The Energies of the γ-Rays from Sb^{122}, Cd^{115}, Ir^{192}, Mn^{54}, Zn^{65}, and Co^{60}

C. E. MANDEVILLE*
The Rice Institute, Houston, Texas
AND
H. W. FULBRIGHT
Washington University, St. Louis, Missouri
(Received August 27, 1943)

The energies of the γ-rays emitted in the disintegration of some radioelements have been determined by means of a magnetic spectrograph. The results may be summarized as follows:

Radioelement	Sb^{122}	Cd^{115}	Ir^{192}	Mn^{54}	Zn^{65}	Co^{60}
Quantum energies (Mev)	0.80 ± 0.02	0.65 ± 0.02	0.63 ± 0.02	0.86 ± 0.02	1.14 ± 0.02	1.33 ± 0.03

The quantum energies were obtained from the end points of distributions in momentum of Compton secondaries arising from the several γ-rays. Qualitative results obtained from observations on several other γ-ray emitters are briefly discussed.

INTRODUCTION

THE distributions in momentum of Compton recoils arising from γ-rays emitted in the disintegration of several radioelements have been obtained by coincidence counting in a magnetic spectrograph.[1] From the end points of the distributions, the quantum energies of the γ-rays may be calculated. The Compton recoil method did not resolve the two quanta at 1.10 ± 0.02 Mev and 1.30 ± 0.02 Mev which have been previously reported[2] to be emitted in the disintegration of Co^{60}.

In addition to a specific discussion of measurements on the gamma-radiation emitted by the radioelements given in the title of this paper, some qualitative remarks are also made with regard to radiations from some other radioactive isotopes which were surveyed only briefly.

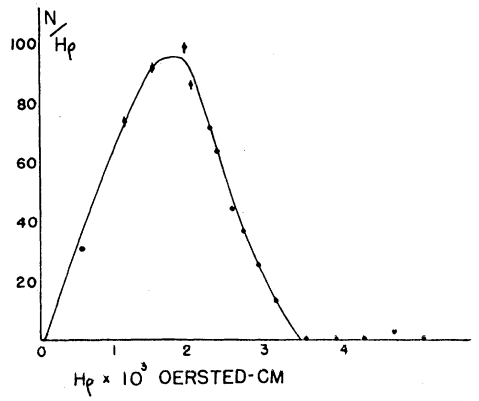

FIG. 1. Momentum distribution of the Compton recoils of the γ-rays from Sb^{122}. This distribution arises from a γ-ray of energy 0.80 ± 0.02 Mev.

Sb^{122}

The gamma-radiation of the 63-hour Sb^{122} has been previously investigated by Mitchell, Langer, and McDaniel.[3] Coincidence absorption experiments by those authors revealed the presence of a γ-ray of energy 0.96 Mev. Their $\beta-\gamma$ and $\gamma-\gamma$ coincidence experiments on Sb^{122} suggested that the γ-ray at 0.96 Mev is the only one emitted in the disintegration of that element. The momentum distribution of the Compton recoils of the γ-rays from Sb^{122} is given in Fig. 1, and the end point of the distribution is found to correspond to a gamma-ray energy of 0.80 ± 0.02 Mev, a somewhat lower value than the previously determined one. From the shape of the curve, it is clear that a single γ-ray is present, confirming in general the conclusions of the Indiana University group.

The Sb^{122} of the curve of Fig. 1 was obtained when pure metallic antimony was irradiated by slow neutrons from the reaction $Be-d-n$ for a period of about 48 hours.

Cd^{115}

Gamma-radiation from Cd^{115} at 0.8 Mev has been reported by Cork and Lawson,[4] employing

* At present at the Radiation Laboratory, the Massachusetts Institute of Technology, Cambridge, Massachusetts.

[1] C. E. Mandeville, Phys. Rev. **62**, 309 (1942); **63**, 387 (1943).

[2] M. Deutsch and L. G. Elliott, Phys. Rev. **62**, 558 (1942).

[3] A. C. G. Mitchell, L. M. Langer, and P. W. McDaniel, Phys. Rev. **57**, 1107 (1940).

[4] J. M. Cork and J. L. Lawson, Phys. Rev. **56**, 241 (1939).

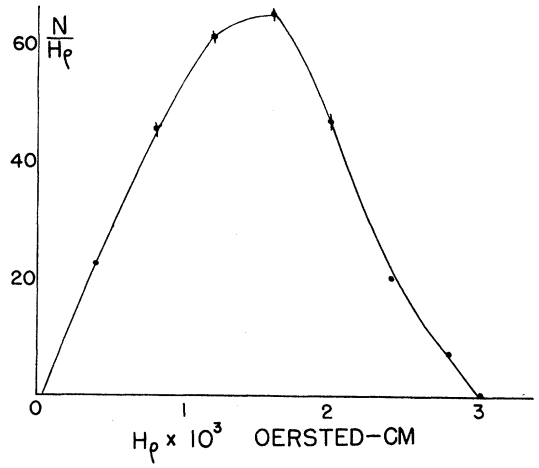

FIG. 2. Momentum distribution of the Compton recoils of the γ-rays from Cd^{115}. The energy of the γ-ray is 0.65 ± 0.02 Mev.

the method of cloud chamber recoils. Later cloud chamber and absorption experiments by Lawson and Cork[5] resulted in the value 0.55 Mev. The momentum distribution of the Compton recoils of the γ-rays from Cd^{115} is given in Fig. 2. The end point of the distribution corresponds to a quantum energy of 0.65 ± 0.02 Mev. The Cd^{115} of Fig. 2 was produced by an irradiation of pure metallic cadmium by slow neutrons. Observations were begun about sixty hours after cessation of bombardment, and the ordinates of the curve of Fig. 2 appeared to decay with a half-period between fifty-four and sixty hours, in good agreement with other values[4,6] obtained for the half-period of Cd^{115}.

Ir^{192}

Pure metallic iridium was irradiated by slow neutrons. The sixty-day Ir^{192} was found to be produced with great intensity. The momentum distribution of the Compton secondaries arising from the γ-rays emitted in the disintegration of Ir^{192} is given in Fig. 3. The shape of the distribution is characteristic of a single γ-ray, and the energy taken from the end point is 0.63 ± 0.02 Mev. It was also observed that γ-rays of low energy (less than 0.5 Mev) and high intensity are emitted by the sixty-day iridium. γ-rays of an energy less than 0.5 Mev are not measurable with the spectrograph.[7] The presence of the intense radiation of low energy is not inconsistent with the view that isomeric transitions may be occurring in iridium.[8]

Mn^{54}, Zn^{65}, and Co^{60}

The distributions in momentum of the Compton recoils of the γ-rays emitted in the disintegration of Mn^{54}, Zn^{65}, and the five-year Co^{60} are given in Figs. 4, 5, and 6. The energies of these γ-rays were found to be 0.86 ± 0.02 Mev, 1.14 ± 0.02 Mev, and 1.33 ± 0.03 Mev, respectively. The energies of these γ-rays have been previously measured by the group at the Massa-

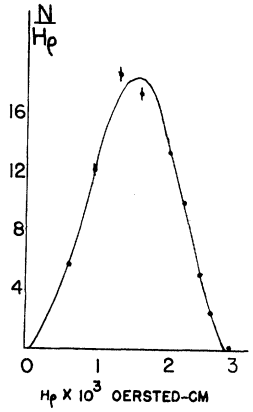

FIG. 3. Momentum distribution of the Compton recoils of the γ-rays from Ir^{192}. The quantum energy is 0.63 ± 0.02 Mev.

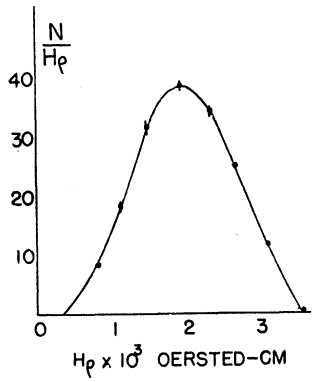

FIG. 4. Momentum distribution of the Compton recoils of the γ-rays from Mn^{54}. The energy of the γ-ray is 0.86 ± 0.02 Mev.

[5] J. L. Lawson and J. M. Cork, Phys. Rev. **57**, 982 (1940).
[6] M. Goldhaber, R. D. Hill, and L. Szilard, Phys. Rev. **55**, 47 (1937).
[7] C. E. Mandeville, Phys. Rev. **64**, 147 (1943).
[8] E. McMillan, M. Kamen, and S. Ruben, Phys. Rev. **52**, 375 (1937).

chusetts Institute of Technology,[2,9,10] and our results are in good agreement with the values obtained by them. It is to be noted that the Compton recoil method does not resolve the two γ-rays[2] at 1.10 ± 0.02 Mev and 1.30 ± 0.02 Mev emitted in the disintegration of Co^{60}.

OTHER MEASUREMENTS

Observations begun about 48 hours after cessation of bombardment seemed to indicate that Sm, Nd, Os, and Ge, when irradiated by slow neutrons, emitted gamma-radiation of too low an energy or too low an intensity to be measured by the spectrograph. The twenty-hour Re^{188} was produced when ReO_2 was irradiated by slow neutrons. A γ-ray of low intensity and of energy about 0.8 Mev appeared to be emitted in the disintegration of Re^{188}. A γ-ray of low intensity and of energy about 1.35 Mev appeared to be associated with the nineteen-hour Ir^{194}.

Prevailing conditions unfortunately did not permit a continuation of the study of radiations from these various radioelements. The results mentioned in this section are therefore to be regarded as only tentative.

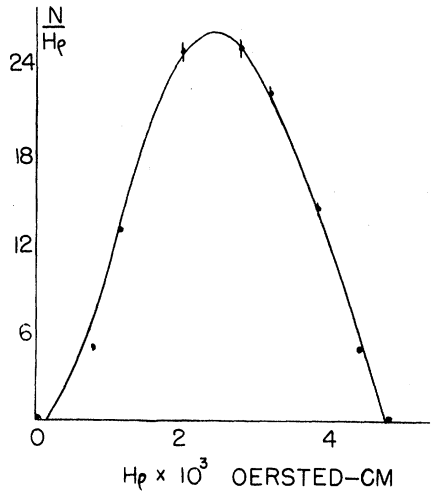

FIG. 5. Momentum distribution of the Compton recoils of the γ-rays from Zn^{65}. The quantum energy is 1.14 ± 0.02 Mev.

[9] M. Deutsch and A. Roberts, Phys. Rev. **60**, 362 (1941); M. Deutsch, A. Roberts, and L. G. Elliott Phys. Rev. **61**, 389 (1942).

[10] L. G. Elliott and M. Deutsch, Phys. Rev., to be published in near future.

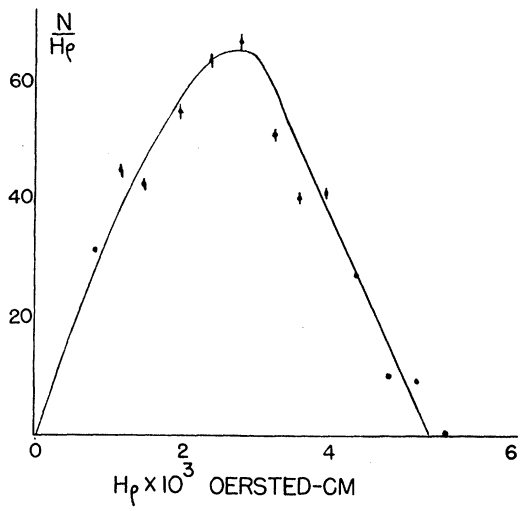

FIG. 6. Momentum distribution of the Compton recoils of the γ-rays from the five-year Co^{60}. The quantum energy is 1.33 ± 0.02 Mev. The two γ-rays previously reported at 1.10 ± 0.02 Mev and 1.30 ± 0.02 Mev were not resolved by the Compton recoil method.

ACKNOWLEDGMENTS

The writers wish to acknowledge the interest in these experiments of Professor A. L. Hughes of Washington University, St. Louis, Missouri, and Professor H. A. Wilson of the Rice Institute. We wish also to express appreciation for the preparation of many of the radioactive sources by the members of the Washington University cyclotron group. The sources of radioactive Mn^{54}, Zn^{65}, and Co^{60} were very kindly sent to us by Dr. Martin Deutsch of the Massachusetts Institute of Technology.

ADDED NOTE

The γ-rays from the sixty-day Ir^{192} have been recently studied by Dr. Martin Deutsch of the Massachusetts Institute of Technology. With the magnetic lens spectrometer, photoelectric lines were observed corresponding to γ-rays of energies 0.307 Mev, 0.467 Mev, and 0.603 Mev. The γ-ray of energy 0.603 Mev (reported in this paper at 0.63 ± 0.02 Mev.) appeared to be less intense than the two softer γ-rays.

The source used in the measurements with the magnetic lens spectrometer was also employed by us.