A Measurement of Mesotron Lifetime

To obtain a proof of the mesotron decay hypothesis and to determine their lifetime without the necessity of making assumptions regarding their energy spectrum and the height of the layer where they are produced, the following observations have been made. The absorption curves of the cosmic radiation of vertical incidence were measured in lead from 0 to 15 inches Pb first on top of Mt. Mitchell, North Carolina (elevation 2040 meters, mean barometric pressure 60 cm Hg) and then at Durham, North Carolina (elevation 123.5 meters, mean barometric pressure 75 cm Hg). In the first series (Mt. Mitchell) the air column of 15 cm Hg $=203$ g/cm^2 was compensated by a layer of graphite of 200 g/cm^2 filling the whole sensitive cone of the counter telescope.

In these measurements we have counted coincidences between four G-M counters. The slabs of absorbing lead were three times the width of the counters and about three times the sensitive length of the counters.

Some of the observed counting rates per hr. were thus:

Inches Pb	0	3	8	15
Mt. Mitchell	46.8	38.2	30.1	25.2
Durham	32.7	28.0	24.3	22.2

We estimate the statistical probable errors of the Mt. Mitchell data to be of the order of 1.2 percent and that of the Durham data to be of the order of 1.5 percent.

A similar series of observations at Mt. Mitchell with 10 cm of lead at the sides of one counter shows that the background showers were quite negligible in their effect on the course of the absorption curve. Furthermore, the number of such sidewise showers was small compared to the difference in counting rates in the two series of data. This large difference between the two series of measurements at Mt. Mitchell and Durham is therefore real and removes any doubt as to the reality of the difference in the absorption of the hard component in air as compared to dense matter. These measurements give, then, strong support to the mesotron decay hypothesis.

For the evaluation of the lifetime we use the following formula for the attenuation factor (reduction of intensity at the lower level):

$$A=(E/(E+Bx))\exp[\mu c^2/c\tau B],$$

where E is the energy at the lower level, B the specific energy loss in air (2×10^6 ev/(g/cm^2) $=2.4\times10^8$ ev/km air), x the distance traveled, μ the rest mass of the mesotron, and τ the lifetime at rest. This formula takes into account the change of energy, i.e., the change in the Lorentz time factor along the path.

From the data of the table the lifetime comes out to be $\gamma(\mu c^2/10^8\text{ ev})\times10^{-6}$ sec., where $\gamma=1.2$, when A is calculated from the values at 8 and 15 inches Pb (corresponding to an average mesotron energy $E\sim4.4\times10^8$ ev) and $\gamma=2.4$ for the values between 3 and 8 inches Pb (average energy $\sim2.8\times10^8$ ev). The latter value might already be falsified by a contribution from the soft component. The accuracy of the measurements is not yet sufficient to make certain the low value of 1.2 for γ, but it seems unlikely that it could be larger than 2. There would be no objection against a lifetime as small as 1.2×10^{-6} sec. from other observations (inclination measurements, barometer effect), if the production of the mesotrons takes place at a somewhat lower altitude than that of the maximum of the soft component or if the mean energy of the mesotrons is somewhat larger than heretofore assumed.

The value of the mesotron lifetime is then of the same order of magnitude as found in previous determinations. The actual measurements themselves are in reasonable agreement with the recent measurements of Rossi and his collaborators[1] insofar as a comparison can be made. From the fraction 26/34 of the mesotrons capable of traversing 12.5 cm or more of lead and which survive after a distance of 1900 meters one calculates a mean path of 7×10^5 cm as compared to Rossi's value of 8.5×10^5 cm.

The observations are being continued, and a full report will be published later.

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[1] B. Rossi, H. van Norman Hilberry and J. Barton Hoag, Phys. Rev. 56, 837 (1939).

Alpha-Particle Groups from the Disintegration of Beryllium by Deuterons

We have been investigating the energies of the alpha-particles from the reaction $Be^9(d,\alpha)Li^7$, with the variable pressure absorption cell described by N. M. Smith, Jr.[1] Since the mean range of these alpha-particles is about 3 cm in air at the deuteron energies available to us, and the effective length of the absorption cell is 6.699 cm, the operating pressures ranged from 15 to 35 cm.

Thin targets containing beryllium were prepared by volatilizing beryllium fluoride from a platinum wire held in the cooler parts of an oxygen-gas flame, and then inserting polished nickel target disks in the flame for 2 to 3 seconds. The cell was calibrated with a thin polonium source, which could be interchanged with the bombarded targets.

Figure 1 shows results with polonium, beryllium, and with a thin carbon target made by smoking one of the nickel disks in a gas flame. The scaling circuit was heavily biased so that counts were not recorded unless the alpha-particles passed through the 3-mm chamber at a velocity corresponding to their highest ionizing efficiency. The abscissae are pressures in the cell in centimeters of mercury. The ordinates for the carbon and beryllium curves are counts per 10^{-3} coulomb. The counting was automatically stopped by an integrator which tripped at 796 microcoulombs. The peak of the polonium curve corresponds to the counting of about 150 particles. The cell temperature for the polonium was 31.6°C, for the beryllium, 29°C.