Lifetimes of levels in ^{46}Ti (populated in ^{43}Ca(α,n) reaction)

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Lifetimes of levels in ^{46}Ti

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Abstract. The reaction ^{43}Ca(α, n)^{46}Ti was used to populate levels in ^{46}Ti at α particle energies of 6·5 and 7·5 MeV. Gamma rays in ^{46}Ti were observed in a Ge(Li)–NaI(Tl) escape-suppressed spectrometer. The Doppler shift attenuation method was used to measure the mean lifetimes of 10 levels in ^{46}Ti. The $J^{\pi} = 0^+$ 2·61 MeV level is shown to have an enhanced E2 transition to the first excited 2^+ state.

The importance of ^{46}Ti and its relationship with the cross-conjugate nucleus ^{50}Cr to an understanding of $(f_{7/2})^n$ configurations has often been stressed (Lewis *et al* 1968, Assimakopoulos *et al* 1972) and therefore the need for electromagnetic transition strengths to test the nuclear models is self-evident. A recent experiment (Dehnhardt *et al* 1973) has determined the lifetimes of the $J^{\pi} = 2^+, 4^+, 6^+$ members of the ground state 'quasi-band' using the recoil distance method (RDM). The lifetimes of some other low-lying levels of ^{46}Ti have also been measured by the Doppler shift attenuation method (DSAM) using the ^{46}Ti(p, p′) reaction (Assimakopoulos *et al* 1972).

During a study of the electromagnetic decay properties of ^{46}Sc by means of the ^{43}Ca(α, p) reaction (Dracoulis *et al* 1973a), levels in ^{46}Ti were also populated in the (α, n) reaction. This afforded the opportunity of measuring the lifetimes of levels in ^{46}Ti in a different stopping regime than that used in the DSAM experiment mentioned above. The techniques used to measure the lifetimes have been described by Dracoulis *et al* (1973a, 1973b) and references therein. The measurements were made at α particle bombarding energies of 6·5 and 7·5 MeV. The results of the experiment are shown in table 1. The agreement between the measurements obtained at the two energies is generally good.

In table 2 we summarize the present information on lifetimes of levels in ^{46}Ti. There is seen to be a systematic difference between the values obtained from the ^{46}Ti(p, p′) reaction and our results from the ^{43}Ca(α, n) reaction. This seems to be a common feature of DSA measurements and reveals that our knowledge of stopping mechanisms is still rather limited. This problem has recently been investigated by Broude *et al* (1973) who have observed large variations in lifetimes measured by the DSAM using different stopping media. We may note however that our lifetime for the 3·30 MeV state agrees well with the RDM measurement. Our lifetime for the 3·44 MeV state is in strong disagreement with the RDM value. There are two points to consider concerning this discrepancy. Firstly, our value lies at the limit of the DSAM and consequently may be unreliable, and secondly, Dehnhardt *et al* (1973) comment that their value is derived

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Table 1. Level energies, attenuation factors and lifetimes in ^{46}Ti.

Level energy (keV)†		Transition	F		τ_m(ps)	
		E_α (MeV)	6·5	7·5	6·5	7·5
3	2611·0	3–1	0·82 ± 0·13	0·76 ± 0·03	0·080 ± 0·060	0·110 ± 0·010
4	2961·8	4–1	0·60 ± 0·03	0·56 ± 0·03	0·195 ± 0·020	0·240 ± 0·020
5	3058·6	5–2	0·023 ± 0·005	0·022 ± 0·010	$9{\cdot}6^{+2{\cdot}9}_{-1{\cdot}8}$	$11{\cdot}0^{+9{\cdot}0}_{-3{\cdot}5}$
6	3168·0	6–1	0·57 ± 0·01	0·65 ± 0·03	0·215 ± 0·010	0·180 ± 0·020
7	3235·7	7–1	—	0·91 ± 0·03	—	0·041 ± 0·012
8	3298·8	8–2	0·08 ± 0·01	0·14 ± 0·01	$2{\cdot}7^{+0{\cdot}6}_{-0{\cdot}4}$	1·6 ± 0·2
9	3441·7	9–5	< 0·036	0·016 ± 0·005	> 6	15^{+8}_{-3}
11	3570·5	11–1	0·54 ± 0·04	0·55 ± 0·03	0·24 ± 0·04	0·26 ± 0·03
12	3723·9	12–1	0·80 ± 0·04	0·85 ± 0·02	0·086 ± 0·015	0·070 ± 0·010
15	3845·0	15–1	> 0·84	> 0·92	< 0·07	< 0·035
16	3888 ± 1	16–6	0·31 ± 0·04	0·28 ± 0·17	0·55 ± 0·10	$0{\cdot}70^{+1{\cdot}30}_{-0{\cdot}40}$

† The level energies are determined to ± 0·7 keV unless otherwise indicated.

Table 2. Lifetimes of levels in ^{46}Ti.

Level (MeV)	τ_m (ps) Present work†	Assimakopoulos *et al* (1973) ‡	§	Dehnhardt *et al* (1973)
1 0·89				6·5 ± 0·7
2 2·01				2·6 ± 0·3
3 2·61	0·11 ± 0·03			
4 2·96	0·22 ± 0·06	0·10 ± 0·04	0·07 ± 0·01	
5 3·06	10^{+3}_{-2}	> 0·65		< 83
6 3·17	0·21 ± 0·05	0·100 ± 0·035	0·071 ± 0·012	
7 3·24	0·041 ± 0·015	$0·023^{+0·015}_{-0·009}$	0·019 ± 0·003	
8 3·30	1·6 ± 0·4			1·5 ± 0·7
9 3·44	15^{+10}_{-5}			83 ± 9
10 3·569		0·072 ± 0·030		
11 3·571	0·26 ± 0·06			
12 3·72	0·075 ± 0·020	$0·047^{+0·027}_{-0·019}$	$0·047^{+0·023}_{-0·015}$	
15 3·85	< 0·035	0·013 ± 0·005	0·012 ± 0·004	
16 3·89	0·55 ± 0·15			
17 3·91		0·027 ± 0·010	0·032 ± 0·006	

† A 25% error has been added in quadrature to the statistical errors to take into account the uncertainties in the stopping powers.
‡ From centroid-shift analysis.
§ From lineshape analysis.

assuming that no long-lived state feeds into the 3·44 MeV level. It appears that further work is necessary to resolve this discrepancy.

The present work provides for the first time a value of the lifetime of the 2·61 MeV, $J^\pi = 0_2^+$ state of ^{46}Ti. The measured lifetime of 110 ± 30 fs leads to an E2 strength for the $0_2^+ \rightarrow 2_1^+$ decay of 50 ± 14 Wu. This is a very strong E2 transition which is however similar to the strength of 65 ± 4 Wu for the $0_2^+ \rightarrow 2_1^+$ decay in ^{42}Ca (Endt and van der Leun 1973). This seems to suggest that the 2·61 MeV state has predominantly the structure $(f_{7/2})^4_\pi (f_{7/2})^4_\nu (sd)^{-2}_\pi$ in analogy to the 1·84 MeV state in ^{42}Ca which is predominantly $(f_{7/2})^2_\pi (f_{7/2})^2_\nu (sd)^{-2}_\pi$. The large E2 strength derives from the mixing of the $(f_{7/2})^{n+2} (sd)^{-2}$, $J^\pi = 0^+$ state with the $(f_{7/2})^n$ ground state configuration.

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