Two-proton decays from light to heavy nuclei. Comparison of theory and experiment.

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Two-proton ($2p$) radioactivity was predicted by V.I. Goldansky in 1960 [1] as an exclusively quantum-mechanical phenomenon. True three-body decay, in his terms, is a situation where the sequential emission of the particles is energetically prohibited from the ground state of a nucleus and all the final-state fragments are emitted simultaneously. Since the experimental discovery of the ^{45}Fe two-proton radioactivity in 2002 [2,3], this field has made fast progress. New cases of $2p$ radioactivity were found for ^{54}Zn [4], ^{19}Mg [5], and, maybe, ^{48}Ni [6]. The $2p$ correlations were recently measured for the ground state decays of ^{45}Fe [7], ^{19}Mg [5,8], ^{16}Ne [8], and ^{6}Be [9].
All these decays exhibit complex correlation patterns. These correlation patterns are well described within the three-cluster theory of two-proton radioactivity (see Ref. [9] and Refs. therein); the example of the ^{6}Be ground state decay is provided in Fig. 1. The correlations are shown to be sensitive to the details of structure and nuclear interactions. Thus experimental studies of correlations can provide important information about the structure of decaying nuclei.
With lifetimes and correlations well described by the theory in a broad range of nuclear masses (^{6}Be, ^{19}Mg, and ^{45}Fe belong to p, s-d, and p-f shells respectively) understanding of the nature of $2p$ radioactivity is geting now a solid empirical support. This is specially important in the view of astrophysical implementations of the three-body decay theory for the inverse processes of the three-body radiative capture in astrophysics, which seem to be not completely understood so far.

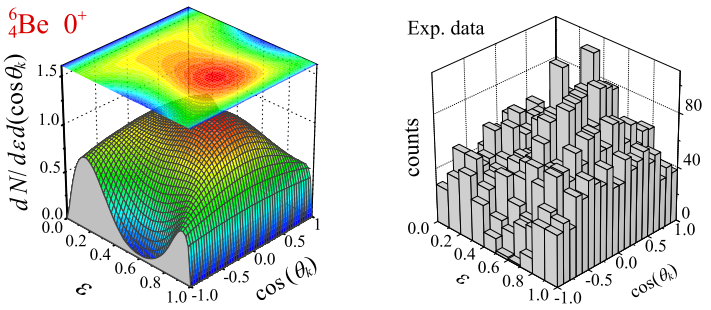

FIG. 1: Complete correlation picture for the ^{6}Be ground state decay [9]. The value ε is a ratio of the energy between two protons to the total decay energy and θ_k is an angle beween vectors of Jacobi momenta.

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