PRECISION MASS MEASUREMENTS

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A new technique analogous to the "peak-matching" method used by mass spectroscopists is being used to measure differences in reaction Q-values to a precision of 100 eV. While at present the method is being applied to the study of charge-dependent corrections in T = 1 superallowed $0^+ \rightarrow 0^+$ beta-decay matrix elements, it could easily be extended to measure mass differences of nuclei farther from beta stability.

The method consists of periodically imposing a voltage on a compound target that is imaged by a high-resolution Q3D spectrometer at 0°. The energy of reaction products -- and hence their position on the focal plane of the spectrometer -- will vary directly with the applied voltage if their charge state differs from the charge state of the primary beam. Thus the energy difference between two groups of the same reaction product can be measured by adjusting the imposed voltage so that the shifted position of one group, as observed on the focal plane, coincides with the unshifted position of the other group. The imposed voltage is then read and used to deduce the difference in the two reaction Q-values. In this manner, corrections for magnetic aberrations, target energy losses, angle uncertainties, beam energy uncertainties, etc., become negligible since "peak-matched" reaction products are compared under identical experimental conditions. The table below lists our first results.

Case (i) was measured to test our technique. The 78.1 keV level in ^{32}P is known from independent γ-ray measurements to a precision of 100 eV. The results agree and give us confidence in the method.

Cases (ii) and (iii) were measured as part of our program to improve the precision of experimental ft-values for superallowed $0^+ \rightarrow 0^+$ transitions. When combined with precise γ-ray measurements of the relevant excited states, these results will lead directly to relative Q_{EC} measurements.

Measured Q-value differences

Case	Reaction A	Reaction B	$Q_A - Q_B$
i	$^{30}Si(^3He,p)^{32}P$ (ground state)	$^{30}Si(^3He,p)^{32}P^*$ (78.1 ± 0.1 keV)	78.02 ± 0.11 keV
ii	$^{26}Mf(^3He,t)^{26}Al^*$ (1057.7 ± 0.5 keV)	$^{14}N(^3He,t)^{14}O$ (ground state)	81.82 ± 0.23 keV
iii	$^{54}Fe(^3He,t)^{54}Co$ (ground state)	$^{50}Cr(^3He,t)^{50}Mn^*$ (651.0 ± 0.5 keV)	41.07 ± 0.10 keV

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