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Study of the ${}^6\text{Li}$ low-lying excited states

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${}^6\text{He}$ is one of the simplest nuclei with a halo in the ground state $0+$; its study has received significant theoretical attention [1]. In [2], an assumption was made about a halo-like structure in the isobar-analog state of the 3.563-MeV, $0+$ ${}^6\text{Li}$ state. This structure is a spatially extended halo-like structure with an alpha particle core and a proton and neutron surrounding it. One of the last theoretical results is the calculations within the ab initio NCSM (no-core shell model) [3]. Calculations showed that the radius of the ground state of ${}^6\text{Li}$, within the error limits, coincides with the radius of the 3.56 MeV state of ${}^6\text{Li}$. Our group is studying the ${}^6\text{Li}$ nucleus, especially its second excited 3.563-MeV, $0+$ state for a long time. One of the first results was the Modified diffraction model (MDM) application [4] to existing literature data. The literature differential cross sections for inelastic scattering of ${}^3\text{He} + {}^6\text{Li}$ with excitation of the 2.19 MeV state, $3+$ at energies of 34 and 72 MeV and 3.56 MeV, and $0+$ state at energies of 24.6 and 27 MeV were analyzed. It was shown that the radius of the 2.19 MeV, $3+$ state, within errors, coincides with the radius of the ground state, and the radius of the 3.56 MeV, $0+$ state is 2.5 ± 0.2 fm [4] and, within errors, coincides with the radius of ${}^6\text{He}$, which allows for the possibility of the presence of a halo (proton-neutron, and in some works called tango-halo) [5]. The obtained value is less than the previously predicted radius of this state of 2.73 fm [2]. During last year's we are adopting "Distorted Wave Born Approximation" (DWBA) to make some qualitative estimations on radii of ${}^6\text{Li}$ excited states. Two new experiments were done: 1) ${}^7\text{Li}$ (d, t) ${}^6\text{Li}$ experiment was performed on the deuteron beam of the U-150M cyclotron at the Institute of Nuclear Physics (Almaty, Republic of Kazakhstan) at an energy of 14.5 MeV; 2) ${}^{10}\text{B}({}^7\text{Li}, {}^6\text{Li}){}^{11}\text{B}$ experiment was performed on the ${}^7\text{Li}$ beam of the U-400 accelerator beam of the FLNR JINR, Dubna at energy of 58 MeV. The angular distributions for the ground and first excited states of ${}^6\text{Li}$ were obtained. The experimental data were analyzed within the framework of the DWBA. We obtained radial dependences of the form factors and the ANC values for ${}^6\text{Li}_{g.s.}$ and ${}^6\text{Li}$ (3.56 MeV) states. The obtained values of the ANC for the ${}^6\text{Li}_{g.s.}$ and ${}^6\text{Li}$ (3.56 MeV) states are similar to those in the literature. This fact confirms correctness of our DWBA analysis. Comparison of the radial dependences of form factors shows that the wave function of the ${}^6\text{Li}$ nucleus in the ${}^6\text{Li}$ (3.56 MeV) state has increased spatial dimension compared to the ${}^6\text{Li}_{g.s.}$ state.

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