Gamma Rays from Cu due to Neutron Inelastic Scattering*

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(Received February 15, 1954)

Monoenergetic neutrons from the $H^2(d,n)He^3$ reaction were used to bombard a Cu scatterer in the form of a ring surrounding a gamma-ray spectrometer. An analysis of the gamma spectrum obtained by subtracting the background counting rate from the counting rate with the Cu scatterer in place yields gamma rays with energies of 0.965, 1.110, 1.67, 1.91, 2.42, and 2.58 Mev.

MONOENERGETIC neutrons from the $H^2(d,n)He^3$ reaction were used to bombard a Cu scatterer in the form of a ring surrounding a gamma-ray spectrometer. The deuterons were accelerated by the University of Kentucky 120-kv accelerator.[1] The gamma rays, resulting from the de-excitation of the Cu nuclei excited by inelastic scattering of the neutrons, were detected in a spectrometer consisting of a NaI(Tl) crystal mounted on a Du Mont 6292 photomultiplier tube. No shielding was used between the neutron source and the NaI crystal. A BF_3 counter was used to monitor the neutron flux.

The pulses from the photomultiplier were analyzed with a single-channel differential pulse-height analyzer. Gamma rays from Na^{22} (0.511 and 1.28 Mev) and Cs^{137} (0.661 Mev) were used to calibrate the spectrometer. The spectrometer had a resolution of 10 percent as measured for the 0.661-Mev gamma from Cs^{137}.

The gamma spectrum obtained by subtracting the background counting rate from the counting rate with the Cu scatterer in place is shown in Fig. 1. The gamma spectrum for the different energy regions is shown in Fig. 2, indicating the longer counting time that was necessary for the higher-energy regions.

As shown in the figures, there are gamma rays with energies of 0.965, 1.110, 1.67, 1.91, and 2.42 Mev, and a probable gamma ray at 2.58 Mev (the photoelectric peak for the 2.58-Mev gamma ray occurs at A in Fig. 2, the Compton at B, and the pair at D). The pair peak of the 1.91-Mev gamma ray and the Compton for the 1.110-Mev gamma ray are obscured by the 0.965-Mev photoelectric peak. The estimated probable error of these energy assignments is two or three percent.

The comparison of these results with those of other investigators[2–7] is shown in Table I.

The energies listed in references 2, 3, and 4 were found by investigation of radioactive decay; those listed in references 5, 6, and 7 are from neutron inelastic scattering.

TABLE I. Comparison of energy assignments. All energies are in Mev.

This paper	Reference 2	Reference 3	Reference 4	Reference 5	Reference 6	Reference 7
0.965	0.960				0.88	
1.110		1.11	1.12	1.1		1.13
1.67			1.49		1.47	1.53
1.91	1.89					
2.42				2.2		2.19
2.58	2.60					

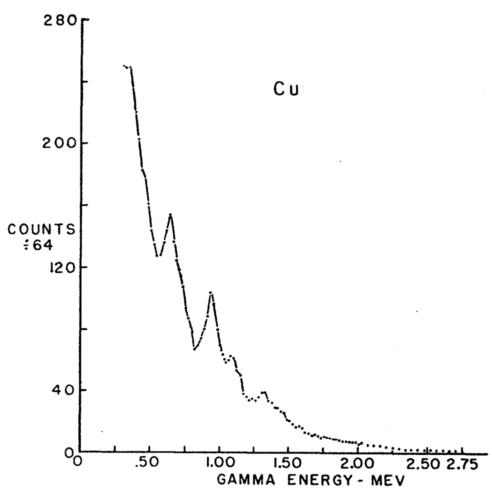

FIG. 1. The gamma-ray spectrum from a Cu scatterer. The ordinate has been normalized with respect to the BF_3 monitor counter.

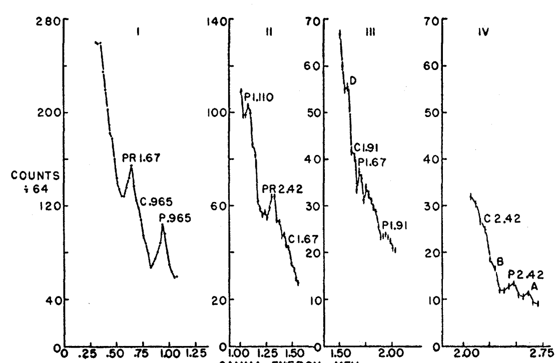

FIG. 2. The gamma-ray spectrum from a Cu scatterer shown in greater detail. The probable errors for region I are of the order of magnitude of the points of the curve. The channel width in region I was 0.022 Mev and in regions II, III, and IV 0.044 Mev. The ordinates have been normalized with respect to the BF_3 monitor counter. P refers to photoelectric peak; C to Compton edge; PR to pair peak. A, B, and D explained in the text.

* Sponsored by the Office of Ordnance Research, U. S. Army.

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