Mev. In comparing the relative transition probabilities it must be remembered that the pairs are approximately twenty times as effective in producing ionization as are the gamma-rays, hence the latter are in all cases much more numerous.

It is interesting that although these pairs occur at definite resonance energies they do not coincide with the gamma-ray resonances. For example, at 920 kv the ionization due to gamma-radiation is nearly ten times as intense as that produced by pairs, while at 840 and 1190 kv the reverse is true. Clearly, therefore, the pairs are not produced by internal conversion of gamma-rays in the usual sense, but are emitted directly from a nucleus in an excited state. Presumably this is a state in O^{16} with $j=0$ and the transition is to the ground state which is known to have $j=0$. It is, however, possible that some or all of the pairs observed originate from a transition in Ne^{20}. If so, gamma-rays of approximately 7.5 Mev energy should accompany the pairs and we cannot exclude this possibility from our experiments so far. If the transition is in O^{16} alpha-particles should be observable at the pair resonances. Since no single quantum transition is allowed from such a state, the lifetime must be very long. Professor Oppenheimer has made a tentative estimate of 10^{-4} second for the half-life.

It seems probable that the pairs observed by Crane and Halpern[8] at 600 kv—11 pairs per thousand quanta—are to be attributed to this process rather than to internal conversion.

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September 27, 1939.

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Low Energy Gamma-Radiation from Lithium Bombarded with Protons

By means of the method described in the preceding letter we have investigated the radiation from Li^7+H^1 as function of proton energy. The target used consisted of separated Li^7 with a stopping power of approximately 30 kev.[1]

The filter used in front of ionization chamber No. II was 1.33 cm of lead. The readings of chambers Nos. I and II are shown in curves 1 and 2, respectively, and curve 3 is the difference between 1 and 2 (Fig. 1).

The resonance at 440 kev appears to be due entirely to the well-known 17.5 Mev gamma-radiation, while the radiation above 800 kev is strongly absorbed in lead.

We have measured the attenuation of the radiation at 1080 and 1290 kev and find an apparent absorption coefficient $\mu=1.50\pm0.10$ cm^{-1} in lead and $\mu=0.12\pm0.01$ cm^{-1} in aluminum. For annihilation radiation from N^{13} we find,

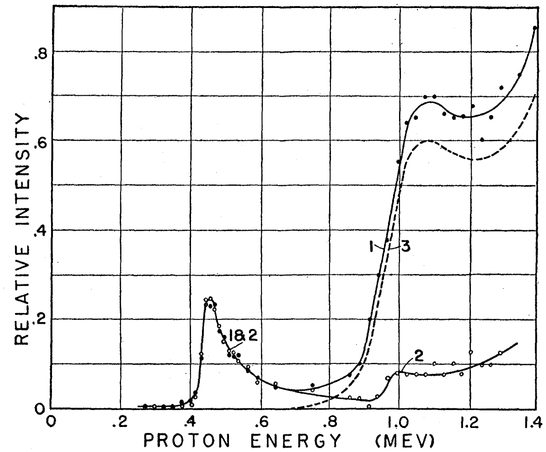

Fig. 1. Relative intensity of ionization *vs.* bombarding energy. Curve 1—radiation filtered by 0.15 mm lead. Curve 2—radiation filtered by an additional 1.33 cm lead. Curve 3—difference between 1 and 2.

with the same arrangement, $\mu=1.43\pm0.05$ cm^{-1} in lead. This gives the value 495 ± 25 kev for the gamma-rays at 1080 and 1290 kev bombarding energy.

From this and from the character of the yield curve above 800 kev it seems reasonable to assume that this radiation originates from excitation of Li^7 without capture of the proton in analogy with the well-known excitation of Li^7 by He^4. Rumbaugh, Roberts and Hafstad[2] have observed the same state in the following reactions:

$$\begin{aligned} Li^6+H^2 \rightarrow (Be^8) &\rightarrow Li^7+H^1 \\ &\rightarrow {}^*Li^7+H^1 \\ &\rightarrow Be^7+n^1 \\ Be^7 &\rightarrow {}^*Li^7-e^-. \end{aligned}$$

From the difference in proton ranges they find the separation of the states in Li^7 to be 455 ± 15 kev, and from the attenuation of the radiation following the decay of Be^7, 425 ± 25 kev.

Although our value 495 ± 25 kev is somewhat higher there can be little doubt that the same state in Li^7 is involved.

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[1] We are indebted to Professor Rumbaugh and the Bartol Foundation for their kindness in supplying us with this target.
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On the Equality of the Proton-Proton and Proton-Neutron Interactions

A comparison of the ^1S proton-proton interaction and the ^1S proton-neutron interaction has been made recently by Breit, Hoisington, Share and Thaxton.[1] It is the purpose of this letter to add a remark to this subject. With the meson type of potential, $Ce^{-\lambda r}/r\lambda$, a variational calculation has been made of the binding energy of H^3 of high accuracy (error <0.1 percent).[2] This calculation together with the value of the binding energy of H^2 and the scattering of thermal neutrons by protons gives the following values for the constants in the meson potential for the ^3S neutron-proton interaction:

$$C(^3S) = -62.75\ mc^2;\quad \lambda(^3S) = 1.536\ (mc^2/e^2). \qquad (1)$$

Any change within reasonable limits of the ^1S proton-neutron interaction affects this determination of the ^3S interaction very little. If one assumes the range, $\lambda(^1S)$, of the ^1S interaction between neutron and proton is the same as $\lambda(^3S)$, one gets the following constants:

$$C(^1S) = -36.32\ mc^2;\quad \lambda(^1S) = \lambda(^3S). \qquad (2)$$

This calculation uses the experimental value for the scattering of thermal neutrons by protons of 18.3×10^{-24} cm^2. It may be noted that a 35 percent change in the value of the scattering cross section gives only 1.5 percent change in $C(^1S)$ for fixed $\lambda(^1S)$.

The proton-proton interaction as deduced from scattering experiments leads to the following interaction constants as determined by Share, Hoisington and Breit:[3]

$$C = -89.1\ mc^2;\quad \lambda = 2.38\ (mc^2/e^2). \qquad (3)$$

The constants in (3) are considerably different from those in (2) where it was assumed that the proton-neutron ^1S range was the same as the proton-neutron ^3S range. If one assumes that the ^1S proton-proton interaction constants (3) also holds for the ^1S proton-neutron interaction, one may also fit the experimental data on the scattering of thermal neutrons by protons.[1]

If the fitting of the proton-proton scattering data is unambiguous, then either of two conclusions is indicated: that $\lambda(^3S) \neq \lambda(^1S)$; or that the ^1S proton-proton interaction does not equal the ^1S proton-neutron interaction. These conclusions will not be appreciably affected by the introduction of spherically symmetric spin-spin forces, but may be affected by other spin-spin forces such as give rise to the quadripole moment of H^2.

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