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THE LIFETIME OF THE HEAVY MESON

J. Reginald Richardson

August 26, 1948

Berkeley, California

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THE LIFETIME OF THE HEAVY MESON

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Mesons of mass about 300 m_e have been produced by the 380 Mev alpha particle beam of the 184-inch cyclotron[1]. These mesons are susceptible to $\pi \longrightarrow \mu$ decay[2].

(1) E. Gardner and C. M. G. Lattes, Science, 107, 270 (1948)

A preliminary investigation has been made of the loss of negative mesons from a beam

(2) C. M. G. Lattes, G. P. S. Occhialini, and C. F. Powell, Nature 160, 453, 486 (1947)

of these particles, and since this beam is moving in a region at a pressure of 10^{-5} mm Hg, the assumption is made that this loss corresponds to the $\pi \longrightarrow \mu$ decay process.

The alpha particle beam in the cyclotron is in a horizontal plane. A target of 1/16 inch graphite is provided, and then the mesons are selected by a semicircular spiral channel which rises 1/2 inch vertically in one semicircle (180 degrees). At this point six photographic plates are exposed. The horizontal projection of the channel has an inner diameter of 4.5 inches and an outer diameter of six inches and is oriented in such a way that it selects negative mesons whose initial horizontal component of velocity is in the same direction as the alpha particle beam at the target. A similar channel is provided for mesons spiraling downward at an equal angle, but it is unobstructed at the 180 degree position. These mesons then spiral downward, passing one inch below the center of the target and through another channel to the 540 degree position, having dropped 1.5 inches in 1-1/2 turns. At this point another set of six plates is exposed simultaneously with the first. The ratio of the number of mesons in these two sets of plates when corrected for geometry will give the loss of mesons

in the time corresponding to one revolution in the magnetic field. This "cyclotron" time is independent of the speed of the meson. The desirable 360 degree focusing properties mean that in a uniform magnetic field the geometrical correction is simply a factor of three in the above case. Because the experiment was done in the fringing field of the cyclotron, room was left in the second part of the lower channel for the slight precession caused by this non-uniform field. The effect of the vertical focusing forces due to the fringing field was investigated theoretically and also experimentally by performing the experiment at different cyclotron radii. Most of the data were taken at a cyclotron target radius of 76 inches where the alpha particle energy is 350 Mev. At this radius the correction for vertical focusing is negligible compared to the statistical uncertainty in the experiment. In order to check the possible presence of any unknown asymmetry, the channels were interchanged, so that the 180 degree channel spiraled down and the 540 degree channel spiraled up. No difference could be detected and the two situations are represented with approximate equality in the final results. In each case a simultaneous background exposure was made at the 540 degree position in a channel which was an extension of the 180 degree channel. The plates placed here would record any mesons which originated in places other than the target. This background was negligibly small.

Some 250 plates have been exposed during the course of the investigation. Although a check was made on the thickness of the emulsion in the individual plates, the number of plates used was so large that the resulting correction was very small. Fortunately the background of neutron recoils, etc., in the photographic plates was practically identical in the 180 degree and 540 degree positions, so that the search for mesons was made under identical conditions. The 18 plates of a run were all developed at once and received identical treatment.

Although all the mesons observed had a range consistent with a mass in the neighborhood of 300 m_e it was decided to count only those mesons which ended in stars. Sixteen star-producing mesons were observed in the plates at 540 degrees whereas the number expected on the basis of geometry would be 41. The latter number is based

statistically on a count of 80 mesons. Assuming a mass of 300 m_e for the meson, the time for one revolution turns out to be 7.6×10^{-9} seconds. Therefore the number of mesons obtained, together with the assumption mentioned earlier indicates that the half life of the star-producing negative mesons for $\pi \longrightarrow \mu$ decay is $(5.7 \pm 1.1) \times 10^{-9}$ seconds, where the error indicated is the statistical probable error(3).

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(3) Dr. Lattes has received a personal communication from the Bristol group indicating that they have results on the $\pi \longrightarrow \mu$ decay which are not inconsistent with this figure.

The writer takes pleasure in acknowledging his gratitude to Dr. E. Gardner and Dr. C. M. G. Lattes for their kind suggestions and instruction in the use of their technique for investigating mesons. Thanks are due to Mr. A. Bishop and Mr. F. Adelman and the cyclotron crew for help in making the bombardments. The writer is grateful to Professor Ernest Lawrence for encouragement and for the opportunity to work in the Radiation Laboratory. This work was performed under the auspices of the Atomic Energy Commission.