Precise life-time measurement of the T= 1/2 mirror β transitions

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Introduction

In order to determine the correlation parameters of the β-decay in T=1/2 mirror transition, the *ft* value is needed to determine ρ, the ratio of Gamow-Teller to Fermi matrix elements. The *ft* value that characterizes any β transition depends on three measured quantities: the total transition energy, $Q_{EC,}$ the half=life, $t_{1/2}$, of the parent state, and the branching ratio, *R*, for the particular transition of interest. The Q_{EC} value is required to determine the statistical rate function, *f*, and the half-life and branching ratio combine to yield the partial half-life, *t*.

A recent review of all T=1/2 β mirror decays [1] indicates that ^{37}K and ^{21}Na are of great interest and possibly the best candidates for testing the Standard Model. In order to make the Standard Model predictions of the correlations parameters negligible compared to planned experiments [2,3], we have measured the life-times of ^{37}K and ^{21}Na. The half-lives in these cases are the largest contributors to the total uncertainty of their *ft* values.

Experimental details and results

^{37}K was produced via the fusion evaporation reaction, p (^{38}Ar, 2n) ^{37}K in inverse kinematic at a primary beam energy of 29 MeV/u. The Momentum Achromatic Recoil Spectrometer (MARS) was used to produce a secondary beam of ^{37}K with a purity of 98.5%. The secondary beam exited the vacuum system through a kapton foil and then passed through a thick plastic scintillator, a series of Al degraders and eventually implanted in the centre of an Al-Mylar tape. The fast-tape transport system quickly transported the sample to a well shielded location, placing it in the centre of a 4π proportional gas counter [4]. The total data set was divided into 13 runs with different settings of the experimental parameters: bias voltage, discriminator threshold, dominant dead-times and thickness of the Al degrader. Each run consisted of 100-300 cycles, which yielded a total of 4×10^6 β events. Data was analyzed in two different ways. In the first method (summed fit), each cycle was dead-time corrected and the cycles from a given run were summed and fit using the Levenberg-Marquardt χ^2 minimization algorithm. In the second method (global fit) all the cycles were simultaneously fit in a given run with a single half-life parameter but with different background levels. The fit function consists of four exponentials (^{37}K, ^{35}Ar, ^{34}Cl and ^{33}Cl) plus a constant background. The decay curve observed with the global fit overlayed is shown in Fig. 1.

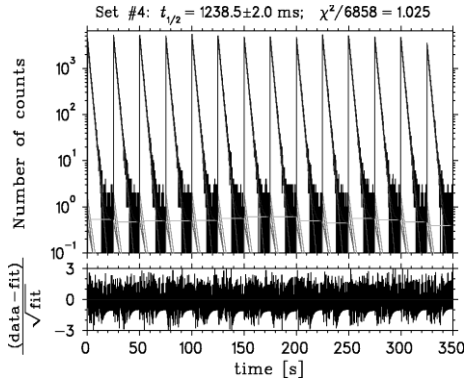

Fig.1 Typical decay curve containing 14 cycles in a single run and fit using global analysis.

The two analyses yield the same result in the half-life to within ±0.30 ms. Our preliminary result for the ^{37}K half-life is $t_{1/2}$ = 1236.5 ±0.5 ±0.8 ms [5], where the first uncertainty is statistical and the second is from systematic. The dominant systematic arises from the ^{35}Ar and ^{33,34}Cl contaminants. The present measurement improves over the previous measurement [6] by almost an order of magnitude.

^{21}Na was produced via the p(^{22}Ne, 2n)^{21}Na reaction in inverse kinematic at a primary beam energy of 25 MeV/u. MARS was again used to produce a secondary beam of ^{21}Na, this time with

a purity of 99.9%. We followed the same procedure as described above for measuring the half-life of ^{21}Na and to check for possible systematic effects. The analysis is in progress to extract the precise half-life with an associated error budget. Details of the experimental setup and data analysis will be presented.

References

[1] O. Naviliat-Cuncic and N. Severijns, Phys. Rev. Lett **102**, 142302 (2009)
[2] D. Ashery et al. Progress in Research, Cyclotron Institute, texas A&M University (2009-2010)p. I-58.
[3] P.A. Vetter *et al.*, Phys. Rev. C **77**, 035502 (2008).
[4] V. E. Iacob *et al.*, Phys. Rev. C **82**, 035502 (2010).
[5] To be submitted to Phys. Rev. C.
[6] G. Azuelos *et al.*, Phys. Rev. C **15**, 1847 (1977).