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LETTER TO THE EDITOR

Gamma-rays from proton capture in ^{26}Mg.

Gamma-rays produced by the resonance capture of 454 kev protons in natural magnesium have been investigated with a scintillation spectrometer. This resonance has been assigned to the reaction $^{26}Mg(p, \gamma)$ ^{27}Al by Tangen [1]), as the final nucleus emits no positrons. The resonant energy has been determined most accurately by Hunt and Jones [2]) as 454.2 ± 0.3 kev. Natural magnesium exhibits many resonances [1]) [2]) in the low energy region, of which the 454 kev resonance is the most prominent one. Gamma-rays of energy $E\gamma = 4.9$ and 6.2 Mev have been found from this resonance by Russell et al. [3]) with an aluminum absorption method. The only scintillation spectrometer investigation of this reaction has been made by Casson [4]) at the 338 and 314 kev resonances. At $E_p = 338$ kev γ-rays of $E\gamma = 2.83 \pm 0.14$ and 5.80 ± 0.25 Mev and at 314 kev a γ-ray of $E\gamma = 4.2 \pm 0.2$ Mev are observed.

The protons in the present experiment were supplied by the 700 kev cascade generator of this laboratory and a beam current of 2 — 4 μA (after magnetic analysis) was commonly used. Thin (50 — 100 μ g/cm^2) layers of natural magnesium on copper disks were used as targets. As the target was mounted on the wall of the vacuum tube, the scintillating crystal could be placed within 1 cm from the target. The scintillation spectrometer used was of conventional type and consisted of a $2 \times 2 \times 3$ cm^3 NaI (Tl) crystal with MgO reflector, an E.M.I. 6260 photomultiplier tube, a linear amplifier, both a one-channel differential discriminator and an ordinary discriminator, scalers and mechanical counters.

The pulse-spectrum was measured by setting the ordinary discriminator on a ixed voltage corresponding to about 1 Mev and counting the number of pulses in each 2 V channel of the differential discriminator for a constant number of pulses of the ordinary discriminator, which thus functions as a monitor. In this way fluctuations of the beam-current, proton-energy and target composition have no influence on the pulse-spectrum. Before and/or after each run a calibration of pulse-height versus energy was made. Usually the 1.28 Mev photopeak from Na^{22} and the pair-peak from $^{19}F(p, a\gamma)^{16}O$ at 5.11 Mev were used to this purpose. Occasionally also use was made of the photo- and pair-peaks of $E\gamma = 2.37$ Mev. from $^{12}C(p, \gamma)^{13}N$. A small correction had to be made for the influence of the stray magnetic field of the analyzing magnet on the electron collection in the photomultiplier. The slit system had to be cleaned regularly to avoid γ-rays from capture in ^{12}C of carbon deposits.

Owing to the low yield of γ-rays from this reaction (a rough estimate of the thick target yield is 1 disintegration per 2×10^{10} protons) the statistics in each of our twelve runs are rather poor. Moreover, it is difficult to add the results from different runs as the voltage energy scale was not always the same. However, most of the peaks given in Table I were present, whenever their energy regions were investigated and are therefore considered to be reliable. Typical pulse-spectra are given in Fig. 1.

The interpretation of a pulse spectrum in terms of γ-ray energies is a rather intricate affair in the energy region of our concern viz. 0.5 — 9 Mev. Information about the relative heights of photo-, Compton-, pair + 0.51 Mev, and pair-peak at various energies may be derived from the pulse spectra of the same γ-rays as used in the energy calibration. On this basis the various peaks are attributed to 9 different γ-rays as shown in Table I. The data however was insufficient to permit an

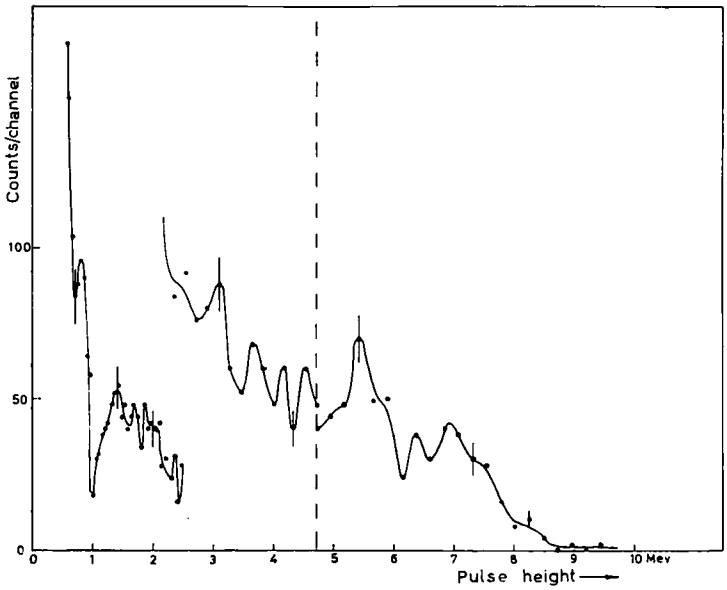

Fig. 1. The ^{26}Mg(p, γ) ^{27}Al gamma-spectrum at the 454 kev resonance. Three runs on different parts of the pulse spectrum (with different amplifier gains) are combined in this figure. The number of counts per channel is given in arbitary units, but the statistics are indicated. It is to be noted, that the pulse heights in Table I are deduced from the average of all runs, and not only from the runs in this Figure.

TABLE I

Gamma-rays deduced from observed peaks in the pulse spectrum				
γ-ray	pair- peak	pair-peak + 0.51 Mev	photo-peak	$E\gamma$
γ_1			0.81	0.81 ± 0.05
γ_2	1.30	(1.79)		(2.28 ± 0.10)
γ_3	1.79	2.33		2.80 ± 0.10
γ_4	3.08	(3.58)		(4.10 ± 0.15)
γ_5	3.58	4.16		(4.58 ± 0.15)
γ_6	4.72	5.13		5.74 ± 0.15
γ_7	5.57	6.05		6.54 ± 0.20
γ_8	6.84			7.86 ± 0.20
γ_9	7.57	8.29		8.70 ± 0.20

estimation of relative intensities. As the Q-value of the reaction ^{26}Mg(p, γ) ^{27}Al is 8.26 Mev [6]), the total excitation energy of the capture level is $8.26 + {}^{26}/_{27} \times 0.454 = 8.70$ Mev. The γ_9 corresponds thus to the direct transition to the ground state. As $E\gamma_1 + E\gamma_8 = 8.67$ Mev, $E\gamma_2 + E\gamma_7 = 8.82$ Mev, $E\gamma_3 + E\gamma_6 = 8.54$ Mev and $E\gamma_4 + E\gamma_5 = 8.68$ Mev, all these sums agree within the limits of error with the total disintegration energy and it is tempting to ascribe them to cascades from the capturing state through respectively the 0.84, 2.21, 2.74 and either the 4.06 or 4.58 Mev level to the ground state (Fig. 2). The levels quoted above have been determined most accurately from the ^{27}Al(p, p') ^{27}Al reaction by Z i m m e r m a n and B r o w n e [5]). Their values agree reasonably well with less precise earlier measurements [6]). Although γ_6 would fit better a transition to the 3.00 Mev level, the presence of the 2.80 Mev γ-ray renders a cascade through the 2.74 Mev level more probable.

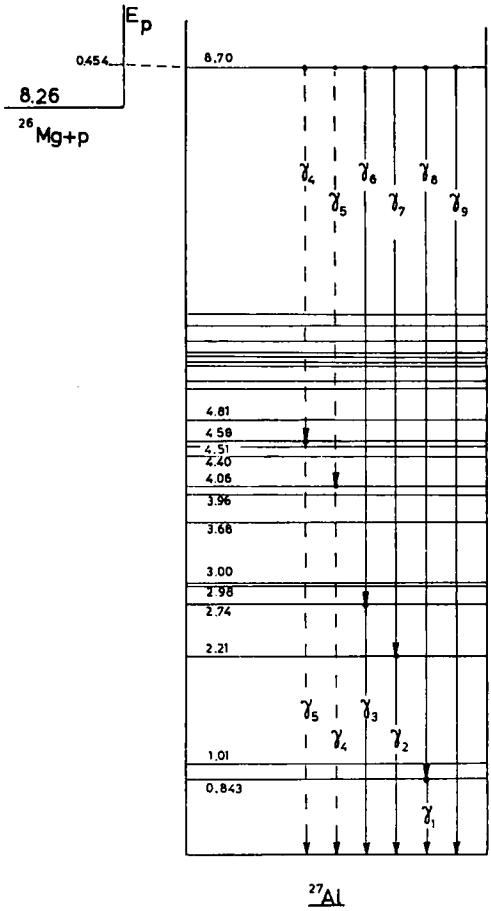

Fig. 2. Energy level diagram of ^{27}Al showing the transitions assigned to the observed γ-rays. Excitation energies are obtained from Zimmerman and Browne [5]).

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