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ELASTIC HADRON SCATTERING ON THE 7Be NUCLEUS AT INTERMEDIATE ENERGIES

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The study of the scattering of hadrons with nuclei is a key element of the theory of the atomic nucleus and nuclear reactions. This is a test that allows one to investigate both the structure of the nucleus and the nuclear interaction. The best studied both experimentally and theoretically is the scattering of protons. For example, a large cycle of studies on the structure of light exotic nuclei by means of scattering of intermediate-energy protons was carried out by the GSI-PNPI collaboration (Germany-Russia). The experiments were carried out on a GSI radioactive beam (Darmstadt, Germany) in inverse kinematics, at an energy of 0.7 GeV / nucleon, in the range of momentum transfers 0.002≤ | t | ≤ 0.05 (GeV / c) 2. The same scientific collaboration recently carried out a similar new and very important experiment [1] for 7Be and 8B nuclei.
The choice of these nuclei as the object of research is not accidental. These nuclei are associated with the currently most discussed nuclear physics application - nuclear astrophysics. The 8B nucleus is formed on the Sun as a result of the 7Be (p, γ) 8B reaction and emits a high-energy neutrino, which can be experienced in ground-based experiments. The proton capture rate in 7Be strongly depends on the structure of 8B. The size of 8B and the shape of the proton density distribution at large distances determine the rate of proton capture and can be used in theoretical calculations of the solar neutrino flux. Therefore, a comprehensive study of the structure of these nuclei in different ways, and primarily through hadron scattering, is an important task.
In this work, we carry out a theoretical analysis of small-angle scattering of 0.7 GeV hadrons by a 7Be nucleus within the framework of Glauber's diffraction theory. The external parameters of Glauber's theory are the wave function of the target nucleus and the elementary amplitudes of the interaction of an incident particle with nucleons and nucleon clusters of the nucleus. We describe the internal state of the 7Be nucleus in a dynamic two-cluster (α-τ) model with forbidden states. This wave function describes well the main characteristics of both the ground and low-excited states of the nucleus under study. The next external parameter of Glauber's theory is the elementary amplitudes of hadron-nucleon and hadron-cluster scattering. They are usually parameterized for the energy region of interest from independent experimental data. In our problem, the α-particle is considered structureless and for it in the scientific literature there are parameters of elementary amplitudes, while there are no parameters for hadron-τ scattering. Therefore, the interaction of an incident proton and mesons with a τ-cluster is expressed through interactions with individual nucleons entering this cluster.
Within the framework of the diffraction theory, we obtained here an expression for the matrix elements of elastic p7Be- and π7Be scattering. The wave function of the target nucleus is expanded in Gaussian, so all the integrals in the matrix element are taken analytically. This greatly improves the accuracy of the calculation. We will not present the expression for the matrix element itself because of its cumbersomeness. The calculations performed on the scattering of protons are in good agreement with the experimental data. Unfortunately, experimental data are available only for small proton scattering angles. We carried out theoretical calculations up to scattering angles of 40 °, taking into account single and double scattering. A similar calculation of the cross section was also performed for the scattering of π-mesons. A comparative analysis of the obtained results is made.
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[1] A.V. Dobrovolsky et al. / Distribution of nuclear matter in proton-rich 7Be and 8B nuclei as a result of elastic scattering of intermediate-energy protons in inverse kinematics / Nuclear Physics A 989 (2019) 40–58

Primary authors: ABDRAMANOVA, Gulbanu (Kazakh National University named al-Farabi); IMAMBEKOV, Onlassyn (Kazakh National University named al Farabi)

Presenter: IMAMBEKOV, Onlassyn (Kazakh National University named al Farabi)

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