On the Spin and Parity of the $\tau$-Meson.

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Summary. — The angular distributions of the secondaries of the $\tau$-meson have been calculated for eight combinations of spin and parity, using the hypothesis accepted until now about the type of interaction. Comparing these distributions with the experimental data, one finds a satisfactory agreement for the cases of even spin and odd parity, especially for the $[0,-]$ case.

1. — Introduction.

The determination of spin and parity of heavy unstable particles represents, at present, one of the main objectives for the understanding of these states of matter. In fact, it strongly influences every rigorous formulation of the interactions in which these particles are produced or absorbed. Moreover, it is very important as a criterion for deciding if the various modes of decay of those K-mesons, which have been observed, represent several particles which may be considered as intrinsically different (i.e. with different values of spin and parity) or the different decay modes of the same particle.

Amongst the unstable particles presently known, only in the case of the $\tau$-meson does it seem possible to obtain some information about these essential internal parameters: since the three secondaries are all charged, it is possible to determine experimentally all the energy and angular distributions in such a three-body decay: so that, if one makes a comparison with the corresponding theoretical distributions, calculated separately for various values of spin and parity, one might decide the values of these internal parameters. For this reason the $\tau$-meson has been occupying a privileged position amongst the unstable particles, and several works have been already devoted to the subject.
In a previous work, when the experimental techniques did not permit the determination of the sign of the charged secondaries, Dalitz (1), considering these particles as indistinguishable, analyzed the kinematics of the \( \tau \)-meson decay. For this purpose, he used a bidimensional representation in which the configuration for any \( \tau \)-event was given as a point on a plane surface: an eventual uniformity of the point distribution would then indicate the pseudoscalar nature of the \( \tau \)-meson. He also calculated the energy spectra corresponding to several combinations of spin and parity, but the results were relatively insensitive to the variation of these parameters and the poor experimental statistics then available did not allow to draw any definite conclusions. Later, when the technique of nuclear emulsions had progressed sufficiently, it was possible to establish the signs of secondaries of the \( \tau \)-mesons which were thus found to be positively charged, i.e. \( \tau^+ \). Dalitz then, in a second work (2), took the sign of the charge in consideration, and obtained the result that, in this case, the energy distribution of the unlike meson was much more sensitive to variations of spin and parity than in the case when the charges were unknown; and thus it was hoped to arrive at the determination of these parameters. A similar study was made by Fabri (3): he divided the theoretical results concerning the energy distributions of unlike mesons in a way which was more suitable for comparison with the experimental distributions obtained from the very poor statistics at that time available. In this way it was possible to exclude some combinations of spin and parity of the \( \tau \)-meson.

In the above mentioned works, the energy distributions only have been explicitly calculated; moreover, the calculations have been made for the five simplest cases, i.e. \([0, -], [1, +], [1, -], [2, +] \) and \([3, -] \). Recently, experimental results have shown a notable increase and Dalitz (4), basing his arguments on the low energy part of the spectrum of the negative secondaries, has concluded that probably the only possible cases for the \( \tau \)-meson are even spin and odd parity, i.e. \([0, -], [2, -], [4, -] \), \([6, -] \) if one considers that low values of the spin are the most probable.

However, the energy distributions of unlike secondaries presented by Amaldi (5) at the Pisa Conference, show a very similar behaviour for these four combinations; so that, at present, experimental evidence is still not sufficiently abundant to allow us to discriminate between these four possibilities.

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