GAMMA TRANSITIONS IN $^{44}$Ti AND $^{48}$Cr FROM HEAVY ION INDUCED REACTIONS

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Résumé. — Les temps de vie d’états excités du $^{44}$Ti ont été déterminés par la méthode de la distance de recul, dans la réaction $^{32}$S($^{14}$N, pn)$^{44}$Ti. On en a déduit les temps de vie $\tau_m = 5.0 \pm 2.0$ et $1.0 \pm 0.5$ ps pour les niveaux respectivement à $1 083$ keV ($2^-$) et $2 454$ keV ($4^+$). Le premier état excité du $^{48}$Cr a été identifié à $752 \pm 1$ keV, grâce à une expérience de coincidence triple proton-neutron-γ dans la réaction $^{40}$Ca($^{19}$B, pn)$^{44}$Cr.

Abstract. — Lifetimes of excited states in $^{44}$Ti have been determined with the recoil-distance method on the $^{32}$S($^{14}$N, pn)$^{44}$Ti reaction. The mean lives $\tau_m = 5.0 \pm 2.0$ and $1.0 \pm 0.5$ ps have been deduced for the levels at $1 083$ keV ($2^-$) and $2 454$ keV ($4^+$), respectively. The first excited state in $^{48}$Cr has been identified at $752 \pm 1$ keV with a proton-neutron-γ triple coincidence on the $^{40}$Ca($^{19}$B, pn)$^{44}$Cr reaction.

1. Introduction. — Even-Even, $N = Z$ nuclei above $^{40}$Ca($^{44}$Ti, $^{44}$Cr, $^{52}$Fe), are of special interest in connection with the quartet structure in $^{7/2}$ nuclei. However, those nuclei are rather difficult to reach by ordinary reactions. Not much is known, therefore, about their level structure.

We have started a series of investigation on those nuclei by means of gamma spectroscopy via compound nuclear reactions caused by heavy-ion bombardment. Some first results have been obtained for the lifetimes of the lower states in $^{44}$Ti and the position of the first excited state in $^{48}$Cr.

2. The $^{44}$Ti nucleus. — At $E_{14N} = 28$ MeV, i.e. around the Coulomb barrier the reaction $^{32}$S($^{14}$N, pn)$^{44}$Ti has been found stronger than the competing ones $^{32}$S($^{14}$N, 2pn)$^{43}$Sc and $^{32}$S($^{14}$N, 2p)$^{44}$Sc. Therefore, at this energy with a beam current of 10 nA, the measurements of the mean life of the first two excited states in $^{44}$Ti have been undertaken by means of the recoil-distance method.

The measuring set-up is very similar to that one used in ref. [1]. The target consisted in a layer of 0.6 mg/cm$^2$ CdS deposited under vacuum onto 2 mg/cm$^2$ Au foils; the recoiling $^{44}$Ti nuclei were stopped in 4 mg/cm$^2$ Au foil. Both target and stopper were stretched in order to have layers as uniform as possible.

Gamma ray spectra (Fig. 1) have been recorded at target to stopper distances ranging from 5 to 500 μm in steps $\geq 5$ μm with a 50 cm$^3$ Ge(Li) detector placed at 90° to the beam-direction 5 cm from the target.

Both γ-rays belonging to the $2^+$, $4^+$ and $4^+$-$2^+$ transitions [2] in $^{44}$Ti with $E_γ = 1 083$ and 1 371 keV respectively could be analyzed.

The experimental results of the recoil-distance measurements for the $2^+$ state are shown in figure 2. If one subtracts the long lived component (probably due to the feeding of the $2^+$ level from long living excited states) one gets $\tau_m = 5.0 \pm 2.0$ ps for this state.

The deduction of the mean life of the $4^+$ state was complicated by the fact that in the stopped peak, indicated in figure 1 at $E_γ = 1 371$ keV, one has also the contribution from the γ-rays of the first excited state in $^{24}$Mg, $E_γ = 1 368$ keV, populated by the $^{12}$C($^{14}$N, pn)$^{24}$Mg reaction. Therefore, only the flight peak could be analyzed leading to $\tau_m = 1.0\pm 0.5$ ps for the $4^+$ state in $^{44}$Ti.

The transition strengths (in Weisskopf units) of the first $2^+$ states in the even Titanium isotopes known (42 $\leq A \leq 50$) are reported in table I. It seems that the strength of the transition in $^{44}$Ti is about a factor 2 smaller than in $^{46,48}$Ti which may tentatively indicate that collective effects in that nucleus are becoming smaller.

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FIG. 1. — Spectra of γ-rays from CdS target bombarded with 28 MeV 14N ions recorded at several distances (D) between target and stopper. The peak at 1 158 keV belongs to 44Ca (2+→0+) transition populated by β+ decay of 44Sc through the 32S(14N7p)44Sc reaction.

Lifetimes of the first 2+ states in 42Ti, 44Ti, 46Ti, 48Ti, 50Ti,

(*) BROWN (B. A.) et al., Topical Conference on « The Structure of 1 f 7/2 Nuclei » B.3.7.1971, Legnaro (Padova). Italy.


3. The 48Cr nucleus. — Several reactions have been tried in order to populate excited states in 48Cr; namely 40Ca(16O, 2n)48Cr, 40Ca(14N, 2pn)48Cr, 40Ca(12C, α)48Cr, 40Ca(10B, αn)48Cr. This last one has been the most successful with E19b = 25 MeV, i. e. around the Coulomb barrier.

In order to identify unambiguously the first excited state in 48Cr, previously reported [3] at 0.67 MeV, triple coincidences p-n-γ have been performed. Back-scattered protons were detected with an annular Si-surface barrier detector at 180° at 7 mm from the target, neutrons with a liquid scintillator NE 213 (Elron pulse-shape-discrimination system) at 90° and γ-rays with a 50 cm^3 Ge(Li) detector at 0°. The target consisted of a 2 mm thick Ca metal. The results of the coincidences are presented in figure 3; from these and from the data obtained by the other reactions the gamma ray at Eγ = 752 ± 1 keV has been assigned to the decay of the first excited (2+) state in 48Cr.

![Fig. 1. Spectra of γ-rays from CdS target bombarded with 28 MeV 14N ions recorded at several distances (D) between target and stopper.](image1)

![Fig. 2. Results of recoil-distance measurements for the first excited state in 44Ti.](image2)

![Fig. 3. Results of p-n-γ triple coincidence. The peaks at 88, 262 keV are coming from levels in 47V populated through the 40Ca(19B, 2pn)47V reaction, the peak at 752 keV has been assigned to the first excited state in 48Cr.](image3)

References

[1] KUTSCHERA (W.), DEHNHARDT (W.), KISTNER (O. C.), KUMP (P.), POVH (B.) and SANN (H. S.), to be published in Phys. Rev.
