FRAGMENTATION OF ^6Li NUCLEI AT 4.5 A GeV/c MOMENTUM IN PHOTOEMULSION

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It was shown in [1] for independent emission of equal mass fragments that the value $\eta = \langle P_\perp(lab)\rangle / \langle P^*_\perp(C.M)\rangle \approx \sqrt{2}$. In the fragmentation of ^{22}Ne projectiles in the photoemulsion η was observed to differ from $\sqrt{2}$, which could mean the existence of excited pre-fragments. It was interesting to continue such investigations with the lightest projectiles — nuclei of ^6Li.

In the experiment the charge of the fragment, angles φ and α between X-axis, directed along with the projectile vector $\vec{P}_0$, and projections of the fragment total momentum P on XOY and XOZ planes have been measured as well as angles $\Theta_{12}(\Theta_{23}, \Theta_{13})$ for events with 2 and 3 fragments. The value of P was determined by the measurement of multiple scattering, then the mass number A was obtained according to the minimum value of t:

$$t = \mid P - P_0 \cdot A \mid / \Delta P, \tag{1}$$

where A is $1, 2, 3$ ($Z = 1$) and $3, 4, 6$ ($Z = 2$). The weight of given measurement proportional to the density of normal distribution with a mean value $P_0 \cdot A$ and a variance $(\Delta P)^2$ was used to obtain the histogram shown in Fig.1. Meanweighted values $\langle P\rangle_A$ at each A show that measurements of P are rather reliable: $\langle P\rangle_A = (4.3 \pm 0.6)$ GeV/c and (8.2 ± 0.7) GeV/c for hydrogen and deuteron, $\langle P\rangle_A = (12.9 \pm 1.3)$ GeV/c, (16.9 ± 1.5) GeV/c, (23.6 ± 4.0) GeV/c for helium 3, 4, and 6. Isotopes yields of ^1H and ^2H, ^3He and ^4He are comparable with each other in the ^6Li projectile fragmentation. The same results for the fragmentation of relativistic nuclei with $N/Z = 1$ (^{12}C, ^{16}O) have been obtained in [2]. But another situation is observed in the target fragmentation induced by high energy protons, for example, in the fragmentation of Ni, Ag, Sn, Au and U nuclei by 1 GeV protons [3]. There it was shown that yields of ^3He and ^4He depend on N/Z of the target. Even for ^{58}Ni and ^{112}Sn nuclei with $N/Z \approx 1$,^3He yield does not exceed 10% of ^4He yield. These facts can show the existence of different mechanisms is in projectile and target fragmentation — "fast" and "slow".

22 of 244 particles with $Z = 1$ have $A = 3$ and among 192 fragments with $Z = 2$ only a few particles give the evidence of the observation of ^6He — Fig.1. Nevertheless one can consider the process of the exchange with nucleons ($p \leftrightarrow n$) between ^6Li and photoemulsion nuclei as established. Moreover we observed disintegration of ^6He into two ^3H and $^6Be(^7Be)$ into two helium isotopes. In the last case the event is rather clear and not accompanied by particles from target-nucleus: π-mesons and slow protons.

The fraction C_A of events for each A at fixed value of Z was determined by least squares method. Histograms are well reproduced by a mixture of three normal distributions with 8 free parameters: C_1, C_2, σ_1, σ_2, σ_3, $\langle P_1\rangle$, $\langle P_2\rangle$, $\langle P_3\rangle$. Such method of the statistical separation of isotopes has given value of C_A at fixed Z and A, conceding with the same values obtained by t-minimum method.

In total we have found 13 events corresponding to exchange and pick-up reactions of ^6Li projectiles with nuclei of the photoemulsion. Among them there are 3 events of the disintegration of excited ^6He into two ^{3}H with the momentum of each fragment $P(^3H) = (12 \pm 1)$ GeV/c. This channel of nucleon exchange reaction has the cross section $\sigma_{ex} = (12 \pm 3)$ mb or approximately 1.5% of the total cross section.

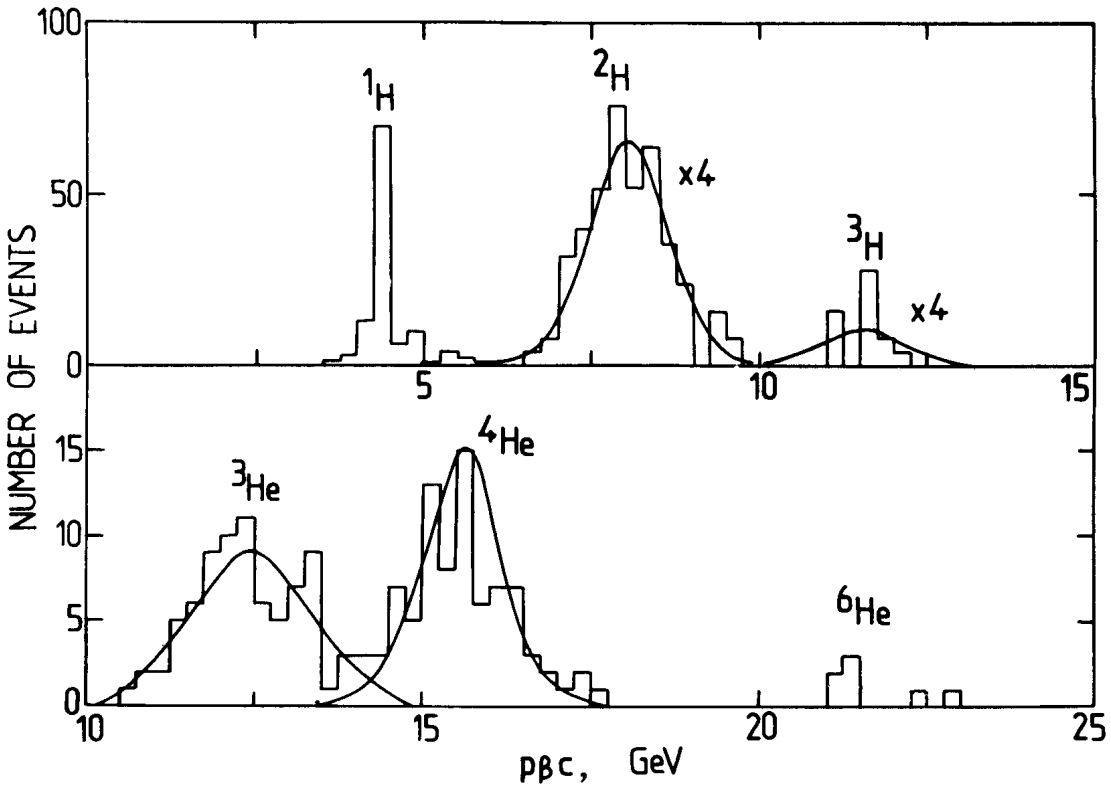

Fig.1. Energy distribution of hydrogen and helium isotopes. Histogram — experiment, curves — the fit of experimental data by normal distributions

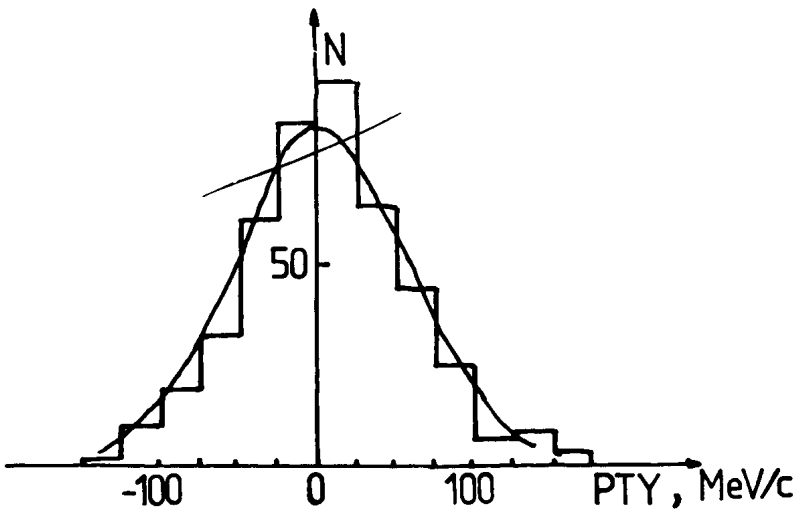

Fig.2. Distribution of projections of transverse momenta for protons. Smooth curve — normal distribution with $\sigma_0 = 54.8$ MeV/c

The distribution of projections of the transverse momenta for fragments-protons $PTY = P_0 \sin\varphi$ (Fig.2) is the normal distribution $N[0, \sigma_0^2]$ at $\sigma_0 = 54.8 \pm 2.5$ MeV/c. For transvers momenta we have the Rayleigh distribution. The value of σ_0 obtained in this experiment is smaller than σ_0 evaluated from the value of Fermi momentum P_F for ^6Li — 76 MeV/c [4]. Moreover σ_0 defined in this experiment is observable value whereas P_F and hence σ_0 are fitted parameters of the model in [4]. The magnitude of P_F determined from our measurements of σ_0 is equal to 111 ± 6 MeV/c for protons in ^6Li.

The distribution of projections of the transverse momentum PTY for particles with $Z = 2$ are also well reproduced by the normal distribution. For ^4He $\sigma_0 = (137.4 \pm 8.7)$ MeV/c. The expected value of σ_0 with regard to of α-particle will be approximately 71 MeV/c. Thus measured value of $\sigma_0(^4He)$ is twice more then the expected one. Using the Uncertainty Principle with equal sign $\langle P_\perp \rangle \langle R_{FR} \rangle = \hbar/2$ one can estimate that $\langle R_{FR} \rangle_p / \langle R_{FR} \rangle_\alpha \approx 2$, where $\langle R_{FR} \rangle$ is the characteristic dimension of the fragmentation region for p and α-particle correspondingly. It means that the region of ^6Li nucleus from which we observed the emission of α-particles is twice less than the region for proton emission.

For events with two and three fragments through their invariant masses one can find the transverse momentum of fragments in CM system — $P_\perp^*$. For all well identified pairs of fragments — proton-proton, proton-α-particle we did not observe the difference between the value η defined upper and $\sqrt{2}$. So, for all events η is 1.36 ± 0.05 in experiment, and η is 1.39 ± 0.02, obtained by Monte Carlo method. Thus, there is no evidence for the existence of excited pre-fragments stage in the fragmentation of relativistic ^6Li nuclei.

REFERENCES

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