ФИЗИКО-МАТЕМАТИЧЕСКИЕ НАУКИ

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INVESTIGATION OF INCLUSIVE CROSS SECTIONS FOR THE FORMATION OF ^{1}H, ^{2}H AND 3H NUCLEI IN1^{6}OP INTERACTIONS AT 3.25 A GEV / C

Summary. *At the first time by full geometry condition the hydrogen isotopes formations inclusive cross sections in different topological channels of the oxygen nucleus decay are obtained. It is shown, that proton formations inclusive cross sections is proportionally as the topological cross sections as the residual nucleus charge.*

Key words: *^{16}Op-collisions, nuclear forces, light nuclei, topological channels, proton, ^{1}H, ^{2}H, ^{3}H, fragment, ϖ^+-meson, ϖ^--meson, inclusive cross section, isotope, charge of the oxygen nucleus, fictitious parameters.*

The present work is a continuation of the cycle of studies of the processes of fragmentation of oxygen nuclei in ^{16}Op collisions at 3.25 A GeV / c and is devoted to the study of inclusive cross sections for the yield of light nuclei ^{1}H, ^{2}H and ^{3}H. The total statistics of the experimental material is 13759 measured ^{16}Op-events [1, 285; 3, p.58].

As was shown in [4, p.280], only 19 channels are experimentally observed from 22 possible topological channels of fragmentation of the ^{16}O nucleus, which include 18 with the formation of multiply charged fragments ($Z_f \geq 2 = 2–8$) and 1 channel with complete decay of the initial nucleus into single-charge fragments ($Z_f \geq 2 = 0$). It should be noted that out of 18 channels with the formation of multiply-charged fragments — 10 is accompanied by the release of doubly-charged fragments of ^{3}He, ^{4}He and ^{6}He. The formation of ^{1}H nuclei occurs in 19, ^{2}H in 17 and ^{3}H in 15 possible channels (see Table). If the yield of ^{4}He nuclei dominates in the channels with the formation of doubly charged fragments, averaging 79.7%, and the nuclei of ^{3}He (19.7%) and ^{6}He (0.6%) are formed [4, p.285], then in the channels with the formation of singly-charged fragments an abundant yield of proton fragments is observed, Which is approximately 2/3 of the total inclusive cross section for the formation of singly-charged fragments.

The inclusive cross sections for the formation of ^{1}H, ^{2}H and ^{3}H nuclei were calculated using the total cross section of the topological channel (σ_t) (Table) and the mean multiplicities of these fragments in the corresponding topologies according to the formula:

$$\sigma_{ink} = \langle n_{fr} \rangle \cdot \sigma_t, \quad (1)$$

Where n_{fr} is the multiplicity of the considered fragments — protons, deuterons and tritium in the corresponding topological channels. The results of the determination of the inclusive cross sections for the formation of the above-mentioned isotopes of the hydrogen nucleus (^{1}H, ^{2}H and ^{3}H) and also the cross sections of various topological channels for the fragmentation of oxygen nuclei [3, p.285. 4, p.58] are presented in the table.

Table

The cross sections of the topological channels for the fragmentation of oxygen nuclei and the inclusive cross sections for the formation of the ^1H, ^2H and ^3H nuclei calculated in accordance with (1).

Topology	The total charge of multiply charged fragments	Section of the topological channel, mbn	Inclusive cross section for the formation of fragments in a topological channel, mbn		
			^1H	^2H	^3H
0	0	6.43±0.46	30.57±2.53	12.38±1.01	6.86±0.69
2	2	23.58±0.88	91.17±3.99	33.34±1.47	16.2±0.94
3	3	5.29±0.46	18.13±1.78	5.15±0.53	1.94±0.29
22	4	36.44±1.10	106.91±3.85	29.57±1.23	10.99±0.72
4	4	5.60±0.43	16.36±1.51	4.54±0.49	1.15±0.23
5	5	16.46±0.73	37.09±2.00	7.10±0.56	1.34±0.25
23	5	11.53±0.62	26.52±1.71	5.74±0.51	1.33±0.25
6	6	54.16±1.34	89.33±2.84	12.75±0.73	2.6±0.37
24	6	6.66±0.47	10.50±0.99	2.10±0.32	0.62±0.17
33	6	1.26±0.20	2.18±0.43	0.38±0.12	0.12±0.06
222	6	31.27±1.02	52.30±2.15	9.50±0.61	2.11±0.31
7	7	65.35±1.47	51.67±1.82	2.33±0.33	0.63±0.24
25	7	7.45±0.50	5.69±0.58	0.44±0.13	0.07±0.06
34	7	0.66±0.15	0.52±0.17	0.10±0.07	0.04±0.04
223	7	3.11±0.32	2.66±0.39	0.33±0.11	0±0
8	8	46.70±1.24	4.84±0.46	0.10±0.06	0±0
26	8	10.14±0.58	1.98±0.37	0±0	0±0
224	8	0.93±0.18	0.40±0.16	0.02±0.02	0±0
2222	8	3.51±0.34	0.57±0.19	0±0	0±0

As can be seen from the table, the largest inclusive cross section for the formation of ^1H nuclei is observed in the topological channel (22), while for ^2H and ^3H nuclei the maximum cross sections take place in the channel (2). It would seem that the most advantageous for abundant proton formation is a topological channel with the formation of one double-charge fragment, i.e. (2), since in this case the number of protons in the residual nucleus is 1.5 times greater than in the channel (22). However, due to the higher value of the cross section of the topological channel (22) compared to (2), and also the maximum yield of the ^2H and ^3H nuclei, compensation occurs, leading to a decrease in proton production in the channel (2) rather than the channel (22). It also follows from the table that the relative yields of the fragments under consideration vary greatly with the total charge of the topological channel.

The total inclusive cross section for the formation of ^1H nuclei is 549.2 ± 8.2, $^2H_1$–126.0 ± 2.6, $3H_1$–46.0 ± 1.6 mb.

It can be seen (Fig. 1a)that the behavior of the inclusive cross sections for the formation of isotopes of hydrogen nuclei is analogous to the behavior of the cross sections of topological channels combined in the total charge (Fig. 1a) and has a sawtooth shape: the spectra have maxima at even values of the total charge up to Z_s = 6, minima for odd ones. This feature is due to the more abundant production of evenly charged fragments, especially the doubly-charged fragments in comparison with the odd-charged ones, apparently connected with the α-cluster structure of the 16O fragmenting nucleus. It should be noted that the decrease in the inclusive cross section for proton production at Z_s = 8 in comparison with Z_s = 7 is due to the strong influence of the charge conservation law, since the appearance of a proton at Z_s = 8 is due to the transfer of the proton target charge to the projectile neutron, i.e. Processes of quasi-elastic charge exchange pn→np. Figure 1b shows similar data on inclusive cross sections for the formation of deuterons and tritium. The data of the table and Fig. 1 suggest the proportionality of the inclusive cross sections for the formation of protons by the charge of the residual nucleus and the cross section of the topological channel. In this connection, we approximated the dependence of the inclusive cross sections for the formation of protons on the total charge and the corresponding cross section of a given group as a function of the form:

$$\sigma_{in}(Z_s, \sigma_s) = \sigma_s(\alpha\,(Z_0 - Z_s) + \beta), \qquad (2)$$

Where Z_s, σ_s are the total charge and the cross section for the realization of the given group, Z_0 is the charge of the oxygen nucleus, and α and β are the parameters to be phytized. The parameter β takes into account the

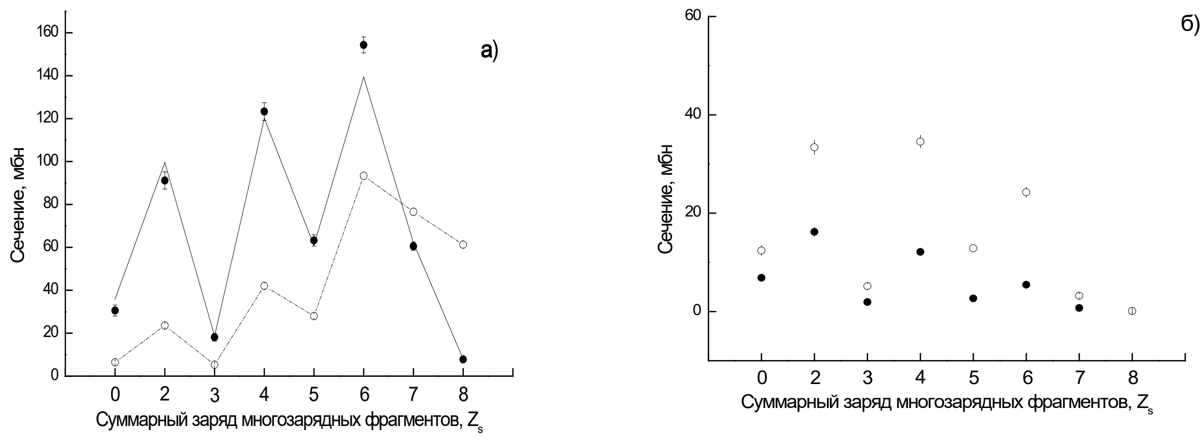

Fig. 1

additional formation of protons due to the transfer of the charge of the proton target to one of the projectile neutrons. The result of the approximation is shown in Fig. La by a solid line. It can be seen that such an approximation satisfactorily describes the experiment.

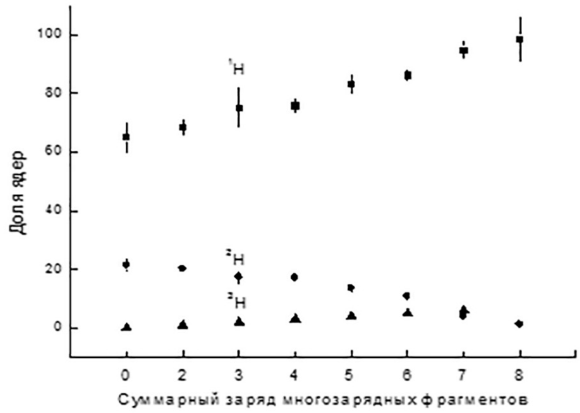

Fig. 2

In Fig. 2 shows the dependence of the yields of the $^1H_1$, $^2H_1$ and $^3H_1$ nuclei among singly-charged fragments on the total charge of the fragments. It is interesting to note the differences in the behavior of the yields of these light isotopes: the proportion of protons increases almost linearly to the limiting values of the total charge Z_s, while the yields of the deuteron and tritium monotonically decrease to zero.

From the above data, it can be concluded that the structure of the fragmenting nucleus strongly affects not only the formation of multiply-charged fragments, but also the formation of isotopes of the hydrogen nucleus.

Signatures to drawings

Fig. 1. Topological (1a — ○) and inclusive cross sections for the formation of the nuclei ^1H (1a — ●), ^2H (1b — ○) and ^3H (1b — ●) as a function of the total charge of multiply charged fragments. The solid curve in Fig. 1a) is the result of approximating the inclusive cross sections for the formation of ^1H nuclei by expression (2), the dashed line is drawn along topological sections for clarity.

Fig. 2. Dependence of the yield fraction of ^1H (■),^2H (●), and ^3H (▲) nuclei among singly-charged fragments on the total charge of fragments with $z_f > 2$.

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