Letters to the Editor

GAMMA RAYS FROM A Po-O^{18} *NEUTRON SOURCE*

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In a previous paper[1] it has been shown that in a Po-O neutron source the (α, n) reaction operates on the isotope O^{18}. The neutrons yielded by the reaction $O^{18}(\alpha, n)Ne^{21}$ are accompanied by 0.35 Mev γ rays with a relative intensity of $30 \pm 10\%$.

A neutron source of 120,000 n/sec intensity was used in the present measurements. The source was a solution of Po^{210} nitrate in water enriched with O^{18} to 24%. A single-crystal scintillation spectrometer and n-γ and γ-γ coincidence circuits were used to investigate the gamma spectra. A 40×40 mm crystal of NaI(Tl) was used in the spectrometer. The resolution of the Cs^{137} γ line was 12%.

Figure 1 shows the γ spectrum of Po-O^{18}, taken up to 1.6 Mev. The 0.35-Mev γ line corresponds[2] to the first excited level of Ne^{21}. The 1.38-Mev γ line corresponds to the transition from the second excited level to the first excited level. The 0.803-Mev γ line accompanies the decay of Po^{210}.

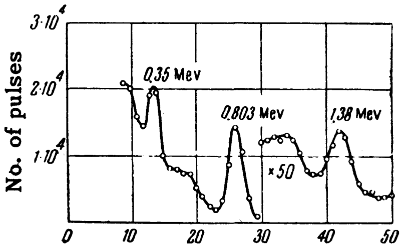

FIG. 1. Gamma spectrum of Po-O^{18} source.

The Po-O^{18} spectrum contains a certain number of pulses with energies up to 2.8 Mev. Some of these are evidently due to neutrons registered by the NaI(Tl) crystal. Others are possibly due to hard γ rays which could not be detected in the course of these measurements because of low intensity.

The intensities of the 0.35-Mev and 1.38-Mev γ lines were determined from the areas under the full energy peaks (photopeaks). The crystal counting efficiency and the ratio of the area under a photopeak to that under the entire spectral curve were taken from other references.[3,4]

The intensity of the 0.35-Mev line, relative to the neutron yield, was found to be $45 \pm 5\%$. To determine this particular intensity, the gamma spectrum was measured separately, at a high amplification factor. The intensity of the 1.38-Mev line was $10 \pm 2\%$. Upper limits for the relative intensities of the 1.73-Mev γ line (direct transition from the second level of Ne^{21} to the ground level) and of the 2.84-Mev line (direct transition from the third level) were determined from the complete gamma spectrum of the Po-O^{18} source. The upper limit was 1% for the 1.73 Mev line and 2% for the 2.84 Mev line.

To verify the results obtained with the single-crystal spectrometer, the Po-O^{18} γ spectrum was measured with the use of neutron coincidences. A tolane crystal with 20 mm of lead shielding was used to count the neutrons. The coincidence circuit had a resolving time of 6×10^{-9} seconds.

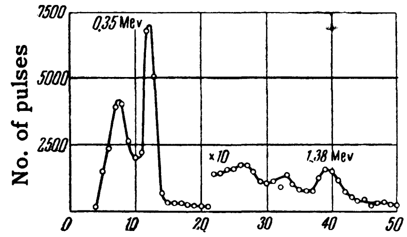

FIG. 2. Gamma spectrum of Po-O^{18} source, taken with neutron coincidence.

Figure 2 shows the γ-ray spectrum taken with neutron coincidence. The 0.35- and 1.38-Mev lines are also seen here. The sharp Compton-scattering cutoff of the 0.35-Mev line is associated with the sensitivity threshold of the coincidence circuit. The presence of the 1.38 — 0.35 Mev cascade transition was also confirmed by γ-γ coincidence measurements.

Thus, it is possible to establish from these $O^{18}(\alpha, n)Ne^{21}$ γ-ray measurements that the decay of the intermediate nucleus Ne^{22} proceeds 55% to the ground level of Ne^{21}, 35% to the first excited level, and 10% to the second excited level. The Ne^{21} nucleus undergoes transition from the second excited level at 1.73 Mev to the ground state by γ cascade, releasing 1.38-Mev and 0.35-Mev γ rays. The probability of direct transition is at least tenfold smaller.

[1] Serdyukova, Khabakhpashev, and Tsenter, Izv. Akad. Nauk SSR, Ser. Fiz. 21, 1017 (1957), Columbia Tech. Transl. p. 1018.

[2] F. Ajzenberg and T. Lauritsen, Revs. Modern Phys. 27, 77 (1955).

[3] Miller, Reynolds, and Snow, Rev. Sci. Instr. **28**, 717 (1957).

[4] A. Stanford and W. Rivers, Rev. Sci. Instr. **29**, 406 (1958).

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219

ON THE ROTATIONAL LEVELS OF Li^7

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THE conjecture that structural subgroups consisting of two, three, and four nucleons can be formed within light nuclei has been made by many authors.[1-4] In references 5 and 6, the disintegration of Li^7 into an α particle and a triton as a result of Coulomb excitation and of scattering of a heavy nucleus has been treated in terms of the α-triton model. One can easily see that such a model will lead to rotational levels in Li^7. The axis of symmetry will be given by the line connecting the centers of mass of the α particle and of the triton while the axis of rotation will be perpendicular to the symmetry axis and will go through the center of mass of the system.

Recently Blair and Henley[7] have shown that several levels of Be can be interpreted as rotational states if this nucleus is visualized as consisting of two separate α particles oscillating along an axis connecting their centers of gravity. In the present paper it will be shown that one can also interpret some levels of Li^7 as having rotational character if one assumes the α-triton model.

As is well known, the ground-state spin of Li^7 differs from zero ($J_0 = 3/2$). Taking further into account that the present model has just an axis of symmetry (not a center of symmetry) one deduces that the rotational spectrum will have angular momenta $J = J_0,\ J_0 + 1,\ J_0 + 2, \ldots$ while the parities will coincide with the ground-state parity ($3/2^-$). The energies of the levels are given by the expression

$$E_J = (\hbar^2/2I)]\, J(J+1) - J_0(J_0+1)], \qquad I = \mu\overline{r^2}, \qquad (1)$$

where μ is the reduced mass of the $(\alpha + t)$ system, and r is the distance between α and t. It follows from (1) that the ratios of the excitation energies of the rotational levels are

$$E_{5/2} : E_{7/2} : E_{9/2} \ldots = 1 : 2.40 : 4.20 \ldots$$

Amongst the levels of Li^7 there exists[8] one 7.46-Mev level with spin $5/2^-$. Taking this to be the first rotational level, we see that the 17.5-Mev level can be assumed to be the next rotational level with spin $7/2^-$ since the experimental ratio 2.35 of the energies is close enough to the theoretical ratio 2.40.

To verify our treatment we must obtain the right value for the energy of the first level, viz. 7.46 Mev. To that end we utilize the rms value 2.71×10^{-13} cm obtained by Hofstadter[9] for the charge radius of the Li^7 nucleus. Assuming that the mean distance between the α particle and the triton equals roughly the charge radius, we obtain from (1) a value 8.22 Mev, which is close enough to the experimental value of 7.46 Mev. If we require that the energy of the first level coincide exactly with the experimental value, we obtain for the rms distance a value 2.85×10^{-13} cm. This value is somewhat larger than the charge radius. However, as is known the nuclear radius always turns out larger than the charge radius.

The value obtained for $\overline{r^2}$ allows also the evaluation of the quadrupole moment of the Li^7 nucleus. Taking it into account that the quadrupole moments of He^4 and He^3 vanish, we obtain, in a coordinate system in which the origin coincides with the center of mass of the $(\alpha + t)$ system and where the z axis is oriented along the axis of symmetry of the nucleus, the following expression for the quadrupole moment operator;

$$\hat{Q} = (68/49)\sqrt{4\pi/5}\, r^2 Y_{20}(\vartheta). \qquad (2)$$

In our coordinate system the wave function of the $(\alpha + t)$ system will have the form

$$\psi = [\delta(\mathbf{r} - \mathbf{R}_0)]^{1/2}, \qquad \mathbf{R}_0 = (\sqrt{\overline{r^2}}, 0, 0). \qquad (3)$$

Using this expression, we obtain for the intrinsic quadrupole moment of Li^7

$$Q_0 = 68\overline{r^2}/49 = 11 \cdot 10^{-26}\ \text{cm}^2.$$

This value is several times larger than the experimental value, $2 \times 10^{-26}\ \text{cm}^2$. However we have to consider the obtained value to be more or less acceptable when we recall that even the unified model which describes the nuclear states rather satisfactorily leads to too large a value for the quadrupole moment. Also, the hydrodynamic model (assuming that Li^7 is deformed in the sense of the unified model and utilizing the energy of the first rotational level) yields a value for the quadrupole mo-