Lower Excited States of Ca^{42}

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Weak gamma rays in the decay of K^{42} were investigated in order to give spin-party assignments for low-lying excited states of Ca^{42}. The second excited state was found to be a 0^+ state from directional correlation measurements and the third excited state has low spin value, probably 2^+. Except for these two states the level sequence seems to be very much like that of Ti^{50} which has a similar configuration of two $f_{\frac{7}{2}}$ nucleons outside of a doubly magic core.

THERE have been many theoretical treatments on the lower energy states of calicium isotopes.[1-3] Detailed experimental information on the lower energy levels of[4] Ca^{41} and of[5-7] Ca^{43} have recently become available for comparison with calculations, but little is known about the characteristics of the lower states of Ca^{42}. The level scheme of Ca^{42}, however, is very important since parameters for two nucleon states around the Ca^{40} core are derived from it.

In order to give spin-parity assignments for states found from nuclear reaction studies,[8] a careful study of weak gamma rays in the decay of K^{42} was undertaken.

Very pure samples of KNO_3 were activated by the JRR-1 reactor at the Japan Atomic Energy Research Institute for producing the K^{42}. Sodium impurities of about 10 ppm were removed after the irradations. The gamma-ray spectra were observed with both a 4 in.×4 in. NaI and a pair of $1\frac{1}{2}$ in. crystals in a coincidence set-up, connected to a 100 channel analyzer. The resolution of the coincidence spectrometer was $2\tau=30$ mμsec. Three weak gamma rays of energies 0.9 Mev, 1.94 Mev, and 2.42 Mev, respectively, were found in addition to the well-known 1.53- and 0.31-Mev gamma rays. The 0.9-Mev and 1.94-Mev gamma rays were found to be coincident with the 1.52-Mev raditions. The relative intensities of gamma rays are tabulated in Table I. The log *ft* values for the beta transitions feeding the states from which these gamma rays originate are also tabulated assuming the decay scheme in Fig. 2.

In order to determine the spin of the second excited state, directional correlation of the 0.31- and 1.53-Mev gamma rays was measured. The result is shown in Fig. 1. Comparison with theoretical correlation functions and the beta-decay selection rules requires this state to be a 0^+ state. This is in contradiction with the previous assignment[9] but in agreement with the suggestion made by Way *et al.* from systematics.[10]

The third excited state at 2.422 Mev must be either 2^+ or 1^+ but the systematics favor the 2^+ assignment. The 3.44-Mev state can be a 2^- or 3^- state and the height of the state is just the height where the lowest odd parity state appears. The 3^- assignment is more likely to be true from the systematics of such states.[11]

The 2.750-Mev state is not observed in this decay and is the lowest state which can be a 4^+ state. Gamma radiation via such a high 4^+ state is probably difficult to observe. Since this energy is too low for an odd parity state and since a 1^+, 2^+, or 3^+ assignment likely requires some beta branching which must be followed

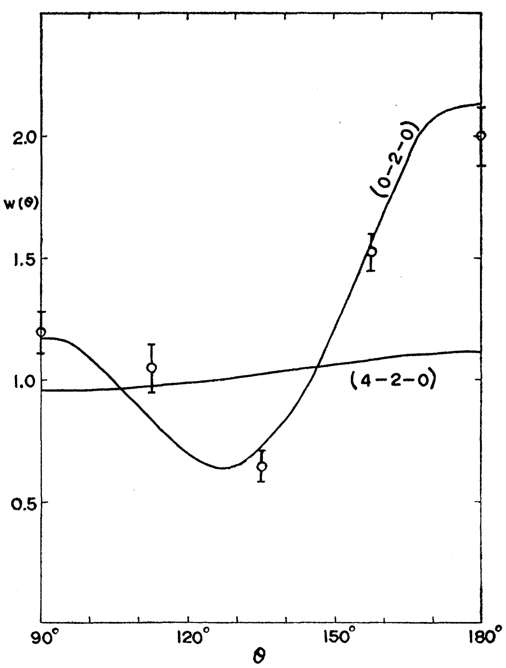

FIG. 1. Directional correlation of 0.31- and 1.52-Mev gamma-rays. Solid lines are theoretical curves corrected for solid angles and the source length.

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TABLE I. Gamma rays in the decay of K^{42}.

$E\gamma$ (in Mev)	Relative intensity	Coincidence with	Initial state	β-ray[a] log ft	Spin assignment
		(Ground-state beta decay)		8.4[b]	0^+
1.52	100		1.523		2^+
0.31	1	1.52	1.836	9.3[b]	0^+
2.42	0.2		2.422	8.7	$2^+(1^+)$
0.9	0.3	1.52	2.422		
1.94	0.3	1.52	3.44	5.5	$3^-(2^-)$

[a] Decay scheme in Fig. 2 was assumed and a beta-ray branching of 18% to the 1.523-Mev level and a decay energy of 3.545 Mev was adopted.
[b] log f_1t instead of log ft.

by gamma rays, the most likely spin-parity assignment for this level is either 4^+ or 0^+. Assignment of a very high spin value would be also unrealistic.

It is interesting to compare the level sequence of Ca^{42} with the levels in Ti^{50}. The level scheme obtained from (d,p) reaction data and the decay[12] of Sc^{50} is shown in Fig. 2 together with the level scheme of Ca^{42} with present spin-parity assignments. The latter is expected to show a sequence corresponding to a configuration due to the Ca^{40} doubly magic core plus two $f_{\frac{7}{2}}$ neutrons and the former a configuration due to the Ca^{48} doubly magic core plus two $f_{\frac{7}{2}}$ protons. There is a striking similarity between these sequences if the 2.750-Mev level in Ca^{42} is actually a 4^+ state, except for the 0^+ and 2^+ states at 1.836 Mev and 2.422 Mev. These additional states may be understood as due to the core excitation since the assumption of core excitation is also required for explaining the existence of many low-lying, nonsingle particle states in Ca^{41}. There does not seem to be a parallel situation in the case of the Ca^{48} core although the experimental evidence is not so certain yet.

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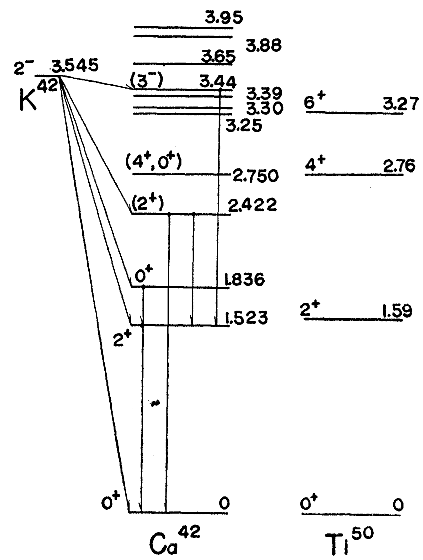

FIG. 2. Decay scheme of K^{42} and levels in Ca^{42} and Ti^{50}.

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