JYFLTRAP : Q_{EC}-values of the superallowed decays of ^{34}Cl and $^{38}K^m$

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We have now completed and published three successful measurements of the Q_{EC} values for superallowed $0^+ \rightarrow 0^+$ transitions from $T_z = 0$ nuclei using the JYFLTRAP Penning-trap mass spectrometer at the University of Jyvaskyla cyclotron facility in Finland. The first comprised the results for $^{26}Al^m$, ^{42}Sc and ^{46}V [1] and the second, ^{50}Mn and ^{54}Co [2]. In the most recent [3], our collaboration determined the Q_{EC} values for the superallowed decays of ^{34}Cl and $^{38}K^m$. The Q_{EC} values for these two transitions had previously been determined to a claimed high precision with (*p,n*) threshold measurements, and combined (*p*,γ) and (*n*,γ) Q-value measurements, the methods used in the past before Penning traps became available for on-line measurements. They had never been measured with a Penning trap. These two cases thus provided an excellent means to test carefully for any systematic discrepancies between reaction-based and trap-based measurements, a subject of some concern [4] when one combines both types of measurement in the determination of a world average.

As we did in our previous experiments, we produced ^{34}Cl and $^{38}K^m$ via (*p,n*) reactions. A powerful advantage of this approach is that, not only were the superallowed emitters of interest produced in the primary reactions but ions from the target material itself – the beta-decay daughters of these emitters – were also released by elastic scattering of the cyclotron beam. As explained in Ref. [1], with the JYFLTRAP system we can isolate a specific nuclide from the reaction products and measure the cyclotron frequency of its ions in the Penning trap. For each determination of a Q_{EC} value, the cyclotron frequency measurements were interleaved: first we recorded a frequency scan for the daughter, then for the mother, then for the daughter and so on. This way, most potential systematic effects could be reduced to a minimum or eliminated. For each measurement, data were collected in several sets, each comprising ~10 pairs of parent-daughter frequency scans taken under the same conditions.

Our results for the Q_{EC} values of ^{34}Cl and $^{38}K^m$ were 5491.662(47) keV and 6044.223(41) keV respectively. The uncertainties, 47 and 41 eV, are the smallest ever obtained for any superallowed Q_{EC} value. Penning-trap results for four transitions, including these two, are compared with reaction-based results in Fig. 1. There is no evidence for any systematic difference between the two types of measurement, although there is an obvious error in the (*p,n*) measurement of the $^{26}Al^m$ Q_{EC} value. Excluding this result, the weighted average difference (reaction result minus Penning-trap result) is 15(85) eV. Any systematic difference between reaction and trap measurements, if it exists at all, must be below 100 eV, which is below – and usually well below – the uncertainties quoted on the reaction-based measurements themselves.

These new Q_{EC}-value results leave the uncertainties in the *ft* values for the ^{34}Cl and $^{38}K^m$ transitions totally dependent on the uncertainties of their half-lives. The *ft*-value uncertainties would now be reduced by nearly an order of magnitude if the half-life measurements were to be improved by that factor.

We plan to complete our measurements on the "traditional nine" superallowed transitions by measuring the Q_{EC} values for ^{10}C and ^{14}O in an experiment scheduled for May 2010.

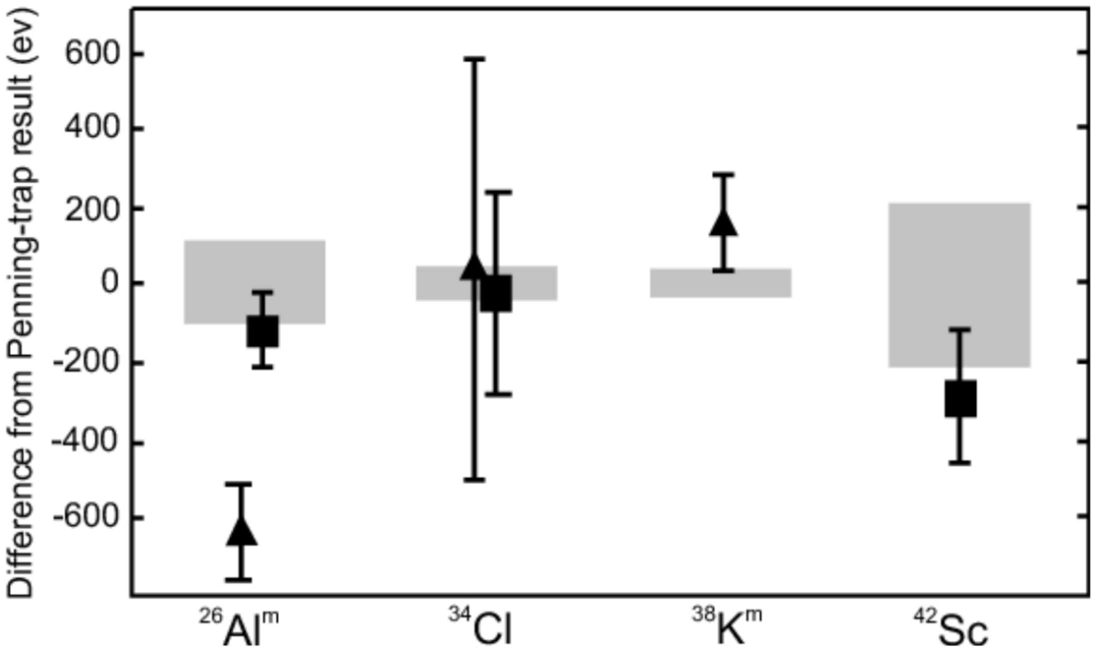

FIG. 1. Differences between precise reaction-based and Penning-trap QEC value measurements for $^{26}Al^m$, ^{34}Cl, $^{38}K^m$ and ^{42}Sc. The (p,n)-threshold measurements are shown as triangles and the (p,γ)+(n,γ) measurements appear as squares. The grey bands about the zero line represent the uncertainty of the Penning-trap measurements. (Experimental references are given in [3].)

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[3] T. Eronen, V.-V Elomaa, J. Hakala, J.C. Hardy, A. Jokinen, I.D. Moore, M. Reponen, J. Rissanen, A. Saastamoinen, C. Weber and J. Aysto, Phys. Rev. Lett. **103**, 252501 (2009).

[4] J.C. Hardy, I.S. Towner and G. Savard, Int. J. Mass Spectrometry **251**, 95 (2006).