ANALYSIS OF \( \tau \)-MESONS

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ABSTRACT

We describe in this paper measurements made on the decay products of 11 \( \tau \)-mesons observed in large nuclear emulsion block detectors. Out of the 33 charged decay products, 27 have been arrested in the block, and were identified as \( \pi \)-mesons. The charge of the \( \tau \)-meson was found to be positive in 6 cases. In one case the charge of the \( \tau \)-meson is possibly negative and in 4 cases it could not be determined. Omitting one \( \tau \)-meson in which a high energy \( \gamma \)-ray is emitted and which has been reported earlier\(^1\) the weighted mean Q-value of the remaining 10 \( \tau \)-mesons is:

\[
Q_\tau = 76 \pm 0.3 \text{ MeV}
\]

which gives the mass of the \( \tau \)-meson as:

\[
m_\tau = 968.7 \pm 0.6 \text{ m}_\pi
\]

This value is slightly higher than the mean value 965.5 \( \pm 0.7 \text{ m}_\pi\) compiled by Amaldi et al.\(^2\) from measurements of various laboratories.

We have so far observed 11 cases of disintegration of \( \tau \)-mesons at rest into charged \( \pi \)-mesons. These events occurred in three emulsion block detectors whose construction has been described elsewhere.\(^3, 4\) Of these 11 \( \tau \)-mesons, 7 were found by tracing \( \pi \)-mesons from the end of their range back towards their origin; the remaining 4 \( \tau \)-mesons were discovered during systematic scanning. Ten of the 11 \( \tau \)-mesons could be traced back to the nuclear explosion in which they originated.

Of the 33 charged decay products, 27 came to rest in the emulsion blocks, and were identified as \( \pi \)-mesons (18\( \pi^+ \), 8\( \pi^- \), and 1 more \( \pi \)-meson with a probably negative charge). The charge of the \( \tau \)-meson was positive in 6 cases. In 1 case (\( \tau_n \)) observational conditions at the end of one of the \( \pi \)-meson tracks are unfavourable. The \( \pi \)-meson becomes suddenly very steep near the end of its range and stops after travelling another 712 \( \mu \) in the emulsion. We have not been able to detect any decay electron at the
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point where the particle stopped nor any point where change of direction or of grain density suggests that the \( \pi \)-meson decayed into a \( \mu \)-meson. Hence this \( \pi \)-meson might be negative. If this interpretation is accepted \( \tau \) gives rise to two negative and one positive \( \pi \)-meson.

Table I gives the results of measurements on all 11 events. \( \tau_1 \), \( \tau_2 \) and \( \tau_3 \) have already been reported. Their Q-values given in Table I are slightly different from those reported earlier, because we have based all our analyses on a slightly modified range energy relation.

\( \tau_4 \) is abnormal since nearly 50\% of the available kinetic energy is carried away by a \( \gamma \)-ray and not by the three \( \pi \)-mesons. This event has been discussed in detail in an earlier paper by Daniel and Yash Pal. \( \tau_5 \) and \( \tau_6 \) suffer inelastic collisions before they come to rest. These collisions have been discussed in a previous paper by Daniel and Lal, but the data on the decay products of these \( \tau \)-mesons have not been published before.

The first four columns in Table I give information on the parent particle. The \( \tau \)-meson number is given in column 1, column 2 gives the description of the nuclear event in which the \( \tau \)-meson originates (we use here the nomenclature of Brown et al.). The range of the \( \tau \)-meson before it comes to rest and the energy of the \( \tau \)-meson at emission are given in columns 3 and 4 respectively.

The next 4 columns of Table I give information on the decay products. The charge of the \( \pi \)-meson is given in column 5 when it can be inferred from its behaviour at rest (\( \mu - e \) decay or capture star). When the charge of the \( \pi \)-meson is unknown a question mark is inserted.

The range of the \( \pi \)-mesons is given in column 6. All range measurements were carried out independently by two observers. The symbol (t) in column 6 signifies that the particle comes to rest in the block and its total range has been measured. The symbol (o) indicates that the particle escapes and only the observed portion of the range is given.

The energy of the \( \pi \)-meson is listed in column 7. The range-energy curve which we used is based on a flat \( \mu \)-meson range of \( 574.5 \pm 7.7 \mu \) while in our detector the mean range of flat \( \mu \)-mesons obtained from the decay of \( \pi \)-mesons at rest is \( (579.9 \pm 3.6) \mu \). Hence we have reduced the observed ranges by the ratio \( 574.5/579.9 \), before using the range-energy relation.

The angle between the tracks is given in column 8. The Q-values and their estimated errors are obtained as follows: If all the three \( \pi \)-mesons come to rest in the block, the Q-value was obtained by merely adding the