAY 76C. TEODORO 78 favors $J = 3/2$, but cannot make a parity discrimination. BIAGI 87C is consistent with $J = 3/2$ and favors negative parity for this J value.

TABLE VI. The predicted total and partial decay widths (MeV) and partial decay width ratios of $\Xi(1820)$ as the $|70,{}^2 8, 1, 1, \frac{3}{2}^-\rangle$ assignment compared with the experimental data of ALITTI 69 [55].

Channel	$\Gamma_i^{\rm th}$	$\Gamma_{\rm total}^{\rm th}$	$\Gamma_{\rm total}^{\rm exp}$	$\frac{\Gamma_i}{\Gamma_{\rm total}}\vert_{\rm th}$	$\frac{\Gamma_i}{\Gamma_{\rm total}}\vert_{\rm exp}$
$\Xi\pi$	2.9	32.8	24^{+15}_{-10}	0.09	0.1 ± 0.1
$\Sigma\bar{K}$	10.6	...	...	0.32	0.30 ± 0.15
$\Lambda\bar{K}$	7.3	...	...	0.22	0.30 ± 0.15
$\Xi(1530)\pi$	12.0	...	...	0.37	0.30 ± 0.15

$\Xi(1950)$

实验已发现多个Ξ（1950）？？

We list here everything reported between 1875 and 2000 MeV. The accumulated evidence for a Ξ near 1950 MeV seems strong enough to include a $\Xi(1950)$ in the main Baryon Table, but not much can be said about its properties. In fact, there may be more than one Ξ near this mass.

$\Xi(1950)$ WIDTH

VALUE (MeV)	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
60±20 OUR ESTIMATE					
68±22		ADAMOVICH	99B	WA89	Σ^- nucleus, 345 GeV
100±31	129	BIAGI	87	SPEC	Ξ^- Be $\rightarrow (\Xi^-\pi^+)\pi^-$X
25±15±1.2	63	BIAGI	87C	SPEC	Ξ^- Be $\rightarrow (\Lambda\overline{K}^0)$ X
60± 8	150	BIAGI	81	SPEC	SPS hyperon beam
159±57	139	BRIEFEL	77	HBC	2.87 $K^- p \rightarrow \Xi^-\pi^+$X
87±26	44	BRIEFEL	77	HBC	2.87 $K^- p \rightarrow \Xi^0\pi^-$X
60±39	56	BRIEFEL	77	HBC	$\Xi(1530)\pi$
63±78		DIBIANCA	75	DBC	$\Xi\pi$
38±10		ROSS	73C		$(\Xi\pi)^-$
35±11	29	BADIER	72	HBC	$\Xi\pi$, $\Xi\pi\pi$, YK
56±26	21	GOLDWASSER	70	HBC	$\Xi\pi$
98±23	66	DAUBER	69	HBC	$\Xi\pi$
80±40	27	ALITTI	68	HBC	$\Xi^-\pi^+$
140±35	35	BADIER	65	HBC	$\Xi^-\pi^+$

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VALUE (MeV)	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
60±20 OUR ESTIMATE					
68±22		ADAMOVICH	99B	WA89	Σ^- nucleus, 345 GeV
100±31	129	BIAGI	87	SPEC	Ξ^- Be $\rightarrow (\Xi^-\pi^+)\pi^- X$
25±15±1.2	63	BIAGI	87C	SPEC	Ξ^- Be $\rightarrow (\Lambda\overline{K}^0) X$
60± 8	150	BIAGI	81	SPEC	SPS hyperon beam
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87±26	44	BRIEFEL	77	HBC	2.87 $K^- p \rightarrow \Xi^0\pi^- X$
60±39	56	BRIEFEL	77	HBC	$\Xi(1530)\pi$
63±78		DIBIANCA	75	DBC	$\Xi\pi$
38±10		ROSS	73C		$(\Xi\pi)^-$
35±11	29	BADIER	72	HBC	$\Xi\pi$, $\Xi\pi\pi$, YK
56±26	21	GOLDWASSER	70	HBC	$\Xi\pi$
98±23	66	DAUBER	69	HBC	$\Xi\pi$
80±40	27	ALITTI	68	HBC	$\Xi^-\pi^+$
140±35	35	BADIER	65	HBC	$\Xi^-\pi^+$

Ξ（1950） $J^P=5/2^-$

TABLE VIII. The total and partial decay widths (MeV) of the well-established four-star baryons $N(1675)$, $\Sigma(1775)$, and $\Lambda(1830)$, which correspond to $|70,^4 8, 1, 1, \frac{5}{2}^-\rangle$. The data are obtained from PDG.

Assignment	Channel	Γ_i^{th}	Γ_{total}^{th}	Γ_{total}^{exp}	$\frac{\Gamma_i}{\Gamma_{total}}\|_{th}$	$\frac{\Gamma_i}{\Gamma_{total}}\|_{exp}$
$N(1675)\frac{5}{2}^-$	$n\pi$	25.3	81	$130 \sim 165$	0.31	0.35–0.45
	$\Delta\pi$	50.6	...	...	0.62	0.50–0.60
	$N\eta$	5.8	...	...	0.07	0.01
$\Sigma(1775)\frac{5}{2}^-$	$\Sigma\pi$	8.0	76	$105 \sim 135$	0.11	0.02–0.05
	$\Lambda\pi^0$	19.1	...	...	0.25	0.14–0.20
	$n\bar{K}$	32.1	...	...	0.42	0.37–0.43
	$\Sigma(1385)\pi$	4.8	...	...	0.06	0.08–0.12
	$\Delta(1232)\bar{K}$	1.0	...	...	0.01	...
	$\Lambda(1520)\pi$	11.2	...	...	0.14	0.17–0.23
$\Lambda(1830)\frac{5}{2}^-$	$\Sigma\pi$	52.2	94	$60 \sim 110$	0.55	0.35–0.75
	$\Sigma(1385)\pi$	41.7	...	...	0.45	>0.15
$\Xi(1950)\frac{5}{2}^-$	$\Xi\pi$	71.33	105	80 ± 40	0.68	...
	$\Sigma\bar{K}$	7.8	...	...	0.07	...
	$\Lambda\bar{K}$	13.6	...	...	0.13	...
	$\Xi(1530)\pi$	10.9	...	...	0.10	...
	$\Sigma(1385)\bar{K}$	1.2	...	...	0.01	...

值得在Ξπ等主要衰变道进一步寻找，相对分支比很重要！

Ξ（1950） $J^P=5/2^+$

TABLE IX. The total and partial decay widths (MeV) of the well-established four-star baryons $N(1680)$, $\Sigma(1915)$, and $\Lambda(1820)$, which are considered the pure $|56,^2 8, 2, 2, \frac{5}{2}^+\rangle$ state. The data are obtained from PDG.

Assignment	Channel	Γ_i^{th}	Γ_{total}^{th}	Γ_{total}^{exp}	$\frac{\Gamma_i}{\Gamma_{total}}\vert_{th}$	$\frac{\Gamma_i}{\Gamma_{total}}\vert_{exp}$
$N(1680)\frac{5}{2}^+$	$n\pi$	38.0	59	120 ~ 140	0.64	0.65–0.70
	$\Delta\pi$	21.0	...	...	0.36	...
	$N\eta$	0.4	...	...	0.01	0.0–0.01
	ΛK	0.03	...	...	0	...
$\Sigma(1915)\frac{5}{2}^+$	$N\bar{K}$	1.2	63	80 ~ 160	0.02	0.05–0.15
	$\Lambda\pi$	10.4	...	...	0.16	...
	$\Sigma\pi$	26.7	...	...	0.42	...
	$\Sigma(1385)\pi$	6.2	...	...	0.10	...
	$\Delta(1232)\bar{K}$	18.4	...	...	0.29	...
$\Lambda(1820)\frac{5}{2}^+$	$N\bar{K}$	14.8	30	70 ~ 90	0.49	0.55–0.65
	$\Sigma\pi$	5.8	...	...	0.19	0.08–0.14
	$\Sigma(1385)\pi$	9.8	...	...	0.32	...
$\Xi(1963)\frac{5}{2}^+$	$\Xi\pi$	1.0	19	25 ± 15	0.05	...
	$\Sigma\bar{K}$	9.2	...	...	0.48	...
	$\Lambda\bar{K}$	0.8	...	...	0.04	...
	$\Xi(1530)\pi$	5.2	...	...	0.27	...
	$\Sigma(1385)\bar{K}$	2.5	...	...	0.13	...

值得在ΣK等主要衰变道进一步寻找！

Ξ（1950） $J^P=5/2^+$

TABLE IX. The total and partial decay widths (MeV) of the well-established four-star baryons $N(1680)$, $\Sigma(1915)$, and $\Lambda(1820)$, which are considered the pure $|56,{}^2 8,2,2,\frac{5}{2}^+\rangle$ state. The data are obtained from PDG.

Assignment	Channel	Γ_i^{th}	Γ_{total}^{th}	Γ_{total}^{exp}	$\frac{\Gamma_i}{\Gamma_{total}}\|_{th}$	$\frac{\Gamma_i}{\Gamma_{total}}\|_{exp}$
$N(1680)\frac{5}{2}^+$	$n\pi$	38.0	59	120 ~ 140	0.64	0.65–0.70
	$\Delta\pi$	21.0	...	...	0.36	...
	$N\eta$	0.4	...	...	0.01	0.0–0.01
	ΛK	0.03	...	...	0	...
$\Sigma(1915)\frac{5}{2}^+$	$N\bar{K}$	1.2	63	80 ~ 160	0.02	0.05–0.15
	$\Lambda\pi$	10.4	...	...	0.16	...
	$\Sigma\pi$	26.7	...	...	0.42	...
	$\Sigma(1385)\pi$	6.2	...	...	0.10	...
	$\Delta(1232)\bar{K}$	18.4	...	...	0.29	...
$\Lambda(1820)\frac{5}{2}^+$	$N\bar{K}$	14.8	30	70 ~ 90	0.49	0.55–0.65
	$\Sigma\pi$	5.8	...	...	0.19	0.08–0.14
	$\Sigma(1385)\pi$	9.8	...	...	0.32	...
$\Xi(1963)\frac{5}{2}^+$	$\Xi\pi$	1.0	19	25 ± 15	0.05	...
	$\Sigma\bar{K}$	9.2	...	...	0.48	...
	ΛK	0.8	...	...	0.04	...
	$\Xi(1530)\pi$	5.2	...	...	0.27	...
	$\Sigma(1385)\bar{K}$	2.5	...	...	0.13	...

值得在ΣK等主要衰变道进一步寻找！

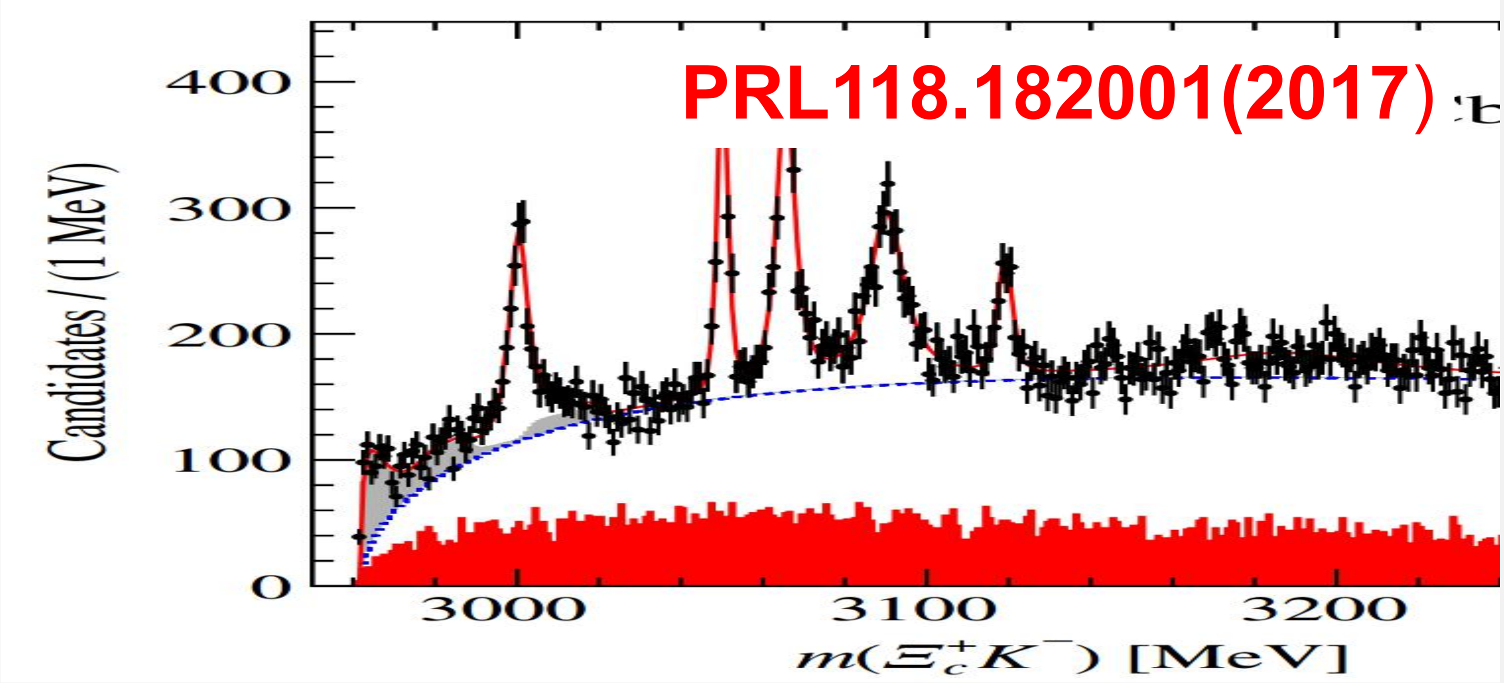
Ω_c激发态

KL, LY, XH, QZ, PRD95,016010(2017)

KL, YX, XH, QZ, PRD96,016016(2017)

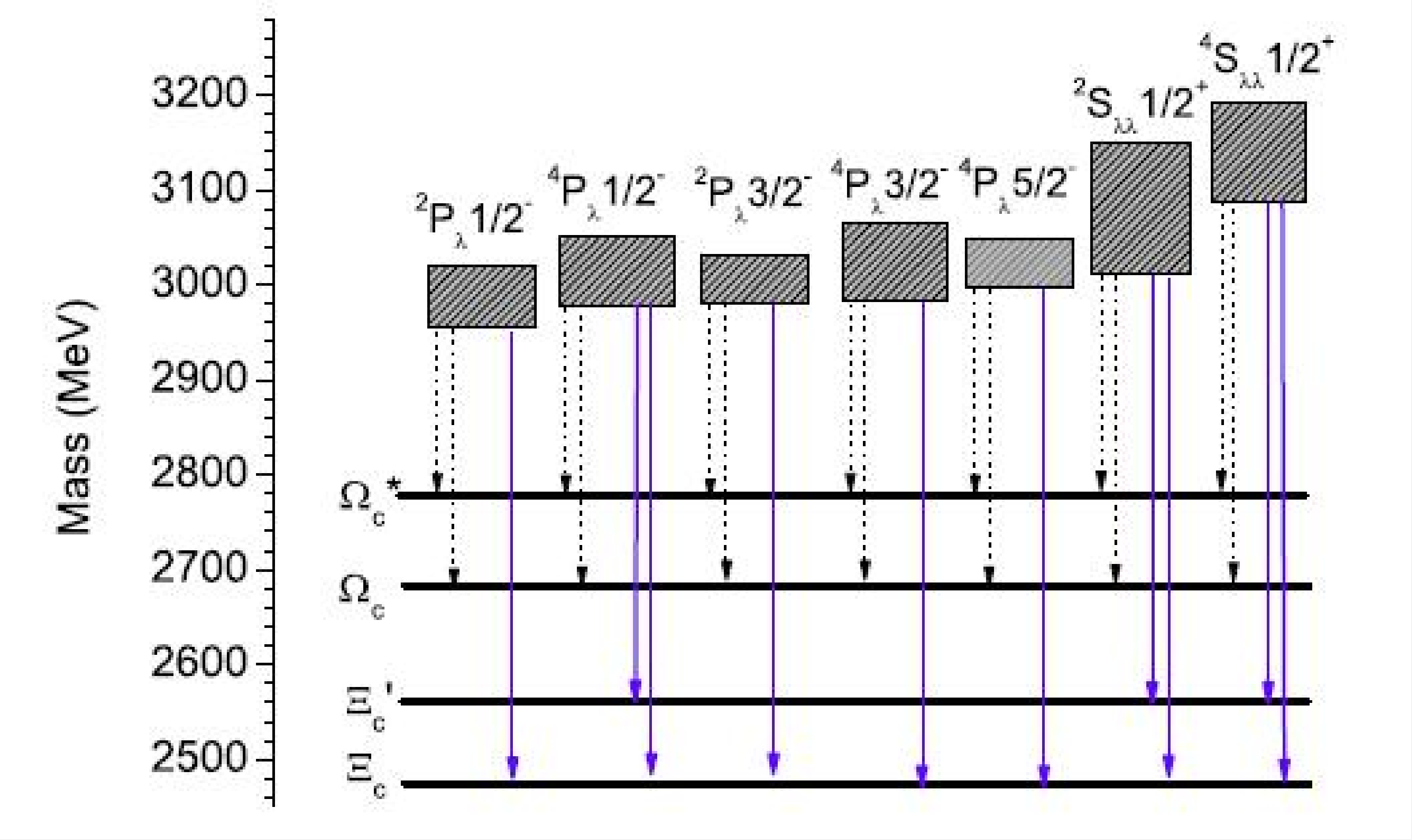
KL, QF, XH, PRD99,014011(2019)

LHCb的发现：五个Ω激发态？



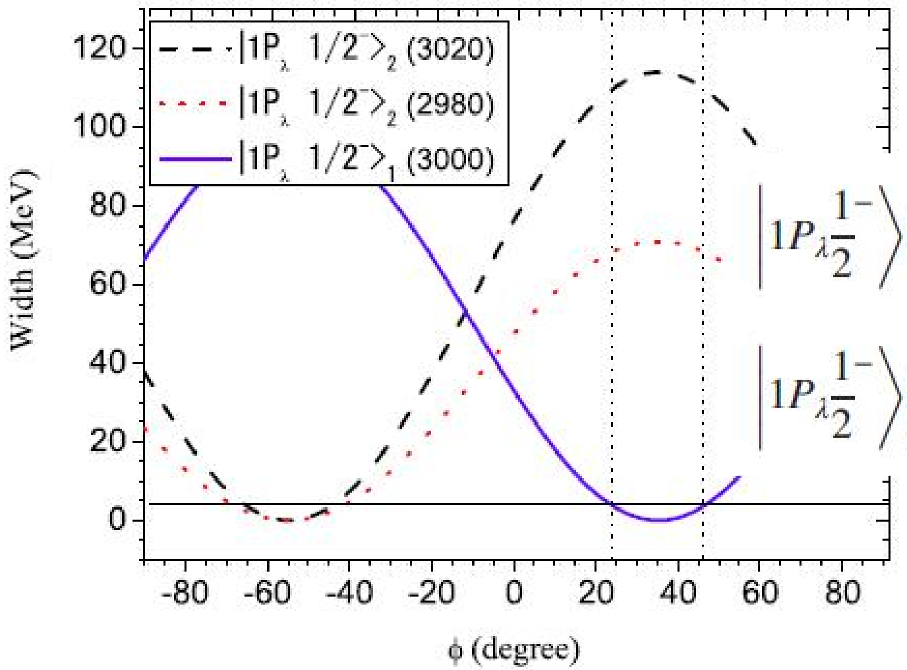
Resonance	Mass (MeV)	Γ (MeV)
$\Omega_c(3000)^0$	$3000.4 \pm 0.2 \pm 0.1^{+0.3}_{-0.5}$	$4.5 \pm 0.6 \pm 0.3$
$\Omega_c(3050)^0$	$3050.2 \pm 0.1 \pm 0.1^{+0.3}_{-0.5}$	$0.8 \pm 0.2 \pm 0.1$ <1.2 MeV, 95% C.L.
$\Omega_c(3066)^0$	$3065.6 \pm 0.1 \pm 0.3^{+0.3}_{-0.5}$	$3.5 \pm 0.4 \pm 0.2$
$\Omega_c(3090)^0$	$3090.2 \pm 0.3 \pm 0.5^{+0.3}_{-0.5}$	$8.7 \pm 1.0 \pm 0.8$
$\Omega_c(3119)^0$	$3119.1 \pm 0.3 \pm 0.9^{+0.3}_{-0.5}$	$1.1 \pm 0.8 \pm 0.4$

夸克模型预言的Ωc激发态



基于衰变性质的夸克模型理解

PRD95,116010（2017）



$$\left|1P_{\lambda}\frac{1}{2}^{-}\right\rangle_1 = +\cos(\phi)\left|1^2P_{\lambda}\frac{1}{2}^{-}\right\rangle + \sin(\phi)\left|1^4P_{\lambda}\frac{1}{2}^{-}\right\rangle,$$

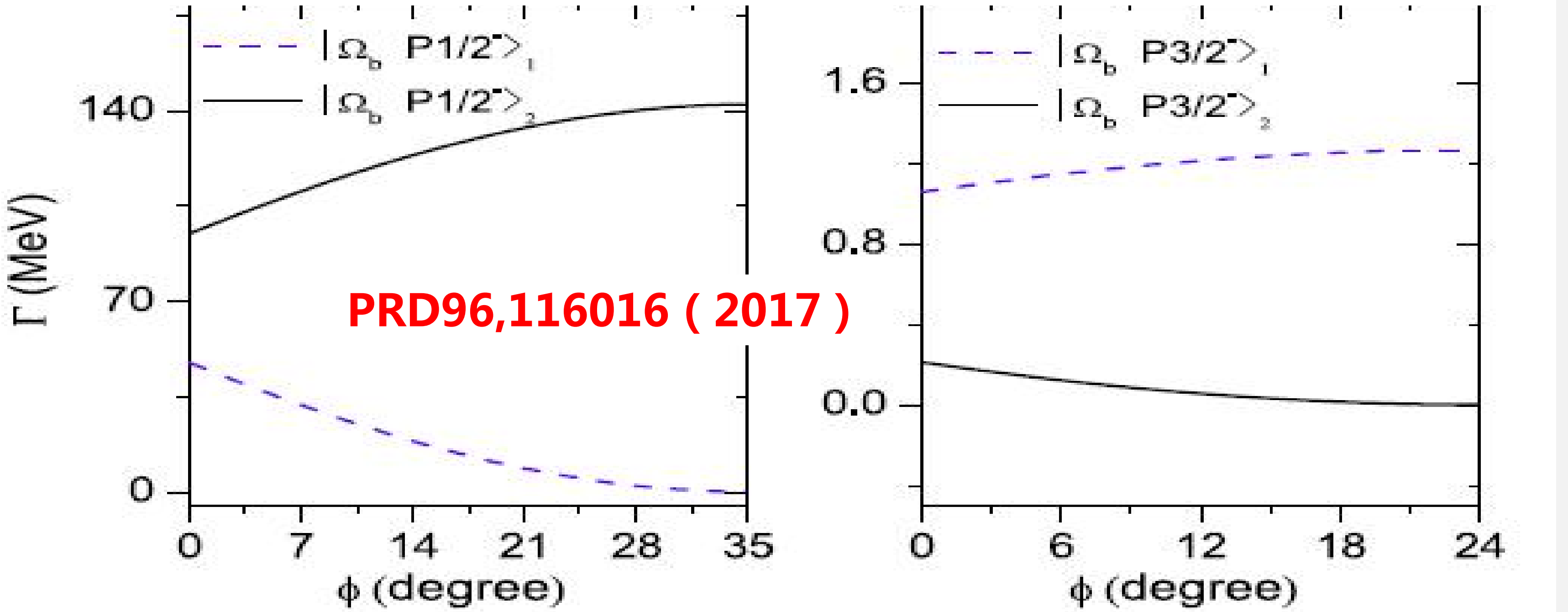
$$\left|1P_{\lambda}\frac{1}{2}^{-}\right\rangle_2 = -\sin(\phi)\left|1^2P_{\lambda}\frac{1}{2}^{-}\right\rangle + \cos(\phi)\left|1^4P_{\lambda}\frac{1}{2}^{-}\right\rangle,$$

State	Mass	$\Gamma(\Xi_c\bar{K})$	$\Gamma(\Xi_c'\bar{K})$	$\Gamma^{\rm th}_{\rm total}$	$\Gamma^{\rm exp}_{\rm total}$
$\lvert 1P_{\lambda}\frac{1}{2}^{-}\rangle_1$	3000	4.0	⋯	4.38/4.28	4.5 ± 0.9
$\lvert 1^4P_{\lambda}\frac{3}{2}^{-}\rangle$	3050	0.61	⋯	0.94	0.8 ± 0.3
$\lvert 1^2P_{\lambda}\frac{3}{2}^{-}\rangle$	3066	4.61	⋯	4.96	3.5 ± 0.4
$\lvert 1^4P_{\lambda}\frac{5}{2}^{-}\rangle$	3090	9.32	0.03	9.53	8.7 ± 1.8

Ω_b的衰变性质？能否找到他们？

TABLE X. Partial widths for the strong and radiative decays of the Ω_b baryons.

State	Mass (MeV) [24]	$\Gamma[\Xi_b K]$ (MeV)	$\Gamma[\Omega_b\gamma]$ (keV)	$\Gamma[\Omega_b^*\gamma]$ (keV)	Γ_{total} (MeV)
$\|\Omega_b {}^4S\frac{3}{2}^+\rangle$	6088	...	0.09	...	...
$\|\Omega_b {}^2P_{\lambda}\frac{1}{2}^-\rangle$	6339	49.38	154	1.49	49.53
$\|\Omega_b {}^2P_{\lambda}\frac{3}{2}^-\rangle$	6340	1.82	83.4	1.51	1.90
$\|\Omega_b {}^4P_{\lambda}\frac{1}{2}^-\rangle$	6330	94.98	0.64	99.23	95.08
$\|\Omega_b {}^4P_{\lambda}\frac{3}{2}^-\rangle$	6331	0.22	1.81	70.68	0.29
$\|\Omega_b {}^4P_{\lambda}\frac{5}{2}^-\rangle$	6334	1.60	1.21	63.26	1.66



PRD96,116016（2017）

Σ_c和Σ_b的衰变性质？能否找到他们？

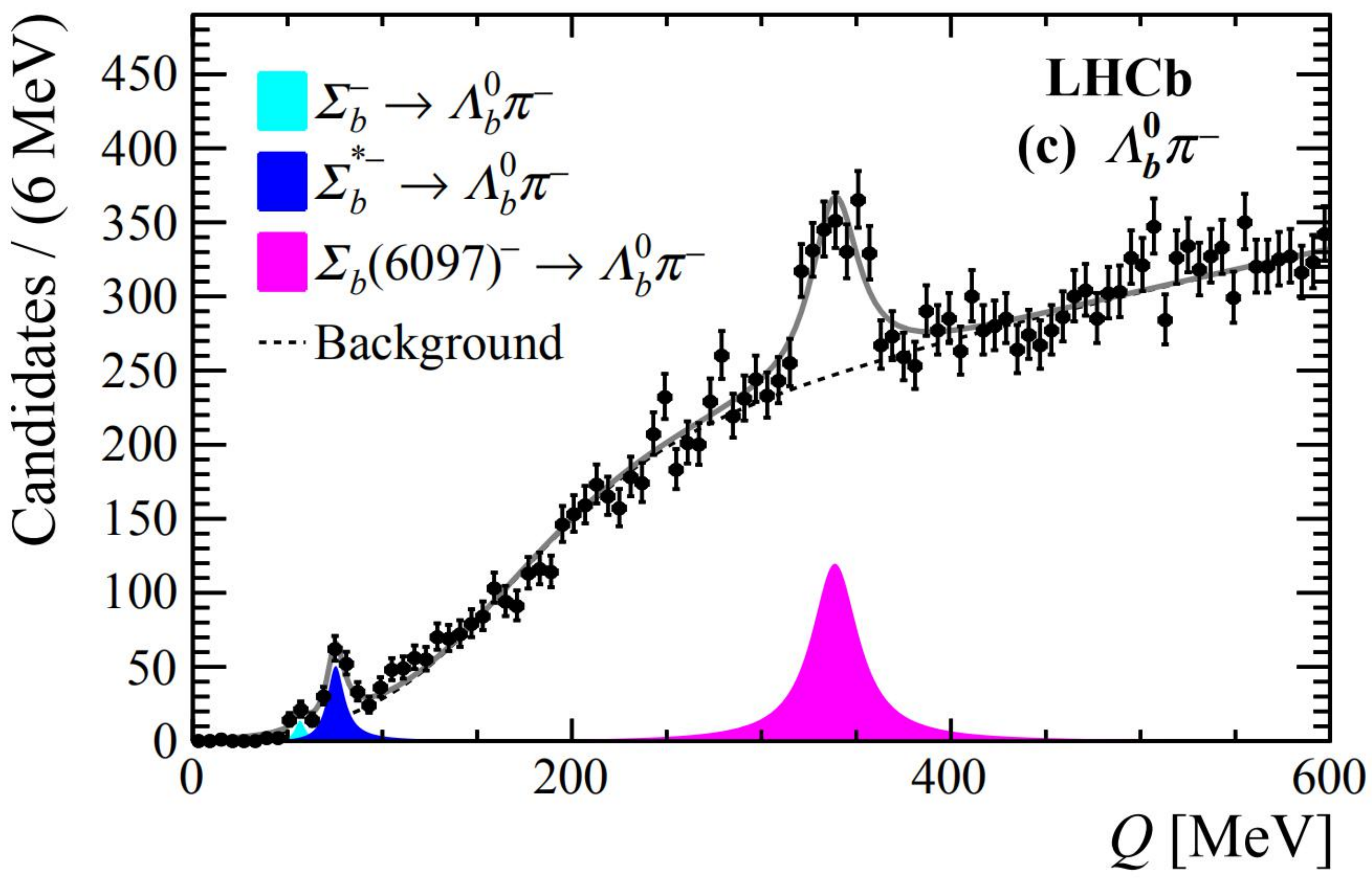
TABLE V. Partial widths (MeV) and branching fractions for the strong decays of the $1P$-wave states in the Σ_c and Σ_b families.

$\vert ^{2S+1}L_\lambda J^P\rangle$	Σ_c states	Channel	Γ_i (MeV)	$\mathcal{B}_i$	Σ_b states	Channel	$\Gamma_{\rm th}$ (MeV)	$\mathcal{B}_i$
$\vert ^2P_\lambda \frac{1}{2}^-\rangle$	$\Sigma_c(2713)$	$\Lambda_c\pi$	6.49	28.65%	$\Sigma_b(6101)$	$\Lambda_b\pi$	1.74	7.68%
		$\Sigma_c\pi$	16.08	70.99%		$\Sigma_b\pi$	19.26	85.00%
		$\Sigma_c^*\pi$	0.08	0.35%		$\Sigma_b^*\pi$	1.66	7.33%
		total	22.65			total	22.66	
$\vert ^2P_\lambda \frac{3}{2}^-\rangle$	$\Sigma_c(2798)$	$\Lambda_c\pi$	22.53	61.73%	$\Sigma_b(6096)$	$\Lambda_b\pi$	29.31	74.60%
		$\Sigma_c\pi$	8.84	24.22%		$\Sigma_b\pi$	4.81	12.24%
		$\Sigma_c^*\pi$	5.13	14.05%		$\Sigma_b^*\pi$	5.17	13.16%
		total	36.5			total	39.29	
$\vert ^4P_\lambda \frac{1}{2}^-\rangle$	$\Sigma_c(2799)$	$\Lambda_c\pi$	6.66	37.78%	$\Sigma_b(6095)$	$\Lambda_b\pi$	4.00	28.15%
		$\Sigma_c\pi$	10.30	58.42%		$\Sigma_b\pi$	9.50	66.85%
		$\Sigma_c^*\pi$	0.67	3.80%		$\Sigma_b^*\pi$	0.71	5.0%
		total	17.63			total	14.21	
$\vert ^4P_\lambda \frac{3}{2}^-\rangle$	$\Sigma_c(2773)$	$\Lambda_c\pi$	3.62	14.66%	$\Sigma_b(6087)$	$\Lambda_b\pi$	5.38	20.46%
		$\Sigma_c\pi$	0.29	1.17%		$\Sigma_b\pi$	0.20	0.76%
		$\Sigma_c^*\pi$	20.78	84.16%		$\Sigma_b^*\pi$	20.71	78.78%
		total	24.69			total	26.29	
$\vert ^4P_\lambda \frac{5}{2}^-\rangle$	$\Sigma_c(2789)$	$\Lambda_c\pi$	25.03	75.35%	$\Sigma_b(6084)$	$\Lambda_b\pi$	31.38	81.85%
		$\Sigma_c\pi$	2.29	6.89%		$\Sigma_b\pi$	1.09	2.84%
		$\Sigma_c^*\pi$	5.90	17.76%		$\Sigma_b^*\pi$	5.77	15.05%
		total	33.22			total	38.34	

LHCb发现新态Σ_b(6097),P态候选者？

$$\Gamma[\Sigma_b(6097)^+] = 31.0 \pm 5.5 \pm 0.7 \text{ MeV}.$$

$$\Gamma[\Sigma_b(6097)^-] = 28.9 \pm 4.2 \pm 0.9 \text{ MeV},$$



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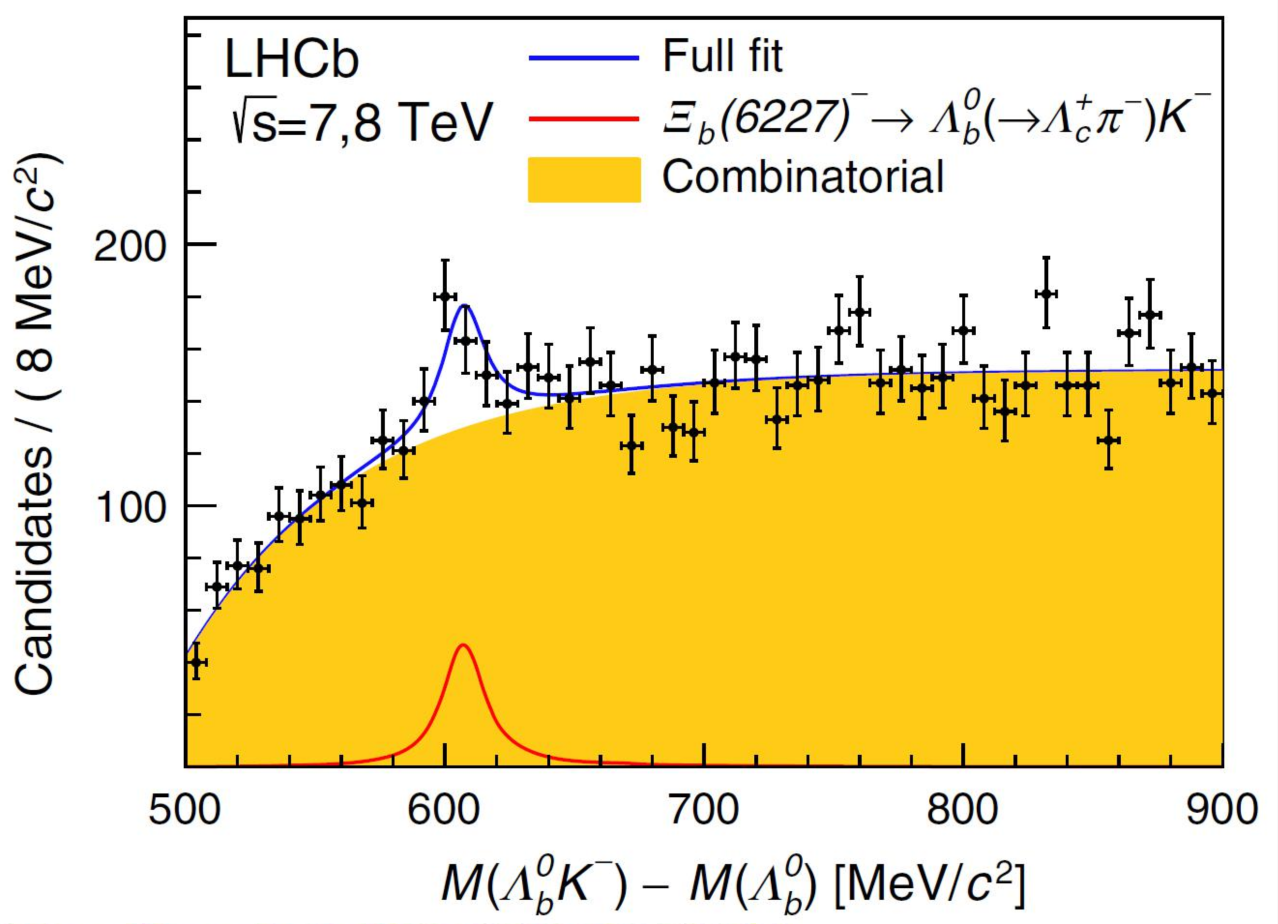
Ξ'$_c$和Ξ'$_b$的衰变性质？能否找到他们？

TABLE VIII. Partial widths (MeV) and branching fractions for the strong decays of the 1P-wave states in the Ξ_c' and Ξ_b' families.

$\vert ^{2S+1}L_\lambda J^P\rangle$	State	Channel	Γ_i (MeV)	$\mathcal{B}_i$	State	Channel	Γ_i (MeV)	$\mathcal{B}_i$
$\vert ^2P_\lambda \frac{1}{2}^-\rangle$	$\Xi_c'(2936)$	$\Lambda_c K$	7.11	32.81%	$\Xi_b'(6233)$	$\Lambda_b K$	12.11	44.77%
		$\Xi_c \pi$	3.90	18.00%		$\Xi_b \pi$	4.77	17.63%
		$\Xi_c'(2580)\pi$	10.08	46.52%		$\Xi_b' \pi$	9.23	34.12%
		$\Xi_c'(2645)\pi$	0.58	2.68%		$\Xi_b'(5945)\pi$	0.94	3.48%
		total	21.67			total	27.05	
$\vert ^2P_\lambda \frac{3}{2}^-\rangle$	$\Xi_c'(2935)$	$\Lambda_c K$	3.73	17.86%	$\Xi_b'(6234)$	$\Lambda_b K$	4.14	17.14%
		$\Xi_c \pi$	10.85	51.94%		$\Xi_b \pi$	14.91	61.74%
		$\Xi_c'(2580)\pi$	3.89	18.62%		$\Xi_b' \pi$	2.37	9.81%
		$\Xi_c'(2645)\pi$	2.42	11.58%		$\Xi_b'(5945)\pi$	2.73	11.30%
		total	20.89			total	24.15	
$\vert ^4P_\lambda \frac{1}{2}^-\rangle$	$\Xi_c'(2854)$	$\Lambda_c K$	18.56	50.09%	$\Xi_b'(6227)$	$\Lambda_b K$	17.28	53.60%
		$\Xi_c \pi$	15.02	40.54%		$\Xi_b \pi$	10.01	31.05%
		$\Xi_c'(2580)\pi$	3.44	9.28%		$\Xi_b' \pi$	4.54	14.08%
		$\Xi_c'(2645)\pi$	0.03	0.07		$\Xi_b'(5945)\pi$	0.41	1.27%
		total	37.05			total	32.24	
$\vert ^4P_\lambda \frac{3}{2}^-\rangle$	$\Xi_c'(2912)$	$\Lambda_c K$	0.50	4.06%	$\Xi_b'(6224)$	$\Lambda_b K$	0.98	6.19%
		$\Xi_c \pi$	1.70	13.79%		$\Xi_b \pi$	2.67	16.87%
		$\Xi_c'(2580)\pi$	0.13	1.05%		$\Xi_b' \pi$	0.10	0.63%
		$\Xi_c'(2645)\pi$	10.00	81.10%		$\Xi_b'(5945)\pi$	12.08	76.31%
		total	12.33			total	15.83	
$\vert ^4P_\lambda \frac{5}{2}^-\rangle$	$\Xi_c'(2929)$	$\Lambda_c K$	4.06	20.10%	$\Xi_b'(6226)$	$\Lambda_b K$	4.20	17.22%
		$\Xi_c \pi$	12.24	60.59%		$\Xi_b \pi$	16.37	67.12%
		$\Xi_c'(2580)\pi$	1.06	5.25%		$\Xi_b' \pi$	0.60	2.46%
		$\Xi_c'(2645)\pi$	2.84	14.06%		$\Xi_b'(5945)\pi$	3.22	13.20%
		total	20.2			total	24.39	

LHCb发现新态$\Xi_b(6227)$,P态候选者？

$$\Gamma[\Xi_b(6227)^-] = 18.1 \pm 5.4 \pm 1.8\ \text{MeV},$$



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