JOINT INSTITUTE FOR NUCLEAR RESEARCH

Laboratory of High Energies

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Submitted to JETP

An event of $\tilde{\Sigma}^-$ -hyperon production and decay has been found in the course of scanning 40 thousand photographs which have been taken on the 8.3 BeV/c negative pions beam by means of a propane bubble chamber in a steady magnetic field of 13.700 oersted. In Fig. 1 the photograph of this event is given. π^- -meson (track 1) at the point 0 gives a star consisting of four high energy charged particles (tracks 2,6,7,16), two K^0-mesons (tracks 4,5,14,15) and one particle with small energy (a short track 17). The track of positively charged particle 2 has a deflection at point A. At a distance of 7.7 mm from the point of deflection there is a six-prong star. The centre of the star lies in the plane of tracks 2 and 3 with an accuracy determined by a measurement error (47'). The decay of particle 2 at the point A into particle 3 and neutral particle N in the direction AB is in very good agreement with the kinematics of the $\tilde{\Sigma}$-decay (see Table 1). Track 3 is that of a $\tilde{\pi}^+$ meson.

The momentum of particle N can be determined from the balance of transverse momenta of particles 3 and N at the point A.

If the decay is assumed to follow the scheme $\tilde{\Sigma} \rightarrow \tilde{\pi}^+ + \tilde{n}$ we obtain $M_2 = 1182 \pm 14$ MeV.

The balance of energy and momentum at the point B is given in Table II. The star B has five positive particles (tracks 8,9,11,12,13) and one negative (track 10). The negative particle is a π^- -meson. Tracks 9,11,12,13 stop in the chamber, and we think that they are protons. Particle 8 has a very large momentum and escapes the chamber. It follows from the measurements of ionization* and momentum that track 8 is a π meson. The measurement of the energy balance at the point B shows that the energy of charged particles of the star B is much larger than the kinetic energy of a neutron with the momentum 1628 ± 100 MeV/c. Therefore, the star B may be due only to the annihilation of an antineutron on the carbon nucleus. The most probable reaction is

$$\tilde{n} + C \rightarrow He_2^4 + 4p + 3n + \pi^+ + \pi^- + n\pi^\circ .$$

The energy carried away by neutrons (they are assumed to have the same energy as protons $E = 144 \pm 5$ MeV), as well as the binding energy of nucleons in a nucleus $E_{bind} = 64$ MeV must be added to the energy of charged particles. Assuming that besides charged π mesons there are also

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* S. Otwinowski and I. Vrana (private communication) have studied the possibility of the ionization measurements in our chamber. About 40 metres of the particle tracks have been measured on 60 different pictures (the momentum and nature of these particles are well-known). It was established that for the track 20 cm long one can reliably (96%) identify π mesons and protons up to the momentum 1200 MeV/c.

The measured magnitude of the ionization of track 8 (20 cm long) is equal to 1.02 ± 0.19, while for the proton according to $1/\beta^2$ /2,3/ it must be 1.86, and for π mesons 1.04.

neutral π *mesons which carry away on the average half the energy of charged* π *mesons, it is necessary to add* $E_{\pi^o} \approx \frac{1}{2} E_{\pi^\pm} = 645$ *MeV. Thus, the total energy of star 3 is*

$$E = 2336 \text{ MeV}.$$

The energy thus obtained is close to the total energy of antineutron annihilation. Therefore, at the point A the decay $\tilde{\Sigma}^- \to \pi^+ + \tilde{n}$ *occurs.*

The probability of the accidental coincidence of different phenomena on one picture which could imitate the phenomenon under consideration is equal to $\sim 10^{-9}$ *(according to our estimates).*

We consider the most probable reaction in the primary star (Tables III and IV) to be

$$\pi^- + C \to \tilde{\Sigma}^- + K^o + \tilde{K}^o + K^- + p + n + \pi^+ + \pi^- + \text{recoil nucleus.}$$

For the lifetime of $\tilde{\Sigma}^-$ *there was obtained the value*

$$t_{\tilde{\Sigma}^-} = (1.18 \pm 0.07)\ 10^{-10} \text{ sec.}$$

Thus, these data point out that we have observed a new type of a particle - a charged antihyperon.

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Table I.

Kinematics at the point A

Track	The sign of charge	P_{meas} MeV/ c	$P_{calcul.}$ MeV/ c	Particle	Angle
2	+	1104 ±600	1798±100	$\tilde{\Sigma}^-$	
3	+	244± 10		π^+	$\varphi_{2,3} = 39^\circ 38' \pm 20'$
AB	0		1628± 100	$\tilde{n}$	$\varphi_{2,AB} = 5^\circ 29' \pm 20'$

Table II.

Kinematics at the point B

Track	The sign of charge	$P_{meas.}$ MeV/c	P_{calcul} Mev/ c	Particle	$E_{kin.}$ MeV	E_{mass} MeV	Total E MeV
			1628± 100	$\tilde{n}$	940±100	2·939	2818 ± 100
8	+	1044±55		π^+	920±56	140	
9	+	445±9		p	101±3		
10	-	183± 25		π^-	90 ± 20	140	
11	+	228±4		p	27±2		
12	+	270±5		p	38±2		
13	+	257±5		p	27± 2		

ΔP 703

$\Sigma E = 1203 \pm 60 + 280 = 1483 \pm 60$

$E_n = /3x/48 \pm 3/ = 144 \pm 5$

$E_{cb.} = 8 x 8 = 64$

1691 ±61

$E_{\Sigma^0} = 1/2 E_{\pi^\pm}$ 645

2336

Table III.

Kinematics at the point 0

Track	Sign of the charge	$P_{meas.}$ MeV/ c	$P_{calcul.}$ MeV / c	Particle	Visible E_{kin} MeV	E_{mass} MeV	Total energy MeV
1	-	-	8300±600	π^-	8200± 600	+140	8340±600
2	+	1104±600	1798±100	Σ^-	964±80	1196	
V_1^0	0		654±29	K^0 or $\tilde{K}^0$	323± 27	494	
6	-	1456±70		K^-	1043±60	494	
7	+	790±45		π^+	663± 45	140	
V_2^0	0		1475±71	K^0 or $\tilde{K}^0$	1060±60	494	
16	-	300±50		π^-	190± 50	140	
	0			n		939	
					4243± 138	+3897	= 8140±138

Table IV.

Kinematics at the points 0' and 0''

Track	Sign of the charge	$P_{meas.}$ MeV/ c	$P_{calcul.}$ MeV/c	Particle	Angle	Noncoplanarity angle
V_1^0	0		654±29	K^0 or $\tilde{K}^0$		$\eta = 33'$
4	-	324 ±25		π^-	$\varphi_{V_1^0,4} = 41^\circ 18' \pm 15'$	
5	+	453± 22		π^+	$\varphi_{V_1^0,5} = 24^\circ 43' \pm 15'$	
V_2^0	0		1475 ±71	$\tilde{K}^0$ or K^0		$\eta = 8'$
14	+	208 ± 8		π^+	$\varphi_{V_2^0,14} = 26^\circ 50' \pm 15'$	
15	-	1299±70		π^-	$\varphi_{V_2^0,15} = 5^\circ 3' \pm 15'$	

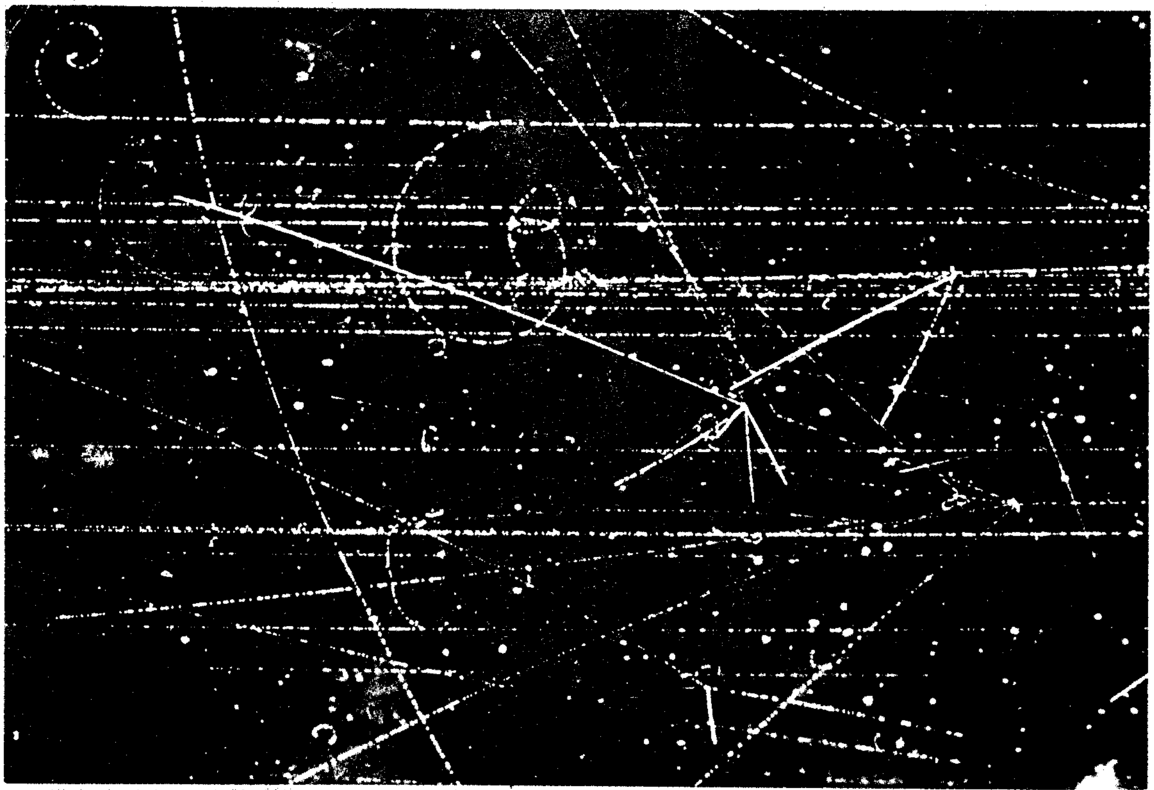

Fig. 1.

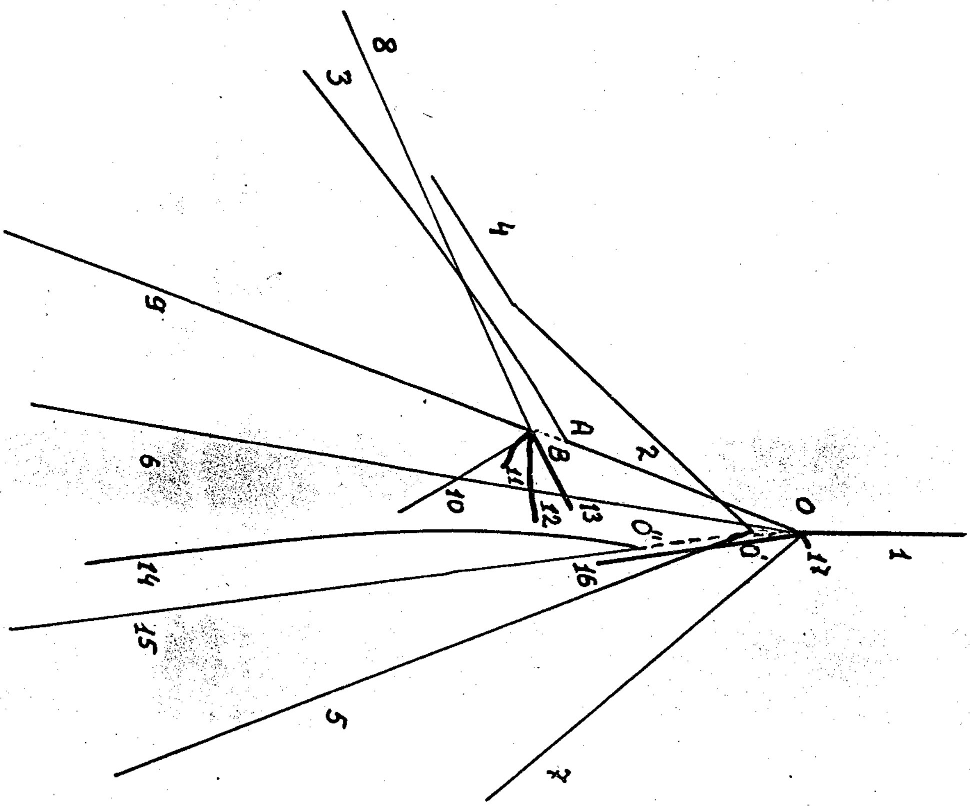

Fig. 2.