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PRODUCTION OF HYPERFRAGMENTS BY ANTIPROTONS AT REST ANNIHILATING ON NUCLEI IN NUCLEAR PHOTOEMULSION

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Early studies of interactions of antiprotons with the nuclei of photonuclear emulsion [1] revealed that $K\bar{K}$ meson pairs are produced in $(5.0 \pm 1.1)\,\%$ of the annihilations at primary antiproton energies lying in the range between 0 and 215 MeV. Detailed investigation of the production of strange particles eventually led to one of the detected antiproton annihilations, at (96.0 ± 6.0) MeV, being identified [2] as an annihilation «star» with a ${}^4_\Lambda H$ hyperfragment among the secondary particles.

Recent studies of the production of K-mesons and Λ-hyperons in annihilation processes on nuclei ranging from helium to tantalum [3—5] revealed an unexpectedly high yield of Λ^0-hyperons, if compared with the obtained output of K^0-mesons; especially surprizing were the equal production yields obtained for these particles in processes involving the capture of antiprotons at rest by ${}^4He$ and ${}^{20}Ne$ [6].

Examination of various theoretical models for Λ^0 production in the annihilation of antiprotons on nuclei and their comparison with available experimental data [7] reveals it to be possible, within the model assuming hyperons to be produced in the secondary rescattering reactions of annihilation K-mesons on nucleons of the residual nucleus, to achieve a satisfactory description not only of the yields of these particles, but also of their momentum spectra and of the strange particle rapidity distributions and charged particle multiplicity distributions [5, 8].

The large number of slow Λ^0-hyperons, that are produced in the rescattering of K-mesons, results in favourable conditions for the formation of hypernuclei in annihilation processes. Estimations [3] show that about 10% of the Λ^0-hyperons produced in the capture of antiprotons by nuclei are bound into hypernuclei.

Experimental confirmation of the above idea of hypernucleus formation in antiproton annihilation at rest was obtained in experiments at LEAR [9,10]. On the basis of delayed fission events occurring in antiproton annihilation on ${}^{238}U$ and ${}^{209}Bi$ the heavy hypernucleus production probability per antiproton stop was shown in this case to lie within the range between $8.0 \cdot 10^{-4}$ and $4.0 \cdot 10^{-3}$ [11].

Thus, antiproton annihilation processes on nuclei, together with the capture and charge exchange of K^--mesons [12], may be considered one more source of hyperfragment production.

In this report the first results are presented of an investigation of the production and decay processes of hyperfragments resulting from the annihilation on nuclei of antiprotons stopping in nuclear photoemulsion. This work continues the studies of antiproton interactions with nuclei performed, applying the photoemulsion method, in compliance with the programme of the PS-179 experiment at CERN.

Detailed descriptions of methodical issues related to the construction and irradiation of photoemulsion chambers, as well as the details of scanning and measurement of antiproton absorption events in photoemulsion are given in refs. [13,14].

In each of the 4880 annihilation stars detected in «along-the-track» scanning of the beam antiprotons all the black tracks («b»-particles* [14]) were followed within each individual photoemulsion layer, and any secondary interactions were recorded.

As candidates for events involving the emission of a hyperfragment «double stars» were chosen, intending events in which a «b»-track connected the primary annihilation star with another, secondary star. A total of 28 such events were found.

Subsequent analysis of the secondary stars revealed that 24 of these events could be attributed to the capture by nuclei in the photoemulsion of slow π^--mesons produced in the annihilation process (σ_π-stars). Each of the four remaining events was thoroughly studied: all the charged particle tracks present in the stars were followed up to their stopping point or exit from the photoemulsion chamber; for each track, whenever possible, measurement was performed of its relative ionization or of the number of gaps between the clusters of silver grains; for each star the angles were measured between the tracks of charged particles and calculations were carried out of the angles in space. Identification of the charged particle tracks in the stars and determination of the relevant kinetic energies were based on the obtained experimental data and on known standard dependences: range-energy, relative ionization-energy, number of gaps-type of particle in the case of mesons, nucleons, hyperons and light nuclei in standard nuclear photoemulsion [15].

A special feature of all four events was the observation in each of these annihilation stars of a charged kaon track. A peculiarity of three of the secondary

* We recall the classification of particle tracks occurring in nuclear photoemulsion: «b-particle» — black track; «g-particle» — gray track; «s-particle» — track of relativistic particle [14].

related stars is the presence among the secondary prongs of an explicitly identified π^--meson track.

A detailed analysis of the fourth event revealed that in this case the secondary star resulted from the annihilation of a slow antiproton that underwent elastic scattering on hydrogen in the photoemulsion.

Thus, in the case of three of the selected events there exist quite sufficient foundations for considering them henceforth candidates for events of the formation and mesonic decay of hyperfragments produced in the capture process of antiprotons by nuclei in the photoemulsion.

A microphotograph of event Numb.1 is present in Fig.1. The primary annihilation star exhibits eight prongs: (4 «b-» particles, 2 «g-» particles and 2 «s-» particles).

The two «s-particle» tracks of relative ionization close to unity and 16.5 mm and 24.1 mm long, up to the exit points from the chamber, were identified as tracks of π-mesons of kinetic energy between 150 and 200 MeV. One of the «g-particle» tracks, 8.7 mm long and of ionization (2.6 ± 0.1), was attributed to a (21.0 ± 3.0) MeV π-meson; the other one, 25.4 mm long and exhibiting ionization increasing from (2.4 ± 0.1) at departure from the star to (3.6 ± 0.1) at the exit point from the photoemulsion chamber, was identified as the track of a K-meson of kinetic energy $T_K = (83.0 \pm 5.0)$ MeV.

Of the four «b-particle» tracks the single-charged particle of range 2.8 mm was attributed to a (25.4 ± 2.0) MeV proton; the two tracks 3.6 μm and 59.2 μm long, respectively, could with equal probability be tracks of hydrogen or helium isotopes; the last «b-particle» upon travelling 1.8 μm produced a secondary 2-prong star with a 119°40′ angle between the two prongs and can be considered as resulting from the meson decay of a hyperfragment.

Both prongs belonging to this secondary star stop inside the photoemulsion chamber. The range of one of them with relative ionization equal to (1.5 ± 0.1) is 28.3 mm; at the end of this track a typical σ_π-star is produced. This permits us to conclude, with a large degree of reliability, that the track is of a π^--meson with kinetic energy (43.0 ± 2.0) MeV.

The other track is 855.7 μm long and may be identified as the track of a 1- or 2-charged particle.

Short-ranged prongs (1.8 μm; 3.6 μm; 59.2 μm) being present in the annihilation star indicate that the antiproton was captured by a light (C, N, O, S) nucleus in the photoemulsion, since, owing to the high Coulomb barrier of heavy nuclei (Ag, Br) in the photoemulsion, the probability of low-energy particles leaving the nucleus is quite small. Thus, in searching for possible hyperfragments, produced in antiproton annihilation, one may consider only light hyperfragments, such as isotopes of hydrogen or helium.

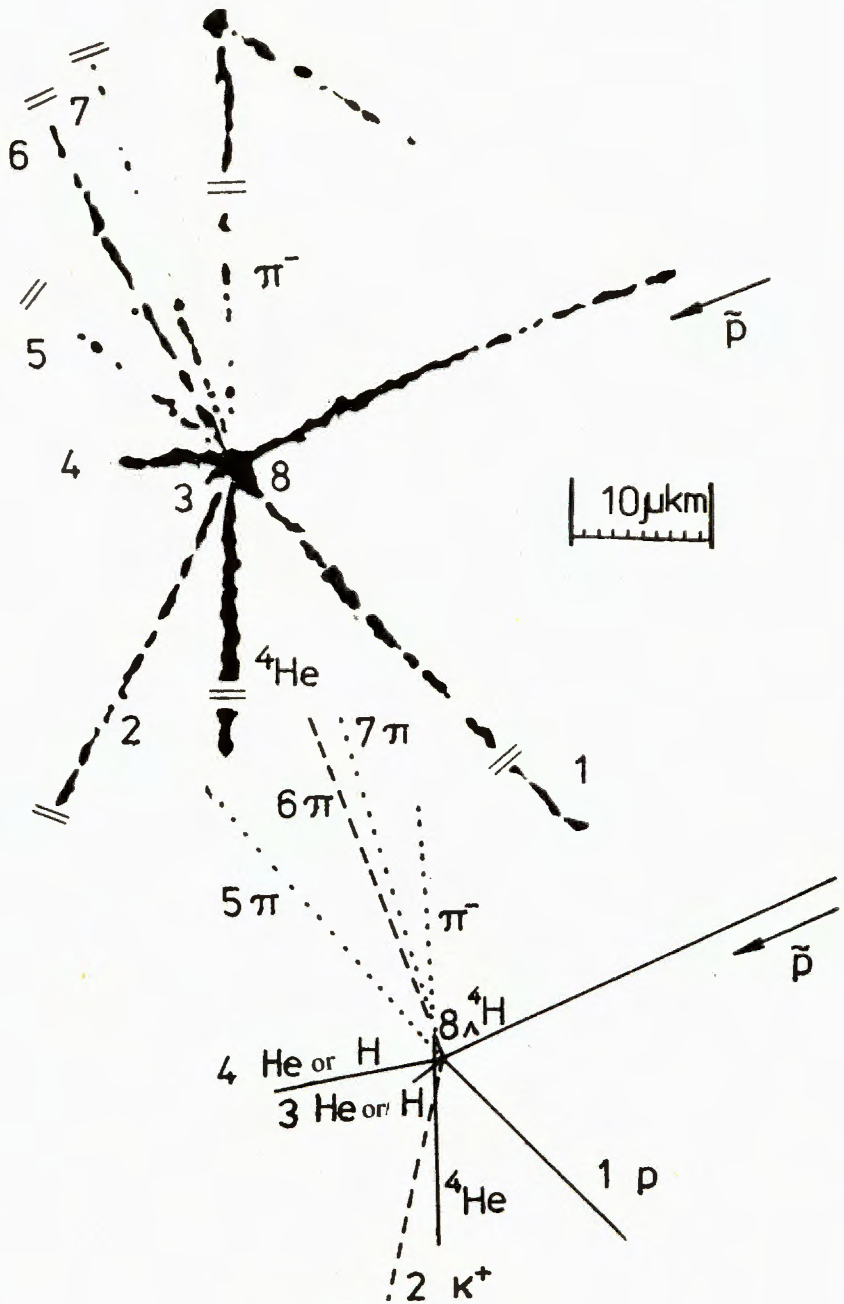

Fig.1. Microphotograph of event (1)

The hypernuclei $^3_\Lambda H$ and $^4_\Lambda H$ undergo 2-particle meson decays. The experimentally determined characteristics of the secondary star were utilized for calculation of the effective masses of possible hyperfragments, that may decay into a π^--meson and helium nucleus with visible tracks. The best agreement between the table value of the hypernucleus mass and the calculated effective mass corresponded to the $^4_\Lambda H$ hyperfragment, decaying via the channel $^4_\Lambda H \to \pi^- + {}^4He$: the mass difference in this case is $M_{^4_\Lambda H} - M^{(calcul.)}_{eff.} =$ $= (3922.3 - 3919.6)$ MeV $= 2.7$ MeV.

The apparent energy balance for the visible prongs, calculated under the assumption that annihilation of an antiproton stopping in the photoemulsion takes place on a light nucleus, allows determination of the possible production channels of the hyperfragment $^4_\Lambda H$ on carbon or nitrogen nuclei:

$$\bar{p} + {}^{12}C \to K^+ + \pi^- + \pi^+ + \pi^- + \pi^0 + p + {}^2H + {}^4He + {}^4_\Lambda H$$

$$\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad |{\to}\, \pi^- + {}^4He, \qquad (1)$$

$$\bar{p} + {}^{14}N \to K^+ + \pi^- + \pi^+ + \pi^- + \pi^0 + p + {}^4He + {}^4He + {}^4_\Lambda H$$

$$\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad |{\to}\, \pi^- + {}^4He. \qquad (2)$$

The relationship between the initial energies in reactions (1) and (2) and the energies released permits one to draw the conclusion that the most probable mechanism for hyperfragment production in these reactions is the charge exchange of K^--mesons resulting from the annihilation process on the nucleons of the residual nucleus. One of the possible charge exchange channels may be the reaction

$$K^- + [{}^4He] \to {}^4_\Lambda H + \pi^0. \qquad (3)$$

In this case it is possible, on the basis of the crucial features of the interaction of stopping antiprotons with the nucleons situated at the periphery of the nucleus [14], to attempt to describe the production process of the hyperfragment $^4_\Lambda H$ in antiproton annihilation on the carbon nucleus in accordance with scheme (1) (see Fig.2).

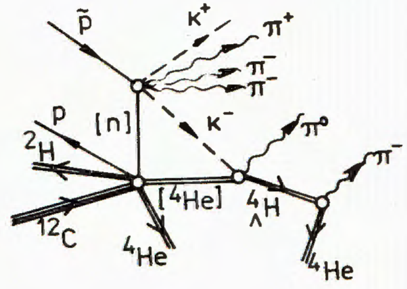

Fig.2. Possible scheme for mechanism of reaction (1)

A microphotograph of event II is presented in Fig.3. The primary 7-prong star consists of four «s»-prongs and three «b»-prongs. An analysis reveals that the «s»-prongs are reliably identified as follows: a K^+-meson of kinetic energy of the about 220 MeV, two π-mesons of energies (40.5 ± 2.0) MeV and (37.5 ± 2.0) MeV, respectively, and a proton with kinetic energy (190.0 ± 5.0) MeV.

One of the «b»-tracks with a range, up to the stopping point, equal to 2639.0 μm is identified as the track of a deuteron of energy 32.8 MeV, while the other one with a range of 1137.0 μm is interpreted as the track of a doubly charged particle. The third «b»-track, upon pasing 5.8 μm, produces a 3-prong secondary star, one of the tracks of which belongs to a π-meson of kinetic energy (28.0 ± 3.0) MeV, while the other two with ranges equalling, respectively, 161.6 μm and 626.3 μm may be considered tracks of singly charged particle.

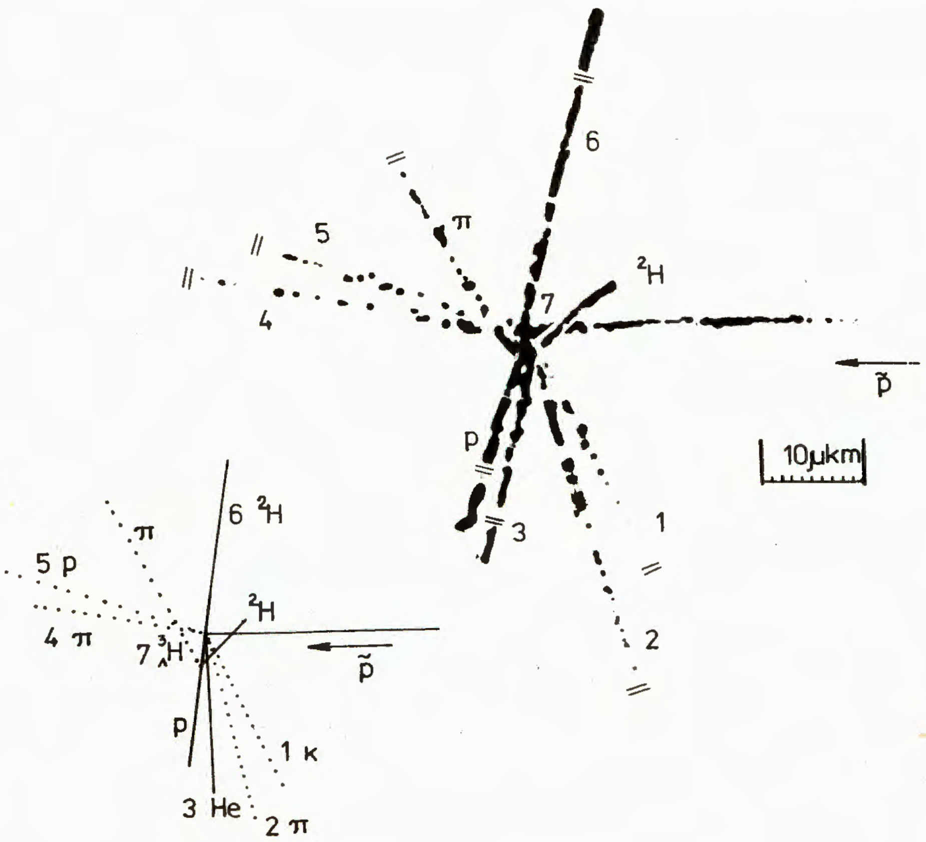

Fig.3. Microphotograph of event (2)

Consistent investigation of all possible mesonic decay channels of the light hyperfragments, that could result in the production of a 3-prong star in the photoemulsion, as well as calculations of the effective masses of hypernuclei based on the experimental data for the secondary star show that the best agreement between the table and the estimated masses is achieved for the hypernucleus ${}^3_\Lambda$H decaying via the channel ${}^3_\Lambda H \to \pi^- + p + {}^2H$; the difference between the masses, in this case, is

$$M_{eff}^{(calcul)} - M_{{}^3_\Lambda H} = (2998.2 - 2991.0) = 7.2 \text{ MeV}.$$

Since, like in the first event, the antiproton annihilated on a light nucleus in the photoemulsion and the hyperfragment ${}^3_\Lambda$H was produced as a result of the K^--meson undergoing charge exchange via the channel

$$K^- + \left[{}^4He\right] \to {}^3_\Lambda H + n + \pi^0, \qquad (4)$$

when interacting with part of the residual nucleus, we determined both the possible hyperfragment production reaction on a nitrogen nucleus

$$\bar{p} + {}^{14}N \to K^+ + \pi^- + \pi^+ + \pi^0 + p + n + {}^2H + {}^6He + {}^3_\Lambda H$$
$$\qquad\qquad\qquad\qquad\qquad\qquad \lfloor\!\to \pi^- + p + {}^2H. \qquad (5)$$

as well as a possible mechanism of this process (Fig.4).

A microphotograph of the third event is presented in Fig.5. The annihilation star consists of 12 prongs: 9 «b»- and 3 «g»-tracks. Identification of the «g»-tracks revealed that they are tracks of a K^+-meson of kinetic energy (45.0 ± 5.0) MeV, a proton of energy (25.0 ± 2.0) MeV and a π-meson with an energy of the order of 100 MeV.

Identification of the nine «b»-tracks was performed by separating them in accordance with the number of clusters of developed grains of silver (the «method of shadowed scalling marks» [16]), while the kinetic energies of the respective particles were determined by the measured total ranges in the photoemulsion. The following were identified: three tracks of ^{4}He nuclei with energies (25.0 ± 2.0) MeV, (28.0 ± 2.0) MeV and (31.5 ± 2.0) MeV; two tracks of ^{3}He nuclei with energies

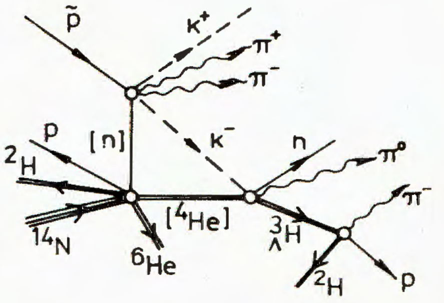

Fig.4. Possible scheme for mechanism of reaction (5)

(164.0 ± 2.0) MeV and (181.0 ± 2.0) MeV; two tritons with energies (18.0 ± 2.0) MeV and (19.0 ± 2.0) MeV; a deuteron of energy 1.3 MeV.

The ninth «b»-track, 1.8 μm long, gives rise at its termination in the photoemulsion to a three-prong secondary star, two short prongs of which, 21.4 μm and 238.5 μm long, can be identified as tracks of single-charged particles, while the third prong terminating in a «ρ»-stop belongs to a π^--meson of kinetic energy (16.5 ± 2.0) MeV.

The effective masses of possible hypernuclei were calculated under the assumption that the secondary star resulted from a mesonic decay of the light hyperfragment.

It turned out that the best agreement between the effective hypernucleus mass derived from the experimental data and the table value corresponded to the ${}^4_\Lambda H$ hyperfragment, decaying via the channel

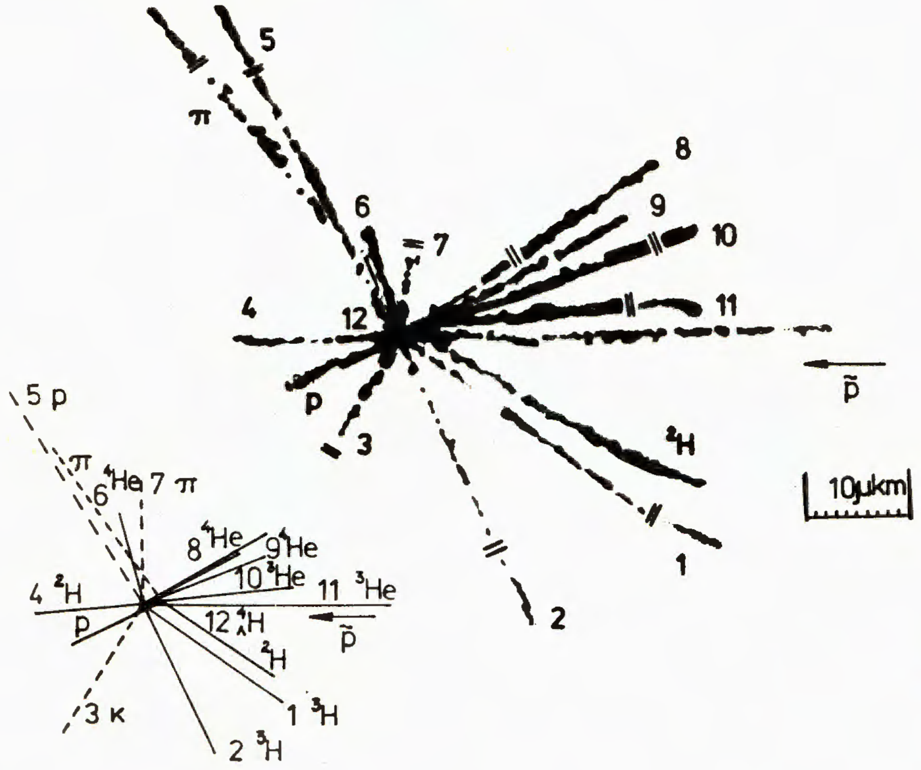

Fig.5. Microphotograph of event (3)

$$ {}^4_\Lambda H \rightarrow \pi^- + p + {}^2H + n. \qquad (6) $$

The mass difference in this case is $M^{(calcul.)}_{eff.} - M_{{}^4_\Lambda H} =$ (3922.4 – – 3922.3) MeV = 0.1 MeV.

Attempts at determining the appropriate channel for antiproton annihilation on a light nucleus in the photoemulsion resulting in the production of a twelve-prong star, involving the hyperfragment ${}^4_\Lambda H$, pointed to the following reaction on the sulpher nucleus:

$$ \bar{p} + {}^{32}S \rightarrow K^+ + \pi^- + \pi^0 + p + {}^2H + {}^3H + {}^3H + {}^3He + {}^3He + {}^4He + {}^4He + {}^4He + {}^4_\Lambda H $$
$$ \qquad \qquad \qquad \qquad \qquad \qquad \qquad \qquad \qquad \qquad \qquad \qquad \lfloor\rightarrow \pi^- + p + {}^2H + n \qquad (7) $$

Like in the preceding events, the hyperfragment was assumed to be produced in a secondary reaction on the nucleons of the residual nucleus by charge exchange of the annihilation K^--meson via channel (3), and a possible scheme of this process is depicted in Fig.6.

Thus, analysis of the obtained experimental data permits us to conclude that the first observation of three events of the production, flight and mesonic decay of the light hyperfragments ${}^3_\Lambda H$ and ${}^4_\Lambda H$ is reported in the present work.

The probability of such reactions taking place per antiproton stopping in the photoemulsion amounts to $(6.1 \pm 3.5) \cdot 10^{-4}$.

All the detected events involving production and subsequent pionic decay of hyperfragments were interpreted as annihilation events of stopping antiprotons on light, (C, N, O, S), nuclei in the photoemulsion. Therefore, if one assumes that, like in the case of π^--meson absorption, 38% [17] of the antiprotons are captured by light nuclei in the photoemulsion, then the probability of hyperfragment production per stopping antiproton will be equal to $(1.6 \pm 0.9) \cdot 10^{-3}$.

The clearly identified track of a (90.0 ± 2.0) MeV K-meson (its track range up to its stopping point in the photoemulsion is 43.3 mm, and the relative ionization at the track's starting point is (2.3 ± 0.1) partaining to the

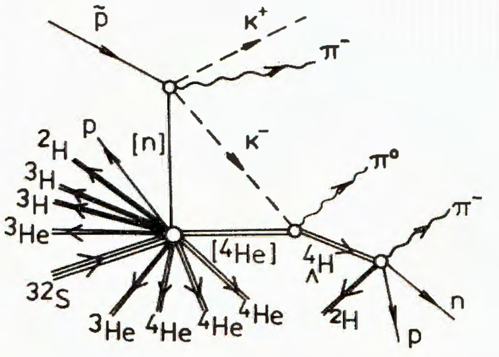

Fig.6. Possible scheme for mechanism of reaction (7)

fourth detected event may either indicate the production, in the antiproton annihilation proccess, of a hypernucleus or the production of a charged or of a neutral particle of non-zero strangeness. This event was also analyzed in detail. Its microphotograph is presented in Fig.7.

It was already noted above that the primary two-prong star represents an elastic scattering event of a 20.0 Mev antiproton on hydrogen in the photoemul-

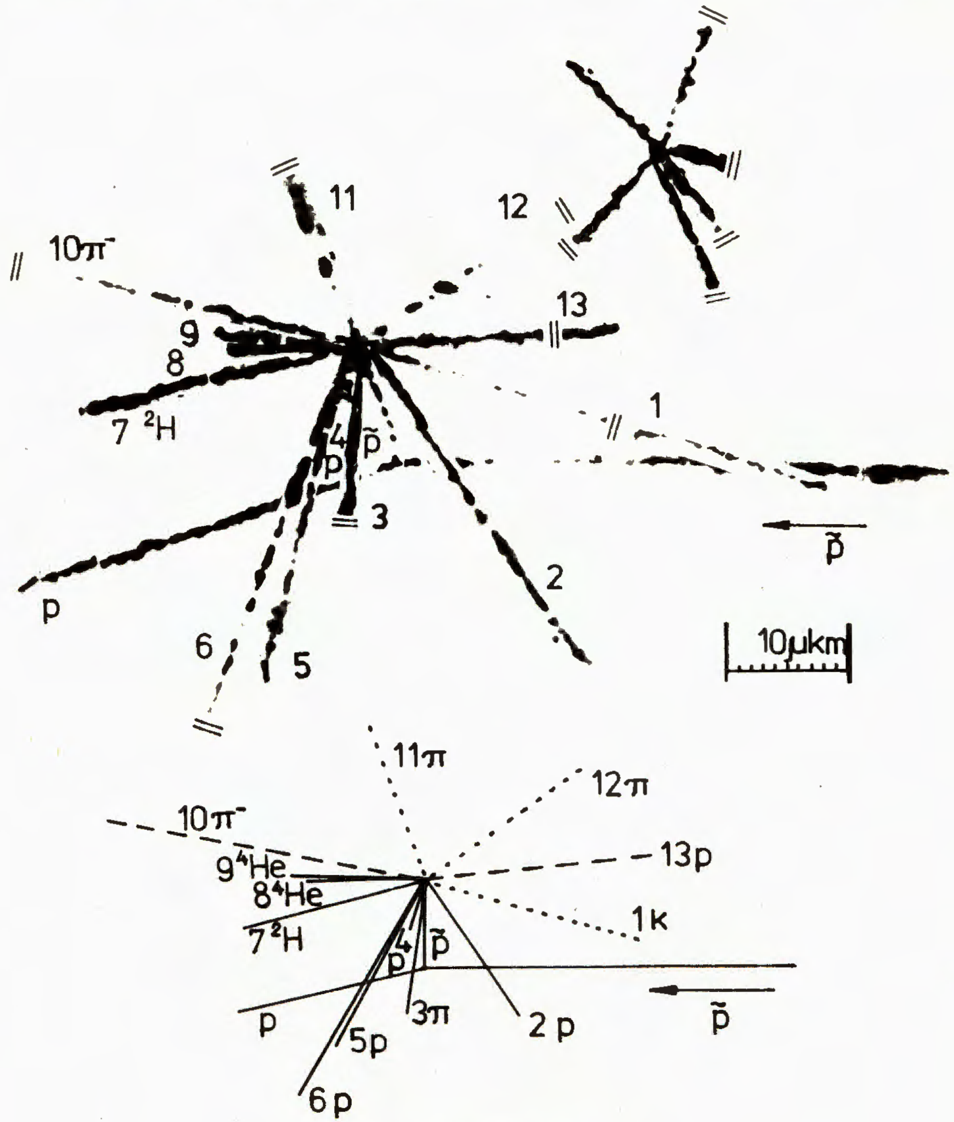

Fig.7. Microphotograph of event (4)

sion: the relations between the scattering angles, the energies and the coplanarity of all the particles participating in the scattering totally comply with the kinematics of this process. The secondary 13-prong star is a result of the elastically scattered antiproton stopping and undergoing annihilation on a nucleus in the photoemulsion. Of the charged particle tracks belonging to this star the tracks of the following particles were identified, besides that of the K-meson: four π-mesons of kinetic energies (52.7 ± 5.0) MeV, (24.5 ± 5.0) MeV, (70.0 ± 5.0) MeV and ≈ 250 MeV; five protons of energies 0.4 MeV, 6.8 MeV, 15.7 MeV, > 34.9 MeV and (71.1 ± 2.0) MeV; two ^{4}He nuclei with kinetic energies (22.6 ± 2.0) MeV and (23.9 ± 2.0) MeV; a (10.7 ± 2.0) MeV deuteron.

The energy balance between the primary and final energies indicate that an undetected neutral strange particle could not be produced in the case being considered. Among the twelve tracks there was also no charged partner found for the K-meson, that was required for strangeness conservation. Therefore the only possibility left for complying with the conservation law is the production of a hyperfragment decaying in the immediate vicinity of the centre of the annihilation star. Examination of various combinations of charged particles in the star, that could correspond to mesonic decay products of a light hyperfragment revealed that the best agreement of the experimentally determined effective mass of such a nucleus with the table value is provided by the hyperfragment $^3_\Lambda$H, decaying via the channel

$$^3_\Lambda\mathrm{H} \to \pi^- + {}^2\mathrm{H} + p. \qquad (8)$$

The mass difference in this case amounts to $M_{^3_\Lambda\mathrm{H}} - M^{(calcul.)}_{eff.} = = (2991.0 — 2989.0)$ MeV = 2.0 MeV.

The following possible hyperfragment production channel involving the capture of an antiproton by a light nucleus in the photoemulsion was found, remaining within the framework of the assumption that the intranuclear charge exchange of a K^--meson produced in the annihilation process

$$K^- + \left[{}^4\mathrm{He}\right] \to {}^3_\Lambda\mathrm{H} + p + \pi^- \qquad (9)$$

is responsible for hyperfragment production:

$$\bar{p} + {}^{16}\mathrm{O} \to K^+ + \pi^- + \pi^- + \pi^- + p + p + p + p + {}^4\mathrm{He} + {}^4\mathrm{He} + {}^3_\Lambda\mathrm{H} \qquad (10)$$

$$\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad \lfloor\!\to \pi^- + p + {}^2\mathrm{H}$$

the mechanisms for such a reaction were also found.

The possible mechanisms of reaction (10) differ from the ones previously considered in that here the annihilation process occurs on a [^{2}n] (Fig.8a) or [^{4}He] (Fig.8b) cluster, instead of a surface neutron of the primary nucleus.

Observation of a hyperfragment production event, not associated with any visible track leaving the annihilation star, compels us to consider the probability, determined in this work, of hypernucleus production, involving mesonic decay in antiproton capture processes by nuclei in photoemulsion, to be an estimate of the lower limit for such a process. The total hyperfragment production probability in antiproton annihilation reactions must account for events with mesonless decays and for two types of events involving π^-- and π^0-mesonic decays of hypernuclei in the photoemulsion (both with a visible hyperfragment track and without any such track).

A specific feature of the supposed formation mechanism of $^3_\Lambda$H and $^4_\Lambda$H hypernuclei (Figs.2, 4, 6, 8) is the charge exchange of the annihilation K^--meson on the intranuclear cluster [^{4}He] of the residual nucleus, involving production in this process of a π^0- or π^--meson and of a hyperfragment, that with a lifetime equal to 10^{-10} sec [11] decays into a π^--meson and isotopes of hydrogen or helium.

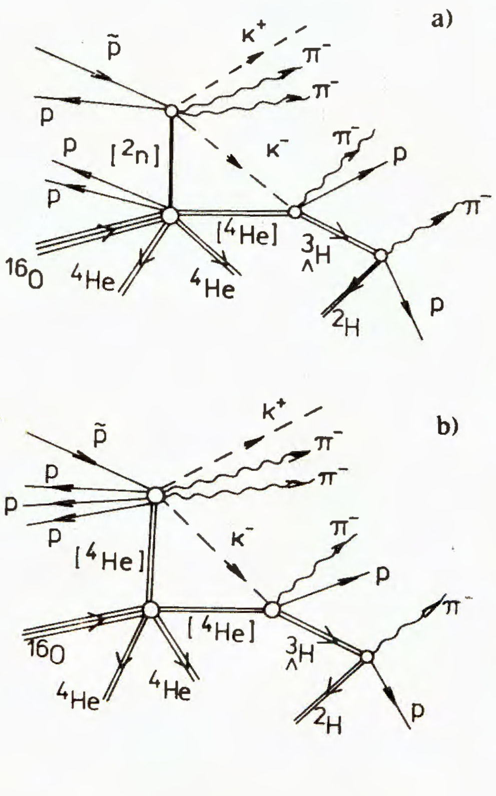

Fig.8. Possible scheme for mechanism of reaction (10)

An alternative mechanism for the production of such hyperfragments in antiproton annihilation on the light (C, N, O, S)-nuclei in photoemulsion may be the formation of an excited residual nucleus with a Λ^0-particle stuck in it, that upon passage of a certain time interval decays into fragments, among which there also happens to be a light hypernucleus.

An example of the assumed mechnism is represented by the following possible scheme of reaction (1):

$$\bar{p} + {}^{12}\mathrm{C} \to K^+ + \pi^- + \pi^+ + \pi^- + \pi^0 + {}^{11}_{\Lambda}\mathrm{B}^*$$
$$\qquad\qquad\qquad \hookrightarrow {}^4_\Lambda\mathrm{H} + {}^4\mathrm{He} + {}^2\mathrm{H} + p$$
$$\qquad\qquad\qquad\qquad \hookrightarrow \pi^- + {}^4\mathrm{He}. \qquad (11)$$

The experimentally determined kinetic energies of the secondary particles, resulting from the decay of a hypothetical intermediate hypernucleus, permit calculation of the excitation energy of such a nuclear system. Estimations reveal that it amounts to 100 MeV. The obtained excitation energy for the intermediate state of the nucleus is extremely high, so the existence of the proposed alternative production mechanism of light hyperfragments seems dubious. It still remains unclear, however, at which moment the intermediate excited nucleus undergoes breakup, since the breakup may occur either at the first stage of antiproton annihilation, or it may be accompanied by the secondary charge exchange reaction of the K^--meson.

A final conclusion concerning the preferential hyperfragment production mechanism in processes of antiproton annihilation on nuclei can be made only upon significant enhancement of the number of hyperfragment events and after a detailed theoretical analysis of such a process.

It wouid be of special interest to carry out an experimental study of the annihilation on ^{4}He nuclei of stopping antiprotons involving the production of $^3_\Lambda$He hyperfragments via the channel

$$\bar{p} + {}^4\mathrm{He} \to K^+ + \pi^- + \pi^0 + {}^3_\Lambda\mathrm{H}$$
$$\hookrightarrow \pi^- + {}^3\mathrm{He}$$
$$\hookrightarrow \pi^- + {}^2\mathrm{H} + n \qquad (12)$$
$$\hookrightarrow \pi^- + p + 2n\ .$$

A possible scheme for the mechanism of such a reaction is presented in Fig.9. In accordance with this scheme a required event is to be selected, first, by the detected annihilation vertex formed by the K^+- and π^--mesons and, secondly, by identifying the second decay vertex from the outgoing π^--meson and nucleons of the residual nucleus, this vertex appearing with a time delay equal to the lifetime of the $^3_\Lambda$H hypernucleus (10^{-10} s). If one could deter-

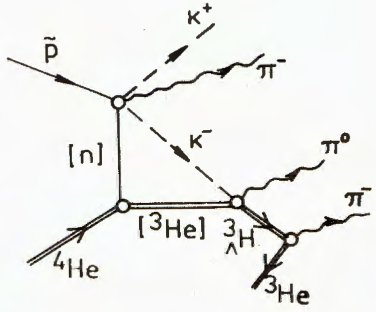

Fig.9. Possible scheme for mechanism of reaction (12)

mine the time interval, at a nuclear scale, between the departures of the annihilation K^+-meson and of the π^0-meson produced in the charge exchange of the K^--meson on the [^{4}He] cluster, then the measurement of such a time interval would represent an «experiment» performed on a cluster target in a microlaboratory.

Vast statistical material relevant to annihilation on ^{4}He nuclei of stopping antiprotons has been obtained with the experimental installation OBELIX (CERN experiment PS-201). A detailed analysis of the events detected in this experiment will doubtlessly aid significantly in comprehension of the production mechanism of light hypernuclei, occurring in annihilation processes.

Thus, the following conclusions may be drawn from the examination of all the set of obtained experimental data.

1. Three events have been observed, for the first time, of the production, departure and mesonic decay of the light hyperfragments ${}^3_\Lambda$H and ${}^4_\Lambda$H in the annihilation on the light (C, N, O, S)-nuclei of antiprotons stopping in photoemulsion.

2. The lower limit of the production probability of ${}^3_\Lambda$H and ${}^4_\Lambda$H hyperfragments per single antiproton stopping in nuclear photoemulsion equals $(6.1 \pm 3.5)\cdot 10^{-4}$.

3. The balance between the total initial and final energies in the considered reactions justifies the conclusion, that the most probable hyperfragment production mechanism is the charge exchange, on nucleons of the residual nucleus, of K^--mesons resulting from the annihilation process.

The production of a hypernucleus on the few-nucleon [^{4}He] cluster is assumed to be a possible charge-exchange channel.

4. An experiment, to be performed on the ^{4}He nucleus, is proposed for testing the considered mechanism of antiproton annihilation involving the production of hyperfragments, and possible triggers are indicated for the detection of such processes.

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18.	Applied researches
19.	Biophysics

Батусов Ю.А. и др. E1-92-256

Образование гиперфрагментов при аннигиляции остановившихся антипротонов на ядрах в фотоэмульсии

Впервые зарегистрированы события образования, вылета и мезонного распада легких гиперфрагментов ${}^{3}_{\Lambda}H$ и ${}^{4}_{\Lambda}H$ в процессах аннигиляции остановившихся антипротонов на ядрах (C, N, O, S) в ядерной фотоэмульсии. Установлено, что нижняя граница вероятности образования гиперфрагментов ${}^{3}_{\Lambda}H$ и ${}^{4}_{\Lambda}H$ на одну остановку антипротона в фотоэмульсии равна $(6,1 \pm 3,5)\cdot 10^{-4}$. Показано, что наиболее вероятным механизмом рождения гиперфрагментов является перезарядка образованных в результате аннигиляционного процесса K^{-}-мезонов на нуклонах ядра-остатка.

Работа выполнена в Лаборатории ядерных проблем ОИЯИ.

Препринт Объединенного института ядерных исследований. Дубна 1992

Batusov Yu.A. et al. E1-92-256

Production of Hyperfragments by Antiprotons at Rest Annihilating on Nuclei in Nuclear Photoemulsion

Events have been observed, for the first time, of the production, departure and mesonic decay of the light hyperfragments ${}^{3}_{\Lambda}H$ and ${}^{4}_{\Lambda}H$ in the annihilation on the light (C, N, O, S)-nuclei of antiprotons stopping in nuclear photoemulsion. The lower limit of the production probability of ${}^{3}_{\Lambda}H$ and ${}^{4}_{\Lambda}H$ hyperfragments per single antiproton stopping in nuclear photoemulsion has been determined to be $(6.1 \pm 3.5)\cdot 10^{-4}$. The charge exchange, on nucleons of the residual nucleus, of K^{-}-mesons resulting from the annihilation process has been demonstrated to be the most probable mechanism of hyperfragment production.

The investigation has been performed at the Laboratory of Nuclear Problems, JINR.

Preprint of the Joint Institute for Nuclear Research. Dubna 1992