Краткие сообщения ОИЯИ № 1(58)-93 *JINR Rapid Communications № 1(58)-93*
УДК 539.12

ONE MORE WEAK DECAY OF THE HEAVY, STABLE, $S = -2$, POSITIVELY CHARGED H^+ DIBARYON

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We have succeeded in observing one more event which is unambiguously interpreted as a weak two-body decay of the heavy, stable, $S = -2$, positively charged H^+ dibbaryon. Its mass equal to $M_{H^+} = (2409.3 \pm 13.0)$ MeV/c^2 is in fair agreement with the masses of the three (two neutral and one positive) heavy stable dibaryons, (2408.9±11.2), (2384.9±31.0) and (2377.5±9.5) MeV/c^2, recently found.

The investigation has been performed at the Laboratory of High Energies, JINR.

Еще один случай слабого распада тяжелого стабильного положительно заряженного H^+-дибариона со странностью $S = -2$

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Нам удалось наблюдать еще одно событие, однозначно интерпретируемое как слабый двухчастичный распад тяжелого стабильного положительно заряженного дибариона со странностью $S = -2$. Масса его, равная (2409,3±13,0) МэВ/с^2, удовлетворительно согласуется с массами трех (двух нейтральных и одного положительного) тяжелых стабильных дибарионов, (2408,9±11,2), (2384,9±31,0) и (2377,5±9,5) МэВ/с^2, найденных недавно.

Работа выполнена в Лаборатории высоких энергий ОИЯИ.

On the photographs of the JINR 2m propane bubble chamber, exposed to the 10 GeV/c proton beam of the Synchrophasotron, systematic search for the heavy, stable, $S = -2$, positively charged dibaryon has been undertaken via its two- and three-body weak decay modes $H^+ \to p + \Lambda$, $\Lambda \to p + \pi^-$, and $H^+ \to p + \pi^0 + \Lambda$, $\Lambda \to p + \pi^-$. For this purpose the statistical sample of the so-called one-positive-prong secondary events has been used. In these events the Λ-hyperons point to the vertices of one-positive-prong stars created by positive particles, emitted from the parent interactions of primary 10 GeV/c protons in propane.

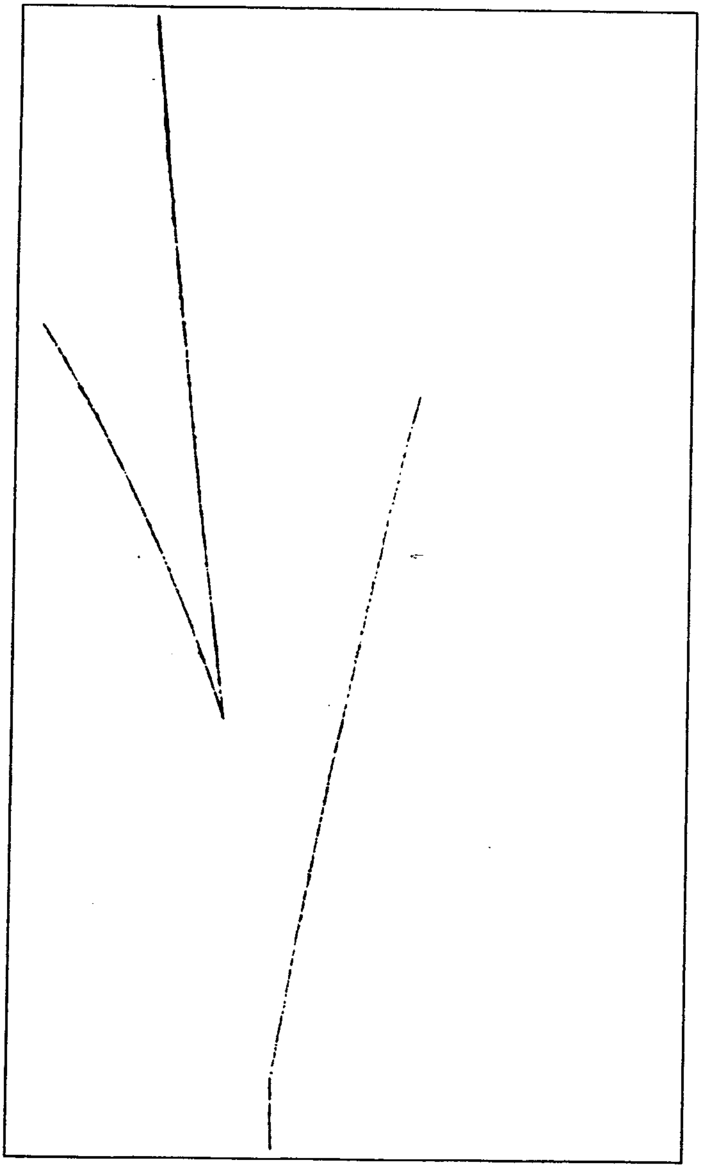
Recently we have succeeded in observing a weak three-body decay of a very slow, $p_{H^+} = (50.6 \pm 40.0)$ MeV/c^2, heavy, stable, $S = -2$, positively charged dibaryon, $H^+ \to p + \pi^0 + \Lambda$, $\Lambda \to p + \pi^-$, of a mass $M_{H^+} = (2377.5 \pm 9.5)$ MeV/c^2 [1] which within the limits of errors coincides with the masses of the two neutral, heavy, stable, $S = -2$ dibaryons $M_H = (2408.9 \pm 11.2)$ and (2384.9 ± 31.0) MeV/c^2 observed earlier [2,3]. The statistical sample of one-positive-prong secondaries contains no more similar slow or even nearly stopping candidates for the H^+. Each event of this sample has been tried for the weak decay hypotheses $H^+ \to p + \Lambda$, $\Lambda \to p + \pi^-$ and $H^+ \to p + \pi^0 + \Lambda$, $\Lambda \to p + \pi^-$. If neither of these hypotheses fitted the event, it was rejected. If either of them or both hypotheses fitted the event, the hypotheses on possible imitating reactions (Table 1) have been tried. All known [4] Λ-, Σ^0-baryons ($\equiv Y^0, X^0$), strange K^0, K^{0*} and nonstrange π^0, M^0 mesons, 43, 24 and 73 in numbers, respectively, were supposed to decay via neutral decay modes and their masses were used in fitting procedures. Note, that the reactions 3,5,7,9,12 simultaneously imitate the channels of the Λ, $K^{\overset{+}{0}}$ associated production as well as the $\Sigma^+\Lambda$ conversion processes accompanied by multiple pion production. The multiplicities of pions and their momenta are defined by the differences of $M_{Y^0} - M_\Lambda$, $M_{K^{0*}} - M_{K^0}$, $M_{M^0} - M_{\pi^0}$ masses. All events of the last sample (except the event found on the 1st of August 1992, which is

Table 1. Possible imitating reactions. $M(2n) = 2Mn$

1.	$\pi^+ + n \to$	$K^+ + \Lambda$, $\Lambda \to p + \pi^-$
2.		$K^+ + \pi^0 + \Lambda$, $\Lambda \to p + \pi^-$
3.		$K^+ + Y^0$, $Y^0 \to \pi^0 + \Lambda$, $\Lambda \to p + \pi^-$
4.		$K^+ + \Sigma^0$, $\Sigma^0 \to \gamma + \Lambda$, $\Lambda \to p + \pi^-$
5.		$K^+ + X^0$, $X^0 \to \gamma + \Lambda$, $\Lambda \to p + \pi^-$
6.	$K^+ + n \to$	$K^+ + K^0 + \Lambda$, $\Lambda \to p + \pi^-$
7.		$K^+ + K^{0*} + \Lambda, \Lambda \to p + \pi^-$
8.	$p + n \to$	$p + K^0 + \Lambda$, $\Lambda \to p + \pi^-$
9.		$p + K^0 + \Lambda, \Lambda \to p + \pi^-$
10.	$\Sigma^+ + n \to$	$p + \Lambda$, $\Lambda \to p + \pi^-$
11.		$p + \pi^0 + \Lambda$, $\Lambda \to p + \pi^-$
12.		$p + M^0 + \Lambda$, $\Lambda \to p + \pi^-$
13.	$\Sigma^+ + (2n) \to$	$p + n + \Lambda, \Lambda \to p + \pi^-$

Table 2. The measured (M) and the (2V—5C) best-fit parameters (F) for the reaction sequence $H^+ \to p + \Lambda$, $\Lambda \to p + \pi^-$; M_{H^+} (MeV/c^2), p_i (MeV/c) tangents of dip angles α_i and azimuthal angles β_i (radians). C.L. in %

Weak Decays		P_i		$\mathrm{tg}\alpha_i$		β_i	
		M	F	M	F	M	F
$H^+ \to p + \Lambda$	p	2262.6±88.4	2266.7±82.6	0.10008±0.00266	0.09978±0.00295	1.42858±0.00172	1.42851±0.00169
	Λ	—	4664.9±114.5	−0.03237±0.00443	−0.02701±0.00159	1.75743±0.00065	1.75705±0.00061
$\Lambda \to p + \pi^-$	p	4517.5±264.6	4189.6±95.0	−0.02472±0.00164	−0.02555±0.00155	1.73572±0.00116	1.73727±0.00085
	π^-	441.1±33.4	483.3±31.3	−0.03676±0.00836	−0.03922±0.00820	1.92989±0.00581	1.92942±0.00471
H^+-dibaryon		–	6837.6±144.8	0.00046±0.01161	0.01449±0.00186	1.64731±0.00756	1.65040±0.00320
M_{H^+} = 2409.3±13.0			χ^2(2V−5C)=7.81		C.L.=16.72	$T > 0.473 \cdot 10^{-10}$s	



The two-body weak decay of the second fast, heavy stable, positively charged dibaryon, $H^+ \rightarrow p + \Lambda, \Lambda \rightarrow p + \pi^-$

analysed in detail below) were successfully fitted at least by one of the 1—13 trivial hypotheses listed in Table 1 as well and by this reason had been rejected. The ionization measurements always confirmed these negative decisions. Indeed, the best-fit masses of these fake dibaryons were very large (up to 5000 MeV/c^2) at rather moderate momenta. This circumstance ensured small velocities and large expected relative ionizations of the H^+, up to 7.8, contrary to the measured ones.

Thus of all the sample of one-positive-prong secondaries only one event was successfully fitted only by the H^+ weak decay hypothesis, $H^+ \rightarrow p + \Lambda$, $\Lambda \rightarrow p + \pi^-$ (see the Figure). Both the three-body weak decay hypothesis, $H^+ \rightarrow p + \pi^0 + \Lambda$, $\Lambda \rightarrow p + \pi^-$ and the hypotheses 1—13 of Table 1 failed to fit this event. The relative ionization of the H^+ estimated on its short track meets well the expected one, 1.52± 0.14. Note, that the (1V—1C) weak decay hypotheses $Y^0 \rightarrow \pi^0 + \Lambda$, $\Sigma^0 \rightarrow \gamma + \Lambda$ and $X^0 \rightarrow \gamma + \Lambda$ failed to fit the event. Therefore there was no reason to use them in the reactions 6—13. The results of the (2V — 5C) kinematical fit are shown in Table 2.

Unfortunately the vertex of the parent primary interaction is not seen on the frame (see the Figure). Therefore it was impossible to estimate the full time of flight of the H^+ before its weak decay, $T > 4.7 \cdot 10^{-11}$ s. By the same reason we were deprived of possible attemps to perform exclusive multivertex kinematical analysis. The formally estimated effective cross section for the production of the H^+ dibaryons via two-body weak decay mode $H^+ \rightarrow p + \Lambda$, $\Lambda \rightarrow p + \pi^-$ in $p^{12}C$ collisions at 10 GeV/c is 100 nb.

The average mass over two measurements of the neutral heavy stable dibaryon is $\langle M_H \rangle = 2396.9$ MeV/c^2 with standard deviation $S = 17.0$ MeV/c^2 and the dispersion of the average $\sigma = 12.0$ MeV/c^2. For its positively charged component one has $\langle M_{H^+} \rangle = 2393.4$, $S = 22.4$ and $\sigma = 15.9$ MeV/c^2.

Both $\langle M_H \rangle$ and $\langle M_{H^+} \rangle$ are rather close to the stable dibaryon mass value ≈ 2370 MeV/c^2 predicted by the soliton Skyrme-like model [5,6,7]. We have not succeeded in finding candidates for the negatively charged heavy stable dibaryons weakly decaying via $H^- \rightarrow \pi^- + n + \Lambda$, $\Lambda \rightarrow p + \pi^-$ or $H^- \rightarrow p + \pi^- + \pi^- + \Lambda$, $\Lambda \rightarrow p + \pi^-$ modes. In order to establish wether such a charge asymmetry is significant, one needs for larger statistics. Further we intend to search for the charged heavy dibaryons via weak decay modes $H^+ \rightarrow p + \pi^+ + \pi^- + \Lambda$, $\Lambda \rightarrow p + \pi^-$; $H^+ \rightarrow p + p + K^-$, $K^- \rightarrow \mu^- + \gamma$, or $\pi^- + \pi^0$; $H^- \rightarrow \pi^- + n + \Lambda$, $\Lambda \rightarrow p + \pi^-$, $H^- \rightarrow p + \pi^- + \Lambda$, $\Lambda \rightarrow p + \pi^-$ as well as the light and heavy neutral dibaryons via weak decay modes $H(H^0) \rightarrow p + \Sigma^-$, $\Sigma^- \rightarrow n + \pi^-$ and

$H(H^0) \to p + \pi^- + \Lambda, \Lambda \to p + \pi^-$. Of all $H^{\substack{+\\0\\-}}$ weak decay modes considered above and in [1,2,3] the simplest topology belongs to the $H^+ \to p+p+K^-$ mode. Therefore it seems to be best suited for a counter experiment with live target. Note, that within the limits of errors, $M_{H^+} \approx 2M_p + M_{K^-}$. Then the proton and K^- laboratory momenta are $p_p \approx M_p(\beta\gamma)_{H^+}$ and $p_{K^-} \approx M_{K^-}(\beta\gamma)_{H^+}$. The weak decay via this mode would look out as a narrow trident with the radii of curvature in a magnetic field $R_{K^-}/R_p \approx M_{K^-}/m_p$. The large difference of masses of the K^-, p and H^+, $M_{K^-}/M_p = 1.90$, $M_{H^+}/M_p = 2.55$ and $M_{H^+}/M_{K^-} = 4.85$ enables one to use for their identification the Cherenkov counter and TOF techniques. But even in this case for an unambiguous identification of the H^+ one needs for either 1V—3C or 2V—4C kinematical analysis, depending on coordinates of the K^- weak decay vertex.

Authors are indebted to A.M.Baldin for his support of this work.

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Received on December 7, 1992.