Study of Nuclear Matter Distributions of Neutron-Rich He-Isotopes by Proton Scattering in Inverse Kinematics

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The study of neutron-rich light nuclei near the drip line has attracted much attention as they exhibit a particular nuclear structure, namely an extended distribution of the valence neutrons surrounding a compact core. Recently the differential cross section for elastic proton scattering from ^{6,8}He and ^{8,9,11}Li at 700 MeV/u using the technique of inverse kinematics was successfully measured at GSI [1,2,3]. A high-pressure hydrogen-filled ionization chamber was used as the target and a proton detector. The experiments were performed in the small range $0.002 \leq | t | \leq 0.05$ $(\mathrm{GeV/c})^2$ of the four-momentum transfer squared t and have yielded valuable information on the nuclear sizes and radial structure of nuclear matter density distributions. Recently, a novel experimental approach has been accomplished with the aim to deduce the differential p^{6,8}He cross sections in the t-range $0.05 \leq | t | \leq 0.25$ $(\mathrm{GeV/c})^2$ close to the expected first diffraction minimum. The experimental setup allowed to track and identify the projectile nuclei in coincidence with the recoil protons. The major difference with respect to the previous experiments was that instead of the active gaseous target, a 600 mg/cm^2 liquid hydrogen target was used and a position sensitive scintillator wall measured the recoil proton energies via time-of-flight [4]. The experimental arrangement allowed for a very low-background data taking. At present, only preliminary results for the p^{6,8}He differential cross sections at the larger t-range have been obtained. An example of the measured p^{6}He cross section is shown on Fig. 1 together with the fit of the combined data sets at low and high momentum transfer using a double-gaussian parametrisation for modelling the matter distribution in core and halo as input for a Glauber calculation (for details see [2,4]). The density distributions of nuclear matter obtained for ^{6}He are shown in Fig. 2. Solid curves are the results of averaging of densities deduced from fits to the data using different model parametrisations (for details see [4]). As it was predicted by theoretical calculations [5], the recently measured data together with the data from the previous experiment allow to deduce the size and radial shape of the core in ^{6,8}He with higher precision. The analysis of the p^{8}He cross section is currently in progress.

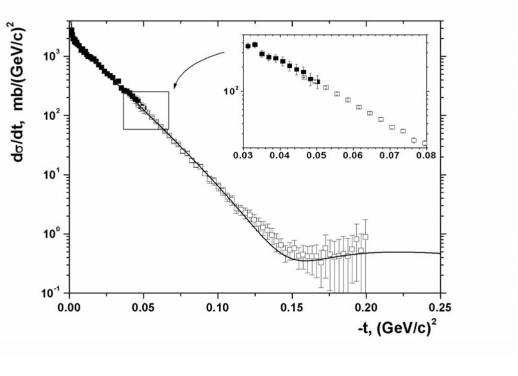

Figure 1: Experimental differential cross section of p ^{6}He elastic scattering versus momentum transfer squared t. Full symbols are data taken from [1], empty symbols are data from the actual measurement. The insert shows the area of overlap. The solid curve is the result of a fit of the combined data set.

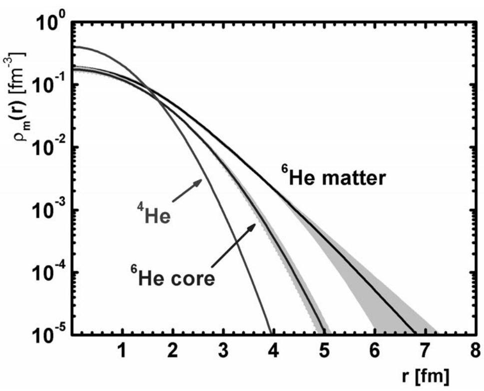

Figure 2: Density distribution of the total nuclear matter and the core in ^{6}He. The shaded areas represent the envelopes of the density variation within the different model parametrizations used. The ^{4}He density distribution is shown for comparison. All density distributions are normalized to the number of nucleons.

References

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