The Radiations of Lanthanum-140

C. L. PEACOCK, J. F. QUINN, AND A. W. OSER, JR.
Tulane University, New Orleans, Louisiana
(Received December 7, 1953)

The radiations of La^{140} have been studied with a magnetic spectrometer of radius 20 cm. The beta spectrum is complex consisting of five groups whose maximum energies are: 0.83 Mev, 1.10 Mev, 1.34 Mev, 1.67 Mev, and 2.15 Mev. Gamma rays with energies of 0.110 Mev, 0.130 Mev, 0.240 Mev, 0.270 Mev, 0.328 Mev, 0.485 Mev, 0.815 Mev, and 1.60 Mev, respectively, were found. The 1.60-Mev gamma is very intense. A tentative decay scheme is proposed.

I. INTRODUCTION

THE radiation spectra of La^{140} have been shown by previous studies to be quite complex.[1] The results of these studies were summarized in various proposed decay schemes. A later report[2] on the gamma radiations of Ce^{140} following the beta transitions of La^{140} noted the presence of fifteen gamma-ray energies with varying intensities. A decay scheme which differed from all previous ones was proposed on the basis of the energies of these gamma radiations.

The present work was undertaken as a further study of this isotope in an attempt to formulate its decay scheme. Although particular attention was directed toward the beta-ray energies, the gamma rays were also studied.

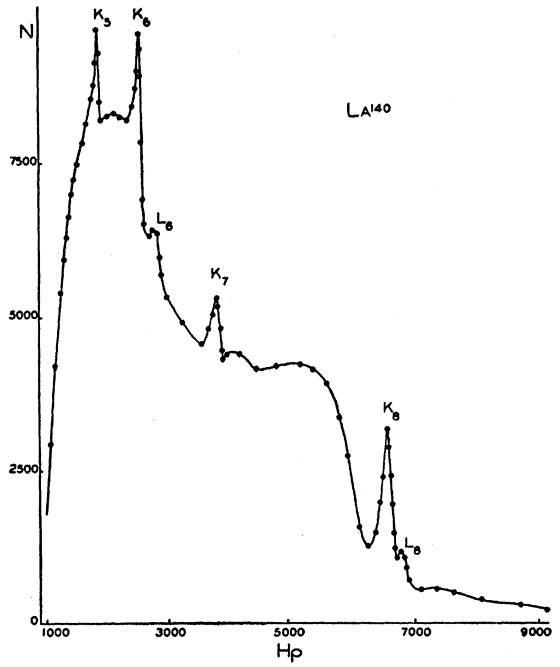

FIG. 1. The photoelectron spectrum of the gamma rays of La^{140} from a lead radiator.

[1] A summary of references to studies made before 1949 can be found in the article by Beach, Peacock, and Wilkinson, Phys. Rev. 76, 1624 (1949).
[2] J. M. Cork *et al.*, Phys. Rev. 83, 856 (1951).

APPARATUS AND METHODS

This study was carried out with a 180-degree type of magnetic spectrometer of radius 20 cm. The magnet was of the ring-shaped type. It was used to give a homogeneous field inside the vacuum chamber. Both conventional mica window and very thin Zapon film window G-M tubes were used as detectors. The resolution of the instrument was set at about 2 percent.

Sources were prepared from lanthanum which had been chemically separated from an equilibrium mixture of barium[140] and lanthanum[140]. The source material was obtained from the Oak Ridge National Laboratory. The lanthanum was precipitated as $La(OH)_3$ by the addition of NH_4OH to the equilibrium mixture. It was then converted to the chloride by the addition of HCl. Repeated precipitations assured a barium free sample. The beta sources, which were evaporated on very thin films of LC 600, had a thickness of less than 0.1 mg/cm².

TABLE I. Gamma radiations of La^{140}.

K_1	0.110 Mev	K_5	0.328 Mev
K_2	0.130 Mev	K_6	0.485 Mev
K_3	0.240 Mev	K_7	0.815 Mev
K_4	0.270 Mev	K_8	1.60 Mev

III. RESULTS

Figure 1 shows the spectrum of photoelectrons ejected from a lead radiator as detected by a mica window counter. The photoelectron peaks observed in this distribution can be interpreted to correspond to gamma rays of the following energies: 0.328 Mev, 0.485 Mev, 0.815 Mev, and 1.60 Mev. (The numbering system in the figure corresponds to the designations in Table I.)

Figure 2 shows a fitted composite of several studies made on the electron spectrum. Various portions of the curve were given particularly careful study at different times with the aim of locating the lines due to the internally converted gamma rays already reported[2] as well as searching for others. These portions were then corrected for decay and fitted together. The lines observed in this curve may be attributed to gamma rays whose energies are as follows: 0.110 Mev, 0.130 Mev, 0.240 Mev, 0.270 Mev, 0.328 Mev, 0.485 Mev, 0.815

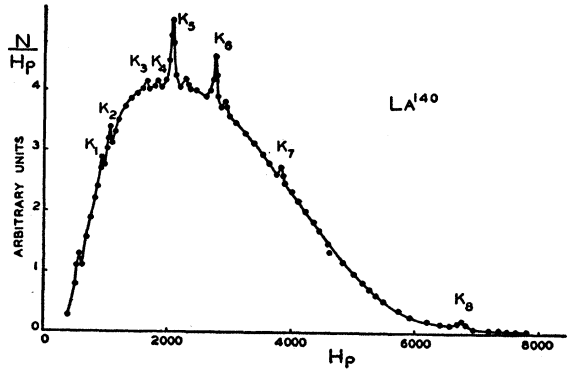

FIG. 2. An electron spectrum of La^{140}.

Mev, and 1.60 Mev. It is to be noted that those peaks found in the photoelectron spectrum are also contained in this latter group. A summary of the results of the gamma-ray studies is presented in Table I. The intensities of the first four gamma rays could not be determined from this work due to the small magnitude and the complicated decay scheme. The ratio of the intensities of the last four gamma rays as determined

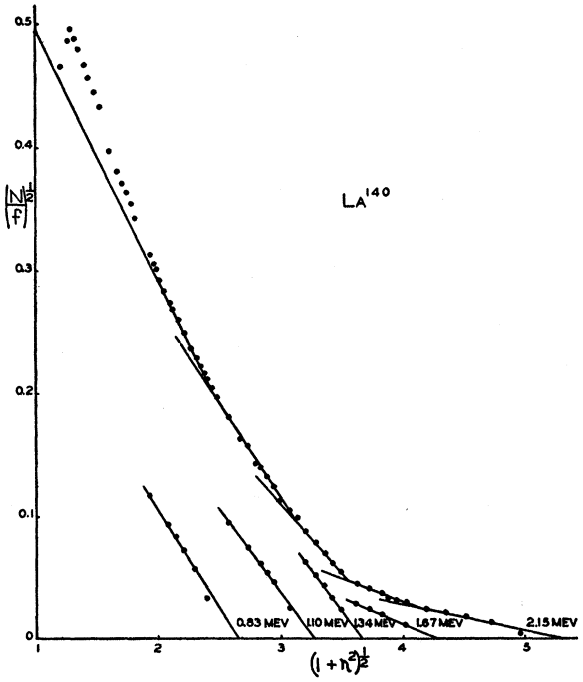

FIG. 3. A Fermi analysis of the beta rays of La^{140}.

from the photoelectric conversion is 0.328:0.485:0.815: 1.60 as 1:1:1:10. However, the 0.328-Mev and 0.485-Mev gamma rays show a greater internal conversion than do the others. It is noted that these energies compare favorably with reported values.[2] Some of the reported lines, however, were not found in this study.

The distribution of beta rays was analyzed by the Fermi plot method with the aid of tables prepared at

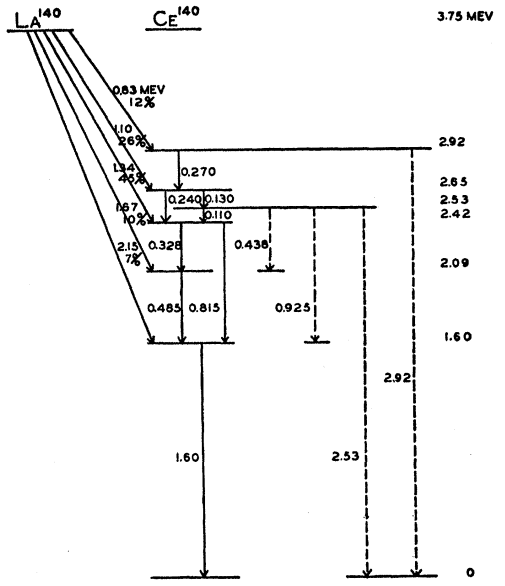

FIG. 4. Suggested disintegration scheme of La^{140}.

the Bureau of Standards.[3] Those points corresponding to electron lines due to converted gamma rays have been omitted from the analysis. Figure 3 shows a typical plot of a representative beta-ray distribution. It is noted that this plot indicates complexity. In fact, the plot seems to have definite curvature in the region below 1.34 Mev. This could denote forbiddenness of the 1.34-Mev group of beta rays. If, however, the groups are assumed to have straight line plots, the distribution plot can be analyzed into groups whose maximum energies are: 2.15 Mev, 1.67 Mev, 1.34 Mev, 1.10 Mev, and 0.83 Mev. It is felt that the deviation below 0.4 Mev is due mainly to source thickness.

From the values of the gamma- and beta-ray energies obtained in this study, a disintegration scheme can be formulated. This scheme is shown in Fig. 4. The 1.60-Mev gamma ray has been found to be in coincidence with the highest energy beta-ray group, as well as with the 0.815-Mev gamma ray.[4,5] Other gamma-ray energies fit remarkably well between the energy levels suggested by the beta-ray analysis. These are denoted in the decay scheme by the solid lines. Two of the gamma energies reported by Cork *et al.*, but not found in this study, can also be fitted into the scheme, as well as the 2.53 Mev gamma-ray energy reported by Wattenberg[6] and the 2.92 Mev one reported by Bishop *et al.*[7] These are denoted by the dotted lines in Fig. 4.

---

[3] L. F. Curtiss and I. Feister, *Tables for the Analysis of Beta Spectra*, National Bureau of Standards, Applied Mathematics Series No. 13 (U. S. Government Printing Office, Washington, D. C., 1951).

[4] B. L. Robinson and L. Madansky (to be published).

[5] R. G. Wilkinson (private communication).

[6] A. Wattenberg, Phys. Rev. **71**, 497 (1947).

[7] Bishop, Wilson, and Halban, Phys. Rev. **77**, 416 (1950).