Reinvestigation of the Radioactivity of Sb^{124}

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The beta-spectrum of Sb^{124} was studied with a thin-lens spectrometer with particular emphasis on the internal conversion of the 0.607- and 1.7-Mev gamma-rays and the shape of the high energy beta-spectrum. The conversion coefficients of the 0.607-Mev gamma-ray were found to be $\alpha_K=3.63\pm0.40\times10^{-3}$, $\alpha_L=5.15\pm1.0\times10^{-4}$. Comparison of α_K with theoretical values indicated the transition to be electric quadrupole. An upper limit of 5×10^{-4} has been set on the conversion coefficient of the 1.7-Mev gamma-ray. The highest energy beta-component was shown to be first-forbidden. The next highest beta-component may possibly be first forbidden also.

CONSIDERABLE work has been done on the radiations of Sb^{124} whose decay is both interesting and complex.[1-4] However, in consequence of the seeming difficulty of reconciling some experimental results with theory, especially with regard to assignment of spin and parity changes, further study of this radioisotope has been undertaken. In the present investigation the beta-spectrum of Sb^{124} was studied with particular interest in the internal conversion of the 0.607- and 1.7-Mev gamma-rays.

The measurements were carried out by means of a thin-lens spectrometer[5] with baffles arranged for a resolving power of 1.8 percent. The field current was supplied by a bank of storage batteries and measurements of the field were accurately determined by means of a type-K potentiometer. The instrument was calibrated on the internal conversion line of Cs^{137}. The abscissa (I) of Fig. 1 is measured in arbitrary current units in which one current unit represents $B\rho$ equal to 811.4 gauss-cm.

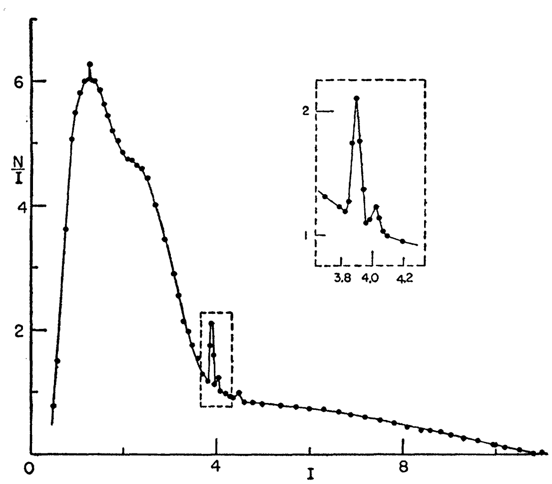

FIG. 1. Beta-spectrum of Sb^{124}. Inset shows the K- and L-conversion line of the 607-kev transition.

The beta-source was prepared by drying $SbCl_3$ rapidly on an aluminized Zapon film having a thickness of 0.034 mg/cm^2. The thin source disk, 5 mm in diameter, was covered with a 0.017 mg/cm^2 layer of Zapon. A Geiger counter with a Zapon window of 0.25 mg/cm^2 was used for detecting the beta-particles. This window had a low energy cutoff of approximately 10 kev.

The momentum spectrum of Sb^{124} is shown in Fig. 1. The inset shows the region of the 607-kev internal conversion line. Careful investigation of this region showed a clear separation of the K and L conversion lines. Since this gamma-ray follows all beta-rays in the proposed decay scheme,[1] the K and L internal conversion coefficients can be determined from the ratio of the areas under each conversion line to that of the entire continuous spectrum. Likewise, of course, the K/L ratio can be evaluated. The experimental values were found to be

$$\alpha_K=0.00363\pm0.0004,\quad \alpha_L=0.000515\pm0.0001,\quad K/L=7.1.$$

If we compare the α_K value with the theoretical values of Rose *et al.*,[6] we find closest agreement with the value

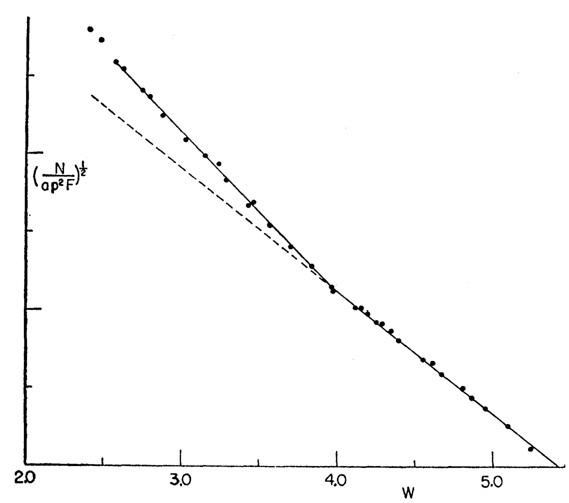

FIG. 2. Fermi plot of upper beta-spectrum of Sb^{124}. The upper part has been made linear by applying the B_{ij} correction.

[1] Kern, Zaffarano, and Mitchell, Phys. Rev. **73**, 1142 (1948).
[2] C. S. Cook and L. M. Langer, Phys. Rev. **73**, 1149 (1948).
[3] E. T. Jurney and A. C. G. Mitchell, Phys. Rev. **73**, 1153 (1948).
[4] Langer, Moffat, and Price, Phys. Rev. **79**, 808 (1950).
[5] George A. Bradley, thesis, University of Michigan (1952) (unpublished).
[6] Rose, Goertzel, and Perry, *K-Shell Internal Conversion Coefficients; Revised Tables*, Oak Ridge National Laboratory Report ORNL-1023 (unpublished).

for electric quadrupole. This agrees with the result of Metzger[7] regarding the multipole order of the 607-kev gamma-ray. On the other hand, the present result indicates that there is no need for revising the presently accepted decay scheme.

A careful search was made for conversion electrons which might be associated with the 1.7-Mev transition. Although no excess of electrons was found, it is possible to set an upper limit of 0.0005 for the conversion coefficient. (It is assumed that 62 percent of the transitions go through this state.) The values, as given in the table of Rose, indicate that this transition cannot be as highly forbidden as electric octupole or magnetic quadrupole.

A Fermi plot of the high energy part of the beta-spectrum was made. Plotted as an allowed spectrum (not shown) the curve was not linear, but the upper portion was made linear by applying the B_{ij} correction factor as shown in Fig. 2. This indicates that the highest energy component is first forbidden in agreement with the proposal of Langer.[4] The end-point energy was found to be 2.27 ± 0.01 Mev. It is possible that the next lower energy component is likewise first forbidden, although the evidence of the Fermi plot cannot be conclusive in this regard.

A noteworthy feature of the beta-spectrum is the appearance of two distinct low energy components. These undoubtedly are the components having end-point energies of 480 and 650 kev.

[7] F. R. Metzger, Phys. Rev. 86, 435 (1952).

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Angular Distributions of Protons and Tritons from Deuteron-Induced Reactions on Be^9†

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The angular distributions and absolute cross sections for the reactions $Be^9(d,p)Be^{10}$, $Be^9(d,p)Be^{10*}$ (3.37 Mev), and $Be^9(d,t)Be^8$ have been determined with 3.6-Mev deuterons. Both proton distributions have shapes characteristic of $l_n=1$ in the Butler theory. The peak cross sections found for these reactions are 3.1 ± 0.6 and 4.5 ± 0.9 mb/steradian, respectively. The triton distribution is peaked at 0°. Its cross section at 5° is 15.5 ± 3 mb/steradian.

I. INTRODUCTION

THE angular distributions of protons from the $Be^9(d,p)Be^{10}$ (ground state) and $Be^9(d,p)Be^{10*}$ (3.37 Mev excited state) reactions have been examined by El Bedewi[1] and by Black[2] and have been found to be characteristic of p neutron capture ($l_n=1$) according to the Butler theory. In those experiments observations were not made at small enough angles to show clearly the existence of a maximum in the proton distribution corresponding to the formation of Be^{10} in its 3.37-Mev excited state. Thus there seemed to be a slight chance that the assignment $l_n=0$ instead of $l_n=1$ might be correct.

Our experiment was undertaken to extend the previous work to smaller angles and to obtain an absolute cross section for the (d,p) processes. In the course of the work we also investigated the $Be^9(d,t)Be^8$ reaction.

II. THE EXPERIMENT

Collimated deuterons from the Rochester 26-inch cyclotron, having a mean energy of 3.6 Mev and an energy spread of less than 0.1 Mev, were directed through the scattering chamber into a Faraday cup. The current of deuterons into the cup was amplified and integrated electronically. A Be scattering foil[3] of average mass 0.48 mg/cm² was mounted in the center of the scattering chamber. An argon-filled ionization chamber having a Frisch grid and a 0.003-in. aluminum window was used to detect charged particles emerging from the target. Its position could be adjusted from outside the scattering chamber to any angle up to 160°. The pressure in the chamber was about 100 psi, sufficiently high so that the ranges of all heavy charged particles entering were less than the length of the ion chamber. Pulses from the ion chamber were amplified, then fed into a thirty-channel pulse-height analyzer.[4] An electromagnetically retractable polonium alpha-particle source was built into the ion chamber for testing and energy calibration purposes.

Observations were made at angles ranging from 4° to 160°, beam current integrator readings being used for normalizing except at angles less than 13° where the ion chamber intercepted the deuteron beam. An auxiliary scintillation counter was used for normalizing in those cases.

III. RESULTS

A typical pulse-height distribution is shown in Fig. 1. The assignments of the three peaks to the reactions

† Work performed under the auspices of AEC.
[1] F. A. El Bedewi, Proc. Phys. Soc. (London) 65, 64 (1952).
[2] C. F. Black, Phys. Rev. 87, 205 (1952).
[3] Originally prepared and sent to this laboratory several years ago by Dr. Hugh Bradner.
[4] Fulbright, McCarthy, and McCutchen, Phys. Rev. 87, 184 (1952).