Absorption of 2.8-Mev Gamma-Rays in Lead

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IN a recent paper[1] an absorption coefficient of 0.405 cm^{-1} for 2.85-Mev gamma-rays in lead was reported. This value, taken together with the result of a similar measurement in copper, was interpreted as indicating an "insufficiency" in the Klein-Nishina formula for this energy, since the absorption coefficient predicted by the theory (which also takes into account absorption caused by the photoelectric effect and pair production) is 0.46 cm^{-1}.[2] On the other hand, complete agreement was found at 1.30 and 1.14 Mev. The discrepancy of more than 10 percent at 2.85 Mev is the more striking since the theory has been confirmed at higher and lower energies by many workers.

The reported low absorption coefficients were obtained by measuring the ionization produced by the gamma-rays of radioactive Na after passing through various thicknesses of lead and copper. Since this radiation is assumed to contain both 1.38- and 2.85-Mev gamma-rays,[3] the absorption coefficient of the high energy component had to be deduced from the absorption of the mixture.

To provide further information on this matter we have measured the absorption of Na gamma-rays in lead by an arrangement which, for two reasons, practically excluded the effect of the low energy component. First, we used a minimum absorber thickness of 9.5 cm, so that the ratio of the high energy to the low energy quanta is raised to 3:1 according to the theory[2] or even higher according to the above-mentioned paper;[1] second, we recorded the gamma-radiation with a twofold Geiger-Mueller counter arrangement of high resolving power, the counter walls being of such a thickness that only electrons of energies greater than 2 Mev had an appreciable chance of penetrating both counters and being recorded.

On account of a strong activity in the room in which the experiment was performed[4] the counters were surrounded on all sides by at least 19 cm of lead, except for an opening on the side facing the Na source in which lead was placed to make up a number of absorber thicknesses between 9.5 and 19 cm. The source was placed 40 cm from the first counter, a position which allowed a suitable counting rate even at the greatest thickness. The effect of the imperfect geometry of this arrangement was overcome by pointing the counter telescope toward the source, causing it to be insensitive to radiation proceeding in any other direction than straight from the source. This directional effect occurs because most of the electrons which are produced by 2.8-Mev gamma-rays and which have sufficient energy to penetrate both counters are Compton electrons emitted in a forward direction. This was proved by turning the counter telescope through 90°, which reduced the counting rate by a factor of 3.

Using lead absorber thicknesses of 9.50, 12.13, 14.60, and 19.0 cm we found an absorption coefficient of 0.467 ± 0.009 cm^{-1}. The absorption curve is of pure exponential form, indicating that the 1.98-Mev radiation was indeed eliminated by the method used. The result thus substantiates the present theory.

[1] J. M. Cork and R. W. Pidd, Phys. Rev. **66**, 227 (1944).
[2] W. Heitler, *The Quantum Theory of Radiation* (Clarendon Press, Oxford, 1936).
[3] Actually experiments by P. Gerald Kruger and W. E. Ogle indicate that there are four gamma-ray lines between 2.6 and 2.9 Mev. Since in this region the absorption coefficient varies very slowly with energy, this fact is of minor importance for absorption measurements (private communication).
[4] The arrangement was primarily set up for a different purpose.

The Nuclear Isomerism of Gold

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STRONG activity has been observed when gold is irradiated with high energy x-rays. This activity has been observed when self-quenching counters, having gold cathodes, have been irradiated directly; and it can also be detected when a gold sheet is irradiated and quickly placed before a counter with a thin (1.5 mil) aluminum window.

This activity is attributed to a metastable state of stable ${}_{79}Au^{197}$ produced by line absorption in the following reaction: ${}_{79}Au^{197}+\gamma\rightarrow{}_{79}Au^{197*}$.

The period, evaluated from a decay curve extending over one minute, has been found to be 7.5 ± 0.5 second and the energy of the metastable level, which has been evaluated from the measurement of the energy of the conversion electron by absorption in aluminum foils, is 250 kev.

Since the spin of gold in the ground state is 3/2, the spin of Au* is probably 9/2 or 11/2.

It is of interest to note that gold, along with platinum[1] and mercury,[2] form a triad similar to the one formed by silver, cadmium, and indium.

A detailed study of the energy levels which combine with the metastable state is in progress and will be reported in the near future.

[1] Sherr, Bainbridge, and Anderson, Phys. Rev. **59**, 400 (1941).
[2] G. Friedlander and C. S. Wu, Phys. Rev. **63**, 227 (1943); McMillan, Kamen, and Ruben, Phys. Rev. **52**, 375 (1937); Pool, Cork, and Thornton, Phys. Rev. **52**, 239 (1937).

Gamma-Ray Absorption

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IN a recent paper[1] the linear absorption coefficient for certain gamma-rays in lead and copper was reported. Attention was given particularly to the 2.75-Mev radiation from sodium (24), showing an apparent discrepancy between observed and computed values of the absorption coefficients in lead and copper. To examine more conclusively the behavior of the other radiations mentioned, namely, that from zinc (65) and from cobalt (60), much stronger sources of these gamma-rays were studied.

A sample of radio-cobalt of 32 millicuries equivalent intensity was kindly lent by Professor R. D. Evans of the Massachusetts Institute of Technology and a sample of zinc was bombarded as a probe in the cyclotron in this