

STUDY OF NEUTRON REMOVAL MECHANISMS IN THE ${}^9\text{Be}({}^7\text{Be}, {}^6\text{Be})\text{X}$ REACTION AT INTERMEDIATE ENERGIES

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In this work, the population mechanisms of the ${}^6\text{Be}$ nuclear states in the ${}^9\text{Be}({}^7\text{Be}, {}^6\text{Be})\text{X}$ neutron removal reaction at a beam energy of 67 MeV/nucleon are investigated using theoretical models of increasing complexity. The analyzed experimental data were obtained at the National Superconducting Cyclotron Laboratory (NSCL, MSU, USA) in 2011 and stand out as a record in terms of statistics and detail for radioactive ion beam reaction studies. Previously, these data were analyzed exclusively from the perspective of the ${}^6\text{Be} \rightarrow {}^4\text{He}+p+p$ decay, utilizing the simplest “sudden removal approximation”, where the transition amplitude is expressed via the projectile form factor. However, this model proves unsatisfactory as it fails to describe the experimental results even at a qualitative level.

The simplest model that satisfies energy-momentum conservation and allows for a semi-analytical treatment is the “quasi-free scattering” model formulated within the Plane Wave Born Approximation (PWBA). This approach describes the scattering of a projectile nucleon on the target nucleus as a whole. To perform a meaningful comparison with experiment, target thickness effects, detector geometry constraints, and inelasticity effects in the ${}^9\text{Be}+n$ channel were incorporated into the model. Nevertheless, this approximation managed to reproduce only a fraction of the momentum distribution. However, incorporating absorption in the participant-target channel within the PWBA framework can only reproduce the data using unrealistic model parameters.

For a complete description of the experimental data, a new model describing neutron scattering on individual target nucleons has been developed, provisionally named “symmetric quasi-free scattering”. When combined with the PWBA formalism and adjusted for target thickness and detector array geometry, this model successfully describes the experimental data with high accuracy for both low-lying and highly excited states. Furthermore, the data obtained in the same experiment for the two-body decay channel ${}^6\text{Be} \rightarrow {}^3\text{He}+{}^3\text{He}$ also demonstrate good agreement with this approximation.

This report presents a comparative analysis of the experimental data interpreted within the sudden removal approximation, the standard PWBA formalism, and the “symmetric quasi-free scattering” model for both low-lying and highly excited states in the three-body ${}^6\text{Be} \rightarrow {}^4\text{He}+p+p$ decay channel. Additionally, simulation results obtained using the “symmetric quasi-free scattering” model and the PWBA formalism for the two-body ${}^6\text{Be} \rightarrow {}^3\text{He}+{}^3\text{He}$ decay channel are demonstrated.

References 1. L. V. Grigorenko et al. Phys. Lett. B 677, 30–35 (2009). 2. I. A. Egorova et al. Phys. Rev. Lett. 109, 202502 (2012). 3. L. V. Grigorenko et al. Phys. Rev. C 80, 034602 (2009).

Primary author(s) : Mr. MAKAROV, Danila (Flerov Laboratory of Nuclear Reactions, JINR, Dubna, Russia; National Research Nuclear University MEPhI, Moscow, Russia); Prof. GRIGORENKO, Leonid (Flerov Laboratory of Nuclear Reactions, JINR, Dubna, Russia; NRC “Kurchatov Institute”, Moscow, Russia; National Research Nuclear University MEPhI, Moscow, Russia); Mr. KHIRK, Mishel (Flerov Laboratory of Nuclear Reactions, JINR, Dubna, Russia); Mr. SHAROV, Pavel (Flerov Laboratory of Nuclear Reactions, JINR, Dubna, Russia)

Presenter(s) : Mr. MAKAROV, Danila (Flerov Laboratory of Nuclear Reactions, JINR, Dubna, Russia; National Research Nuclear University MEPhI, Moscow, Russia)

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