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THE OBSERVATION OF A STABLE DIBARYON

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We have succeeded in observing a V°-particle which is unambiguously interpreted as a weak decay of the stable dibaryon $H \to p + \Sigma^-$, $\Sigma^- \to n + \pi^-$. Its mass is $M_H = (2218 \pm 12)$ MeV/c^2 with a standard deviation $S = 12$ MeV/c^2 and the error of the mean $\sigma = 2.8$ MeV/c^2.

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

Обнаружение стабильного дибариона

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Мы обнаружили V°-частицу, которая однозначно интерпретируется как слабый распад стабильного дибариона $H \to p + \Sigma^-$, $\Sigma^- \to n + \pi^-$. Его масса $M_H = (2218 \pm 12)$ МэВ/с^2 при стандартном отклонении $S = 12{,}0$ МэВ/с^2 и погрешности среднего $\sigma =$ $= 2{,}8$ МэВ/с^2.

Работа выполнена в Лаборатории высоких энергий ОИЯИ.

We have reported in /1/ on the observation of a candidate for the stable H-dibaryon. Let us briefly remind the main results which are important later on.

We have detected a fast (8 GeV/c) V°-particle emitted from a two-prong star produced in the 10 GeV/c proton — ^{12}C collision (Fig. 8 in /1/). A one-vertex 2C-fit of the $H \to p + \Sigma^-$ weak decay hypothesis to the event led to $M_H = (2173.94 \pm 13.10)$ MeV/c^2 at $\chi^2_2 = 0.1432$, C.L. = 93.10%. The hypotheses of all other two- and three-body decays of the V°-particle were reliably rejected. The measured invariant mass of the V° for the H-hypothesis is (2172.82 ± 15.47) MeV/c^2. The expected $\Sigma^- \to n + \pi^-$ weak decay was not detected, the probability of surviving the Σ^--hyperon at 5 GeV/c on its track length of 40 cm being equal to 11.36%. A two-vertex 3C-fit of the hypothesis $p + d \to H + p + K^+ + K^{\circ}$, where d is a deuteron-mass intranuclear dibaryon cluster and K° is unseen either because it suffers $K_S \to \pi^{\circ} + \pi^{\circ}$ decay or $K^{\circ} \equiv K^{\circ}_L$, led to

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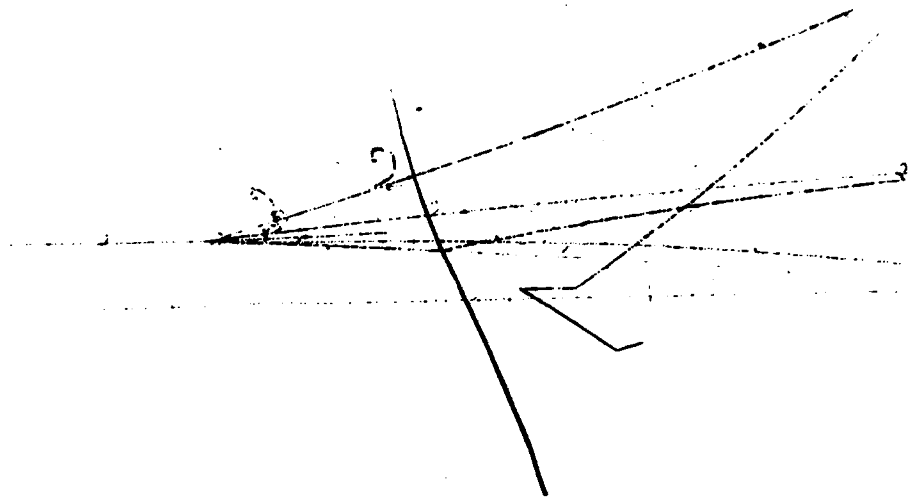

Weak decay of the stable H*-dibaryon* $H \rightarrow p + \Sigma^-$, $\Sigma^- \rightarrow n + \pi^-$ *detected in the JINR 2m propane bubble chamber.*

M_H= (2174.60 ± 13.10) MeV/c ^{2} at χ^2_3 =2.82, C.L. = 42.0%. The time of flight is τ =0.668 · 10^{-10}s.

In october, 1988 we found a second candidate for the H-dibaryon suffering a weak decay. A 10 GeV/c beam proton produces a six-prong star and a V°-particle decaying into a slow proton which stops in propane after rescattering and a faster negative short grey kinked track (see the Figure). The ionization of this particle cannot be properly measured because of small track length (2 cm). A visual comparison of its blackness with that of the nearby passing beam proton track indicates that its ionization is perhaps 1.8-2.0 of the minimum ionization. And the track after the kink certainly belongs to a π^--meson, because the measured relative ionization is 1.02 ± 0.25 againts 2.10 for a K^- of the same momentum.

Hypotheses of combinations of sequences of two-body decays, rescattering on neutron or ^{12}C-nucleus as well as conversion reactions able to imitate the observed event (Table 1) were tried. For this purpose two-vertex (the first — the V°-vertex, the second — the kink) 3C-kinematical fits were performed (Table 1). Here we have five unmeasured parameters: momenta of the V°-particle and of the negative grey-track particle, momenta, dip and azimuthal angles of neutrals emitted from the second vertex. As usual, hypotheses of a confidence level less than 1% were rejected. Thus, the hypotheses of all reactions given in Table 1 had to be rejected. The lines 9 and 10 refer to the weak decay hypothe-

Table 1. Results of the kinematical two-vertex 3C-fits of the imitating reactions to the observed event. χ^2_3 *is averaged over eighteen measurements.* n - *is for the neutron*

No	Imitating reactions		χ^2_3	C.L., %
1.	$\Lambda \to p + \pi^-$,	$\pi^- + n \to \pi^- + n$	874.0	—
2.		$\pi^- + {}^{12}C \to \pi^- + {}^{12}C$	869.39	—
3.	$\Xi^\circ \to p + \pi^-$,	$\pi^- + n \to \pi^- + n$	83.93	—
4.	_	$\pi^- + {}^{12}C \to \pi^- + {}^{12}C$	86.54	—
5.	$K^\circ + n \to p + K^-$,	$K^- \to \mu^- + \nu$	595.28	—
6.		$K^- \to \pi^- + \pi^\circ$	610.31	—
7.		$K^- + n \to \Lambda + \pi^-$	611.79	—
8.		$K^- + n \to \Sigma^\circ + \pi^+$	606.00	—
9.	$A^\circ(2470.70) \to p + \Xi^-$,	$\Xi^- \to \Lambda + \pi^-$	53.60	—
10.	$A^\circ(2366.20) \to p + \Xi^-$,	$\Xi^- \to \Lambda + \pi^-$	18.45	0.039
11.	$\Lambda + n \to p + \Sigma^-$,	$\Sigma^- \to n + \pi^-$	11.53	0.82

ses of the neutral component of the strangeness S = -3 dibaryon (let us name it A(A°, A^-)-dibaryon) at two values 2366.20 and 2470.70 which follow from the two quark-models considered in [2]. ($M_{A1} = M_{\Omega^-} + M_p - E_{B1}$ $\langle E_{B1} \rangle = 244.5$ MeV/c^2, $E_{B2} = 140$ MeV/c^2).

One cannot exclude the imitation of the event by the reaction sequence $n + n \to p + \pi^- + n$, $\pi^- + n \to \pi^- + n$ or $\pi^- + {}^{12}C \to \pi^- + {}^{12}C$. But profitting by the one-pion exchange model of the charge-conjugated reaction $p + p \to n + p + \pi^+$ developed in [3,4] and by the mathematical program for the calculation of its differential cross section density $d^5\sigma/(dp_p d\Omega_p d\Omega_{\pi^-})$ for coplanar geometry [5], we were able to conclude that the expected number of imitating events was $2 \cdot 10^{-5}$ on 100K photographs.

Then we have tried the hypotheses of two possible exotic weak decay modes of the observed V° (Table 2) with unknown masses. Now we have six unmeasured parameters with the unknown V°–particle mass. Therefore, two-vertex 2C-fits were performed at this time. Only the hypotheses of $H \to p + \Sigma^-$, $\Sigma^- \to n + \pi^-$ turned out to be significant. The fitted mass averaged over eighteen measurements is $M_H = (2218 \pm 12)$ MeV/c^2 with a standard deviation $S = 12.0$ MeV/c^2 and the error of the mean $\sigma = 2.8$ MeV/c^2.

The measured and fitted parameters are given in Table 3. Note, that the relative ionization of a 875 MeV/c Σ^--hyperon is $I/I_0 = 2.0$.

Table 2. Results of the kinematical two-vertex 2C-fits of the exotic two-body weak decays to the observed event. χ^2_2 is averaged over eighteen measurements

Two-body exotic decays	χ^2_2	C.L., %
$H \to p + \Sigma^-$, $\Sigma^- \to n + \pi^-$	0.7346	69.43
$A^\circ \to p + \Xi^-$, $\Xi^- \to \Lambda + \pi^-$	14.18	0.059

For completeness the analysis was repeated associating the V°-particle with two nearest stars: the first one, three-prong event, is 3 cm distant from vertex of the V°-particle and is due to one of the secondaries of the six-prong star as clearly seen in the Figure. The other star is 17 cm remote from the V°-vertex and is not shown in the Figure. In both cases the fits were unsuccessful, first of all, because of a strong noncoplanarity of the star vertices to the V°-decay plane. Thus, the V°-particle should be associated only with the six-prong star which is 10 cm distant from it. The time of flight is $\tau = 1.37 \cdot 10^{-10}$s.

We have failed to fit the observed six-prong star and the V°-particle by any exclusive reaction channel either in pp or in pd interactions. (Note that the total electric charge of the star is $Q = +2$. As above, d is a dibaryon subnuclear deuteron-mass substructure).

Thus, the analysis shows that the observed event has to be interpreted as the observation of a weak decay of the stable dibaryon $H \to p + \Sigma^-$ this time with the detected subsequent $\Sigma^- \to n + \pi^-$. The masses of the fast /1/ and this event are within 2.2 errors. One cannot exclude that these are two different objects. But if we have observed one and the same particle of different momenta, its average mass is $M_H = (2197 \pm 9)$ MeV/c^2.

In any case the obtained mass M_H does not contradict the predictions /6,7,8,9,10/.

The estimate of the H-production effective cross section remains to be ~ 40 nb per ^{12}C nucleus /1/.

New estimates of the M_H exceed the $M_{\Lambda p \pi}$-threshold. Therefore, we are also searching for the H-decay via a supplementary weak decay mode $H \to \Lambda + p + \pi^-$.

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Table 3. The measured (M) and fitted (F) momenta p_i, *tangents of dip angles* $tg\alpha_i$ *and azimuthal angles* β_i *from the sequence of weak decays* $H \rightarrow p + \Sigma^-$, $\Sigma^- \rightarrow n + \pi^-$

		$H \rightarrow p + \Sigma^-$		$\Sigma^- \rightarrow n + \pi^-$		H-dibaryon
		p	Σ^-	n	π^-	
P_i	M	315.9 ± 6.8	—	—	316.7 ± 33.9	—
(MeV/c)	F	315.9 ± 6.8	874.7 ± 77.0	643.0 ± 73.4	314.7 ± 5.1	1091.5 ± 79.1
$tg\alpha_i$	M	0.30422 ± 0.02574	-0.46960 ± 0.02962	—	-0.20251 ± 0.01263	-0.27362 ± 0.00853
	F	0.30112 ± 0.02489	-0.47953 ± 0.02011	-0.56406 ± 0.03697	-0.20254 ± 0.01262	-0.27246 ± 0.00816
β_i	M	1.02667 ± 0.012703	1.62400 ± 0.01772	—	2.21007 ± 0.00740	1.45785 ± 0.00142
(rad)	F	1.02554 ± 0.01313	1.61944 ± 0.01556	1.31926 ± 0.01650	2.22223 ± 0.00680	1.45789 ± 0.00142

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