Mechanism responsible for formation of the anomaly in the reaction $^{12}C(d, {}^{6}Li){}^{8}Be$

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It is shown that the anomalous (ghost) state in the excitation spectrum of the ^{8}Be nucleus can form both in direct processes and in reactions proceeding via the compound nucleus.

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In investigations of the angular distribution of the anomalies (ghosts) in the excitation spectrum of the ^{8}Be nucleus at $E^* = 750$ keV in the reaction $^{12}C(d, {}^{6}Li){}^{8}Be$ $E_d = 13.6$ MeV (Ref. 1), it was demonstrated that the mechanism of the reaction in which

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this anomalous state forms can be interpreted as a direct mechanism. This is indicated by the similarity of the angular distribution of the anomaly to the angular distribution of ^{6}Li nuclei from the reaction ^{12}C(d, ^{6}Li)^{8}Be$_{\text{gnd}}$. It is also shown in Ref. 1 that the energy dependence of the cross section for the formation of this anomalous state in the narrow range of deuteron energies $E_d = 12.7$–13.6 MeV is analogous to the same dependence for the ground state of the ^{8}Be nucleus. However, the earliest investigations of the reaction ^{12}C(d, ^{6}Li)^{8}Be$_{\text{gnd}}$ (Ref. 2) make it necessary to consider the following two circumstances. The first circumstance is the presence of singularities in the excitation function for the reaction ^{12}C(d, ^{6}Li)^{8}Be$_{\text{gnd}}$ at $\Theta_{\text{lab}} = 18°$ and $\Theta_{\text{lab}} = 30°$ (Ref. 3) in the interval $E_d = 12.7$–15.0 MeV. At $\Theta_{\text{lab}} = 30°$, the excitation function for this reaction does not have a distinct structure, but at $\Theta_{\text{lab}} = 18°$ there is a broad $\sim$1-MeV minimum near $E_d = 13.0$–14.8 MeV. The second circumstance is the noticeable change in the form of the angular distributions for ^{12}C(d, ^{6}Li)^{8}Be$_{\text{gnd}}$ reactions in the same energy interval. A relatively small ($\sim$400 keV) change in E_d changes the position of the minima in the angular distribution and the magnitude of its maxima. These facts indicate the presence of resonanace effects that occur in compound processes. This experimental situation permits following the redistribution of different mechanisms of the reaction in which the anomalous state forms, as well as to check one of the tests for this state: $\sigma(E^*_{0.750})/\sigma(E_{\text{gnd}}) = f(\Theta_{\text{lab}}) = \text{const}$.

We have already discussed the angular distribution of the reaction ^{12}C(d, ^{6}Li)^{8}Be$_{\text{gnd}}$ at $E_d = 12.7$ and 13.2 MeV.[4] Here we shall examine the angular distribution of ^{6}Li nuclei from the reaction ^{12}C(d, ^{6}Li)^{8}Be$_{0.750}$ at $E_d = 12.7$ and 13.2 MeV.

The experimental angular distributions of ^{6}Li nuclei from reactions ^{12}C(d, ^{6}Li)^{8}Be$_{\text{gnd}}$ and ^{12}C(d, ^{6}Li)^{8}Be$_{0.750}$ were measured using the time-of-flight technique for identifying heavy charged particles. The initial value $E_d = 13.6$ MeV was lowered to $E_d = 12.7$ and $E_d = 13.2$ MeV with the help of absorbers. The geometry of the experiment is described in Ref. 5. The energy resolution with respect to ^{6}Li is $\Delta E_{^6\text{Li}} = 150$ keV.

The angular distributions of ^{6}Li nuclei from the reactions ^{12}C(d, ^{6}Li)^{8}Be$_{\text{gnd}}$ and ^{12}C(d, ^{6}Li)^{8}Be$_{0.750}$ at $E_d = 12.7$ and $E_d = 13.2$ MeV are shown in Fig. 1. If the angular distributions of reaction ^{12}C(d, ^{6}Li)^{8}Be$_{0.750}$ at $E_d = 13.6$ MeV (Ref. 1) and the energies E_d studied are compared, then it is evident that as E_d decreases from 13.6 to 13.2 MeV, the position and magnitude of the second maximum ($\Theta_{\text{cm}} = 50$–$70°$) and of the first minimum ($\Theta_{\text{cm}} = 20$–$45°$) change. A narrow minimum also appears in the region $\Theta_{\text{cm}} = 90°$. Analogous changes also occur in the angular distribution of ^{12}C(d, ^{6}Li)^{8}Be$_{0.750}$ with the transition from $E_d = 13.2$ MeV to $E_d = 12.7$ MeV. This behavior of the angular distribution of ^{12}C(d, ^{6}Li)^{8}Be$_{0.750}$ accompanying a change in E_d indicates that the contribution of compound processes increases considerably.

Thus the experimental data obtained show that the anomalous state of ^{8}Be nuclei with $E^* = 750$ keV can form both in direct processes and in reactions proceeding via the compound nucleus. This is indirectly confirmed by the experimental fact that the anomalous state in the reaction ^{9}Be(p,d)^{8}Be$_{0.750}$ is observed in a wide range of proton energies: $E_p = 5$–39 MeV.[6]

In the first investigations of the anomalous state,[7] a condition characterizing this state was formulated: $\sigma(E^*_{0.750})/\sigma(E_{\text{gnd}}) = f(\Theta_{\text{lab}}) = \text{const}$. Satisfaction of this condi-

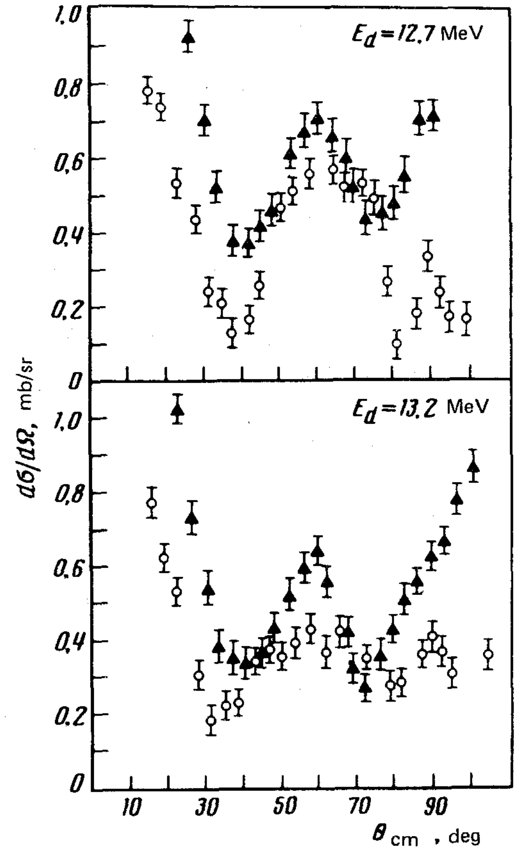

FIG. 1. Angular distribution of ^{6}Li nuclei at $E_d = 12.7$ MeV and 13.2 MeV from the following reactions: ^{12}C(d, ^{6}Li)^{8}Be$_{gnd}$ (▲) and ^{12}C(d, ^{6}Li)^{8}Be$_{0.750}$ (○).

tion for the reaction ^{9}Be(p,d) ^{8}Be$_{0.750}$ at $E_p = 14$ MeV and 26 MeV (Ref. 8) permitted us to attribute the quantum numbers $J^\pi = 0^+$ to the anomalous state and to confirm this assumption by calculations of $d\sigma/d\Omega$ using the method of distorted waves under the assumption of direct transfer of a $p_{3/2}$ neutron.

However, as is evident from Fig. 2, this condition is not satisfied in our case. The ratio $\sigma(E^*_{0.750})/\sigma(E_{gnd}) = f(\Theta_{lab})$ is an irregularly oscillating function of Θ_{lab} and this does not provide any evidence for assuming that the anomalous state has the quantum numbers $J^\pi = 0^+$.

In conclusion, we should note one more characteristic of the angular distributions of the reaction ^{12}C(d, ^{6}Li)^{8}Be$_{0.750}$. The similarity between the angular distribution of the anomalous state and the angular distribution of the reaction ^{12}C(d, ^{6}Li)^{8}Be$_{0.750}$ is not unusual. This similarity is characteristic of all low-lying states of light nuclei, which are populated quite intensely in multinucleon transfer reactions of the type

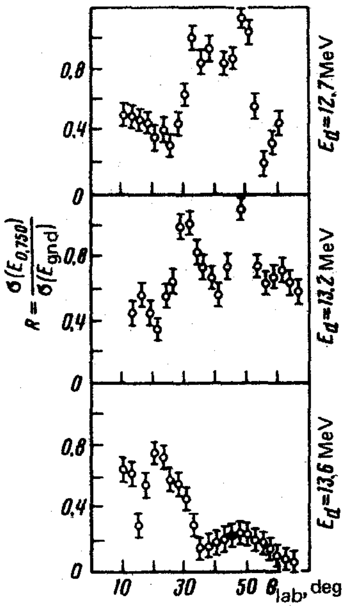

FIG. 2. The ratio $\sigma(E^*_{0.750})/\sigma(E_{gnd})$ as a function of Θ_{lab} at $E_d = 12.7$, 13.2, and 13.6 MeV.

(d, ^{7}Li) and (d, ^{7}Be). This was demonstrated by investigations of the reactions ^{13}C(d, ^{7}Li)^{8}Be (Ref. 9) and ^{19}F(d, ^{7}Li)^{14}N and ^{19}F(d, ^{7}Be)^{14}C (Ref. 10).

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