centre de recherches nucléaires de Strasbourg

C.R.N.

CRN-PN-75-19

FR7601221

LIFETIME OF THE SECOND EXCITED STATE OF ^{43}K

E. Bozek, C. Gehringer, C. Jaeger
and J.C. Merdinger

Institut National de Physique Nucléaire et de Physique des Particules

Université Louis Pasteur de Strasbourg

67037 STRASBOURG CEDEX FRANCE

Parue dans Nuclear Physics A250 (1975) 257

LIFETIME OF THE SECOND EXCITED STATE OF ^{43}K

E. Bozek*, C. Gehringer, C. Jaeger and J.C. Merdinger

Centre de Recherches Nucléaires
et Université Louis Pasteur, Strasbourg, France

Abstract : The lifetime of the 738 keV level of ^{43}K excited by means of the ^{40}Ar (α, p) ^{43}K reaction has been deduced from the distribution of time delays between protons and the decay γ-rays. The half-life was determined as 205 $\pm$ 10 ns. This result favors a $J^{\pi} = 7/2^{-}$ assignment.

[NUCLEAR REACTION ^{40}Ar $(\alpha, p\gamma)$, E = 11.7 MeV ; measured $E_{\gamma}(\theta)$, pγ delay. ^{43}K 738 keV level deduced mean life.]

* Permanent address : Institute of Nuclear Physics, Cracow, Poland

1. Introduction

Among the low-lying states of odd-A nuclei in the upper half of the s-d shell, states with $J^{\pi} = 7/2^{-}$ have been identified and generally interpreted within the framework of the shell model as f 7/2 single-particle excitations. The γ-decay of these states to the $J^{\pi} = 3/2^{+}$ ground states proceeds via M2/E3 transitions whose partial M2 lifetimes are retarded by about an order of magnitude as compared to single-particle estimates. So the lifetimes of these states are long and typically lie in the nanosecond time range when the energy of the transition is of the order of 1 MeV, as it is the case in ^{41}K for example [1].

The ^{43}K second excited state, lying at 0.74 MeV, is a good candidate for the $J^{\pi} = 7/2^{-}$ state. Santo et al. [2] have shown that the $^{44}Ca(t, \alpha)^{43}K$ reaction populates this state via $\ell_p = 3$ pick-up, implying $J^{\pi} = 5/2^{-}$ or $7/2^{-}$. In the ^{44}Ca (p, d) ^{43}Ca reaction, Martin et al. [3] identified the analogue states corresponding to ^{43}K states and their angular distributions lead also to an $\ell_n = 3$ assignment for the analogue state of the 0.74 MeV state in ^{43}K. Since this level γ-decays to the $J^{\pi} = 3/2^{+}$ ground state [4] the half-lives would be vastly different for the two cases : $5/2^{-} \rightarrow 3/2^{+}$ by E1/M2 and $7/2^{-} \rightarrow 3/2^{+}$ by M2/E3. We report here the results of the half-life measurement of this state.

2. Experimental method

A Doppler-shift attenuation measurement was first performed in order to identify the γ-transitions in ^{43}K which correspond to states with long lifetimes. Proton-gamma coincidence spectra from the reaction $^{40}Ar(\alpha, p\gamma)^{43}K$ were measured at 11.7 MeV bombarding energy using a gas target chamber which permitted detection of the protons from the reaction. Pure (99.99 %) natural argon gas at a pressure of 2 atm retained by a 4 mg/cm^2 gold foil was used. Protons were detected in two identical 500 μm thick surface barrier detectors each placed at an angle of 90° with respect to the incident beam direction. These detectors were covered with 53 mg/cm^2 thick tantalum foils to stop elastically scattered α-particles. The necessity of using two particle counters, whose output signals were summed for both energy and timing channels, arose from the smallness of the coincidence yield. The 84 cm^3 Ge(Li) γ-ray detector could be rotated between $\theta_\gamma = 0^o$ and 90^o at 7 cm from the entrance window of the target chamber.

The lifetime of the 738 keV level was determined by measuring the distribution of time delays between protons feeding this state and the 738 keV decaying γ-rays in a time-to-pulse height conversion system. The same detectors as for the DSA measurement were used both for the protons and the γ-ray detection. Time spectra gated by slow-coincidence energy conditions imposed on both particle detectors and γ-rays were accumulated with 2048 channel detail on the time axis. Kinematic energy spreads did not allow separation of the proton groups and the slow-concidence conditions of the particle detectors were adjusted to accept all the reaction protons while eliminating most of the β-rays originating from the ^{43}K ground-state decay. On the γ-ray side a narrow window was set on the photopeak of the 738 keV γ-ray. In order to measure the system response to a prompt event, another time spectrum was recorded simultaneously for which the γ-ray window was set just on the high-energy side of the 738 keV photopeak. This window corresponded to Compton scatterings from γ-transitions arising from upper states, with lifetimes short compared with the electronic time resolution. The data for the lifetime measurement were taken over about 35 hours of accelerator operation for each of two independent runs.

3. Results and discussion

From the DSA measurement, the excitation energy of the second excited state was determined to be 738.4 $\pm$ 0.5 keV in good agreement with the value found from the radioactive decay of ^{43}Ar [4]. Due to the long slowing-down time of the recoiling nuclei at the gas pressure used, all

γ-lines were full-shifted in the 0° spectrum, except for the line at 738 keV which showed the same energy and shape as in the 90° spectrum. This leads to a lower limit $\tau > 6$ ns for the lifetime of this state, while all other observed ^{43}K levels should have lifetimes shorter than 150 ps.

The experimental decay curve for the 738 keV level, observed in one of the electronic-timing measurements, is shown in fig. 1. From a least-squares fit of a straight line to the logarithmic slope super-imposed on a constant background, half-life values of 199 ± 14 and 211 ± 15 ns were obtained for the two runs. This results in a half-life value of 205 ± 10 ns for the 738 keV level. Statistical and time calibration uncertainties are included in the error limits.

The lifetime result gives strong evidence for a $J^{\pi} = 7/2^{-}$ assignment for the 738 keV level. In fact the M2 strength of this g. s. transition would be 6×10^{-2} W. u., quite close to the corresponding strength for well-identified $7/2^{-} \rightarrow 3/2^{+}$ transitions, whereas the E1 strength of the same transition would be 6×10^{-9} W. u. which is much smaller (by four orders of magnitude) than the weakest E1 transition strength known [5] in this mass region.

References

1) P. M. Endt and C. Van der Leun, Nucl. Phys. A214 (1973) 1

2) R. Santo, R. Stock, J.H. Bjerregaard, O. Hansen, O. Nathan, R. Chapman and S. Hinds, Nucl. Phys. A118 (1968) 409 and A 139 (1969) 711 (erratum)

3) P. Martin, M. Buenerd, Y. Dupont and M. Chabre, Nucl. Phys. A 185 (1972) 465

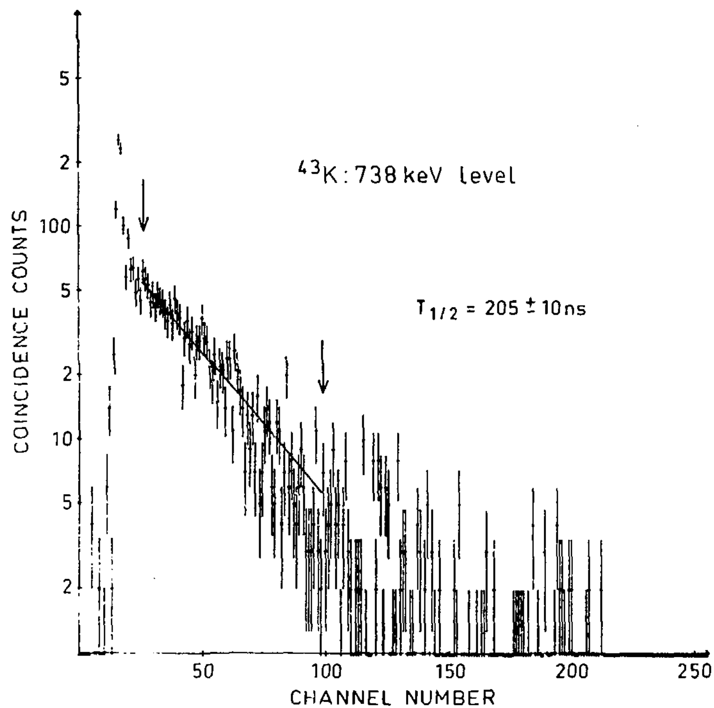
4) J. Hudis, E. Hagebo and P. Patzelt, Nucl. Phys. A 151 (1970) 634

5) P. M. Endt and C. Van der Leun, Nucl. Phys. A 235 (1974) 27

Figure caption

Fig. 1

The experimental decay curve for the 738 keV level in ^{43}K obtained in run 2. A uniform background has been subtracted from these data. Since the proton groups from the $^{40}Ar\ (\alpha, p)\ ^{43}K$ reaction were not resolved, the time spectrum contains a prompt component. The line drawn through the portion of the data between the arrows, illustrates a calculated fit to these data. The time calibration for this distribution is 9.26×10^{-9} sec/channel.



COINCIDENCE COUNTS
5
2
100
5
2
10
5
2
43K: 738 keV level
T1/2 = 205 ± 10ns
50
100
150
200
250
CHANNEL NUMBER