Half Life of ^{101}Mo and ^{101}Tc β^--decay

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Abstract. In this work, the half-lives of the beta-unstable nuclei ^{101}Mo and ^{101}Tc were studied using neutron-irradiated samples of ^{100}Mo to produce ^{101}Mo which in its turn generates ^{101}Tc by beta decay. The gamma activity of each sample was followed for 5 consecutive half-lives in steps of 5 minutes. A total of 22 sources were measured and checked for dead-time influence, and the half-lives were obtained by weighted average. The results are statistically incompatible with the tabulated values.

Keywords: ^{101}Mo; ^{101}Tc; half life
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INTRODUCTION

The half life is a very important parameter on nuclear decays; in particular, the half lives of ^{101}Mo and ^{101}Tc are of relevance to diagnose fission burn-up [1] and to k_0 databases [2]. The presently accepted values [3] are 14.61(3) min for ^{101}Mo and 14.22(1) min for ^{101}Tc.

EXPERIMENTAL PROCEDURE

In the present experiment, ^{101}Mo was produced by neutron irradiation of 5mg-^{100}Mo-enriched samples for 5 minutes in the pneumatic station of the IEA-R1 nuclear reactor under a thermal neutron flux of ~5×10^{12}cm^{-2}s^{-1}. A total of 22 radioactive samples were produced and counted on a 15%-Ge detector coupled to a 4096-channel MCA; each sample was counted for approximately 15 separate consecutive 5-minute acquisitions in order to allow for the decay analysis. ^{101}Mo decays to ^{101}Tc, so the half life of the daughter nuclide was also studied.

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DATA ANALYSIS

For the determination of the half-life of ^{101}Mo, the 191.9keV (I_γ=1000%) and the 591.9 (870%) peaks were analyzed in each spectrum and the peak area (C) was fitted, using a covariant Gauss-Marquardt routine implemented in MatLab environment, to a simple exponential decay (Eq. 1) by two different approaches, one in which C(t) was determined individually for each sample and then the weighted average was calculated and the other in which data from all samples were gathered in a single fit together with a "normalization" parameter for each, so that a single value for the half-life is fitted.

$$C(t) = A \cdot e^{-t \cdot \ln 2 / T_{1/2}} \tag{1}$$

For the determination of the half-life of ^{101}Tc, the 306.9keV (I_γ=1000%) and 545.1keV (I_γ=68%) peaks were once again fitted to Gaussians in each spectrum and the peak area (C) was fitted, using the same fitting routine, but to a rather more complicated function, dependent also on the half-life of ^{101}Mo, as seen in Eq. 2, where $T^1_{1/2}$ is the half life obtained in the previous step for the half life of ^{101}Mo, which is kept constant in this fit, and $T^2_{1/2}$ is the half life of ^{101}Tc, one of the fit parameters (together with the A^1s and A^2s, which are normalization parameters). In this case, a single fit of all the data was not possible, due to the differences in the daughter-father equilibrium in each sample, so the only result for the half-life of ^{101}Tc is obtained from the weighted average of the 22 separate determinations.

$$C(t) = \frac{T^1_{1/2}}{T^2_{1/2} - T^1_{1/2}} A^1 . \left(e^{-\frac{\ln 2}{T^1_{1/2}}.t} - e^{-\frac{\ln 2}{T^2_{1/2}}.t} \right) + A^2 . e^{-\frac{\ln 2}{T^2_{1/2}}.t} \tag{2}$$

RESULTS

The weighted average of the 22 individual fits for ^{101}Mo resulted in a half-life of 14.839(13) min, while the result of the single fit was 14.834(13) min; both values are compatible, but both are significantly larger than the tabulated result (14.61(3) minutes). As for the half-life of ^{101}Tc, the result obtained was 13.752(13) min, which is considerably lower than the tabulated result (14.22(1) minutes); this could be explained as a side effect of the larger half-life obtained for the father nuclide, ^{101}Mo.

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