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Half-lives of ^{10}C, ^{14}O, and ^{23}Mg

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Half-lives of ^{10}C, ^{14}O, and ^{23}Mg have been measured to be 19.28 ± 0.02, 70.43 ± 0.18, and 11.26 ± 0.08 sec, respectively.

[RADIOACTIVITY ^{10}C [from $^{10}Be(p,n)$, enriched target], ^{14}O [from $^{14}N(p,n)$, natural target]; ^{23}Mg [from $^{24}Mg(p,pn)$ natural target]; measured $T_{1/2}$.]

1. INTRODUCTION

The decay of ^{10}C and ^{14}O has been the object of considerable interest because of the importance of these nuclei in the understanding of superallowed β decay.[1] Similar interest exists in mirror nuclide decays such as ^{23}Mg.[2] The need for accuracy has resulted in the remeasurement of many half-lives with the disturbing result that previous precision measurements often deviate 8 to 10 standard deviations from later measurements. The source of these systematic errors has traditionally been sought among the apparatus or methodology of the experiment.

It has been suggested[3] that a quoted result may be suspected of systematic error if the variance of a distribution of sets of measurements is large compared to the variance associated with the location of the centroid of the distribution. In addition, the deviation from the mean is suggested as a better method of assessment of error. It would appear, however, that artificially redefining the error does nothing to remove the systematic errors which separate the centroids of precision measurements.

Recently, attention to the details of the statistical analysis of data has resulted in the recognition of a potentially serious error associated with the logarithmic linearization of data in order to extract half-life values.[4] A weighted mean anomaly is reported in the present work which, together with the previous effect, may account for some of the systematic errors separating precision measurements from accurate measurements.

2. METHODS AND RESULTS

The activities studied were produced by (p, xn) reactions using the McGill synchrocyclotron. The samples were delivered to a low background counting area some 25 m away in about two seconds by means of a pneumatic system. Counting was carried out using Ge(Li) detectors to monitor the characteristic γ rays of the decays and losses were determined by a pulser feedback technique whose accuracy is reported elsewhere.[5] The high-resolution property of the detector was preserved by counting in the multispectrum mode (crystal-clock controlled), while timing information was obtained by the accumulation time of the spectra. A computer simulation of the experiments and data analysis guided the accumulation and treatment of data. Because of repeated runs under nearly identical conditions, two methods of data treatment presented themselves following counting-loss corrections. In one method, the weighted mean of the sets of half-lives was calculated; in the other the spectra were summed to obtain a single half-life value. A serious difference (half a standard deviation) was observed between the two methods which was traced to the process of obtaining the weighted

TABLE I. The half-lives of ^{10}C, ^{14}O, and ^{23}Mg.

Decaying nucleus	Present results (sec)	Previous results (sec)
^{10}C	19.28 ± 0.02	19.27 ± 0.08 [a]
		19.48 ± 0.05 [b]
^{14}O	70.43 ± 0.18	70.48 ± 0.15 [c]
		70.580 ± 0.035 [d]
		70.32 ± 0.12 [e]
		70.91 ± 0.04 [f]
		71.00 ± 0.13 [g]
		71.3 ± 0.1 [h]
^{23}Mg	11.26 ± 0.08	11.41 ± 0.05 [i]

[a] Reference 6.
[b] Reference 7.
[c] Reference 3.
[d] Reference 8.
[e] Reference 9.
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[i] Reference 10.

mean. The origin of this anomaly is that the statistical weight associated *experimentally* with apparent half-lives less than the true mean is different than that attributed to apparent half-lives greater than the mean. This observation is associated with the fact that for a given initial activity the area under the decay curve for half-lives greater than the mean is larger than if the half-life is less than the mean. The effect of the statistical weight difference is to shift the apparent mean as much as a few standard deviations from its true value. A computer simulation shows that for a modest variation of starting activities the effect persists and it is preferable to take unweighted means or better still to sum data before the half-life is extracted.

The present results (Table I) were obtained by correcting each sample for counting losses and summing the corrected data before the half-life was determined. The errors quoted are standard deviations of the mean.

3. DISCUSSION

The present ^{10}C result of 19.28 ± 0.02 sec resolves a discrepancy between the 19.27 ± 0.08 result of Bartis[6] and the 19.48 ± 0.05-sec value of Earwaker, Jenkin, and Titterton.[7]

The ^{14}O experiment yielded a value of 70.43 ± 0.18 sec confirming the result of Alburger[3] (70.48 ± 0.15), of Clark *et al.*[8] (70.580 ± 0.035), and of Singh[9] (70.32 ± 0.12), but disagrees with the earlier values shown.

Finally the 11.26 ± 0.08-sec value presented here disagrees with the 11.41 ± 0.05-sec value of Gross *et al.*[10]

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