Precision Measurement of Transition and Level Energies in ^{233}U

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(Z. Naturforsch. **26 a**, 1092 [1971]; received 16 April 1971)

Gamma ray energies in ^{233}U following the decay of ^{233}Pa were measured with the Risö bent crystal spectrometer. These gamma lines were detected during the study of the $^{232}Th(n,\gamma)^{233}Th$ reaction. Experimental details will be given elsewhere [1]. The energies were calibrated with the X-ray lines [2] and the annihilation line [3]. The energies of seven transitions between 270 and 420 keV were determined with an accuracy which is up to a factor of 10 better than previous measurements by Albridge, Hollander, Gallagher, and Hamilton [4]. The transition energies are shown in the level scheme [4, 5] (Fig. 1). A least squares program was used to fit the level energies to the seven transition energies obtained in this experiment and to four transition energies (below 103 keV) measured precisely by Albridge et al. [4]. Level energies could be calculated with an accuracy of about 20 eV (Fig. 1).

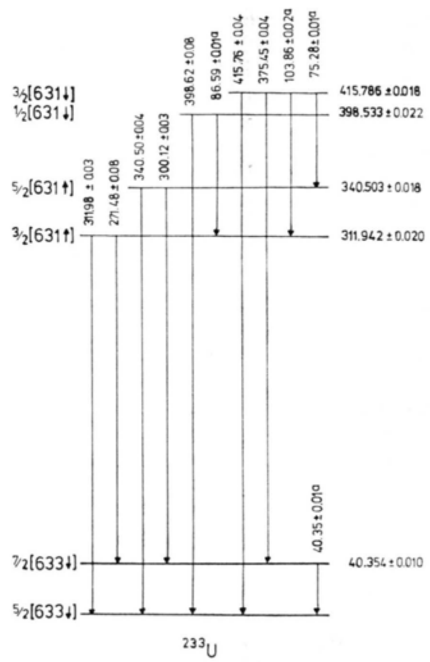

Fig. 1. Level scheme of ^{233}U (Energy in keV; a Energy from Ref. [4]).

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Lifetime of the 23.8 keV state in ^{119}Sn

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(Z. Naturforsch. **26 a**, 1092—1093 [1971]; received 6 April 1971)

The half-life of the 23.8 keV state in ^{119}Sn has been remeasured by conversion electron- and X-ray-γ delayed coincidence techniques. The result is $T_{1/2}=18.45\pm0.2$ ns. The K-conversion coefficient of the 65 keV transition was measured as $\alpha_K=1860\pm150$.

There is a discrepancy in the measurements of the half-life of the Mössbauer level in ^{119}Sn. By X-ray-γ delayed coincidence techniques, using NaI(Tl) detectors, Olsen et al. [1] measured $T_{1/2}=18.5\pm1$ ns, while Lejeune et al. [2] got $T_{1/2}=22.4\pm0.5$ ns by the same technique and $T_{1/2}=23.1\pm0.5$ ns from Mössbauer effect measurements. Lejeune et al. pointed out that small contaminations of the source can influence the measured half-life value. Recently Benczer-Koller and Fink [3] published a remeasurement. Their value for the half-life is $T_{1/2}=17.75\pm0.12$ ns.

In this work, the half-life has been measured using a $BaSnO_3$ source and a Sn-Pd alloy foil source (4.8 mg/cm² Sn-Pd, 18% Sn) with several coincidence circuits. A NaI(Tl) detector and a Ge(Li) detector were used for γ-ray and X-ray detection, and a fast gaseous parallel-plate avalanche counter (PPAC) [4, 5] for the detection of the conversion electrons from the 65 keV

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transition. In this counter a thin aluminized mylar foil was used as one of the electrodes. With the Sn-Pd foil source placed inside the counter-housing at some distance from the foil electrode, the electrons were detected after passing through the foil. By choosing a foil of proper thickness (0.8 mg/cm^2 – with about 20 μg/cm^2 Al) the L-electrons from the 23.8 keV transition could be totally suppressed, and the K-electrons from the 65 keV transition considerably reduced. X-rays and γ-rays from the source could leave the PPAC through a mylar window of 1.6 mg/cm^2.

The results of our measurements are listed in Table 1. A weighted average value for the half-life time is $T_{1/2} = 18.45$ ns $\pm$ 0.2 ns.

Table 1.

source	cascade	detectors	result
Sn-Pd alloy	65 keV-e$^-$ – 24 keV-γ/X-ray	PPAC-NaI	18.5 $\pm$ 0.3 ns
Sn-Pd alloy	65 keV-e$^-$ – 24 keV-γ	PPAC-Ge	18.4 $\pm$ 0.3 ns
$BaSnO_3$	X-ray – 24 keV-γ	NaI-Ge	18.3 $\pm$ 0.8

Fig. 1 shows the decay curve of the 23.8 keV state, obtained by observing delayed coincidences between

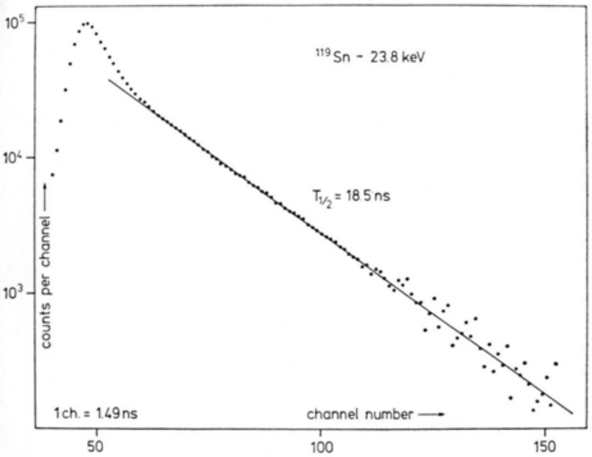

Fig. 1. Decay curve observed with a PPAC detecting the 65 keV conversion electrons and a NaI(Tl) crystal detecting the γ- and X-rays at about 24 keV.

the 65 keV L-conversion electrons and the 24 keV γ-rays. The prompt contribution, due to K-conversion electron-X-ray coincidences, could not be excluded because of the poor energy resolution of the NaI detector, but is well separated from the exponential decay because of the good time resolution of the system (9 ns FWHM). The 23.8 keV γ-rays and the Sn K-X-rays can be resolved using a Ge detector. In this case, only one exponential component is observed in the decay curve (see Fig. 2). A prompt peak, taken with the X-rays, is shown for comparison. There is a small contribution from Pd K_β-X-rays (about 4%) in the energy window of the 23.8 keV γ-line, but this did not produce any considerable prompt peak. Our sources contained several percent ^{125}Sb as contamination, but no contribution from the 1.6 ns half-life of the 35.5 keV state in ^{125}Te was observed in all spectra because of either the sufficiently high energy or time resolution of our systems.

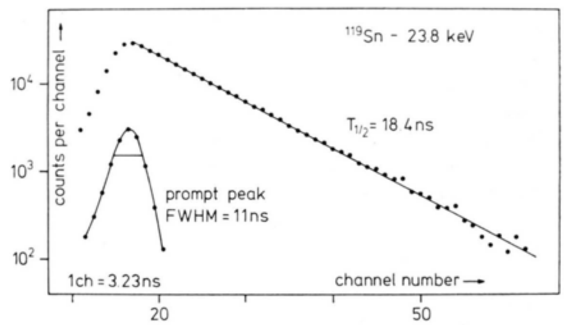

Fig. 2. Decay curve observed with a PPAC detecting the 65 keV conversion electrons and a Ge(Li) detector detecting the 23.8 γ-rays only.

From the intensities of the 65 keV γ-rays and the K-X-rays, measured with the Ge detector, the K-conversion coefficient for the 65 keV transition was estimated to be $\alpha_K = 1860 \pm 150$. The relatively large error results mainly from uncertainties in corrections for source thickness. The measured value is in agreement with the theoretical value of $\alpha_K = 1670$ [6].

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