Two-Proton Emission in the Hyperharmonics Approach

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A mechanism of simultaneous, or direct, emission of two protons will be considered. Such a genuine three-particle decay is a complementary mode to the known sequential emission of nucleons via narrow intermediate states. In the sequential decay an information about correlations of fragments due to initial nuclear structure is lost because of strong final state interactions. This is not the case for a direct decay in which long lived intermediate states are absent. In direct decays the fragment distributions are not distorted significantly by the final state interactions and therefore directly reflect correlations of the respective clusters in structure of the initial nucleus. In comparison with the two-particle case, the three-particle decay is more informative due to additional degrees of freedom, where more observables (*eg* fragment spectra, correlations between fragments) become available. Thus a direct decay into fragments which constitute an initial nucleus as clusters is a promising tool to study the nuclear structure.

Main features of direct decays are experimentally established in the two-proton decay of the ^{6}Be ground and first excited states and their analogs in ^{6}He and ^{6}Li*(T=1) [1]. The strong nucleon-nucleon correlations which are not connected with the final state interaction are observed.

An adequate approach in analysing few-body interactions was suggested by Delves, [2], who has introduced the hyperspherical harmonics (or K-harmonics) basis which gives correct angular wavefunctions like the spherical harmonics in the two-particle case. The new quantum number, *hypermomentum* K, is a three-body analogy of the orbital momentum ℓ. The centrifugal barrier of a three-body system is proportional to the factor $(K+3/2)\cdot(K+5/2)$ corresponding to the $\ell(\ell+1)$ factor for a two-particle barrier. This method is applied for direct three-particle decays [3] where the decay amplitude is expanded in a series in the K-harmonics basis.

The studied direct decays are determined by a single component in the amplitude expansion with a minimal value of hypermomentum, *eg* K is a *good quantum number*. The hypermomentum is not conserved if strong final state interaction exists in any pair of the fragments. The long-range Coulomb interaction influences the fragment distributions as well.

The fragment spectra from studied direct decays reflect the three-body nuclear structure. The α+p+p correlations in A=6 nuclei calculated in [4,5] agree quantitatively with the data analysis. In particular the strong momentum and space correlations between two valence protons are found in ^{6}Be. These are the 'di-proton' and 'cigar' correlations, where the protons form a relatively compact cluster, or are mainly on opposite sides relative to the α-particle, respectively. The observed correlations are induced by a specific three-body quantum effect: kinematic focusing of particles over momenta and in space. This phenomenon generalizes the angular dependance of a two-particle scattering with $\ell \neq 0$ to the three-body $K\neq 0$ case and it has a universal nature. This effect is expected to be essential in other nuclei with three-body structure, *eg* the two-proton emitters ^{17}Ne* and ^{19}Mg. Predictions of the direct 2p-decay modes of these nuclei will be presented.

[1] O.V. Bochkarev et. al., Nucl. Phys. **A505** (1989) 215
[2] L.M. Delves, Nucl. Phys. **20** (1960) 275
[3] B.V. Danilin et. al., Sov. J. Nucl. Phys. **46** (1987) 225
[4] V.I. Kukulin et.al., Nucl. Phys., **A453** (1986) 365
[5] B.V. Danilin et.al., Sov. J. Nucl. Phys. **48** (1988) 766; **49** (1988) 217; **53** (1991) 71