Beta-delayed two proton emission

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Beta-delayed multi-particle emission becomes increasingly important when approaching the drip lines, the main reason being that the Q_β-values increase and the separation energies for emitting particles decrease.

In particular, on the proton rich side of β stability much attention has been directed towards the specific process of β-delayed two-proton emission ($\beta 2p$) since it was hoped that this process would provide direct information on two-proton correlations within nuclei [1]. From an experimental point of view the study of proton rich nuclei is more feasible than neutron rich nuclei for two reasons. Firstly, the detection of delayed protons with good energy resolution in a broad energy range is relatively easy using ordinary Si detectors, whereas neutron detection still presents a challenge. Secondly, for nuclei with Z$\geq$N the super allowed Fermi decay collects a large feeding to the Isobaric Analogue State (IAS). Close to the drip line this state is placed at large excitation energy and is therefore open to two-proton emission.

Since the discovery of $\beta 2p$ in ^{22}Al, ^{26}P and ^{35}Ca at Berkeley, a number of cases have been studied at GANIL : ^{22}Al, ^{23}Si, ^{27}S, ^{31}Ar, ^{43}Cr and recently ^{35}Ca. For chemical reasons only ^{31}Ar has been produced for study at ISOLDE.

It is known in the literature that β2p emission can proceed via three mechanisms: *(i)* sequential emission through an intermediate state, *(ii)* simultaneous emission and *(iii)* decay through an L=0 final state interaction between the two protons, sometimes referred to as "di-proton" or ^{2}He emission. When the mechanism is sequential the distribution of the individual energies of the two protons is restricted by the position of the intermediate state, whereas angular momentum coupling can introduce some minor degree of angular correlation.

Experimentally the early studies on energy and angular correlations in $\beta 2p$ emitters at Berkeley showed that the sequential emission is dominant [2]. The experiments at GANIL has mainly focused in the search for new candidates and determination of branching ratios and decay modes.Therefore, the new information on the mechanism of $\beta 2p$ has mainly come from the experiments on ^{31}Ar at ISOLDE.

A review will be presented of these studies by comparing the new physics results that have emerged from the different experiments and by highlighting the technical development leading to these results. The β-delayed two proton emission is, in most cases, simply an extension of β-delayed single proton emission to high lying states which also are unstable to proton emission, thus no sign of correlations has been seen.

References

[1] V.I. Gol'danskii, JETP Lett. 32 (1980) 554.

[2] D.M. Moltz and J. Cerny, in *Particle Emission from Nuclei*, Vol III, edited by D.N. Poenaru and M.S. Ivascu, CRC Press (1989) p. 133.