Probing Nuclear Structure of Exotic Nuclei and Reactions with Helium Isotopes

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An investigation of important characteristics of nuclear structure near drip-lines in coordinate and momentum space has been performed in [1–3]. Results on charge form factors calculations for several unstable neutron-rich isotopes of light (He, Li), medium (Ni), and heavy nuclei (Kr, Sn) are presented and compared to those of stable isotopes in the same isotopic chain [1]. For the lighter isotopes the proton and neutron densities are obtained within a microscopic large-scale shell model, while for heavier ones the densities are calculated in the framework of deformed self-consistent mean field Skyrme HF+BCS method. The resulting charge radii and neutron skin thicknesses of even-even isotopes of Ni, Kr, and Sn are compared with available experimental data, as well as with other theoretical predictions [2]. The formation of a neutron skin, which manifests itself in an excess of neutrons at distances greater than the radius of the proton distribution, is analyzed in terms of various definitions. Formation of a proton skin is shown to be unlikely. The nucleon momentum distributions for the same isotopic chains of neutron-rich nuclei (Ni, Kr, and Sn) are studied [3] in the framework of the same mean-field method, as well as of theoretical correlation methods based on light-front dynamics and local density approximation in which nucleon-nucleon (NN) correlations at short distances are taken into account. The isotopic sensitivities of the calculated neutron and proton momentum distributions are investigated together with the effects of pairing and NN correlations. The effects of deformation on both the neutron skins and momentum distributions in even-even deformed nuclei far from the stability line are discussed.

A microscopic approach to calculate the optical potential (OP) with the real part obtained by a folding procedure and with the imaginary part inherent in the high-energy approximation is applied to study the ^{6,8}He+p [4,5] and ^{6}He+^{12}C [6] elastic scattering data at energies of tens of MeV/nucleon (MeV/N). The calculated optical potentials and cross sections are based on different models for the neutron and proton density distributions of ^{6,8}He and that obtained from the electron scattering form factors for ^{12}C. The role of the spin-orbit potential and effects of the energy and density dependence of the effective NN forces are studied. Comparison of the calculations with the available experimental data on the elastic scattering differential cross sections at beam energies < 100 MeV/N is performed. The problem of ambiguity of adjusted optical potentials is resolved requiring the respective volume integrals to obey the determined dependence on the collision energy. Estimations of the Pauli blocking effects on the optical potentials and cross sections are also given and discussed. It is shown that the present approach, which uses only parameters that renormalize the depths of the OP, can be applied along with other methods like that from the microscopic g-matrix description of the complex proton optical potential. Conclusions on the role of the aforesaid effects and on the mechanism of the considered processes are made.

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