The Gamma-Radiation from Lithium Bombarded with Protons

The recoil electrons ejected from the glass wall of a cloud chamber by the radiation from lithium bombarded by protons were studied by Crane, Delsasso, Fowler and Lauritsen,[1] and were interpreted as indicating a complex spectrum extending up to 16 Mev. Measurements on pairs ejected from a thin lead sheet were later reported by Delsasso, Fowler and Lauritsen.[2] These were grouped in a band or line at about 17 Mev, and it was therefore concluded that there was little, if any, radiation below about 17 Mev. In a more recent report[3] these authors confirm this distribution of pairs. Hafstad, Heydenburg and Tuve[4] have reported finding recoil electrons which give some indication of radiation at 8 and possibly 11 Mev.

We have made further measurements on this radiation, using an entirely different experimental arrangement.[5] A metallic lithium target was placed in a well inside the cloud chamber and surrounded by a small carbon cylinder having a wall about 2.5 mm thick, as sketched in Fig. 1. Recoil negative electrons and electron pairs were ejected from this thin wall by the gamma-radiation. Nearly all the tracks appearing in the cloud chamber clearly originated in the carbon. The stopping power of the carbon was about 1 Mev for the single electrons and 2 Mev for the pairs. Fig. 2 shows plots of the negative electrons and pairs observed. The distribution of pairs is in agreement with the observations of Delsasso, Fowler and Lauritsen on pairs, and could easily be attributed to a single gamma-ray line at about 17.5 Mev.[6] The distribution of Compton electrons, on the other hand, is consistent, at least as to general over-all shape, with the distribution previously found.[1] The present negative electron distribution indicates that by far the strongest components of the radiation are at about 14.5, 11 and 8.5 Mev, with only a small group at 17.5 Mev. The plot below 8 Mev should not be considered seriously because of the possibility that it may contain some beta-rays from Li^8, formed by deuteron contamination in the ion beam.

The reaction (1) postulated to account for the complex spectrum up to 16 Mev

$$Li^7+H^1\rightarrow He^{4*}+He^4;\quad He^{4*}\rightarrow He^4+\gamma \qquad (1)$$

may still account for the spectrum, but perhaps with the exception of the 17.5 Mev component. It is not so easy to account for radiation as high as 17.5 Mev in this way, because that would leave almost no kinetic energy for the separation of the two alpha-particles. On the other hand, reaction (2), which has been discussed by several authors[4]

FIG. 1.

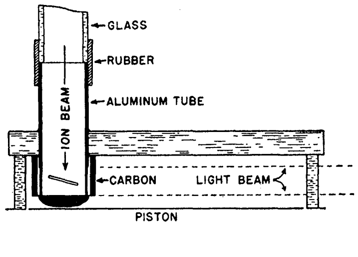
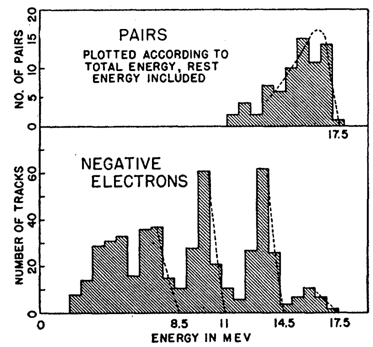


FIG. 2.



to account for the single 17.5 Mev component would not so readily

$$Li^7+H^1\rightarrow Be^{8*};\quad Be^{8*}\rightarrow Be^8+\gamma \qquad (2)$$

explain the presence of radiation of considerably lower energy, because the excited Be^8 nucleus would disintegrate into two alpha-particles too quickly to emit radiation of low energy. A plausible solution of the present problem may be to assume that the reaction occurs both ways, the capture reaction accounting for the highest line and the excited alpha-particle accounting for all the radiation of lower energy.

The striking feature of the plots in Fig. 2 is that the radiation indicated by the highest energy group of Compton electrons seems to give rise to far more pairs (by a factor of 10 at least) than it should, in comparison to the number of pairs produced by the radiation indicated by the lower groups of Compton electrons, especially the group at about 14.5 Mev. In fact, the pairs seem largely to correspond to the small group of Compton electrons at about 17.5 Mev. We have attempted to reconcile the two plots by considering the possible ways in which pairs of low energy can be systematically lost, such as by the stopping and scattering of the members of pairs in the material in which they are produced. These effects, however, are small and do not vary sharply with energy. The ratio of the pair and Klein-Nishina absorption coefficients also does not vary rapidly with energy in this range. Therefore, while the possibility of an explanation on the basis of the above effects should not be given up, we incline at present toward the belief that the contradiction between the pair and Compton electron distributions is real and must be explained in some other way. In the letter which follows a suggestion is offered which may be of help in formulating the problem.

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December 10, 1936.

[1] Crane, Delsasso, Fowler and Lauritsen, Phys. Rev. **48**, 125 (1935).
[2] Delsasso, Fowler and Lauritsen, Phys. Rev. **50**, 389 (1936).
[3] Pasadena Meeting, Am. Phys. Society, Dec. 18–19 (1936).
[4] Hafstad, Heydenburg and Tuve, Phys. Rev. **50**, 504 (1936).
[5] Chicago Meeting, Am. Phys. Society, Nov. 27–28 (1936).
[6] It is important to remember that the spread toward lower energies in the pair distribution should be twice that in the Compton electron groups because the carbon is effectively twice as thick for pairs as for single electrons.