Decay of neutron-rich ^{45}Ar and ^{46}Ar

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The decay of ^{45}Ar and the previously unreported decay of ^{46}Ar have been studied from sources prepared in the ^{48}Ca$(n,2p,2n)^{45}$Ar and ^{48}Ca$(n,2pn)^{46}$Ar reactions. The half-lives of ^{45}Ar and ^{46}Ar were measured to be 20.8 and 8.9 sec, respectively. On the basis of results from γ spectroscopy levels in ^{45}K and ^{46}K are determined. Of 14 γ rays observed in the decay of ^{45}Ar, 13 are placed in a ^{45}K level scheme. The only γ ray observed in ^{46}Ar decay is one from a 1^+ core state in ^{46}K at 1944 keV. The systematics of K nuclei are discussed.

[RADIOACTIVITY ^{45}Ar [from ^{48}Ca$(n,2p2n)$], ^{46}Ar [from ^{48}Ca$(n,2pn)$] medium energy neutrons; measured $T_{1/2}$, E_γ, I_γ; ^{45}K and ^{46}K deduced levels, J, π, logft. Enriched targets, radiochemistry, Ge(Li) detectors.]

I. INTRODUCTION

Much information is available on very neutron-rich nuclei produced by thermal neutron fission, but it is more difficult to devise means for producing and studying neutron-rich nuclei outside the fission region. Such nuclei have been produced[1,2] recently by spallation of suitable targets with fast neutrons. In earlier work[3] a study of relative cross sections for the reactions $(n,2p2n)$, $(n,2pn)$, $(n,2p)$, and $(n,3pn)$ was made using the fast neutron flux generated when the 800-MeV proton beam from the LAMPF (Clinton P. Anderson Meson Physics Facility) accelerator was stopped at the main beam stop in area A. These results indicated that the above reactions could be used to produce very neutron-rich nuclides.

The nuclides ^{45}Ar and ^{46}Ar were observed by Jelley *et al.*[4] as products of the reactions ^{48}Ca$(\alpha,{}^7$Be$)$ ^{45}Ar and ^{48}Ca$(^6$Li$,^8$B$)$ ^{46}Ar. Mass excesses for ^{45}Ar and ^{46}Ar of -29.727 ± 0.06 and -29.732 ± 0.07 MeV, respectively, were measured, but the decay of these nuclides was not observed. We report in this paper the first observation of the decay of ^{46}Ar. Preliminary results from this work were reported[5] at the 1977 Rochester Meeting of the American Physical Society. At the same meeting a report on the decay of ^{46}Ar was also given by a group from CERN.[6]

The nuclide ^{46}Ar is the most neutron-rich $N=28$ isotone known. Its daughter nucleus ^{46}K is of unusual interest since it can be pictured as one proton hole plus one neutron hole in the doubly-magic core nucleus ^{48}Ca. Hopefully the low-lying levels in ^{46}K can be described using the configurations $(\pi d_{3/2},\ \nu f_{7/2})^{-1}$, $(\pi s_{1/2},\ \nu f_{7/2})^{-1}$, and $(\pi d_{5/2},\ \nu f_{7/2})^{-1}$ with the first two dominating. Levels in ^{46}K have been studied by Daehnick and Sherr[7] using the $(p,{}^3$He$)$ reaction and by Daehnick *et al.*[8] using the $(d,\alpha\gamma)$ reaction. These studies revealed six negative parity states with energies up to 1738 keV and J's ranging from 2 to 5. Using Kuo-Brown[9] matrix elements they were able to describe the above states as primarily mixed $(\pi d_{3/2},\ \nu f_{7/2})^{-1}$ and $(\pi s_{1/2},\ \nu f_{7/2})^{-1}$ multiplets. The β^- decay of the 0^+ ground state of ^{46}Ar is not likely to populate any of the above states, so we would expect the β strength to go to higher-lying, low-spin core states.

Prior to our study the decay of ^{45}Ar had been observed only by Tirsell, Multhauf, and Raman,[10] who reported their results at the International Conference on Nuclear Structure and Spectroscopy at Amsterdam. They reported a half-life of 21 ± 1 sec and placed nine γ rays in a level scheme for ^{45}K consisting of seven excited states. This work was recently evaluated in Nuclear Data sheets.[11] Levels in ^{45}K also have been studied by means of the $(d,{}^3$He$)$ (Ref. 12), (t,α) (Ref. 13), and (p,α) (Ref. 11) reactions. The ground state and level at 470 keV are probably the expected $\pi d_{3/2}{}^{-1}$ and $\pi s_{1/2}{}^{-1}$ states, respectively. The character of the higher levels in ^{45}K is not as clear.

II. EXPERIMENTAL METHODS AND RESULTS

In typical irradiations targets were exposed to the neutron flux generated by 800-MeV protons incident on the Cu beam stop for the high-current LAMPF proton beam. Targets were located at 90° to the beam axis and at a distance of about 20 cm from the center of the beam stop. Proton beam currents during irradiation were either 125 or 170 μA depending on the LAMPF target configuration upstream.

Our target consisted of about 50 mg of ^{48}Ca (enriched to 89.8% ^{48}Ca) in the form of Ca stearate. This compound is porous and allows the Ar gas to rapidly diffuse away from the bulk of the target. In typical runs the ^{48}Ca target was sealed in a polyethylene container, placed in a plastic rabbit, and irradiated for an appropriate period. The transit time from the beam stop to the receiving station was typically 15 sec.

In initial runs the gases produced during irradiation were drawn out of the target container with a syringe and counted using a Ge(Li) γ ray detector. A very intense peak at 511 keV from the decay of

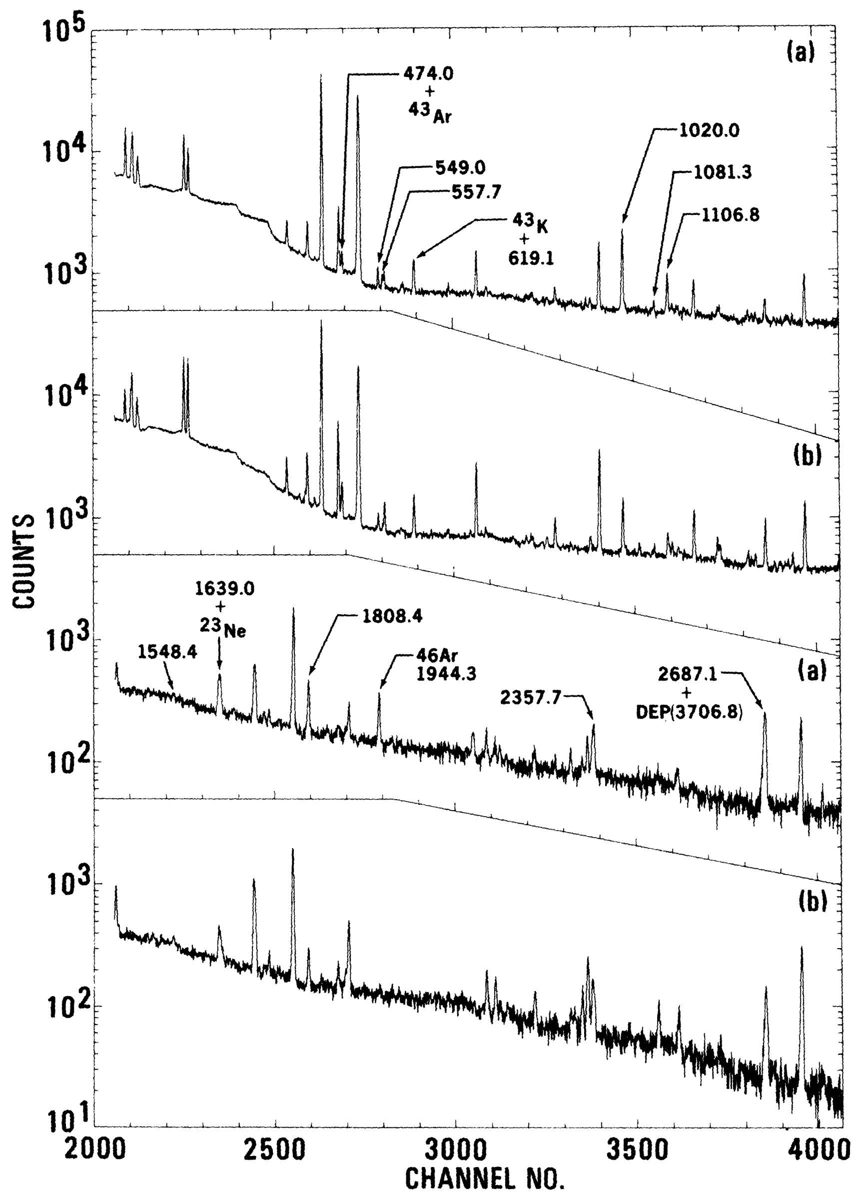

FIG. 1. Spectrum of γ rays from 50 to 2800 keV accompanying the decay of ^{45}Ar and ^{46}Ar. (a) Summed spectra from first and second time bins. (b) Summed spectra from fifth, sixth, and seventh time bins.

^{14}O, ^{15}O, ^{13}N, ^{10}C dominated the γ spectrum and made detection of primary γ rays from short-lived ^{45}Ar and ^{46}Ar impossible; however, γ rays from the decay of longer-lived ^{41}Ar, ^{43}Ar, and ^{44}Ar, and their ^{43}K and ^{44}K daughters were observed. No γ rays from ^{42}K ($T_{1/2}$ = 12.4 h) were seen, and since the production of ^{42}K as a daughter product is blocked by the 33-yr half-life of ^{42}Ar this would indicate that no directly produced K is carried over in the gas transfer.

In the next series of experiments the reaction gases were collected from the ^{48}Ca target 20 sec after the end of irradiation and allowed to decay for 1.5 min. The residual gases were flushed out with compressed air and the containers were counted. γ rays from the daughter isotopes ^{43}K, ^{44}K, ^{45}K, and ^{46}K were observed indicating that our original gas sample contained both ^{45}Ar and ^{46}Ar.

A fast purification procedure was developed to separate Ar from all gases in our sample except the rare gases. After irradiation the ^{48}Ca container was punctured by a hypodermic needle allowing the gases to flow into an evacuated flask resting on top of a Ge(Li) detector. A quartz tube filled with Ti metal heated to 950 °C was placed between the target holder and the flask. The hot Ti acted as a very efficient getter for everything except rare gases. The time from end of irradiation to start of count was typically 18 sec.

In order to obtain good counting statistics for γ rays from ^{45}Ar and ^{46}Ar, a series of 100 irradiations was carried out. Following each irradiation and gas extraction, 10 successive 10-sec γ spectra were accumulated and recorded on magnetic tape with a readout time for each spectrum of 2.1 sec. The spectra for each corresponding 10-sec time bin were subsequently summed vertically over all 100 runs yielding 10 composite spectra for the 10 successive time bins. A γ spectrum covering the energy range 50 to 2800 keV obtained from a horizontal sum of the composite spectra for the first two time bins is shown in Fig. 1(a). Under it in Fig. 1(b) is a later spectrum resulting from the horizontal sum of the fifth, sixth, and seventh time bins. Energies for the γ rays were determined by comparison with secondary standard transitions from the decay of ^{24}Ne, ^{43}Ar, ^{44}Ar, and ^{28}Al in the sample and background. The energies of the secondary standards, the nonlinearity of the system, and the relative efficiency of our Ge(Li) detector were determined using an NBS standard mixed γ source. The peaks were fitted by a least-squares technique using a skewed-Gaussian line shape. The results are summarized in Table I and for the case of ^{45}Ar decay compared with the results of Tirsell *et al.*[10] The γ rays observed in Fig. 1 originated from Ar, K daughters from Ar decay, Ne, and room background. Prominent impurity γ rays are designated in Fig. 1 by isotope, and γ ray energies are also given for peaks from ^{45}Ar and ^{46}Ar decay.

Only one γ ray was attributed to ^{46}Ar decay, namely, the one at 1944 keV. The data from the first four time bins were used to construct a decay curve for ^{46}Ar which is shown in Fig. 2. A value of $T_{1/2} = 8.9 \pm 0.7$ sec was obtained. The 1944-keV peak counts were normalized to the de-

TABLE I. γ rays from ^{45}Ar and ^{46}Ar decay.

Energy (keV) This work	Relative intensity[a] This work	Energy (keV) Ref. 10	Relative intensity Ref. 10	Placement (keV) This work
61.39 ± 0.15	787 ± 150			1081–1020
474.0 ± 0.6	67 ± 45	474.4 ± 0.2	40 ± 2	474–0
549.03 ± 0.15	87 ± 13	549.1 ± 0.2	83 ± 10	2188–1639 2357–1808
557.7 ± 0.4	50 ± 16	557.6 ± 0.2	67 ± 4	1639–1081
619.15 ± 0.2	106 ± 24	619.3 ± 0.2	72 ± 4	1639–1020
1020.05 ± 0.06	1000 ± 67	1020.09 ± 0.08	1000 ± 40	1020–0
1081.3 ± 0.5	86 ± 28			1081–0
1106.85 ± 0.13	339 ± 35	1106.92 ± 0.1	355 ± 14	2188–1081
1548.4 ± 1.7	20 ± 14	1548.7 ± 0.3	92 ± 4	unplaced
1639.0 ± 0.4	266 ± 52	1639.1 ± 0.1	266 ± 10	1639–0
1808.41 ± 0.2	386 ± 44	1808.58 ± 0.08	396 ± 16	1808–0
1944.32 ± 0.19[b]				1944–0[b]
2357.7 ± 0.5	287 ± 40	2357.4 ± 0.2	232 ± 10	2357–0
2687.1 ± 0.7	356 ± 108			3707–1020
3706.8 ± 0.7	860 ± 150	3707.2 ± 0.1	807 ± 40	3707–0

[a]Intensities of γ rays from ^{45}Ar decay normalized to 1000 for the 1020-keV γ ray.
[b]The γ ray at 1944 keV was the only one observed from ^{46}Ar decay.

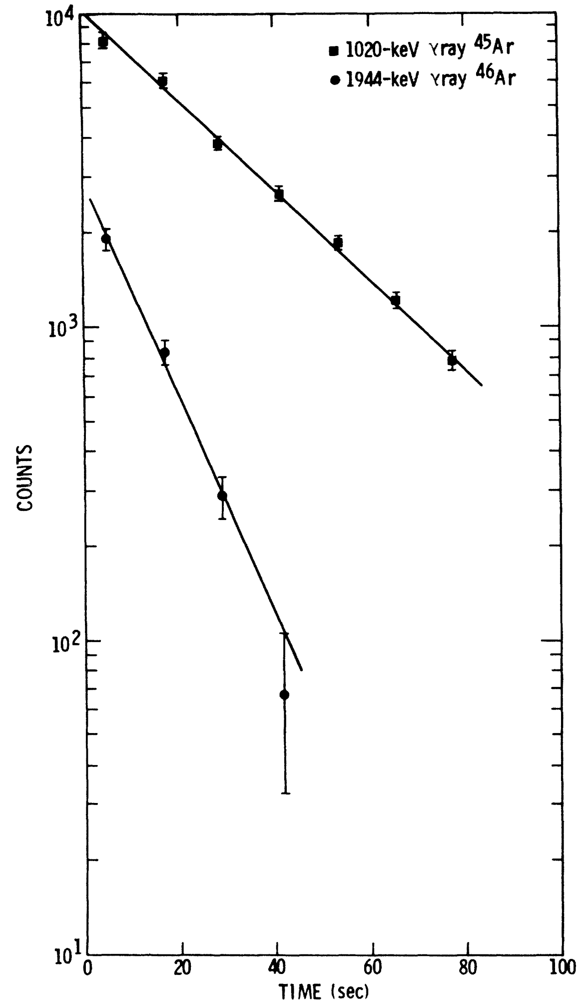

FIG. 2. Decay curves for ^{45}Ar and ^{46}Ar.

cay of the 975-keV γ ray from ^{43}Ar ($T_{1/2}=5.4$ min) in order to correct for changes in the gas concentration at the detector during the early time bins. A total of 14 γ rays were associated with the decay of ^{45}Ar. The decay curve for the 1020-keV γ ray from ^{45}Ar is shown in Fig. 2 and gives a $T_{1/2}$ $=21.0\pm0.6$ sec. A half-life of 20.8 ± 0 5 sec was obtained for ^{45}Ar by using a weighted average of half-lives for γ rays at 61, 1020, 1808, and 2687 + 3707 (DEP) keV. This value is in good agreement with the value of 21 ± 1 sec obtained by Tirsell *et al.*[10]

III. DECAY SCHEMES AND DISCUSSION

A. Decay of ^{46}Ar

The first decay scheme available for ^{46}Ar is shown in Fig. 3. Our value for the ^{46}Ar half-life of 8.9 ± 0.7 sec is in good agreement with the pre-

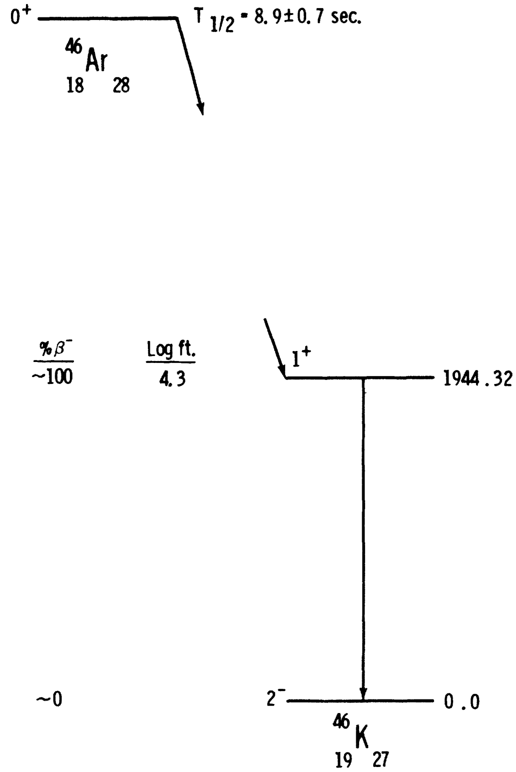

FIG. 3. Decay scheme for ^{46}Ar.

diction of the Gross theory of β decay[14] which gives a half-life range from about 3 to 60 sec. The β feeding to the ^{46}K ground state is assumed to be zero based on a J^π assignment of 2^- for this state. This assignment is consistent with the fact that low-lying states in ^{46}K are $(\pi d_{3/2}, \nu f_{7/2})^{-1}$ or $(\pi s_{1/2}, \nu f_{7/2})^{-1}$ in character, therefore 2^- would be the lowest J^π for the ground state. The one γ ray at 1944 keV observed in ^{46}Ar decay was placed depopulating a 1944-keV level in ^{46}K. Assuming 100% β feeding to this level and using a $Q_\beta=5690\pm70$ keV (Ref. 15) a logft of 4.3 was obtained. The corresponding allowed β transition limits the J^π of the 1944-keV level to 0^+ or 1^+. A $0^+\rightarrow0^+$ β transition is isospin forbidden, thus 0^+ is eliminated. This $J^\pi=1^+$ is consistent with the observation[8] that the 1944-keV level is strongly populated in the ^{48}Ca $(d,\alpha\gamma)$ ^{46}K reaction.

The low-lying states of ^{46}K should be describable in terms of one proton hole and one neutron hole in a doubly-magic ^{48}Ca core. These states should be mostly $(\pi d_{3/2}, \nu f_{7/2})^{-1}$ and $(\pi s_{1/2}, \nu f_{7/2})^{-1}$ in character giving one 2^-, two 3^-, two 4^-, and one 5^- levels. Results from $(d,\alpha\gamma)$ (Ref. 8) and $(p,{}^3\mathrm{He})$ (Ref. 7) reaction studies indicate states at $0(2^-)$, $587(3^-)$, $691(4^-)$, $886(5^-)$, $1370(3^-)$, and $1738(4^-?)$ keV which have been described by calculations[8] using Kuo-Brown matrix elements which include three-hole–one-particle core-polarization corrections. These states were not observed in our decay study since population by β feeding is highly forbidden.

The dominant feature of ^{46}Ar decay is the strong population of a 1^+ level in ^{46}K at 1944 keV by a rather fast allowed β transition . In ^{46}Ar the $f_{7/2}$ neutron shell is just filled. β decay from this shell to a state in the unfilled s-d proton shell in ^{46}K is at least first forbidden but the logft is characteristic of an allowed β transition. Several explanations for this β decay are possible. One is that a $d_{3/2}$ or $s_{1/2}$ neutron β decays to a $d_{3/2}$ or $s_{1/2}$ proton in ^{46}K. This would create a two-hole configuration for ^{46}K but with the neutron hole in the s-d shell rather than the $f_{7/2}$ shell. Another possibility is that the $f_{7/2}$ neutron β decays to an $f_{7/2}$ proton particle state in ^{46}K creating a one-particle–three-hole configuration for the 1944-keV level. Considerations of pairing and Coulomb energy would tend to favor the first explanation but detailed calculations are needed. A similar situation[16] exists for the case of ^{44}K in which a level at 1887 keV with a J^{π} of 1^+ is fed by the bulk of the β strength in the decay of ^{44}Ar and has a logft = 4.0. This level would appear to be similar in structure to the one at 1944 keV in ^{46}K.

B. Decay of ^{45}Ar

The decay scheme for ^{45}Ar obtained in this work is shown in Fig. 4. All but one of the 14 ^{45}Ar γ rays in Table I were placed in the level scheme. Results from Ref. 10 are shown at the right of the

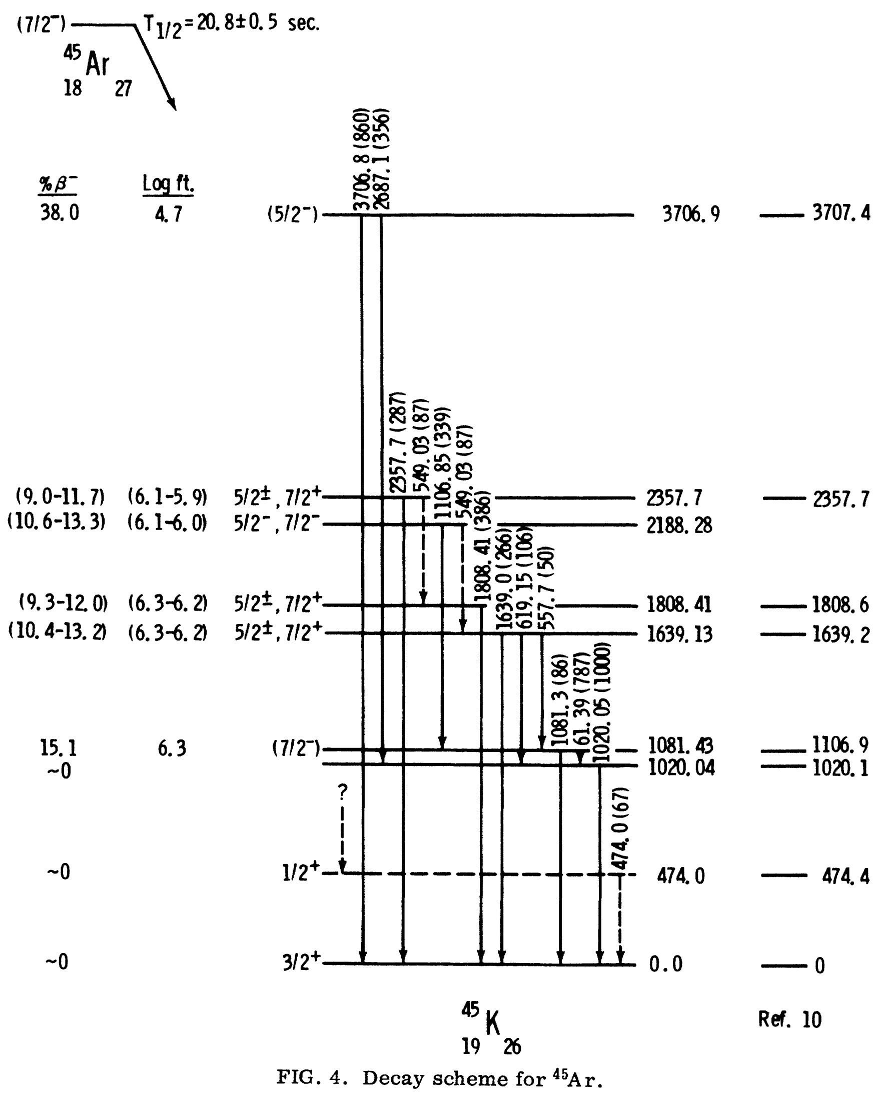

FIG. 4. Decay scheme for ^{45}Ar.

figure. A Q value for ^{45}Ar β decay of 6890 ± 60 keV (Ref. 15) was used in logft calculations. The β feeding to the ^{45}K ground state was assumed to be zero based on the known J^π for the ^{45}K ground state of $\frac{3}{2}^+$ and the assumption that the 27th neutron in ^{45}Ar is in the $f_{7/2}$ state. This latter assumption is consistent with the systematics for other odd A K isotopes. We also assume no β feeding to the 474-keV level. This point is discussed below in more detail. Our value for the ^{45}Ar half-life of 20.8 ± 0.5 sec is larger than the prediction of the Gross theory of β decay[14] which gives a half-life range from 3 to 10 sec.

The 549-keV γ ray, which is indicated by an asterisk in Fig. 4, is placed twice in the level scheme. The intensity indicated is the full intensity of the γ ray. Since this γ ray is probably a doublet it was not used in calculating the ^{45}K level energies. The ranges of % β feeding and logft shown in Fig. 4 were calculated under the extreme assumptions that all of the 549-keV γ ray strength depopulated the 2188-keV or alternatively the 2358-keV levels. The individual levels in ^{45}K are discussed below.

Ground state. The J^π for the ^{45}K ground state is well established[11] to be $\frac{3}{2}^+$ from atomic beam measurements. This level is primarily the $d_{3/2}$ single proton hole state.

474.0 ± 0.6-keV level. This level was observed in (p, α), (Ref. 11) (d,^{3}He) (Ref. 12), and (t, α) (Ref. 13) proton transfer reactions on even-even Ca targets. In each case the transfer was $l = 0$, indicating a J^π of $\frac{1}{2}^+$ and suggesting that this level is primarily a $s_{1/2}$ proton hole state. This J implies negligible direct β feeding to this level. Our evidence for the level is the observation of the 474-keV γ ray which is a very weak member of a γ triplet. This implies that the level is fed by very weak unobserved γ rays from higher levels. We thus included the 474-keV level in our decay scheme. As a consequence the β feeding to other levels adds up to only 98%. The other 2% represents the strength of the 474-keV γ ray and implies β feeding of 2% to unobserved levels in ^{45}K that feed the 474-keV state.

1020.04 ± 0.06-keV level. The level at about 1010 keV observed in the (p, α) (Ref. 11) and (t, α) (Ref. 13) reactions probably corresponds to our level at 1020 keV. No l transfer was given since the (d, ^{3}He) angular distribution was observed to be nonstripping. Contrary to results from previous decay work[10] we observed no β feeding to this level within experimental error. This is due primarily to the observation of feeding by a strong 61-keV γ ray not seen in earlier work.[10] A J of $\frac{5}{2}$ or greater is preferred.

1081.43 ± 0.13-keV level. The major difference between our decay scheme and previous work[10] is the postulation of a level at 1081 keV rather than the one at 1107 keV accepted by Nuclear Data Sheets.[11] We place the 1107-keV γ ray depopulating a level at 2188 keV. The 1081-keV level is justified by the good energy match between the 1081-keV γ ray and the (61 + 1020)-keV cascade, and feeding by both the 558- and 1107-keV γ rays. The level energy is in good agreement with the 1080-keV level seen in both the (t, α) (Ref. 13) and (p, α) (Ref. 11) reactions. A $l = 3$ transfer was observed in (t, α) implying a J^π of $\frac{5}{2}^-$ or $\frac{7}{2}^-$ for the level. Our logf_1t of 8.3 limits J to $\frac{5}{2}$, $\frac{7}{2}$, or $\frac{9}{2}$. Observation of the 1081-keV transition to the $\frac{3}{2}^+$ ground state eliminates $\frac{9}{2}$. We favor $\frac{7}{2}^-$ due to the observation of the strong 61-keV transition depopulating to the 1020-keV level. One would expect the 1081-keV γ ray to dominate if the J^π of the level were $\frac{5}{2}^-$. Our $\frac{7}{2}^-$ assignment is consistent with identification by Santo *et al.*[13] of significant $f_{7/2}$ strength in this level. Similar $\frac{7}{2}^-$ levels have been observed[13] at 1294 keV in ^{41}K and 635 keV in ^{43}K. It is clear that only a part of the $f_{7/2}$ strength is contained in this level since the logft for β decay from the $f_{7/2}$ ^{45}Ar ground state is 6.3 rather than some lower value. [A level at 1417 keV observed in (t, α) work[13] with a J^π of $\frac{1}{2}^+$ was not observed by us, consistent with β decay selection rules.]

1639.13 ± 0.18-keV level. This level is well established by three depopulating γ rays and probably corresponds to a level observed in (p, α) work[11] at 1640 keV. The 558-keV transition (observed but not placed in earlier work[10]) depopulates this level adding further credence to the existence of the level at 1081 keV. A logf_1t of 8.0 limits J to $\frac{5}{2}$, $\frac{7}{2}$, or $\frac{9}{2}$. Strong depopulation to the ground state eliminates $\frac{9}{2}$ and $\frac{7}{2}^-$. The logft suggests a negative parity but is not quite low enough (cutoff is 5.9) to be definitive.

1808.4 ± 0.2-keV level. This level was not observed in reaction studies but was postulated in earlier decay studies.[10] A logf_1t of 8.0 limits J to $\frac{5}{2}$, $\frac{7}{2}$, or $\frac{9}{2}$. The level depopulates only to the ground state, thus $\frac{9}{2}$ and $\frac{7}{2}^-$ are eliminated. Again the low logft mildly favors a negative parity.

2188.18 ± 0.18-keV level. This level was not observed in previous decay work[10] and is based on our placement of the 1107-keV γ ray. It probably corresponds to a level at 2180 keV observed with $l = 3$ in the (p, α) reaction.[11] The $l = 3$ implies a J^π of $\frac{5}{2}^-$ or $\frac{7}{2}^-$. Our logf_1t of 7.8 limits J to $\frac{5}{2}$, $\frac{7}{2}$, or $\frac{9}{2}$ with the low logft suggesting negative parity. The level decays predominately to the ($\frac{7}{2}^-$) level at 1081 but not to the ground state, thus a choice between $\frac{5}{2}^-$ and $\frac{7}{2}^-$ cannot be made.

2357.7 ± 0.5-keV level. The dominant feature of this level is the strong depopulation to the $\frac{3}{2}^+$ ground state. The logf_1t of 7.8 and strong ground state feeding limit the J^π's to $\frac{5}{2}^\pm$ or $\frac{7}{2}^+$. The low logft value mildly favors negative parity.

3706.9 ± 0.6-keV level. Over a third of the total β strength in ^{45}Ar decay goes to this level. The logft of 4.7 limits J^π to $\frac{5}{2}^-$, $\frac{7}{2}^-$, or $\frac{9}{2}^-$. The strong ground state feeding eliminates $\frac{9}{2}^-$ and makes $\frac{7}{2}^-$ ($M2$ transition to ground state) highly unlikely. We thus prefer a $\frac{5}{2}^-$ assignment for this level. A level was observed in the (p,α) reaction[11] at 3690 keV with $l=2$. This would imply a J^π of $\frac{3}{2}^+$ or $\frac{5}{2}^+$; therefore, the level is probably not the same as the one observed in this study. It is interesting that the β strength is so concentrated in this one high-lying state. The low logft could be interpreted in terms of the β decay of the odd $f_{7/2}$ neutron in ^{45}Ar to a $f_{7/2}$ proton in ^{45}K. This level is most likely a one-particle–two-hole proton state with the configuration $(d_{3/2})^{-2}\,(f_{7/2})^1$ or possibly $(d_{3/2})^{-1}\,(s_{1/2})^{-1}\,(f_{7/2})^1$.

C. Comparison of ^{45}K and ^{41}K level structures

The nuclei ^{41}K and ^{45}K are expected to have similar level structures since both have one proton hole in the s-d shell and two neutron particles (holes), respectively, in the $f_{7/2}$ shell. In Fig 5 their level structures are compared up to 2.5 MeV. Levels and J^π's for ^{41}K were obtained from the (n,γ) work of Beckstrand and Shera[17] with inclusion of a level at the 1594 keV from the compilation of Endt and van der Leun.[18] Levels and J^π's for ^{45}K are from this work with inclusions from Nuclear Data Sheets.[11]

Both the ^{41}K and ^{45}K ground states have $J^\pi=\frac{3}{2}^+$ consistent with their interpretation as primarily $d_{3/2}$ proton hole states. The next level for both nuclei has $J^\pi=\frac{1}{2}^+$ and is interpreted as primarily a $s_{1/2}$ proton hole state. The addition of neutron pairs to the singly-magic nucleus ^{39}K has the effect of reducing the energy of the $s_{1/2}$ relative to the $d_{3/2}$ state from 2523 keV at $A=39$ to 474 keV

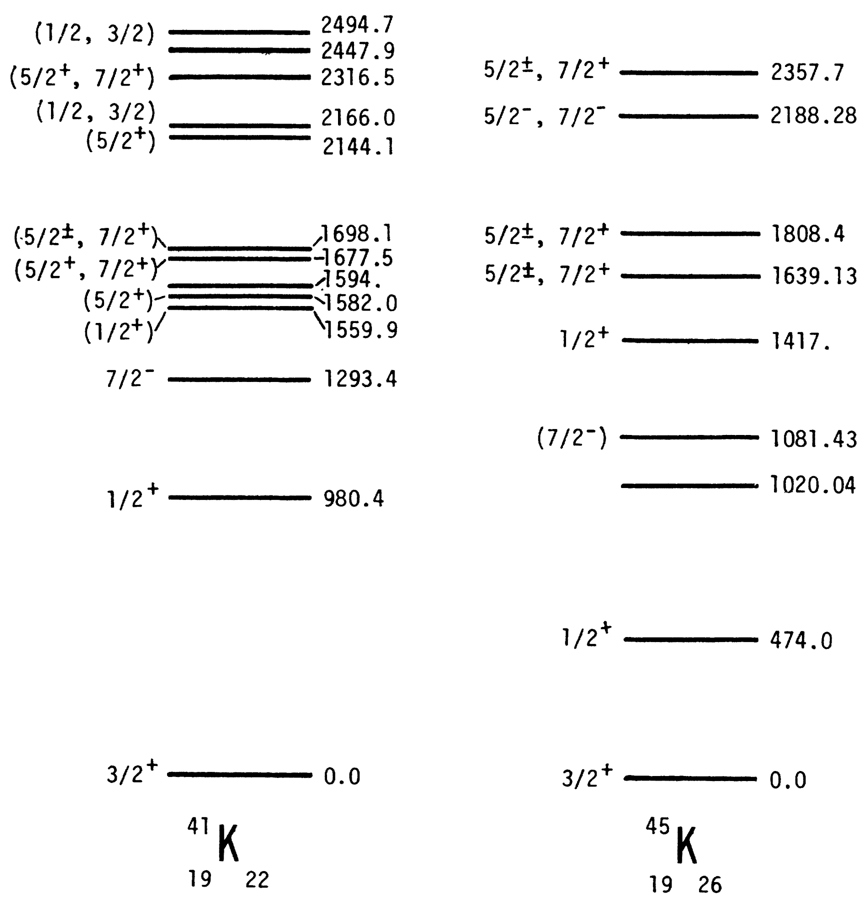

FIG. 5. Comparison of level structures of ^{41}K and ^{45}K.

at $A = 45$. At $A = 47$ the states cross[13] with the $d_{3/2}$ state 359 keV above the $s_{1/2}$ state. The 1293-keV state in ^{41}K has been designated[18] $\frac{7}{2}^-$ and interpreted[17] as resulting from the excitation of the unpaired proton into the $f_{7/2}$ shell resulting in proton configurations of $(d_{3/2})^{-2}$ $(f_{7/2})^1$ with some $(s_{1/2})^{-2}$ $(f_{7/2})^1$ mixing. The $\frac{7}{2}^-$ level in ^{45}K at 1080 keV probably has a similar structure, and a similar state has been observed[13] in ^{43}K at 635 keV. Evidently the addition of a pair of neutron particles (holes) results in a lowering of the excitation energy for the above configurations.

In ^{41}K three states with $J = \frac{5}{2}$ or $\frac{7}{2}$ have been identified[17] between 1.5 and 1.7 MeV. In ^{45}K two states with $J = \frac{5}{2}$ or $\frac{7}{2}$ have been seen by us at 1639 and 1808 keV, and a third state $J > \frac{3}{2}$ was observed in ^{45}K quite low at 1020 keV. Both ^{41}K and ^{45}K have $\frac{1}{2}^+$ states at about 1.5 MeV.[11,17] There is also an energy gap of over 0.35 MeV after the 1698- and 1808-keV levels in ^{41}K, respectively. The structure of ^{41}K and ^{45}K are thus seen to be quite similar with the exception of the state in ^{45}K at 1020 keV.

Positive-parity states in ^{41}K have been interpreted[19] in terms of a pure $\pi(d_{3/2})^{-1}$ $\nu(f_{7/2})^2$ configuration. This description is inadequate but addition of the $\pi(s_{1/2})^{-1}$ $\nu(f_{7/2})^2$ could give some improvement. It would be of interest to perform a similar calculation for ^{45}K using the $\pi(d_{3/2})^{-1}\nu(f_{7/2})^{-2}$ and $\pi(s_{1/2})^{-1}\nu(f_{7/2})^{-2}$ configurations. Our results also suggest the existence of several negative-parity states below 2.5 MeV. These states may result from proton configurations such as $(d_{3/2})^{-2}$ $(f_{7/2})^1$ mixed with $(s_{1/2})^{-2}(f_{7/2})^1$, but again additional calculations on ^{41}K and ^{45}K are needed. In particular, it would be interesting to see if the low-lying state in ^{45}K at 1020 keV could be described.

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