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Half-life determination for ^{27}Mg

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Abstract. In this work, the half-life of the short-lived magnesium radionuclide ^{27}Mg was measured by following the activity of samples after they were irradiated in the IEA-R1 reactor. An exponential decay function was then fitted to the results using the counts from a ^{60}Co source as lifetime chronometer; the individual half-life values obtained for each irradiation were compiled using both the usual unweighted and σ^{-2} -weighted averages, as well as the robust averages obtained using the Normalized Residuals and the Rajeval techniques. The final half-life values obtained aren't compatible with the ENSDF compilation values, but have a similar uncertainty; analysis of the experimental literature values, all from the 50's-60's, show that further measurements should be undertaken in order to achieve a more robust consensus value for this half-life.

1. Introduction

Nuclear applications usually require a good degree of knowledge on several parameters of the nuclei involved, both regarding the safety of the experiment and the reliability of the results. For instance, in Nuclear Activation Analysis (NAA), many nuclear parameters, such as cross section, transition intensities and decay half-life, have to be well known in order to compute the results, and the uncertainties in these parameters frequently undermine the results obtained in the analyzes [1]. In the instrumental variation of NAA, which relies on the use of a well known comparator irradiated together with the samples in order to eliminate most of the nuclear parameters from the equations, the value of the decay half-life is still an important parameter and it appears inside an exponential function, so its uncertainty must be carefully assessed because it may distort the results of the whole analysis.

In the case of magnesium, only the activation of ^{26}Mg produces a radioactive isotope, ^{27}Mg ; its half-life was measured in the 50's as 570.6 (18) s [2], 563.4 (18) s [3], 567.0 s [4] and 567.6 (12) s [5], and the for last time in 1970 as 567.7 (7) s [6], resulting in a compiled value of 567.5 (7) s [7]. It should be noted that most of these measurements were performed using NaI(Tl) detectors, and that in most of them the corrections for dead-time and pile-up, which can play quite a big role in these measurements [8], were not thoroughly assessed.

In this work, the decay of this isotope was studied by following the activity decay for the gamma-rays peaks associated with its decay in neutron-irradiated natural magnesium samples.

2. Experimental Procedure

In the present experiment, samples were produced by cutting ~ 5 mg pieces of a 99.781% pure Mg foil (Reactor Experiments 1553) and packing these pieces into sealed polyethylene bags. These



samples were then irradiated for 20-25 seconds in the IEA-R1 nuclear reactor under a thermal neutron flux of $\sim 5 \times 10^{12} \text{ n}\cdot\text{cm}^{-2}\cdot\text{s}^{-1}$ using a fast pneumatic irradiation facility (sample transit time $\sim 10\text{s}$) and then analyzed by a 20% HPGe detector coupled to a 8192-channel MCA with a source-detector distance of 9 cm. The data collection for each individual sample was made through a batch of 65 subsequent acquisitions of 60 s (realtime).

The resulting spectra were analysed using the Genie-2k software [9], which delivers reliable and accurate peak areas for standard gamma spectra [10]. The determination of the activity of ^{27}Mg was then performed using both the 843.76 keV transition ($I_\gamma = 71.8\%$) and the 1014.52 keV transition ($I_\gamma = 28.2\%$) [7] – it should be noted that a longer-lived peak was found at 846.6 keV, which could interfere with the results obtained using the 843.76 keV transition (see Fig. 1). All the samples were counted together with a ^{60}Co source, and the sum of the counts in the 1173 and 1332 keV transitions was used as a lifetime chronometer, i.e., the number of counts in each of the ^{27}Mg peaks was divided by the sum of counts in both of the ^{60}Co source's peaks to correct for losses related to pile-up and dead time. The individual uncertainties were determined by propagating, for each point, the peak area uncertainties for that specific measurement and for the ^{60}Co peaks used in the normalization; no other uncertainty was considered as a previous study already assessed that peak areas are the only relevant source of uncertainty in this type of measurement [8].

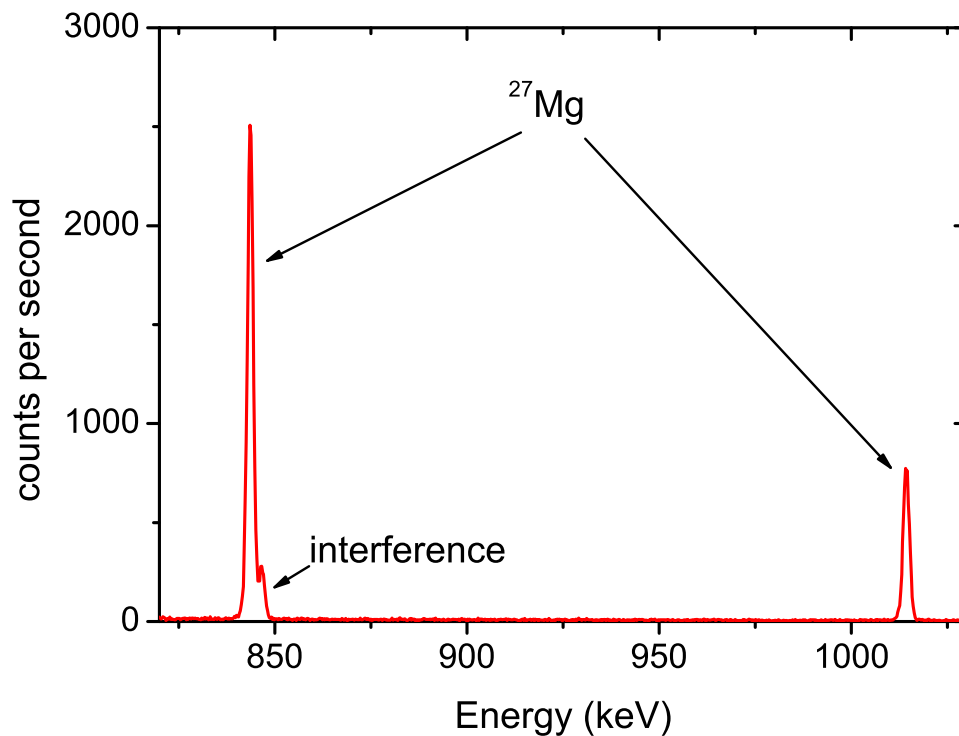


Figure 1. Sample of a spectrum obtained in the measurement of the ^{27}Mg decay, showing both peaks used in this work, together with the interferent peak at 846.6 keV.

A regular exponential decay function was fitted to the results of each of the eight individual measurements using a covariant Gauss-Marquardt routine implemented in the MatLab environment (a sample decay graph can be seen in Fig. 2), and the resulting half-life values (with the corresponding uncertainties, obtained in the fitting procedure) were then averaged using the usual arithmetic and σ^{-2} -weighted means, as well as two robust averaging techniques, *Normalized Residuals* and *Rajeval* [11].

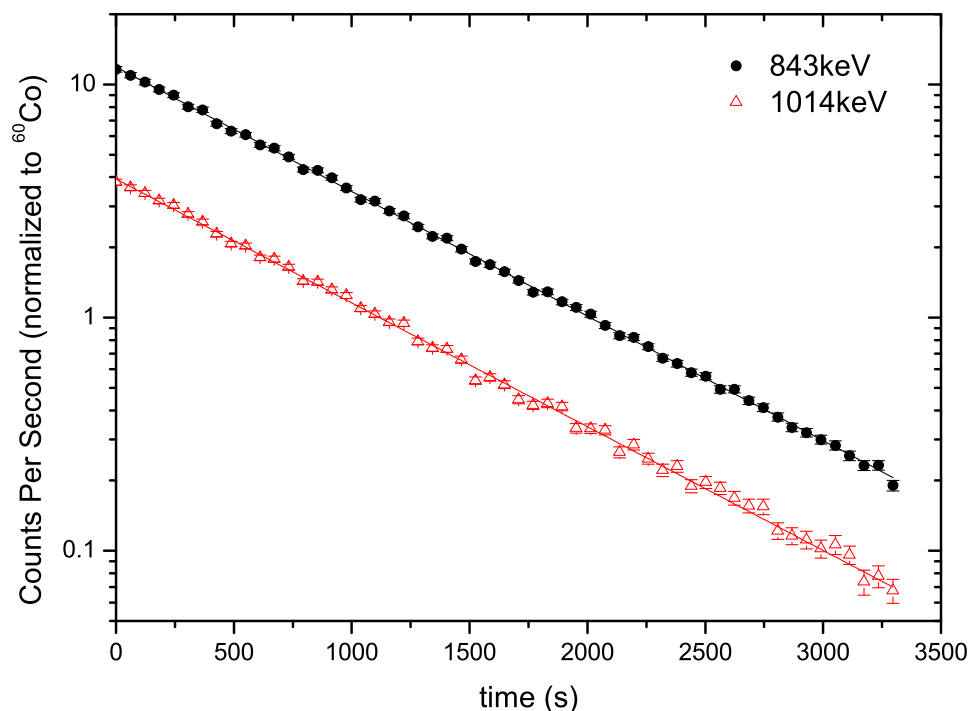


Figure 2. Sample of a activity decay graph, showing the fits for both peaks used in this work.

3. Results

The results obtained in each of the individual measurements are shown in Fig 3, together with the ENSDF compilation value; Table 1 shows the final average results using each of the transitions. The results obtained using both transitions were compatible, indicating that the interferent peak was well taken care of, and as all eight individual results were compatible in both cases, the robust averages gave the same final results as the weighted averages.

Transition (keV)	AM (s)	WM (s)	NR (s)	RT (s)	Ref. (s)
843.76	565.5 (6)	565.5(7)	564.5 (7)	564.5 (7)	567.5 (7) [7]
1014.52	564.9 (11)	565.0 (11)	565.0 (11)	565.0 (11)	

Table 1. Results of the averages for the half-lives of ^{27}Mg using each of the nuclear transitions – *AM*, *WM*, *NR* and *RT* are the arithmetic, σ^{-2} -weighted, Normalized Residuals and Rajeval averages, respectively.

As the half-life values obtained using both transitions were compatible, the most precise value of 564.5 (7) keV is adopted as the final result. This value for the half-life of ^{27}Mg is not compatible to the ENSDF compilation value of 567.5 (7) keV, with a relative error of -0.5% , and is compatible with only one of the results found in the literature – 563.4 (18) s [3]; nevertheless, all the measurements found in the literature are more than 40 years old and used precarious corrections for the pile-up and dead time losses, therefore our result indicates that further measurements should be performed in order to precisely assess the half-life of ^{27}Mg .

4. Conclusions

The result obtained for the half-life ^{27}Mg presented an uncertainty of the same magnitude as the best measurements found on the literature; the results, though, were not compatible with

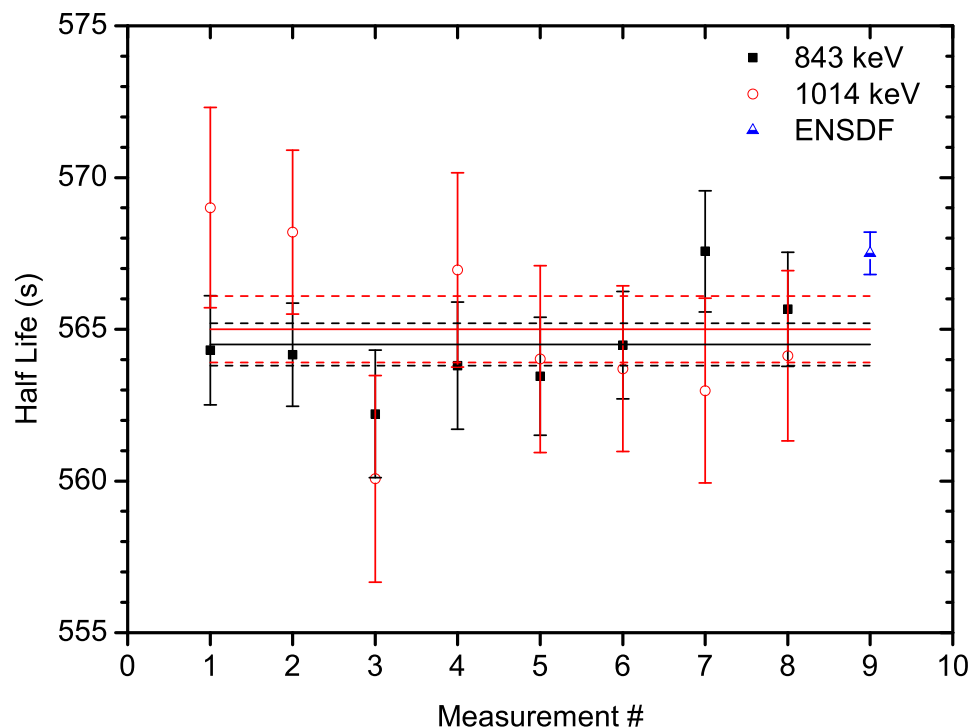


Figure 3. Results of each of the individual measurements for the half-life of ^{27}Mg together with the ENSDF compilation value (in blue, from [7]); the full lines represent the result of the weighted average and the dotted lines the $1 - \sigma$ interval, and the color of the lines correspond to the transition used.

most of the reported values, and are 0.5% lower than the compiled value found in [7], indicating that further measurements should be performed in order to precisely assess the value of this half life.

References

- [1] Lindstrom R M, Zeisler R and Greenberg R R 2007 *Journ. Radioanal. Nucl. Chem* **271** 311–315
- [2] Daniel H, Koester L and Mayer-Kuckuk T 1953 *Z. Naturforsch.* **8a** 447–448
- [3] Lockett E E and Thomas R H 1953 *Nucleonics* **11** 14
- [4] Sargent B W, Yaffe L and Gray A P 1953 *Can. J. Phys.* **31** 235–249
- [5] Poularikas A and Fink R W 1959 *Phys. Rev.* **115** 989–992
- [6] Repace J L 1970 *Radiochim. Acta* **14** 46–49
- [7] Basunia M S 2011 *Nucl. Data Sheets* **112** 1875–1948
- [8] Zahn G S, Oliva J W M and Genezini F A 2013 *Radiat. Phys. Chem.* **85** 70–72
- [9] Canberra 1999 *Genie-2000 Spectroscopy System – operations manual* Canberra Industries USA
- [10] Zahn G S, Genezini F A and Morales M 2009 *Proceedings of the 2009 International Nuclear Atlantic Conference – INAC2009* (Rio de Janeiro, Brazil: Associação Brasileira de Energia Nuclear – Aben)
- [11] Rajput M U and MacMahon T D 1992 *Nucl. Instrum. Meth. A* **312** 289–295