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INVESTIGATION OF THE 3/2⁻ 770 keV SHORT-LIVED ISOMERIC STATE OF ^{51}Cr EXCITED BY 14.7 MeV FAST NEUTRONS

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The production of the 3/2⁻ 770 keV short-lived isomeric state of ^{51}Cr was investigated in the ^{52}Cr(n, 2n) reaction at 14.7 MeV neutron energy. The measured cross section, combined with that known for the whole (n, 2n) process from other experiments, was used to determine the spin-cut-off factor after deriving the isomeric ratio. The halflife of the 3/2⁻ state was deduced as well.

Introduction

The investigation of the isomeric ratios in fast neutron reactions has proved to be one of the most effective methods to learn about the spin distribution properties of the high energy level densities of nuclei. Accordingly, there exist experimental results for almost all known long-lived $T_{1/2}>$sec levels attainable in fast neutron processes [1].

However, there are many metastable nuclear states of much shorter life-times (down to the nsec range), which can presumably be excited by fast neutrons and whose production rates contain the same theoretical information as their longer lived counterparts. Clearly, all new experimental methods, that make possible to investigate the isomeric states with half-lives shorter than the mentioned range of activities, open new groups of nuclei for the research work [2].

Now we report on a simple experimental arrangement that enables us to investigate the production and deexcitation of isomeric states excited by fast neutrons in the nsec range and on the results of the first measurements with it investigating the ^{52}Cr(n, 2n)^{51}Cr process.

Experimental procedure and results

The isomeric state is presumed to be excited by 14.7 MeV neutrons from the ^{3}H(d, n)^{4}He reaction in the experiments. We used the recoiled alpha particles from the neutron producing reaction to determine the zero of time and

measured the delayed gamma rays from the deexcitation process of the isomeric state.

For the detection of the alpha particles an XP 1020 photomultiplier with a thin NE 102/A foil was used. The gamma rays were detected by a 4×4 cm NaI(Tl) cylindrical scintillator mounted on a photomultiplier of the same type as before. The background from the neutron source was decreased by lead shielding as shown in Fig. 1.

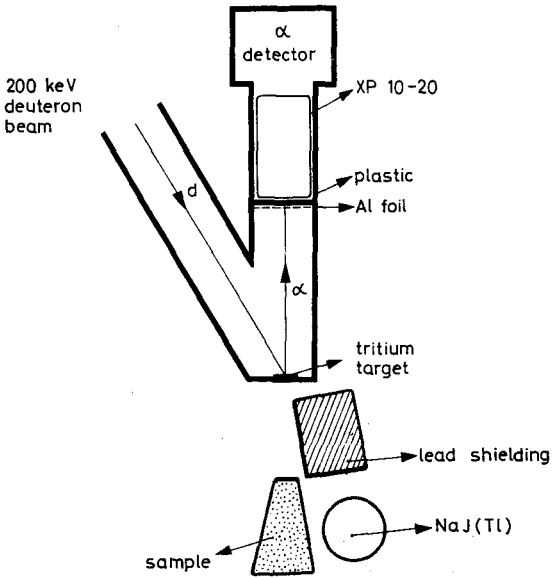

Fig. 1. Target and detector assembly

Fig. 2 shows the block diagram of the electronics. The time resolution of the experimental arrangement was about 2.5 nsec slightly depending on the energy gate of the gamma detector.

In order to testify the suitability of the arrangement for the correct measurement of short-lived activities, we made a control measurement on Fe target of natural composition, which has no known isomeric state in the nsec range over some hundred keV [3]. The time distribution of the signals of the gamma detector could be well fitted by a Gaussian only and no exponential tale of significant amplitude had to be taken into account.

The Cr target was metal powder of natural composition put into a thin-walled truncated cone plastic container, that was placed in the solid angle seen by the alpha detector. The length of the target was chosen to be about one half of the mean free path of the 14.7 MeV neutrons.

The energy gate of the gamma detector was adjusted to get the 770 keV photopeak. The unified efficiency for the NaI(Tl) and the correction for the

gamma attenuation of the target was estimated by careful measurements with known radioactive isotope (^{137}Cs, 662 keV). The energy dependence of the efficiency was taken into account according to [4].

The number of the bombarding neutrons was determined by counting the recoiled alpha particles.

The measured time spectra were decomposed by the method described by [5], assuming that the spectra were essentially the convolution of a Gaussian and an exponential tale.

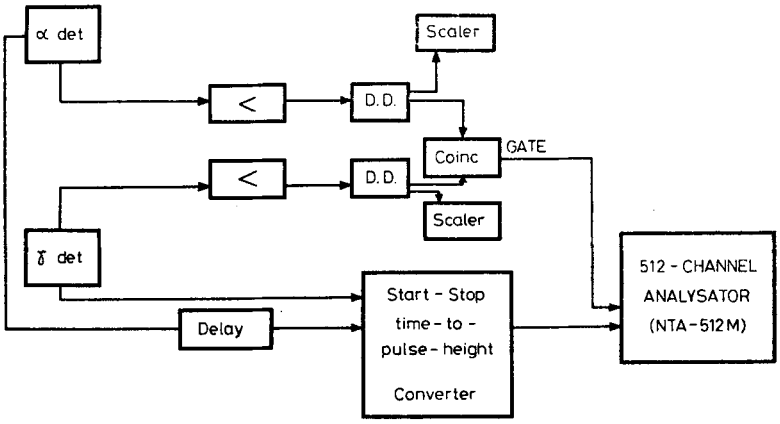

Fig. 2. **Block diagram of the electronics**

The results with their estimated errors from both statistics and from other uncertainties connected with the experimental procedure are collected in Table I.

Table I

The experimental results

Target	σ (mb)	$T_{1/2}$ (nsec)
Cr	61±11	8.3±1.9

Discussion

In order to find the isomeric ratio for the ^{52}Cr$(n, 2n)^{51}$Cr$^{m,g.}$ reaction, the experimental $(n, 2n)$ cross-section for 14.7 MeV was taken from [6].

The excitation of the isomeric state was assumed to perform completely through statistical processes. The extraction of the spin-cut-off parameter was made in the way described in [7], [8]. For the zero spin level density para-

meter a we have applied the value of [9]. The transmission coefficients were taken from [10], the neutron binding energies and the nuclear level spins from [3].

The effect of the high Q value of the $^{52}Cr(n, 2n)$ reaction ($Q = 12.7$ MeV) was taken into account by our method described in [11].

The extracted spin-cut-off factor is $\sigma = 2.3 \pm \frac{1.0}{0.5}$ in agreement with the $\sigma = 2.8$ value of [12].

The value for the ratio of the inertia momentum of the nucleus Θ_P to its rigid-body momentum Θ_R can be extracted from the spin-cut-off parameter:

$$\frac{\Theta_P}{\Theta_R} = 0.29 \pm \frac{0.25}{0.12}.$$

This is in qualitative agreement with the pairing model, which predicts $\Theta_P < \Theta_R$, while the Fermi-gas model predicts Θ_P and Θ_R to be the same in the examined energy region.

The half-life of the $3^-/2$ 770 keV state agrees well with the only other experimental value published so far, $T_{1/2} = 7.56 \pm 0.5$ nsec measured in the $^{48}T_{1/2}(\alpha, n\gamma)$ reaction [13].

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