ENERGY LEVELS OF Mg^{26} FROM THE DECAY OF Al^{26}

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ABSTRACT

Gamma-rays accompanying the decay of long-lived Al^{26} have been studied by means of coincidence scintillation spectrometry. A level scheme for Mg^{26} has been proposed in essential agreement with earlier results.

1. INTRODUCTION

THE low-lying levels of Mg^{26} are of interest since Mg^{24} is known to have a rotational spectrum and Mg^{26} probably lies in the region of transition toward vibrational type of spectrum. One might then expect to find 2^+ and 4^+ levels around 3·6 Mev. which is approximately twice the energy of the first excited state (2^+) at 1·85 Mev. Since there is known to exist a level at 2·97 Mev., which is probably a 2^+ level, judging from its decay mode, it seemed worthwhile to look for a 4^+ level around 3·6–3·8 Mev. The Al^{26}—Mg^{26} decay energy is about 4 Mev. Hence, there is plenty of energy available for electron capture to a 4^+ level. In particular, since the spin of Al^{26} is probably 5^+, allowed decay to 4^+ excited state may even be preferred to decay to low-lying low-spin states *via* forbidden transitions. In fact, a reported gamma-ray of 0·707 Mev. might well represent a transition between the 2^+ and 4^+ levels. Therefore, a careful study of the gamma-spectrum following the decay of long-lived Al^{26} (obtained from Nuclear Science and Engineering Corp., Pittsburgh) was undertaken.

2. EXPERIMENTAL RESULTS

Figure 1 shows a single gamma-ray spectrum measured in a heavily shielded 1″×2″ NaI counter. Only well-known gamma-rays at 1·12, 1·85 and 2·95 Mev. are seen to be present. A careful search was made (both in singles and coincidence spectra) for additional gamma-rays, in particular for the reported 0·707 Mev. gamma-ray. In this search, the low-energy region was scanned by NaI counter covered by a thin Al-window. The results were, however, negative.

Recent experiments of Dearnaley and Ferguson[1] have pointed to the existence of a first excited state in Mg^{26} at $1 \cdot 33 \pm 0 \cdot 02$ Mev., contrary to earlier results which have placed the first exicted state at $1 \cdot 84$ Mev.[2] A special search was made for this reported state, by looking for coincidences between annihilation radiation and a $0 \cdot 51$ Mev. gamma-ray which might possibly connect the $1 \cdot 33$ and $1 \cdot 84$ Mev. levels. Two scintillation counters placed at right angles to each other were used. An upper limit of $1 \cdot 0 \times 10^{-3}$ for the number of photons per $1 \cdot 84$ Mev. gamma-ray could be set.

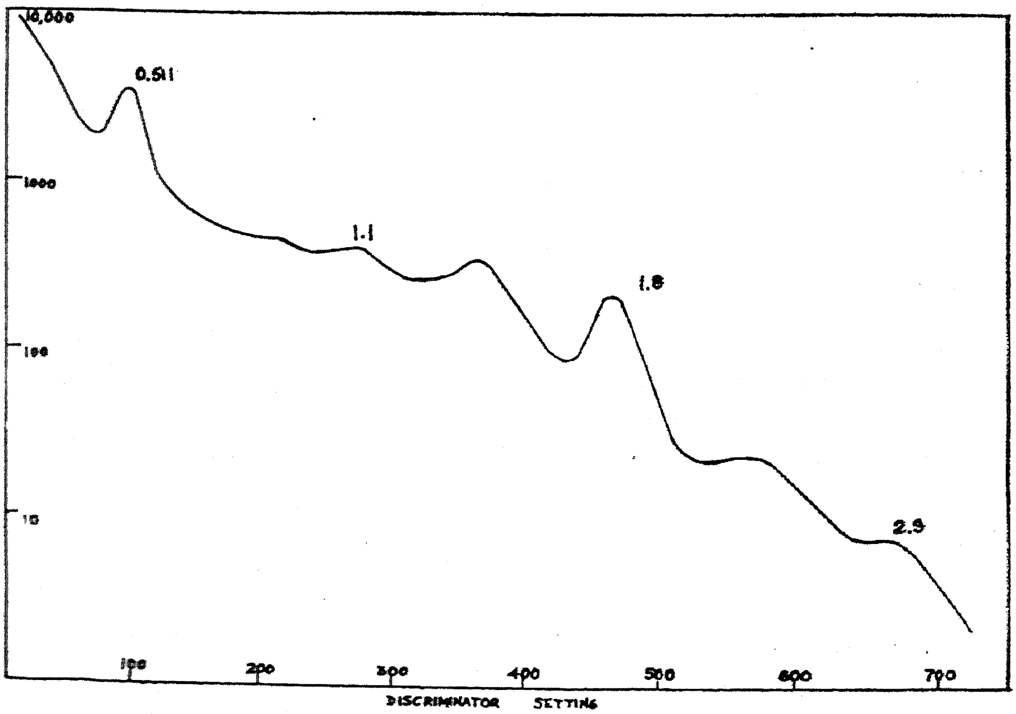

Fig. 1. Al^{26} Singles gamma spectrum in shielded NaI counter

Table I gives the various coincidences observed. The crosses represent positive results.

Table II lists the various gamma-rays and their relative intensities.

From the relative intensity data, one infers a (capture/positron) ratio of about $0 \cdot 11$ to the $1 \cdot 84$ Mev. level. For an allowed transition this ratio is $0 \cdot 01$ and for a unique second-forbidden transition it is approximately given by the relation:

$$\left[\frac{\text{Capture}}{\text{Positron}}\right]_{\text{unique}} \simeq \left[\frac{2\,(W_0 + 1)}{W_0 - 1}\right]^2 \left(\frac{\text{Capture}}{\text{Positron}}\right)_{\text{allowed}} .$$

Here W_0 is the transition energy in m_0c^2 units. The computed ratio is 0·13 in reasonable agreement with the measured value of 0·11. This is also consistent with the $\triangle J = 3$. No shape inferred from the positron spectrum. Besides, the calculated *log ft* value of 13·7 is consistent with the value found for other similar transitions.

TABLE I

Al^{26} Coincidences

γ-rays	0·51 (annihilation)	1·1	1·8	2·9
0·51 (annihilation)	X	..	X	..
1·1	..	..	X	..
1·8	X	X	..	..
2·9	..	..	..	..

TABLE II

Relative gamma-ray intensities

Energy of γ-ray (Mev.)	Relative Intensity
0·7	<1
1·1	5
1·33	<0·1
1·8	100
2·9	06

3. DISCUSSION

The fact that no 0·707 Mev. gamma-ray was observed agrees with the results of Ferguson.[3] The negative result in the search for 1·33 Mev. level reported by Dearnaley and Ferguson[1] implies that the level if at all it exists must be 0^+. However, other arguments can be advanced which make the presence of a 0^+ first excited state in Mg^{26} very unlikely.

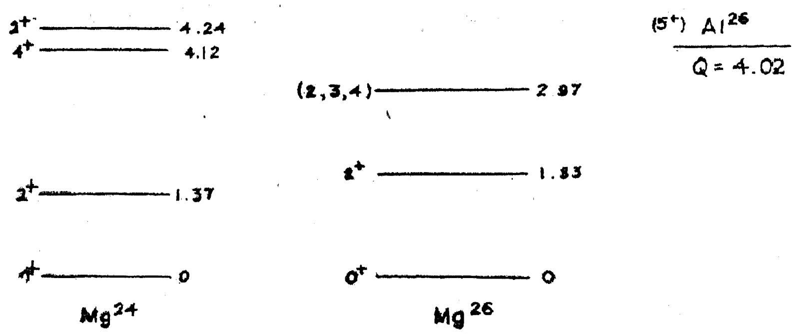

FIG. 2. Level Schemes of Mg^{24} and Mg^{26}

The level scheme for Mg^{26} resulting from the present work is shown in Fig. 2 together with that of the neighbour, Mg^{24}.

The spin of the 2·95 Mev. level may be 1, 2 or 3. One can rule out a choice of 1^+ since the electron capture from the $5^+ Al^{26}$ would be highly forbidden and the decay would not be observed. Among the remaining possibilities, 2^+ is to be preferred over 3^+ because of the cross-over intensity. However, if the spin is 3^-, then no such preference can be justified. Directional correlation studies on the 1·84–1·1 Mev. gamma-cascade can give a more definitive answer for the spin assignment. It would also be interesting to measure the conversion coefficient of the 1·1 Mev. transition. Preliminary angular correlation studies on the above-mentioned cascade have so far been inconclusive due to poor counting statistics. A long-term experiment (which is planned) may hopefully give an unambiguous answer.

4. ACKNOWLEDGMENT

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