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# Search for halo in isobar-analog states

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One of the most striking discoveries in nuclear physics made at the end of the past century was the finding the neutron halo in the ground states of some light nuclei located near the neutron stability boundary. The halo manifests itself in the presence of a diffuse surface region surrounding a core with a normal nuclear density and containing only neutrons. The result is a long "tail" of their wave function and, correspondingly, an increase in the radius of the entire nucleus in a given state.

The discovery of the halo led to a revision of many existing ideas in nuclear physics. The purpose of our research is to search and study halo in isobar - analog states of light nuclei. The study of states with a halo in isobar analogs allows one to investigate the manifestation of isotopic invariance at new objects and to relate the properties of the neutron and proton halo. Of particular interest is the accumulation of information that states possessing halo properties can be located not only in the discrete spectrum, but also in the continuum, and the problem of their unified description is formulated as one of the most important The question of the existence of halo in isobar - analog states has so far not been practically raised in the experimental plan. Our approach is based on measuring the radii of states in which the halo exists or can exist. Its first application made it possible to determine the proton halo in an unbound state of $^{13}$N.

The first object we started was the triplet A=12. Radii of the states of the isobaric triplet $^{12}$B-$^{12}$C-$^{12}$N were determined using two methods asymptotic normalization coefficients (ANC) and modified diffraction method (MDM). We obtained that the 1- excited states at $E_x$ = 2.62, 17.23, and 1.80 MeV, respectively, possess one-nucleon (neutron or proton) halo structure. The enlarged radii and large values of $D_1$ coefficient are also found for the $2^-$ states of $^{12}$B, $^{12}$C, and $^{12}$N at $E_x$ = 1.67, 16.57 and 1.19 MeV, respectively. These IASs also can be regarded as candidates to the states with one-nucleon (neutron or proton) halo.

The second object was triplet A=14. Signs of neutron halo in the $1^-$ (6.09 MeV) state of $^{14}$C have been revealed earlier by two independent groups. We confirmed this result independently and studied isobaric analog $1^-$ states of neighboring $^{14}$N and $^{14}$O nuclei. The differential cross sections of the $^{14}$C($\alpha$,$\alpha$)$^{14}$C$^*$ (6.09 MeV, $1^-$) inelastic scattering, the $^{13}$C($^3$He,d)$^{14}$N$^*$ (8.06 MeV, $1^-$), and the $^{14}$N($^3$He,t)$^{14}$O$^*$ (5.17 MeV, $1^-$) reactions are analyzed by the MDM and ANC. The rms radii for all three mirror nuclei in the studied $1^-$ states are found almost the same. The signs of proton halo in the $1^-$ state of $^{14}$N are identified for the first time.

Our future plans are connected with the radii of states of the $^6$Li and $^6$Be nuclei members of the $^6$He-$^6$Li-$^6$Be isobaric triplet. The formation of a neutron-proton halo in the $^6$Li state (3.56 MeV, $0^+$) was predicted. The theory admits the existence in this state of the so-called "tango structure". A proton or two-proton halo is expected in the ground state of $^6$Be. The radii of the above states will be determined by inelastic scattering and the ($^3$He,t) reaction using MDM.

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