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ABOUT THE EVIDENCE FOR HIGH EXCITED LEVELS OF ^{5}Li ABOVE THE t+2p THRESHOLD IN THE ^{3}He$(\alpha, \mathrm{dt})^2$He REACTION

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In the dt-coincidence matrix obtained due to the α+t interaction at an α-particle's beam energy of 67.2 MeV, a locus of the three-particle ^{3}He$(\alpha, \mathrm{dt})^2$He reaction is observed. The atoms ^{3}He generated as a result of the β-decay of ^{3}H were accumulated in a titanium target. At the energy of excitation above the threshold of decay of ^{5}Li into t+2p (18.2 MeV), two excited levels with parameters $E_1^* = 19.67 \pm 0.18$ MeV; $\Gamma_1 = 0.92 \pm 0.71$ MeV and $E_2^* = 20.43 \pm 0.14$ MeV; $\Gamma_2 = 0.16 \pm 0.14$ MeV are observed.

Excited ^{5}Li nucleus levels are unstable to the cluster decay and so have the cluster nature. Most known and well researched is the α-cluster light nucleus's structure, and it is wellknown that there also exist states which consist of d+^{3}He [1], besides quasimolecular α-particle states with the α+p structure. Moreover, states with the cluster nature are located near correspondent thresholds. The most used method of researching the unbound ^{5}Li states is the analysis of the energy dependence of α+p and d+^{3}He phase shifts of elastic scattering [2, 3]. Such experiments limit the cluster structure of ^{5}Li nucleus's excited levels only by the α+p and d+^{3}He configurations. At the same time, the unbound ^{5}Li nuclear system can be formed as an intermediate product of the consequent reactions [4], as a resonance of the two-particle reaction's excitation function [5], and also in the three-particle reactions which include interaction in the final state, that leads to the forming of the researched nucleus [6, 7]. It is possible to explore the levels located higher than the threshold of ^{5}Li decay into t+2p that equals 18.2 MeV with peculiar cluster quasimolecular configuration of t+^{2}He only in the correlation experiments. The ^{3}He(α, dt)pp reaction under the quite high energies of incident α-particles is promising for revealing the levels of this nature.

In the kinematically complete experiment with α + t interaction at the energy Eα=67.2 MeV [8], a less intensive locus was revealed in the obtained dt-coincidence matrices besides of the locus of the three-particle ^{3}H(α, dt)d reaction. The reasons for this fact were analyzed.

In Fig.1, the dt-coincidence matrix for the detection angles of 15° of deuterons and tritons in the laboratory coordinate system is shown with marked kinematic curves correspondent to the three-particle ^{3}H(α, dt)d reaction with $Q_3 = -23.848$ MeV — curve *1*, formation of a deuteron in the singlet state in the output channel, from the ^{3}He(α, dt)pp reaction with $Q_3 = -26.024$ MeV — curve *2*, or ^{2}He display in consequence of the ^{3}He(α, dt)pp reaction with $Q_3 = -25.293$ MeV — kinematic curve *3*. ^{3}He radiogenic isotope accumulation in the titanium-tritium target as a result of the β-decay of ^{3}H nuclei was discovered by investigation of the interaction of α-particle with tritium on the targets which have been preserved during two years after being used in the experiment [9]. By the way, this effect was not observed on the newly prepared targets. The thermal balance spectrum of the interaction of the three-particle

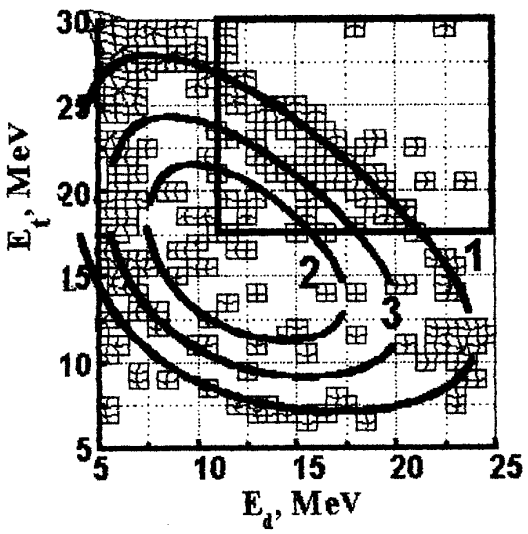

Fig. 1. dt-coincidence matrix from α+t interaction

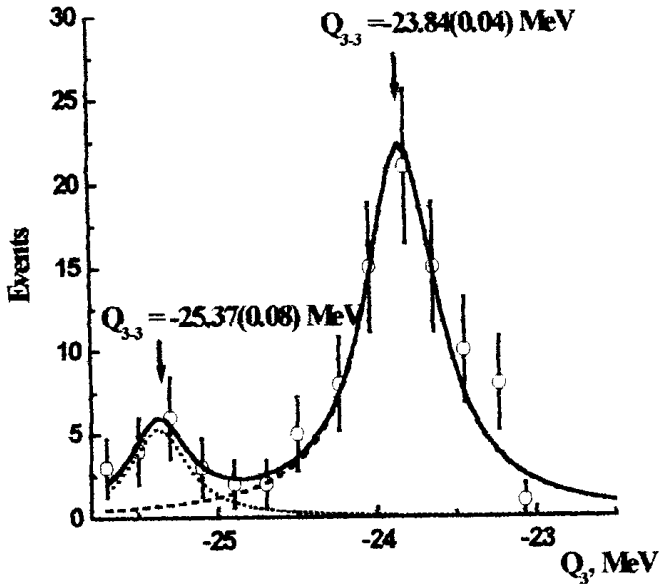

Fig. 2. Q_3 — spectrum, calculated for the marked part of the dt-coincidence matrix (Fig.1)

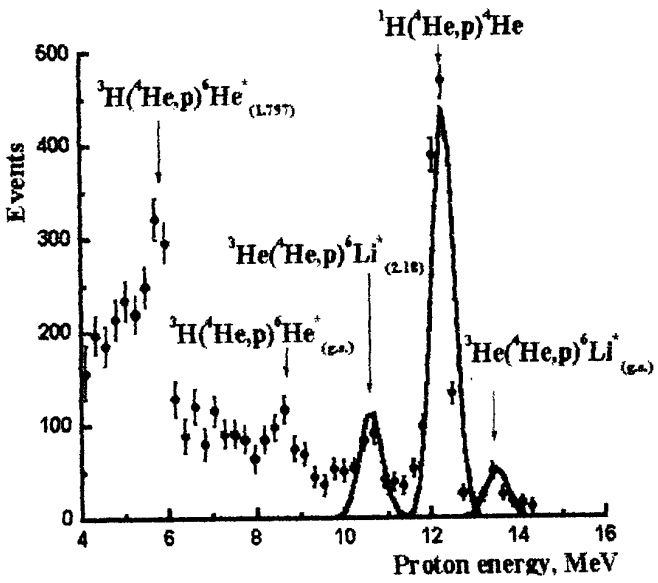

Fig. 3. Proton spectrum from α+t interaction by α-particle beam with an energy of 27.2 MeV and tritiated titanium target

reaction — Q_3 obtained for the distinguished square domain of the coincidence matrix, on Fig.1, taking into consideration the identity of nucleons. It was calculated on the basis of the conservation of momentum and energy according to the method offered in [10]. As seen

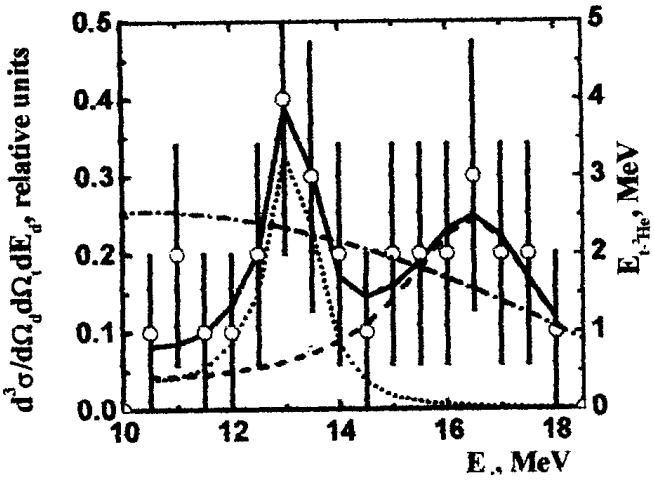

Fig. 4. Projection of a limited part of the upper branch of the locus of the ^{3}He(α, dt)^{2}He reaction on the deutron energy axis

on Fig.2, two peaks are displayed in the Q_3 spectrum. One of them with the value $Q_{3-1} = -23.84$ MeV corresponds to the ^{3}H(α, dt)d reaction and the other with the value $Q_{3-2} = -25.37$ MeV corresponds to the ^{3}He(α, dt)pp reaction, which confirms the ^{3}He presence in the target. Inclusive proton spectra obtained by the interaction of α-particles at an energy of 27.2 MeV with titanium-tritium targets were analyzed in order to estimate the quantity of accumulated radiogenic ^{3}He nuclei in the tritium targets [9]. It was shown that the peaks correspondent to the excitation of the ^{6}Li nucleus states from the two-particle ^{3}He(α,p)^{6}Li reactions are observed in the inclusive proton spectra along with protons from the ^{3}H(α, p)^{6}He reactions. Only the researching of the reactions on the already irradiated targets discovered this effect. On Fig. 3, we show one of such spectra obtained for the detection angle of 33° in the laboratory system of coordinates. Except the peaks correspondent to the forming of ^{6}He nuclei in the ground and the first excited state and recoil protons from elastic αp scattering on the hydrogen admixture, the events correspondent formation of ^{6}Li nuclei in the ground and the first excited state are sharply defined. Angular distributions of the protons, obtained for these levels agree by form with the angular distributions for the gaseous ^{3}He-target [11]. From the comparison of the obtained data with values of the cross-sections given in [11], we estimated that the quantity of the accumulated ^{3}He nuclei in the titanium-tritium targets amounts (30 ± 20)% from the total

quantity of the nuclei of this isotope, created as a result of β-decay of the tritium nuclei in the titanium-tritium targets. This experimental phenomenon is very essential in the further researches of few-nucleon systems, because it enables one to avoid difficulties while working with the gaseous target in the correlation experiment.

The projectile energy in our previous experiments on the ^{5}Li investigations [12] was insufficient for the observation of the excited states which lie higher than the threshold of the decay of ^{5}Li into clusters different from α-particle and proton or states, which are constructed due to α-particle core excitation (E = 20.1 MeV).

Events in the dt-coincidence matrix, which lie on kinematic curve *3* and correspond to the ^{3}He$(\alpha, \mathrm{dt})^2$He three-particle reaction were projected on the deuteron energy axis (see Fig. 4). The relative energy of the t—^{2}He pair which is marked with the dash-dotted line on Fig.4 was used in the spectral analysis and was estimated according to the energy of outgoing deuterons. The ordinate axis is on the right side. The spectrum maxima are observed at relative energies $E_{\mathrm{t-2He}}$ which equal approximately 1.5 and 2.2 MeV which, taking into consideration the threshold of ^{5}Li decay in the t+2p (E = 18.2 MeV) channel, correspond to excited states with energies 19.6 and 20.4 MeV. So the most probable ^{3}He$(\alpha, \mathrm{dt})^2$He reaction mechanism is the quasibinary two-stage process with the deuteron and ^{5}Li nucleus in the excited state created on its first stage. ^{5}Li nucleus decays then into ^{2}He (two protons with the relative energy close to zero) and a triton. The spectrum was approximated with in the consistent decay model with the use of the Breit—Wigner formula according to the technique of least squares, in order to determine the energy positions and resonance widths observed in the experiment. The parameters $E_1^* = 19.67 \pm 0.18$ MeV; $\Gamma_1 = 0.92 \pm 0.71$ MeV and $E_2^* = 20.43 \pm 0.14$ MeV; $\Gamma_2 = 0.16 \pm 0.14$ MeV were derived as a result of this procedure for excited ^{5}Li nucleus levels located higher than the threshold of the decay into a triton and two protons. Calculations with these parameters are displayed in Fig.4, where the dashed line corresponds to the first level, the dotted line corresponds to the second one, and the solid curve is their sum. The obtained values of energy levels positions which lie higher than the decay threshold into t+^{2}He agree with the levels scheme in [13].

Thus, the levels located higher than the threshold of ^{5}Li decay into t+2p (with the t+^{2}He cluster quasimolecular configuration) were discovered in our correlative researches in accordance to the cluster structure of light nuclei, according to which excited states are located generally near the decay thresholds into different constituents [1].

Such a kind of information about the nature of ^{5}Li nucleus excited levels is available only in the correlation experiment, because the generally applicable procedure of analysis of elastic scattering phase shifts cannot be used in this particular case. In spite of low statistics, the obtained result testifies to the future trends of investigation of different exit channels with the interaction of α-particle and ^{3}He in the kinematically complete experiment at energies which greatly exceed the energy of the α-particle excitation. The study of the ^{3}He$(\alpha, \mathrm{dt})^2$He and ^{3}He$(\alpha, \mathrm{d}^3\mathrm{He})$d reactions will give us the opportunity to determine the ratio of the decay modes in the t+^{2}He and d+^{3}He channels which lie higher than the corresponding decay thresholds.

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ПРО ПРОЯВ ВИСОКОЗБУДЖЕНИХ РІВНІВ ЯДРА ^{5}Li ВИЩЕ ПОРОГА ЙОГО РОЗПАДУ НА t+2p В РЕАКЦІЇ ^{3}He$(\alpha, \mathrm{dt})^2$He

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Р е з ю м е

В матриці dt-збігів, отриманих внаслідок $(\alpha + \mathrm{t})$-взаємодії при енергії пучка α-частинок 67,2 МеВ, окрім подій, що відповідають тричастинковій реакції $^3\mathrm{H}(\alpha, \mathrm{dt})^2\mathrm{H}$, спостерігався локус з реакції $^3\mathrm{He}(\alpha, \mathrm{dt})^2\mathrm{He}$, яка можлива внаслідок β-розпаду ядер ^{3}H та накопичення ^{3}He в титан-тритієвій мішені. При енергіях збудження вище порога розпаду ^{5}Li на t+2p (18,2 МеВ) спостерігалися два високозбуджених рівні ^{5}Li з параметрами: $E_1^* = (19,67 \pm 0,18)$ МеВ; $\Gamma_1 = (0.92 \pm 0,71)$ МеВ та $E_2^* = (20,43 \pm 0,14)$ МеВ; $\Gamma_2 = (0,16 \pm 0,14)$ МеВ.

О ПРОЯВЛЕНИИ ВЫСОКОВОЗБУЖДЕННЫХ СОСТОЯНИЙ ЯДРА ^{5}Li ВЫШЕ ПОРОГА ЕГО РАЗВАЛА НА t+2p В РЕАКЦИИ ^{3}He$(\alpha, \mathrm{dt})^2$He

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Р е з ю м е

В матрице dt-совпадений, полученной из $(\alpha + t)$-взаимодействий при энергии пучка α-частиц 67,2 МэВ, кроме событий, соответствующих трехчастичной реакции $^3\mathrm{H}(\alpha, \mathrm{dt})^2\mathrm{H}$, наблюдался локус от реакции $^3\mathrm{He}(\alpha, \mathrm{dt})^2\mathrm{He}$, которая возможна вследствие β-распада ядер ^{3}H и накопления изотопа ^{3}He в титан-тритиевой мишени. При энергиях возбуждения выше порога распада ^{5}Li на t+2p (18,12 МэВ) наблюдались два возбужденных состояния ^{5}Li с параметрами: $E_1^* = (19,67 \pm 0,18)$ МэВ; $\Gamma_1 = (0,92 \pm 0,71)$ МэВ и $E_2^* = (20,43 \pm 0,14)$ МэВ; $\Gamma_2 = (0,16 \pm 0,14)$ МэВ.