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Three-body correlations in direct reactions: Example of 6Be populated in (p, n) reaction

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The nuclear driplines are defined by instability with respect to particle emission, and therefore the entire spectra of the systems beyond the driplines are continuous. The first emission threshold in the light even systems is often, due to pairing interaction, the threshold for two-neutron or two-proton emission, and therefore one has to deal with three-body continuum. Such continuum provides rich information about nuclear structure of ground state and continuum excitations, which is, however, often tightly intertwined with contributions of reaction mechanism. The way to extract this information is to explore the world of various correlations in fragment motions and to look for methods to disentangle contributions of a reaction mechanisms.

The 47 AMeV 6Li beam was produced by the cyclotron U-400M and injected into ACCULINNA facility [1]. The 6Be continuum states were populated in the charge-exchange reaction 1H(6Li,6Be)n collecting very high statistics data (~5x10^6 events) on the three-body alpha+p+p coincidences. The first results of the experiment studying the α+p+p correlations in decays of the 6Be states populated in the (p, n) charge-exchange reaction were published in Ref. [2]. The paper was focused on the proof that the observed 6Be excitation spectrum above ~3 MeV is dominated by the novel phenomenon –isovector breed of the soft dipole mode "built"on the 6Li ground state (g.s.). The correlations in the decay of 6Be states with excitation energy below ~3 MeV, where the data are dominated by the contributions of the known and well-understood 0+ and 2+ states of 6Be, are presented.

A general quantum-mechanical formal issue and important practical task of data interpretation is the extraction of the most complete quantum-mechanical information from the accessible observables. Important but very rare case when extraction of the complete quantum-mechanical information from data is possible is elastic scattering: from angular distributions one can, in principle, extract set of phase shifts which contains all possible information about this process. For the majority of other classes of experimental data, extraction of complete quantum-mechanical information is not possible. For certain classes of reactions the most complete quantum-mechanical information which can be extracted is contained in the density matrix. Because of internal symmetries the density matrix could provide very compact form of data representation depending just on very few parameters.

We demonstrate that basing on the known level scheme it is possible to extract the maximal possible quantum mechanical information about reaction mechanism (e.g. the density-matrix parameters) from the three-body correlations. It is demonstrated how the high-statistics few-body correlation data can be used to extract detailed information on the reaction mechanism. The suggested method of analysis allows for identification of such fine effects like the ratio of the populated states, interference between them and alignment of the states with J>1/2 for other nuclei, and it may be regarded as a general tool for different tasks on radioactive beams.

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