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A Direct Method for the Evaluation of the Lifetime of the Meson

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The method of the delayed impulses has been applied to the study of the instability of the meson. The decay curve of the mesons at rest can be traced, as in the case of a radioactive element, and an evaluation of the lifetime given.

METHOD

THE technique of the delayed impulses from Geiger-Müller counters as devised by R. Maze, has been first used by us for the detection of very broad A showers.[1] The delay was introduced between one of the counters and the nearby coincidence set, in order to compensate the inevitable delays occurring in the transmission of impulses from far distant counters.

In the study of the decay of the meson at rest we have to consider the following pair of events: First, the passage of a meson as detected by a counter telescope (a and b in Fig. 1) and its subsequent stopping in an appropriate absorber A, then the emission by the stopped meson of its decay electron detected by a third counter (c in Fig. 1). The second event is separated from the first by the duration of the life at rest of the particular meson considered. The two impulses coming from the coincidence a, b and from the counter c can be brought in coincidence only if the first is delayed by the proper amount of time before entering the circuit set. So the number of coincidences recorded with a particular delay will measure the number of mesons which have lived, at rest, just that length of time. If we measure the number of coincidences per hour for increasing values of the time delay, we shall expect to find the exponential decrease which characterizes the radioactive decay curves.

EXPERIMENTAL ARRANGEMENT

The experiments described here were begun in 1940 in Paris, but because of the circumstances definite results have been obtained only at the end of 1941.

A beam of mesons was defined by counters a and b which were separated by a lead block 10 cm thick (B in Fig. 1). The beam fell then on an aluminum absorber 4 cm thick covering the whole solid angle. Aluminum was chosen in preference to lead because of its relatively greater transparence for electrons, under thicknesses which are equivalent in stopping power for mesons. The decay electrons issuing from this absorber were detected by a side counter c, placed outside of the beam defined by a and b. All the counters were of the so-called slow type (argon +hydrogen filling) and had an effective area of about 100 cm^2.

Counters a and b were connected with a double coincidence set, and the impulse issuing from this set, as well as the impulses coming from c, passed by two separate time delay circuits before being sent to the final coincidence set. Any time difference ranging from 0 to 10^{-5} sec. could be introduced between them. A difference of one division

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[1] P. Auger, R. Maze, P. Ehrenfest, and A. Freon, J. de Phys. [7] 10, 39 (1939).

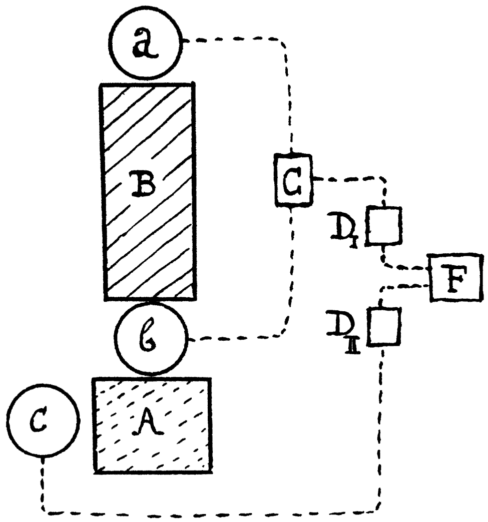

FIG. 1. a, b, counter telescope; C, first coincidence stage; c, side counter; D_I, D_{II}, time delay circuits; F, final coincidence stage.

on the dials of the variable condensers of the delay circuits corresponded to a shift of $(1.5 \pm 0.05)10^{-7}$ sec.

The resolving power of the final coincidence set has been measured by the study of the coincidences obtained when artificial simultaneous impulses are sent into the delay circuits. No coincidences were obtained when the difference of reading on the dials was of more than 7 divisions; with smaller differences all the impulses gave coincidences. From the value of the division (measured with an oscillograph) the resolving time was calculated to 1.05×10^{-6} sec.

If instead of artificial impulses the impulses coming from the counters a and b are sent into the delay circuits, the distribution curve of the number of registered coincidences with varying time differences is not square but bell-shaped because of small variations in the latent period separating the real passage of the particles and the beginning of the counter impulses.

MEASUREMENTS

The number of mesons passing through the telescope was 500 per hour and the number of triple coincidences $a\ b\ c$ without any time delay, (coincidences which are due to showers) was of the order of 10 per hour. This last number suffered no measurable change when the absorber A was set in place, or taken away.

Three series of measurements were made, with differences of 14, 20, and 30 divisions in the readings of the delay circuits dials, the coincidences from $a\ b$ being of course retarded against the impulses from c. The measurements were made in each case with and without the aluminum absorber and are given in mean number per ten hours. The differences are taken as proportional to the numbers of mesons having presented lifetimes at rest within the intervals defined by the delays and by the resolving time of the final stage.

Delay: divisions	14	20	30
Delay: seconds	2.1×10^{-6}	3.0×10^{-6}	4.5×10^{-6}
With absorber	0.8	0.73	0.35
Without absorber	0.17	0.29	0.2
Difference	0.63 ± 0.2	0.44 ± 0.2	0.15 ± 0.1

From these numbers we can estimate the mean lifetime of the mesons at rest (time during which a meson has a probability of one-half for decay) as equal to 1.3 microseconds, with an accuracy of about 50 percent. This result is in better agreement with the results of Nielsen, Ryerson, Nordheim, and Morgan[2] and with those of Rasetti[3] than with the measurements of Rossi, Greisen, Stearns, Froman, and Koontz.[4]

Note added in proof: In the August issue of this Review M. de Souza Santos has reported some results on the lifetime of the meson, obtained with a method which seems very similar to ours. However the curve he obtains for the number of coincidences as a function of the time delay introduced in the transmission of the meson telescope impulse does not show an exponential decrease as in our experiments, but a Gaussian shape around a maximum. The counting rate, as indicated by the low value of the statistical errors, is surprisingly high for the final resolving power claimed, even though the maximum value (for a delay of 5 microseconds) has not been effectively reached.

We should like to point out the similarity of M. de Souza Santos's meson decay curve with the bell-shaped curve which we have obtained when testing the resolving power of our coincidence outfits by the use of delay circuits. Registering the coincidences between the impulses of two counters in a vertical telescope, after their passage through two delay circuits, a symmetrical curve was found, with a high maximum (almost 100 percent of the real number of particles) for a certain adjustment of the delay circuits. We considered this adjustment as corresponding to equal delays on both pulses.

[2] Nielsen, Ryerson, Nordheim, and Morgan, Phys. Rev. **57**, 158 (1940).
[3] F. Rasetti, Phys. Rev. **60**, 198 (1941).
[4] Rossi, Greisen, Stearns, Froman, and Koontz, Phys. Rev. **61**, 675 (1942).