Coincidences in Time in Compton Scattering

The recent experiments of Bothe and Maier-Leibnitz[1] and of Jacobsen[2] have shown conclusively that true coincidences are observable with the arrangement of counter tubes suggested by the simple theory of the Compton effect. One important aspect of the matter has received but scant attention, however. In so using a photon counter, which is set off principally by the recoil electrons coming from the wall of the tube, one is assuming coincidence in time between the arrival of the photon and the ejection of the electron. This is practically equivalent to the assumption of the correctness of the simple theory. Thus, the instrument used in the experiment is used in a manner which presupposes one particular outcome of the experiment. To be sure, if there were a time lag between the arrival of a photon and the ejection of a scattered electron which varied in random fashion the experiment could give no true coincidences for a double reason—the failure of coincidence both in the scatterer and in the photon counter. It is a possible hypothesis, however, that there is a definite time lag before electron emission of essentially the same amount for both scattering processes. This would give experimentally observed coincidences in spite of lack of coincidence in individual scattering events. The ejection of the electron from the scatterer would follow the arrival of the primary photon and departure of the scattered one by a time, τ. This electron would arrive at its counting tube and set it into operation practically instantaneously. The scattered photon would go to its counter and if again scattered there the recoil electron would appear with the same time lag, τ. The two counters would be put into operation simultaneously. For this to happen it would be necessary for τ to be independent of the energy of the photon, which seems unlikely. In Bothe and Maier-Leibnitz's experiments the incident photons have an energy of 2.65 Mev, while the scattered ones arriving at the photon counter have an energy of 1.5 Mev. Fortunately, it is not necessary to give further consideration to this possibility because of the experiments of Piccard and Stahel.[3] They point out that a failure of coincidence between the scattered electron and photon would necessitate the emission of either one or the other with a time lag, although they do not discuss the operation of the photon counter. These considerations led them to perform their ingenious experiments, using rotating disks for scatterers, which show that neither photons nor electrons are emitted more than 10^{-7} seconds later than the incidence of the original photons. The resolving time of the circuits used for detecting coincidence of discharge of counter tubes is of the order of 10^{-5} seconds, so we may conclude from the experiments of Piccard and Stahel that the objection to the counter experiments suggested above is not a valid one. The experiments of Piccard and Stahel supplement as well as confirm those made with the counters. They seem to us to be of an importance greater than that which the modesty of Piccard and Stahel permits them to claim.

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November 9, 1936.

[1] W. Bothe and H. Maier-Leibnitz, Zeits. f. Physik **102**, 143 (1936)
[2] J. C. Jacobsen, Nature **138**, 25 (1936).
[3] A. Piccard and E. Stahel, J. de phys. **8**, 326 (1936).