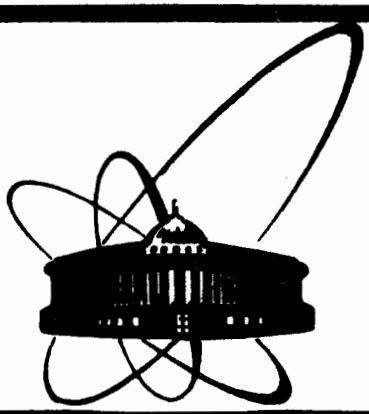

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E1-87-337

# THE OBSERVATION OF $^{4}_{\Lambda}$H RELATIVISTIC HYPERNUCLEI PRODUCED IN $^{4}$He COLLISIONS WITH LIGHT NUCLEI AT 18 GeV/c

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There is hitherto only one experimental result on cross sections for hypernuclei production and their mean life-time obtained by means of projectile relativistic ions /1/. In this paper we present our preliminary results on the cross section for $^{4}_{\Lambda}H$ hypernuclei production in a $^{4}He$ beam (3.7 GeV/nucleon), the estimate of $^{4}_{\Lambda}H$ mean life-time and the upper limit of the cross section for $^{7}_{\Lambda}Li$ production in a $^{7}Li$ beam (3.0 GeV/nucleon).

The data have been obtained with the spectrometer GIBS exposed to extracted beams of nuclei accelerated in the Dubna synchrophasotron. The registering part of the spectrometer is a streamer chamber ($2 \times 1 \times 0.6$ m$^3$) filled with a pure neon gas under atmospheric pressure and placed in a magnetic field of 0.9 T. During the run with the $^{7}Li$ beam the scintillation counters of A, B and C groups (Fig.1) were tuned to select ions with charges 3,3 and 4, respectively, what suggested the $^{7}_{\Lambda}Li$ production in a target with a consequent decay $^{7}_{\Lambda}Li \to \pi^- + {}^{7}Be$. Analogously, during the run with the $^{4}He$ beam the counters of A, B and C groups were tuned to select ions with charges 2,1 and 2, respectively. This suggested the $^{4}_{\Lambda}H$ hypernuclei production in a target with a consequent decay $^{4}_{\Lambda}H \to \pi^- + {}^{4}He$ within the sensitive volume of the chamber.

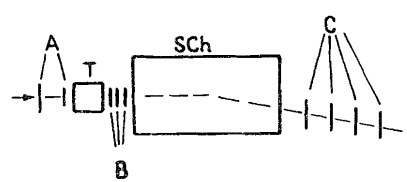


Fig.1. Experimental set-up. A,B,C - the groups of scintillation counters, T-target, SCh-streamer chamber.

As a result of analysis of the obtained pictures, we have found five registered $^{4}_{\Lambda}H \to \pi^- + {}^{4}He$ decays. One event has been registered, which can be interpreted as a $^{7}_{\Lambda}Li \to \pi^- + {}^{7}Be$ decay. The characteristics of the five $^{4}_{\Lambda}H$ decays are given in a table. As is seen from the table, the effective masses of a ($^{4}He + \pi^-$) system are in good agreement with the mass of the $^{4}_{\Lambda}H$ hypernucleus which is equal to 3922.5 MeV/2/. There is also an additional argument for proper identification of these events, namely the difference in the ionization of primary ($^{4}H$) and secondary ($^{4}He$) tracks which is distinctly observable in the pictures. By means of momentum measurements in the two-prong events including $^{4}_{\Lambda}H$ decays, we were able to separate secondary $^{4}He$ and $^{3}He$ nuclei (see Fig.2), which usually have almost the same veloci-

Table

| $M_{eff}$ (GeV/$c^2$) | $P_{He}$ (GeV/c) | $P_{\pi}$ (GeV/c) | l (cm) |
|---|---|---|---|
| 3.9254±0.0034 | 15.82±0.98 | 0.5939±0.0058 | 61.5 |
| 3.9267±0.0042 | 16.38±1.12 | 0.5805±0.0071 | 61.4 |
| 3.9205±0.0018 | 15.90±0.48 | 0.8090±0.0120 | 4.9 |
| 3.9220±0.0018 | 16.18±0.47 | 0.8250±0.0120 | 4.5 |
| 3.9143±0.0094 | 16.71±1.34 | 1.411 ±0.029 | 83.2 |
| 3.9098±0.0097 | 17.30±1.54 | 1,398 ±0.031 | 83.2 |
| 3.9226±0.0041 | 15.77±0.60 | 1.2799±0.0170 | 47.8 |
| 3.9220±0.0044 | 15.78±0.62 | 1.2779±0.0250 | 47.8 |
| 3.9195±0.0027 | 15.97±0.43 | 0.4430±0.0027 | 18.5 |
| 3.9216±0.0027 | 16.27±0.42 | 0.4410±0.0027 | 18.4 |

$M_{eff}$ - effective mass of a ($\pi^-$ + $^4$He) system,

$P_{He}$ - momentum of $^4$He ,

$P_{\pi}$ - momentum of $\pi^-$ meson,

l - $^4_\Lambda$H range in the chamber fiducial volume.

Two results of measurements are given for each of five events.

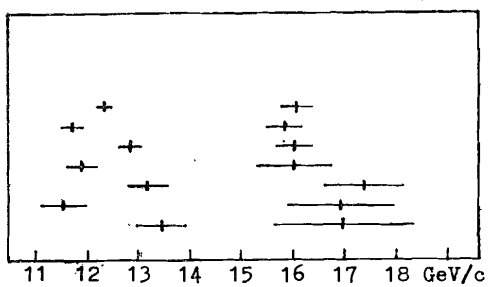


Fig.2. Momentum distribution of He nuclei.

ty. It should be noted that the hypernucleus decays $^4_\Lambda H \to \pi^- + {}^4He$ cannot be imitated by charge exchange reaction $^4H + Ne \to {}^4He + \pi^- + \ldots$ because the $^4H$ isotope decays within nuclear time /3/.

The number of the registered $^4_\Lambda$H decays allows us to estimate the cross section for production with a polyethylene target $\sigma(^4_\Lambda H) \simeq 0.1/R_1$ microbarns, where

$$R_1 = \frac{\Gamma(^4_\Lambda H \to \pi^- + {}^4He)}{\Gamma(^4_\Lambda H \to \text{all channels})}$$

According to Refs. /4-6/, $R_1 \sim 0.5$ and therefore $\sigma(^4_\Lambda H) \sim 0.2$ mcb ($\sim 0.02$ mcb per target nucleon). If for



$$R_2 = \frac{\Gamma(^7_\Lambda Li \to \pi^- + {}^7Be)}{\Gamma(^7_\Lambda Li \to \text{all channels})}$$

we use $R_2 \sim 0.1$ (according to data in /5-7/), then the upper limit of the cross section for $^7_\Lambda$Li production is about 1 mcb (0.1 mcb per target nucleon).

Our cross section data essentially differ from those for $^{16}_\Lambda$O hypernuclei production in a $^{16}$O beam at an energy of 2.1 GeV/nucleon/1/ ($\sim$ 2 mcb per target nucleon) and are in qualitative agreement with theoretical estimations/8,9/ of the cross section for hypernuclei production in peripheral collisions.

The estimation of the $^4_\Lambda$H hypernucleus mean lifetime yields $\tau = (3.3\ ^{+\ 2.3}_{-\ 1.2}) \cdot 10^{-10}$ s.

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Наблюдение релятивистских гиперядер $^{4}_{\Lambda}H$ при взаимодействии $^{4}He$ с легкими ядрами при 18 ГэВ/с


Приводятся предварительные результаты поиска гиперядер, образующихся в пучках релятивистских ионов. Исследовались реакции: $^{7}Li + CH_2 \to {}^{7}_{\Lambda}Li + X$ при энергии 3,0 ГэВ/нуклон с последующим распадом ${}^{7}_{\Lambda}Li \to \pi^- + {}^{7}Be$ и ${}^{4}He + CH_2 \to {}^{4}_{\Lambda}H + X$ при энергии 3,7 ГэВ/нуклон с последующим распадом ${}^{4}_{\Lambda}H \to \pi^- + {}^{4}He$. На имеющейся статистике найдено одно событие, которое может быть интерпретировано как распад ${}^{7}_{\Lambda}Li$ и пять распадов ${}^{4}_{\Lambda}H$. Соответственно верхняя граница сечения образования ${}^{7}_{\Lambda}Li$ - приблизительно 1 мкб / ~ 0,1 мкб на нуклон мишени/, а сечение образования ${}^{4}_{\Lambda}H$ - около 0,2 мкб / ~ 0,02 мкб на нуклон мишени/. Оценка времени жизни ${}^{4}_{\Lambda}H$ дает

$$\tau = (3,3^{+2,3}_{-1,2}) \cdot 10^{-10} \text{ с.}$$

Работа выполнена в Лаборатории высоких энергий ОИЯИ.



Сообщение Объединенного института ядерных исследований. Дубна 1987



Avramenko S.A. et al.


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The Observation of $^{4}_{\Lambda}H$ Relativistic Hypernuclei Produced in $^{4}He$ Collisions with Light Nuclei at 18 GeV/c


Preliminary results of a search for hypernuclei produced in relativistic heavy ion beams are presented. Two reactions have been studied: $^{7}Li + CH_2 \to {}^{7}_{\Lambda}Li + X$ at 3.0 Gev per nucleon with a consequent decay ${}^{7}_{\Lambda}Li \to \pi^- + {}^{7}Be$ and $^{4}He + CH_2 \to {}^{4}_{\Lambda}H + X$ at 3.7 GeV per nucleon with a consequent decay ${}^{4}_{\Lambda}H \to \pi^- + {}^{4}He$. Our available statistics has resulted in five registered ${}^{4}_{\Lambda}H$ decays and one event which can be interpreted as a ${}^{7}_{\Lambda}Li$ decay. Accordingly, the cross section for ${}^{4}_{\Lambda}H$ production is about 0.2 microbarns ( ~ 0.02 mcb per target nucleon) and the upper limit of the cross section for ${}^{7}_{\Lambda}Li$ production is about 1 mcb ( ~ 0.1 mcb per target nucleon). The ${}^{4}_{\Lambda}H$ mean-life has been estimated to be $(3.3^{+2.3}_{-1.2}) \cdot 10^{-10}$ s.

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



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