

REVIEW

of the Ph.D thesis of Nassurlla Maulen titled “**Effects of cluster structure of stable boron and lithium isotopes to form the outputs of nuclear reaction in the interaction with deuterium and helium isotopes**” submitted in fulfillment of the requirements for the degree of Doctor of Philosophy (PhD) in “6D060500–Nuclear Physics”

The Ph.D thesis of Nassurlla Maulen is devoted to the experimental study and theoretical analysis of the differential cross sections of nuclear processes ${}^7\text{Li}(d,d){}^7\text{Li}$, ${}^7\text{Li}(d,t){}^6\text{Li}$, ${}^{11}\text{B}(d,d){}^{11}\text{B}$, ${}^{11}\text{B}(d,t){}^{10}\text{B}$, ${}^{11}\text{B}(\alpha,\alpha){}^{11}\text{B}$, ${}^{11}\text{B}(\alpha,t){}^{12}\text{C}$ at energies of 7-10 MeV/nucleon within the framework of various theoretical models.

1. Relevance of the research topic and its relation to the general scientific and national programs

The nuclei of lithium and boron isotopes are a good example of clustered nuclei, however, the differential cross sections of the scattering processes and nuclear reactions on these nuclei, measured for the front hemisphere, are fairly correctly described in the framework of the shell model. At the same time, the behavior of the angular distributions of nuclear processes in the reverse hemisphere can be described in most cases only taking into account the contribution of the cluster exchange mechanism that make up the studied nuclei.

The work was performed as part of scientific research on the topics: “Study of the excited halo states of neutron-rich nuclei ${}^9\text{Be}$, ${}^{11}\text{B}$, ${}^{13}\text{C}$ in interactions with deuterons” No. GR 0115RK01006 (2015-2017) and “Study of radiation capture and peripheral nuclear transfer reactions of protons at energies near the Coulomb barrier caused by heavy ions for astrophysical and thermonuclear applications, AR05132062/GF (2018-2020).

2. The scientific results within a dissertations requirements (pp. 127 "Rules of awarding scientific degrees" 31.03.2011)

The following research results of the study were obtained in the thesis of Nassurlla Maulen:

Result 1. For the first time, the differential cross sections for elastic and inelastic scattering of deuterons and (d,t) reactions on ${}^7\text{Li}$, ${}^{11}\text{B}$ nuclei at an energy of 14.5 MeV/Nucleon, as well as ${}^{11}\text{B}(\alpha,t){}^{12}\text{C}$ at an energy of 40 MeV in a wide range of angles, were measured.

Result 2. From the complex analysis of experimental data on elastic and inelastic scattering of deuterons and helium ions on the nuclei of lithium and boron isotopes within the framework of the optical model of the nucleus, reliable optical parameters and deformation parameters are determined by the method of distorted waves and the method of coupled channels.

Result 3. Taking into account the contribution of the cluster transfer mechanism, it was possible to reproduce the shape and absolute value of the cross-sectional rise in reactions (d,t) and (α ,t) on ${}^7\text{Li}$, ${}^{11}\text{B}$ nuclei.

Thus, the results obtained in the thesis substantially supplement and refine information on the mechanisms of formation of elastic and inelastic scattering cross sections, and the characteristics of the nucleus under study.

3. The degree of validity and reliability of each scientific result (statement) findings and conclusions set out in applicant's thesis are provided by the use of recognized and widely verified experimental and theoretical methods and models: ΔE - E method was used for registration and identification of the products of nuclear reactions, optical model of the nucleus, the method of distorted wave Born approximation, the double folding model and the method of coupled channels, programs FRESCO and ROOT. The obtained results are in good agreement with the results of other authors in this field of research.

19 papers (10 articles, 8 theses and one patent) were published based on the materials of the dissertation, 3 of them were published in the journals recommended by CCES MES RK, 7 articles with non-zero impact factor (European Physical Journal - Impact factor 2.799) were published in the journals indexed by Thomson Reuters and Scopus. The sufficiency of the completeness of publications of scientific results is beyond doubt.

4. The degree of novelty of each scientific result (statement), applicant's conclusion set out in the thesis

The scientific novelty of the dissertation implies obtaining the new experimental data on the differential cross sections of nuclear reactions ${}^7\text{Li}(d, d){}^7\text{Li}$, ${}^7\text{Li}(d, t){}^6\text{Li}$, ${}^{11}\text{B}(d, d){}^{11}\text{B}$, ${}^{11}\text{B}(d, t){}^{12}\text{C}$, ${}^{11}\text{B}(\alpha, \alpha){}^{11}\text{B}$, ${}^{11}\text{B}(\alpha, t){}^{12}\text{C}$ at energies of 7-10 MeV/nucleon in a wide range of angles. And also in obtaining reliable data: on the parameters of the interaction potentials for the systems "d + ${}^7\text{Li}$ ", "d + ${}^{11}\text{B}$ ", " α + ${}^{11}\text{B}$ "; about deformation parameters and spectroscopic factors from a comprehensive analysis of the obtained experimental data in the framework of various theoretical models.

In connection with this, the following statements submitted for the defense:

1. Differential cross sections of nuclear reactions ${}^7\text{Li}(d, d){}^7\text{Li}$ and ${}^7\text{Li}(d, t){}^6\text{Li}$ at energies of 14.5 and 25 MeV, ${}^{11}\text{B}(d, t){}^{10}\text{B}$ at an energy of 14.5 MeV and ${}^{11}\text{B}(\alpha, t){}^{12}\text{C}$ at an energy of 40.0 MeV and their analysis according to the optical model of the nucleus and the method of distorted waves, eliminates the discrete ambiguity of the real part of the potential for the systems "d+ ${}^7\text{Li}$ ", "d+ ${}^{11}\text{B}$ " and " α + ${}^{11}\text{B}$ " in a wide energy range.

2. The established values of the quadrupole deformation parameters of the ${}^7\text{Li}$ nuclei ($\beta_2=1.1\pm 0.3$) and ${}^{11}\text{B}$ ($\beta_2=-0.80\pm 0.2$), taking into account the channel coupling between the ground and excited states of the studied nuclei, reduce the deviations of the calculated cross sections from experimental ones in the range of average angles to 20–30%.

3. The established values of the spectroscopic factors of the cluster configurations ${}^7\text{Li}\rightarrow$ "d + t" ($SF=1.19$) and ${}^{11}\text{B}\rightarrow$ " 2α +t" ($SF=1.0$) correctly reproduce the rise of the reaction cross sections (d, t) and (α , t) under reverse angles on the studied nuclei and justify their cluster structures.

5. Practical and theoretical significance of the results

The results of the research are of high scientific and practical importance. The obtained new experimental differential cross sections of the scattering processes and OP interaction parameters for the systems ${}^7\text{Li}(d,d){}^7\text{Li}$, ${}^7\text{Li}(d,t){}^6\text{Li}$, ${}^{11}\text{B}(d,d){}^{11}\text{B}$, ${}^{11}\text{B}(d,t){}^{10}\text{B}$, ${}^{11}\text{B}(\alpha,\alpha){}^{11}\text{B}$, ${}^{11}\text{B}(\alpha,t){}^{12}\text{C}$ would significantly replenish the nuclear data bank (EXFOR).

6. Comments, suggestions for thesis

In the description of elastic and inelastic scattering of deuterons by ${}^7\text{Li}$ nuclei, there is a significant discrepancy between the calculated curves and experimental data in the region of mean angles. To improve the agreement between theory and experiment, it was necessary to take into account the contributions from the coupling of channels from other excited states of the ${}^7\text{Li}$ nucleus (for example, from the levels 4.63 MeV ($7/2^-$) and 6.68 MeV ($5/2^-$)). The review discusses in detail the role of folding potential for assessing the validity of the chosen optical potentials. There is no information about this in the obtained results.

In the text of the thesis there are an insignificant number of spelling errors and stylistic errors. The noted shortcomings do not reduce the value of the results obtained by the author and can not affect to the overall positive evaluation of the work.

7. Compliance of the thesis content within the requirements of "Rules of awarding of scientific degrees"

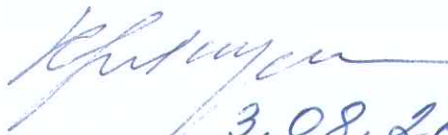
To summarize, I believe that the thesis of Nassurlla Maulen entitled "**Effects of cluster structure of stable boron and lithium isotopes to form the outputs of nuclear reaction in the interaction with deuterium and helium isotopes**" submitted in fulfillment of the requirements for the degree of Doctor of Philosophy (PhD) in "6D060500–Nuclear Physics" is performed at a high scientific and methodological level, and provides a complete and systematic research.

By the volume and content the thesis meets the requirements of "Rules of awarding of academic degrees," the Committee for Control of Education and Science of the MES RK and corresponds to the specialty passport, and the applicant Nassurlla Maulen deserves awarding the degree of Doctor of Philosophy (PhD).

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3.08.2020

