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The work is submitted to the International Scientific Conference «Implementation of integrated model of educational institutions, implements educational programs different levels of education», Republic of Singapore, December, 10-17, 2013, came to the editorial office on 18.11.2013.

MULTICLUSTER STRUCTURE OF ${}^9\text{Be}$ NUCLEUS

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The ground and excited states of the ${}^9\text{Be}$ nucleus are considered in this work. Spectroscopic factors of deuterons and tritons in the ${}^9\text{Be}$ nucleus for different states of the nucleus are calculated. The account of the states with Young [441] diagrams in the pickup reaction of tritons and deuterons by the nuclei ${}^6\text{Li}$ and ${}^7\text{Li}$ respectively enriches significantly the excitation spectra in the lithium transfer reactions.

The ${}^9\text{Be}$ nucleus has a specific nuclear structure. Unlike lighter nuclei from a deuteron to ${}^8\text{Be}$ whose wave functions in the shell model are more than 95% characterized by one predominant configuration, the ${}^9\text{Be}$ nucleus contains no explicitly singled out components. In the many-particle shell model, the wave function of the ground state is composed of 13 components [1], the total contribution of the two components with the [441] Young diagram reaching approximately 96%. The contribution of the states having the [432] Young diagram does not exceed three per cent. It is quite obvious that the predominant configuration of the ${}^9\text{Be}$ nucleus is the αn model [2]. It is this model that best describes the properties of the ${}^9\text{Be}$ nucleus. Only this model yields an apt description of the (γ, p) , (γ, d) , and (γ, t) photonuclear processes on the ${}^9\text{Be}$ nuclear [3] and the hadron elastic scattering reactions at low transmitted pulses [4]. It should be noted that like in the many-particle shell model, the wave function of the ground state in the $2\alpha n$ model is characterized by three components making approximately equal contributions. The shell configuration with the [432] Young diagram corresponding directly to the $\{\alpha td\}$ cluster decomposition correlates to higher excitation energies [1]. At the same time, it was suggested in [5] that the indicated states with the [432] Young diagram be searched for in lithium transfer reactions of types ${}^7\text{Li}({}^6\text{Li}, \alpha){}^9\text{Be}$ and ${}^6\text{Li}({}^7\text{Li}, \alpha){}^9\text{Be}$ (see Fig. 1).

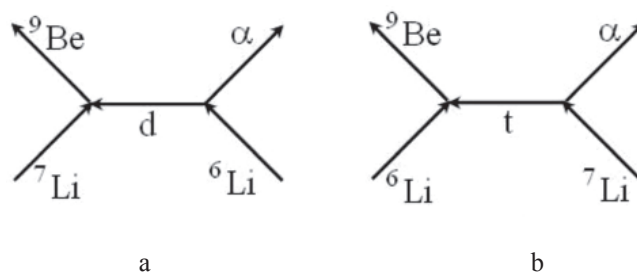


Fig. 1. Diagrams, illustrating the reactions of direct transfer of deuterons (a) and tritons (b) on lithium nuclei

Owing to the low binding energy of ${}^7\text{Li}$ in the $\alpha + t$ channel and of ${}^6\text{Li}$ in the $\alpha + d$ channel, the predominant mechanisms are in both cases the transfer of the deuteron and triton clusters, respectively. The flexibility of the many-particle shell model, however, is that the [441] Young diagram presumes deuteron and triton escape, since (according to Littlewood's rule) decompositions $[441] \rightarrow [43] + [2]$ and $[441] \rightarrow [42] + [3]$ are possible [5]. For a more comprehensive description of the above mentioned lithium reactions, not only the states of the ${}^9\text{Be}$ nucleus with the [432] Young diagram must be considered, but also the states with the [441] diagram. The spectroscopic factors in the ${}^6\text{Li} + t$ and ${}^7\text{Li} + d$ channels including both the [441] and [432] Young diagrams were calculated by the authors. In the transfer reactions, the excitation cross section σ of the levels of the re-

sidual nucleus (${}^9\text{Be}$ in this case) can be represented by the expression $\sigma \sim (2J+1) \sum_L S_L \cdot \Phi$ assuming

a direct mechanism in which S_L are corresponding spectroscopic factors and Φ is a factor depending on the kinematic characteristics. Assuming that Φ is a more or less smooth value in dependence on energy, the peaks observed in the reactions must be related to the peaks of the spectroscopic factors.

The calculated values of the spectroscopic factors are shown in Table 1. The same values are presented in Fig. 2 as histograms comprising the sums of the S -factor values within an energy range of 1 MeV. A comparison with experimental data of [6] shows that the theoretical study correctly represents the main peaks at energies $E = 11.8$; 15.2 ; 17.8 , and 22 MeV. There are also moderate peaks at $E = 0$ and 3 MeV resulting from the [441] Young diagram.

Spectroscopic factors of deuterons and tritons in the ${}^9\text{Be}$ nucleus for different states of the nucleus

Levels of ${}^9\text{Be}$		S_d^L		S_t^L		$(2J+1)\sum_L S_d^L$	$(2J+1)\sum_L S_t^L$
ΔE^* , MeV	J, T	$L=0$	$L=2$	$L=1$	$L=3$	${}^7\text{Li} + d \rightarrow {}^9\text{Be}^*$	${}^6\text{Li} + t \rightarrow {}^9\text{Be}^*$
0–2	3/2, 1/2	$3,6 \cdot 10^{-2}$	$3,7 \cdot 10^{-1}$	$9,0 \cdot 10^{-2}$	$8,2 \cdot 10^{-4}$	1,00	1,00
2–3	3, 1	$2,3 \cdot 10^{-2}$	$8,0 \cdot 10^{-1}$	$9,1 \cdot 10^{-2}$	$7,5 \cdot 10^{-2}$	2,00	1,93
4–5	3/2, 1/2	$4,3 \cdot 10^{-2}$	$3,3 \cdot 10^{-1}$	$2,8 \cdot 10^{-2}$	$2,8 \cdot 10^{-3}$	0,92	0,34
5–6	5/2, 1/2	$2,9 \cdot 10^{-3}$	$3,9 \cdot 10^{-1}$	$3,8 \cdot 10^{-3}$	$4,8 \cdot 10^{-1}$	1,44	8,04
6–7	7/2, 1/2		$2,2 \cdot 10^{-1}$		$3,3 \cdot 10^{-1}$	1,10	7,48
9–10	5, 1	$1,7 \cdot 10^{-1}$	$1,7 \cdot 10^{-1}$	$6,4 \cdot 10^{-1}$	$3,3 \cdot 10^{-2}$	0,44	4,46
10–11	5, 1	$5,0 \cdot 10^{-1}$	$3,0 \cdot 10^{-1}$	$6,2 \cdot 10^{-1}$	$1,6 \cdot 10^{-1}$	2,36	10,36
11–12	6, 1	$5,7 \cdot 10^{-1}$	$5,4 \cdot 10^{-1}$	$5,5 \cdot 10^{-1}$	$1,7 \cdot 10^{-2}$	4,50	9,48
13–14	5/2, 1/2	$6,4 \cdot 10^{-2}$	$2,6 \cdot 10^{-1}$	$6,1 \cdot 10^{-2}$	$5,4 \cdot 10^{-2}$	1,19	1,90
14–15	3/2, 1/2	$4,1 \cdot 10^{-2}$	$2,0 \cdot 10^{-1}$	$4,6 \cdot 10^{-2}$	$4,8 \cdot 10^{-2}$	0,61	1,04
15–16	5, 1	$1,0 \cdot 10^{-1}$	$1,4 \cdot 10^{-1}$	$1,8 \cdot 10^{-1}$	$2,1 \cdot 10^{-1}$	0,54	6,96
17–18	8, 2	$1,1 \cdot 10^{-1}$	$9,7 \cdot 10^{-1}$	$2,1 \cdot 10^{-1}$	$4,4 \cdot 10^{-1}$	2,96	9,34
18–19	3/2, 1/2	$3,3 \cdot 10^{-2}$	$1,9 \cdot 10^{-1}$	$1,9 \cdot 10^{-1}$	$5,9 \cdot 10^{-3}$	0,55	2,20
19–20	5/2, 1/2	$5,4 \cdot 10^{-3}$	$1,1 \cdot 10^{-1}$	$3,9 \cdot 10^{-3}$	$9,0 \cdot 10^{-2}$	0,43	1,49
21–22	13/2, 3/2	$4,1 \cdot 10^{-3}$	$2,3 \cdot 10^{-1}$	$1,3 \cdot 10^{-2}$	$1,6 \cdot 10^{-1}$	0,41	3,04
23–24	17/2, 3/2	$1,3 \cdot 10^{-3}$	$3,3 \cdot 10^{-2}$	$4,1 \cdot 10^{-3}$	$1,1 \cdot 10^{-1}$	0,13	2,12
24–25	2, 1	$2,5 \cdot 10^{-2}$	$5,5 \cdot 10^{-3}$	$3,8 \cdot 10^{-2}$	$3,3 \cdot 10^{-5}$	0,05	1,42

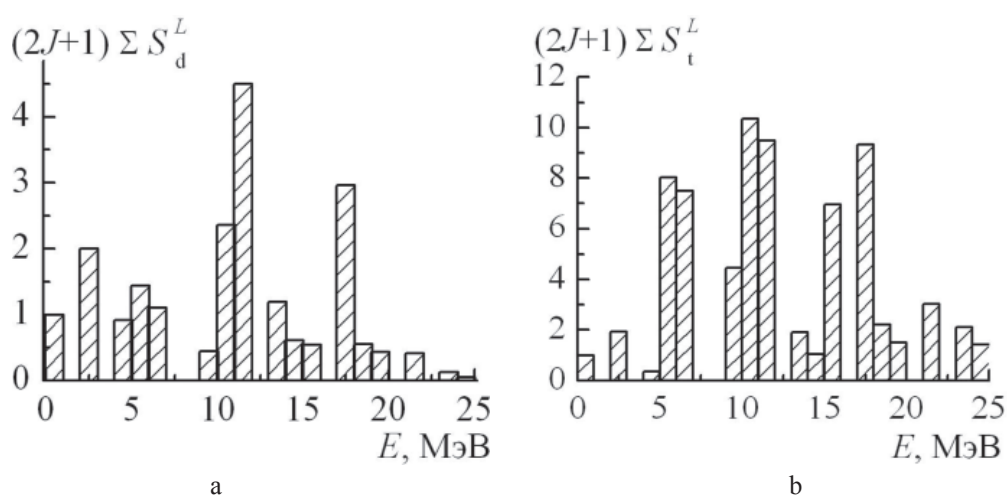


Fig. 2. Excitation spectrum of the ${}^9\text{Be}$ nucleus in reactions:
 a – ${}^7\text{Li}({}^6\text{Li}, \alpha){}^9\text{Be}$; b – ${}^6\text{Li}({}^7\text{Li}, \alpha){}^9\text{Be}$

The three-cluster states of αtd nature can be correlated not only with the orbital [432] Young diagram but also (with no less certainty) with the [441] Young diagram. It is therefore not surprising that the authors managed to provide a successful description of the (γ, d) and (γ, t) photonuclear processes in the ${}^9\text{Be}$ nucleus by using the αan -model [3].

The ground state of the ${}^9\text{Be}$ nucleus has the wave function with the dominant Young [441] diagram, corresponding to the cluster $\{\alpha an\}$ decomposition. The potential three-body model explains also the channels with escape of neutrons, protons, tritons, deuterons and α -particles. The component of the wave function with Young [432] diagram, corresponding to the cluster $\{\alpha td\}$ decomposition, is a small impurity to the wave function of the ground state. Particularly, the cluster αtd -model does not admit the observable in an experiment the escape of neutrons with forming of the ground and the first excited states of the ${}^9\text{Be}$ nucleus, whose wave functions are characterized by Young [44] diagram. The states having αtd -nature, in main are highly excited states of the ${}^9\text{Be}$ nucleus. In αtd -model it is not pos-

sible to observe an escape α -particles with forming of the ${}^9\text{Be}$ nucleus, having in the ground state the Young [41] diagram.

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