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BRIEF REPORTS

Brief Reports are short papers which report on completed research or are addenda to papers previously published in the **Physical Review.** *A Brief Report may be no longer than four printed pages and must be accompanied by an abstract.*

Precision measurement of the half-life of ^{7}Be

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The half-life of ^{7}Be has been measured with high precision using a high-purity germanium detector: $T_{1/2}=53.12\pm0.07$ d. [S0556-2813(96)00107-0]

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The nucleus ^{7}Be decays by electron capture to ^{7}Li. With a branching of 89.5% ^{7}Be decays directly to the $3/2^{-}$ ground state of ^{7}Li, and 10.5% of the decays go to the first excited state in ^{7}Li ($1/2^{-}$ at 478 keV), which decays by γ emission to the ground state [1].

The half-life of ^{7}Be has been measured in several experiments, often with a relatively high precision of about 0.5% or better [2], but the error bars of the different experiments do not always overlap. Experimental results with an uncertainty smaller than 0.2% are 53.52 ± 0.10 d (using a differential ionization chamber [3]), 53.29 ± 0.02 d (experimental method unknown, unpublished [4]), and 53.17 ± 0.07 d (using a NaI(Tl) detector [5]). The adopted half-life, which is the weighted average of these experiments, is 53.29 ± 0.07 d [1,2]. The half-life changes by about 0.1–0.2 % depending on the chemical environment of ^{7}Be [2]. In a stellar environment the half-life of ^{7}Be depends on the plasma density in the vicinity of the ^{7}Be nucleus. This value, which is very important for the solar neutrino flux, can be determined in experiments on ^{7}Be in different charge states which are planned at GSI, Germany [6].

We measured the half-life of ^{7}Be using a high-resolution detector with a precision on the order of the chemical shift ($\approx 0.1\%$) in the same chemical environment as will be used in a subsequent activation experiment [7]: the cross section of the capture reaction $^{6}\mathrm{Li}(p,\gamma)^{7}\mathrm{Be}$ will be determined by the measurement of the 478 keV activity from the produced ^{7}Be nuclei.

The ^{7}Be for this half-life experiment was produced by the reaction $^{7}\mathrm{Li}(p,n)^{7}\mathrm{Be}$ at a proton energy $E_p=1920$ keV not far above the reaction threshold energy $E_{\mathrm{thres}}=1881$ keV. The irradiation was performed at the 3 MV Van de Graaff accelerator ROSENAU of the University of Tübingen. We used a natural LiF target (thickness 200 μg/cm^2) which contains 92.5% ^{7}Li on a carbon backing (thickness 50 μg/cm^2). Because of the conservation of momentum almost all ^{7}Be is emitted in the forward direction and stopped inside the target. The range of ^{7}Be at $E\approx 200$ keV (taken from Ref. [8]) is smaller than the target thickness. The target was bombarded over 3 h with a beam current of about 250 nA.

After the irradiation the target was mounted close in front of a high-purity germanium (HPGe) detector with 45% relative efficiency. The background was reduced by a lead shielding. A typical spectrum is shown in Fig. 1. In addition to the expected γ line at $E_\gamma=478$ keV natural background lines at $E_\gamma=1460$ keV and $E_\gamma=2614$ keV can be seen. Additionally, there are several lines from the decay of ^{124}Sb because the lead shielding was activated during a previous neutron experiment.

Because of the excellent energy resolution of the HPGe detector ($\Delta E_{\mathrm{FWHM}}<2$ keV in the relevant energy region, which is much better than in previous lifetime experiments) a very good signal-to-noise ratio was obtained; the background peaks mentioned above do not impair the determination of the half-life of ^{7}Be in our experiment. A pure background

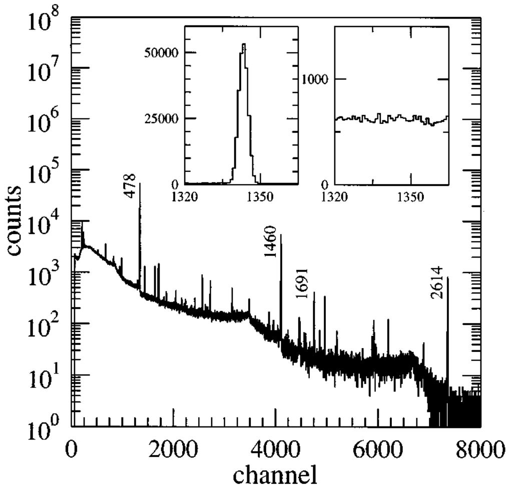

FIG. 1. Typical γ-ray spectrum of the decay of ^{7}Be. The insets show the region of interest with the activated target (left) and without a target (right). Note the different scale of the ordinates in the insets.

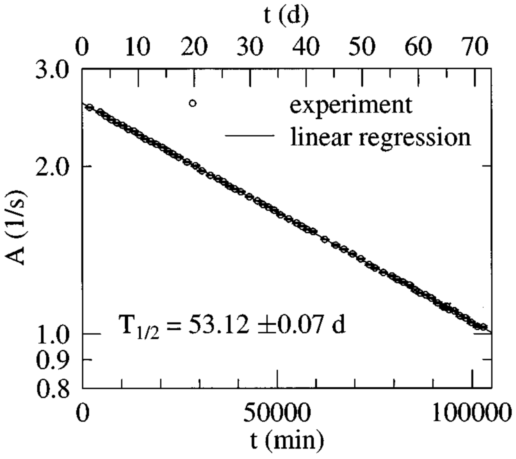

FIG. 2. Activity of the 478 keV γ-ray line from the decay of ^{7}Be.

run was performed without the activated target, and no background peak was observed at the relevant energy (see Fig. 1). Because of the relatively low total count rate ($\approx$20/s) which is only weakly influenced by the decaying ^{7}Be activity [$\approx$(1–2)/s] the dead time of the detector and the data acquisition system can be neglected; additionally, the dead time was monitored by controlling the strength of the natural background peaks.

With this setup we measured 61 runs with durations of $T_d \approx 1$d giving a total measuring time of roughly one half-life. The start and stop times for each run were taken from the time standard signal distributed by the Physikalisch-Technische Bundesanstalt (PTB) in Braunschweig, Germany, via a long wave radio sender. Therefore the uncertainty in time measurements can be neglected.

For each run we determined the activity $A = N_\gamma / T_d$. For the calculation of the half-life the start time T_{start} of each run was shifted by the time $\Delta T = T_d/2$ because of the exponential decay of the activity during one run with duration T_d. The error in the calculation of the half-life using this approximation for ΔT is negligible compared to the statistical error of the calculated half-life.

In Fig. 2, the exponential decrease of the activity A is shown in the dependence of the time $t = T_{\mathrm{start}} + \Delta T$. The result is $T_{1/2} = 53.12 \pm 0.07$ d which is roughly 0.3% (corresponding to twice the uncertainty of the adopted value) shorter than the adopted half-life. The uncertainty of our measurement is given by the uncertainty of the slope of the fitted straight line in Fig. 2. The statistical error ($\approx$0.3%) is dominating the uncertainty in each data point in Fig. 2. Systematic errors like, e.g., errors in the time measurement or dead time effects, can be neglected compared to the statistical error (see above).

Our result is in good agreement with that of Ref. [5] obtained in 1975 with the same accuracy of ± 0.07 d but neither our result nor the result of Ref. [5] confirms the result of Ref. [4] with the quoted high accuracy.

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