Fine Structure of the α-Rays from Protactinium

TSIEN SAN-TSIANG*
Laboratoire de Chimie Nucléaire du Collège de France, Paris, France
M. BACHELET, AND G. BOUISSIÈRES
Laboratoire Curie de l'Institut de Radium, Paris, France
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THE range of the α-particles from protoactinium, Pa, was first determined by Geiger[1] in 1922, the observations leading to a value of the mean range of 3.63 cm, in air at 15°C and 760 mm of Hg. Recently, Ringo,[2] using a 60°-magnetic α-ray spectrograph has obtained a value 5.053 Mev for the energy of the particles, the corresponding value of the mean range being 3.57 cm. In order to examine this disparity and to detect any fine structure in the α-particle spectrum, we have made experiments with a differential ionization chamber and linear amplifier.[3]

The apparatus employed has already been described in an account of the determination of the range of the α-particles from ionium by Professor I. Joliot-Curie and one of us.[4] For the present experiments the Pa was deposited electrolytically on a sheet of nickel, the active deposit containing more than 50 percent Pa mixed with La. Two sources, each of area 0.12 cm², and emitting approximately

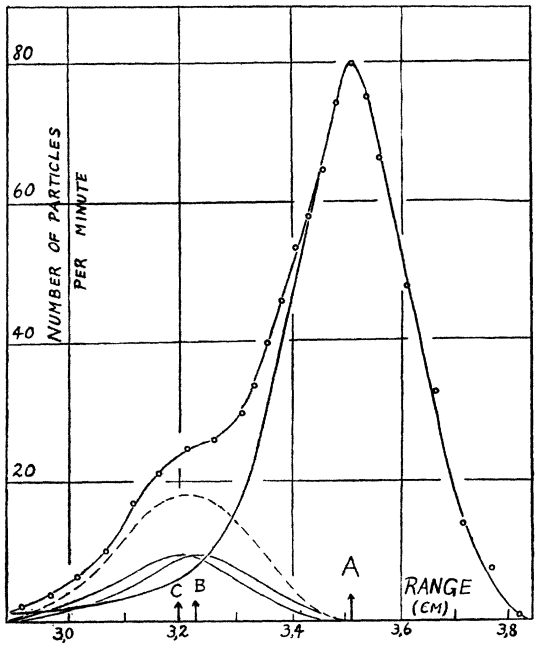

FIG. 1.

3000 and 14,000 particles per second, respectively, were used in succession.

The mean range of the Pa α-particles was determined by comparison with those from Po. Four determinations made with the weaker source gave very concordant results, the mean range being 3.511±0.010 cm at 760 mm, 15°C, the corresponding value for Po being taken as 3.843±0.006 cm.[5]

The frequency range curves have a half-width of 2.1 mm for a very thin polonium source and 2.2 mm for Pa, the latter value being in good agreement with that to be expected from the known thickness of the active layer. Whereas, however, the distribution in range of the Po α-particles shows an almost symmetrical distribution about the mean value, the corresponding result for Pa shows a marked asymmetry corresponding to the presence of particles of lower energy, such as would indicate a fine structure in the α-rays. With the weaker source the number of particles counted was too small to allow any definite conclusions to be drawn and experiments were therefore made with the stronger source.

TABLE I. Energy of gamma-rays.

Groups of α-rays	Mean range (cm)	E_α (Mev)	Energy of disintegration (Mev)	E_γ (kev) from fine structure	E_γ (kev) from β-ray magnetic analysis
A	3.511±0.010	5.00	5.09	290±10	287
B	3.23	4.72	4.80	320±10	323
C	3.20	4.69	4.77		

The second series of experiments were made at four different values of the gas pressure and definitely establish the existence of an α-group of range about 3.2 cm with an intensity about 15–20 percent of that of the main group (see Fig. 1).

If the frequency-range distribution shown in the figure is resolved into two components, as indicated by the dotted lines, it is found that the main group has a half-width of 2.5 mm, concordant with the value to be expected from the known thickness of the active deposit, whereas the smaller group has a half-width of 2.8 mm. The observations are consistent with the assumption that the weak group is complex and made up of two components of nearly equal intensity and mean range 3.20 and 3.23 cm, respectively, each component having a half-width of 2.5 mm.

The energies of the two γ-rays to be expected from such a fine structure in the α-spectrum are given in Table I and agree, within the limits of the experimental error (10 kev), with the values deduced from the magnetic β-ray spectrum which they produce ($E_\gamma = 287$ and 323 kev).[6]

A detailed report of the work will be published shortly in the *Journal de Physique et le Radium.*

* Now temporarily at H. H. Wills Physics Laboratory, Bristol, England.

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