On the Capture of Negative Mesons

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WHILE nothing is known as yet about what happens after the capture of a normal negative meson (mass 100 Mev), it may be of some interest to report a few considerations regarding the end of the life of such a particle, when it is stopped in an element with relatively high Z. In such elements experimental evidence has shown that negative mesons do not undergo the normal decay process,[1–3] and therefore it seems reasonable to assume that they are captured by the nuclei. Now, from general considerations[4] one would expect a nuclear disruption after the meson capture. Assuming that this is the case, Heisenberg[5] has pointed out that it is surprising that no evidence of stars produced this way is as yet available from the cloud-chamber pictures taken for the purpose of photographing the decay process. We want to emphasize here that: (a) a star is easier to recognize than a decay electron, and can hardly be missed; (b) there are, up to now, four photographs of mesons stopped in gas and giving decay electrons, and several more photographs of mesons stopped in gas without indication of decay electrons; among them is one very clear photograph by T. H. Johnson and R. P. Shutt[8] in which a negative meson is shown to stop in the gas (argon) without giving any ionizing particle. It is also presumable that many pictures of the last kind were not published if they did not allow a good measure of the mass;* (c) many authors[6–9] worked with argon, with a magnetic field, or with high pressure. In argon[10] one would expect that negative mesons undergo capture with fairly high probability; on the other hand, the momentum-range relation, or the increase of ionization in a high pressure chamber, makes it unlikely to misinterpret a negative meson going toward the star for a particle coming out of the star. Therefore it seems unlikely that a negative meson produces a star after the capture. This is also compatible with the latest results of Lattes, Occhialini, and Powell.[11]

The recent result of Valley and Rossi[12] seems to indicate another possibility, suggesting that the capture actually is only an acceleration of the normal decay process. However, as the writer observed to the above-mentioned authors, this assumption is rather in disagreement with Rasetti's experiment on the decay electrons of mesons.[13] Rasetti had a narrow meson beam, and protected against side shower with lateral anticoincidence counters. In the path of the beam was an absorber (Fe or Al) beyond which an anticoincidence tray subtended the whole solid angle of the beam. The G-M counters E (Fig. 1, reference 13) which detected the decay electrons were entirely outside of the beam. From the delayed coincidences of the G-M counters E, with respect to the other trays, Rasetti obtained, by extrapolation, the total number of decay electrons $D2$, produced in the aluminum by normal (2.2 microsec. mean life) mesons, and detected by the G-M counters E. At the same time, the prompt coincidences (15 microsec. resolving time) of the counters E obviously comprised: decay electrons of 2.2 microsec. mean life $D2$, plus eventual decay electrons Dx of mean life less than 2 microsec. (which could not contribute to $D2$), plus some scattered mesons Sm and, perhaps, some residual showers Sh. In Fe the prompt coincidences of E were, in 100 hours, 45 ± 5 while $D2$ was 35 ± 7. We have then $Dx+Sm+Sh=(45\pm5)-(35\pm7)=10\pm8.6$. Even assuming $Sm+Sh=0$, we see that $Dx=10\pm8.6$ is too small, in comparison with 35 ± 7, to assume that each negative meson gives one electron. It is true that the low value of the mean life $\tau=2.2$ microsec. found by Rasetti seems to show a systematic error in the apparatus. However, $D2$ is not so closely correlated to τ as it is to the measured ratio η of decay electrons to stopped mesons. This ratio, measured for Al with the same apparatus, was found to be $\eta=0.4\pm0.15$. Now, from the results of Valley and Rossi η seems likely to be somewhat larger than 0.55. Since any systematic error of the apparatus would affect $D2$ exactly in the same proportion as η, it appears that the rate 35 ± 7 is not too large because of a systematic error.

With aluminum as absorber, Rasetti's data give $Dx\leqq10\pm8$ and $D2=20\pm6$. This comparison may be not as conclusive as the comparison between the number of mesons stopped (97 ± 15) and the prompt coincidences of E (30 ± 5), which again is equal to $D2+Dx+Sm+Sh$. This comparison can be done because for the aluminum absorber there is available the value of the total efficiency of the counters E for electrons of 40 Mev emerging from the Al (2.5 cm thick). This value was 0.5, taking into account the finite range of the electrons, since the geometrical efficiency was 0.56. Should every meson give one electron, the rate $(97\pm15)/2$ should be equal or less than 30 ± 5. We emphasize that in the last comparison only data obtained with a circuit of large resolving time (15 microsec.) are taken into account.

Therefore, we have to admit that so far both the cloud chamber and the G-M experiments failed to observe the event following the capture of a negative meson. To check another possibility, an experiment is now in progress at M.I.T.** the purpose of which is to find out whether or not one (or more) photon of energy about 40 Mev (or more) accompanies the stopping of a meson in Fe. Although the data do not have as yet a good accuracy, preliminary results seem to indicate a negative answer.

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