Simultaneous Emission of Particles and Pair Production

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THE agreement between the theory and the experimental results on pair production by radioactive substances has not always been satisfactory. Authors working with cloud chambers[1–4] observe a number of positrons which is much larger than the theoretical predictions, but such an excess was not detected by several authors using counters;[5,6] furthermore some investigators have recorded pair emission by β-rays,[2–4,7] that others have not been able to confirm.[5,6,8] In connection with this problem, simultaneous emission of charged particles has been studied by means of coincidence counters.[9]

The radioactive sources, obtained from the active deposit of thorium were placed between two counters (having windows covered by aluminum foils 10μ thick), so that coincidences were produced by at least two simultaneous rays. Special care was taken to eliminate the effects of electron reflection and of chance coincidences.

By means of absorption measurements and by separating the different bodies of the active deposit from each other, it has been possible to show that the coincidences were chiefly due to the following phenomena: (i) emission of α-particles from ThC′ following the β-disintegration of ThC with a period of the order of 10^{-7} sec.;[10] (ii) emission of electrons of atomic internal conversion from ThB in coincidence with the β-ray of disintegration; (iii) simultaneous emissions from ThC″ probably connected with pair emission.

The absorption of the simultaneous rays from ThC″ (separated by recoil from the active deposit) was consistent with the hypothesis that they were originated by internal production of pairs by the γ-rays of 2.6 Mev; an attempt to study the distribution in angular opening between the simultaneous rays seemed to show a faint asymmetry in agreement with the theory of internal pair emission.[11] The number of pairs emitted per disintegration was evaluated by taking into account the geometrical conditions and the fact that from pair production originate three simultaneous rays (e^+, e^-, and β-ray of disintegration). The number of pairs observed was about 50 times greater than the theoretical prediction; the order of magnitude of this result agrees with the determination from cloud-chamber experiments and shows that it is not the counter technique itself that is responsible for the discrepancy between the results previously obtained by these two methods.

Comparing the number of coincidences observed from the active deposit as a whole (after elimination by absorption of the coincidences due to α-rays and to the soft electrons of atomic internal conversion) with the number of coincidences from ThC″ alone, it was found that pair production from ThC″ was equal to pair production from the whole active deposit. This seems to prove that there is no internal pair production by β-rays, because in this case we should have observed pair production from ThC, which emits β-rays of energetic distribution similar to that of ThC″.

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