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2. On the Range-Energy Relation for Alpha-Particles in Air

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The range-energy curve for α-particles in air established by Holloway and Livingston (Phys. Rev., 54, 18 (1938)) was revised by Bethe (Rev. Mod. Phys., 22, 213 (1950)) and Jesse *et al.* (Phys. Rev., 78, 1 (1950)) to fit in with the fixed points in low energy region obtained from nuclear reactions. In this revision, the source of the error contained in the H–L curve was attributed to the deviation from proportionality of the ionization-energy relation for α-particles in air, which was regarded as an essential property of air.

In the present study, we have examined the specific ionization curve for α-particles in air with almost the same experimental arrangement as H–L's experiment, and obtained the results which claim that the error contained in the H–L curve is to be attributed to columnar recombination rather than the essential deviation of the ionization-energy relation in air.

With a chamber of 1 mm. in depth, we have measured the specific ionizations at two points (the peak of the specific ionization curve and the point 18 mm. apart from the peak) and determined the ratio of them, applying the chamber voltages 50 V/mm., 135 V/mm., and 1,140 V/mm. successively. (i. e. 500 V/cm., 1,350 V/cm. and 11,400 V/cm.) The results are shown in Table I.

Table I.

Field Strength	500 V/cm	1,350 V/cm	11,400 V/cm
Observed Ratio	1.89_4	1.97_9	2.02_8
	± 0.014	± 0.006	± 0.013

The corresponding ratio obtained from the H–L curve is 1.86. The increase of the ratio with the field strength observed by us agrees with the Jaffé's theory of columnar recombination (Ann. Physik, 42, 303 (1913)) and indicates that the H–L curve is strongly influenced by the effect of columnar recombination.

We have also measured the whole specific ionization curve (residual range 0~22 mm.) with the field strength 500 V/cm. and 11-400 V/cm. The curve obtained with 500 V/cm agrees almost with the H–L curve and the curve obtained with 11,400 V/cm shows larger ionization in low energy region in accordance with the results given in Table I.. Integrating the later curve, we obtained a range-energy curve which nearly agrees with the fixed points determined from nuclear reactions.

We can conclude from the present results that the source of the error in the H–L curve is almost entirely due to columnar recombination, and consequently the proportionality of the ionization-energy relation for α-particles in air should be much better than declared by Bethe and Jesse *et al.*

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3. γ-Spectrum of Co^{60}

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A thin double magnetic lens β-ray spectrometer has been employed with a source of Co^{60} of 2 mc sealed in a glass capsul. Its design admited about 1/500 of 4π in solid angle of β-rays from the source into the counter. The spectrometer, with a thin Pb radiator foil (diameter 7 mm) on one end and a mica end-window type G–M counter on the other and with thick Pb between them to avoid the direct γ, is equipped with the thin double magnetic lens at the middle part of the brass cylindrical tube, as explained eleswhere in detail. (M. Deutch *et al.*, R.S.I. **15** 198 (1944), E.A. Quade *et al.*, Phys. Rev. **72**, 234 (1947)). The γ-ray energies were determined by the study of the spectrum of photo-electrons produced in Pb radiator foils. In addition to the photoelectric conversion lines generated in the lead by γ, a broad distribution of compton electrons was obtained. To permit an accurate determination of the photo-electrons from the radiator, attention was given to the effect of the radiator thickness and to the influence of the earth's magnetic field. The momentum p of the focused electrons will be proportional to the strength of the field and the field is proportional to the coil current. Therefore, may write for this relation $p=k\cdot I$, where I is the current in the coil and k is a factor dependent upon the shape of the field. (k is 1.216×10^3 gauss cm/Amp in this case.)

The current required to focus 1.1 Mev conversion line was found to change 16 mA when the current was reversed, so the correction for the earth's magnetic field has been taken as ± 8 mA. The photo-electrons ejected from a radiator for a particular γ-energy will have energies depend upon the depth of the point from which they originate. The coil current which converged the 1.1 Mev photo-conversion electrons was determined by the use of seven Pb foils 21.5 mg/cm² to 83.0 mg/cm² and its resolution was found to be 3.4%. Two peak values of photo-conversion lines correspond to $I_1=4.175$ Amp and $I_2=4.755$ Amp, respectively, with earth magnetic field correction. So we can estimate the rate of two γ-ray energies as 4.175/4.755. This value corresponds to that give by Linde *et al.* (Phys. Rev. **76**, 1838 (1949)) and Jenzen *et al.* (Phys. Rev. **75**, 458 (1949)).
