ABSORPTION OF STOPPED π^--MESONS IN CARBON

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Stars produced by π^- mesons stopped in a four-liter propane bubble chamber were investigated. The distribution of the stars with respect to the number of prongs was determined; the mean number of prongs was found to be 0.84. The distribution of two-prong stars with respect to the opening angle between the prongs was also measured and found to have a sharp peak near 180°. Both results indicate a two-nucleon mechanism of the π^--meson absorption in the carbon nucleus. The probability of π^--meson absorption by an np pair is 70%.

THE lack of clear-cut results concerning the absorption mechanism of π mesons in complex nuclei has led us to investigate this process for negative π mesons stopped in matter.

For this purpose we analyzed the pictures from a propane bubble chamber taken earlier to study the scattering of slow π^- mesons.[1] The use of the propane bubble chamber determines automatically the nucleus with which the interaction has occurred, for in propane the stopped π^- mesons are absorbed only by the carbon.

We selected about 3500 π^- mesons stopped inside the chamber, out of which 1130 were used to construct the distribution of π meson stars with respect to the number of prongs, and 1180 to study the distribution with respect to the opening angle between the prongs.

In the first case, the experimental data were corrected for the detection efficiency of a given number of prongs in a star. Such a correction, as was found out, is essential only for single-prong stars and starless stopping events, and is due to the fact that prongs directed at angles close to 0 and 180° with respect to the direction of motion of the primary meson are often omitted in scanning. In order to make the correction, we constructed the distribution of 1000 single-prong stars with respect to the angle between the prong and the primary meson. From general considerations, this distribution should be isotropic, whereas in the experiment dips were observed at angles 0—20° and 160—180°. These dips were considered as being due to the omission of single-prong stars, or rather to accounting them as starless stopping events. The corresponding overshoot amounted to 12.7%.

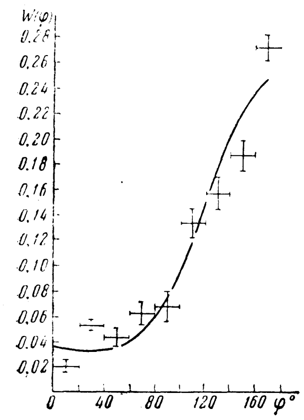
The study of the tracks of secondary particles emitted from π-meson stars leads to the conclusion that the secondary particles are exclusively protons. In this connection it should be noted that the above-mentioned correction does not take into account the fact that protons with energy less than 4—5 MeV (range in propane ≤ 0.5 mm) are in practice undetectable. It was, however, possible to account for this fact in the formulae used. The corrected distribution of stars with respect to the number of prongs is shown in the second column of the table (where the values of the corresponding probability are given).

Assuming [2] that π^- mesons are absorbed in the nucleus only by nucleon pairs [(np) or (pp)], and that a different number of prongs in the stars is a result of the cascade scattering of the recoil nucleons on the remaining nucleons in the nucleus, we can calculate the distribution of stars with respect to the number of prongs. This distribution was calculated taking not more than one collision of the recoil nucleons inside the carbon nucleus into account.

A comparison of the experimental data with the calculation by the least-squares method showed that the absorption probability of a π^- meson nucleus

Distribution with respect to the number of prongs N

N	W_{exp}	W_{calc}
0	0,400±0,019	0,379
1	0,401±0,018	0,440
2	0,159±0,012	0.160
3	0,034±0,005	0.021
4	0,006±0,003	0.000



by a (np) pair amounts to 70—80%, by a (pp) pair to 30—20%, and that the probability of a collision inside the nucleus is 60—80%. These results are similar to the earlier ones [3,4] (more accurately, we found three close pairs of the probability values, lying within the limits given above, and being solutions of the problem).

The distribution with respect to the number of prongs, calculated assuming a 70% absorption probability by a (np) and a 70% probability of a scattering of the recoil nucleon inside the nucleus, is shown in the third column of the table (W_{calc}). (The probability values used correspond to the deepest minimum of the least-squares method.)

We also constructed the distribution of two-prong stars with respect to the projection of the opening angle between the prongs, and the distribution with respect to the projection of the angle between a prong and the direction of motion of the primary π meson. As expected, the latter distribution was found to be isotropic. The distribution with respect to the projection of the opening angle between the prongs shows a characteristic increase with increasing value of the projection of the angle (see the figure). This fact confirms the assumed nucleon-pair mechanism for the absorption of the π^- meson in the nucleus.

For a qualitative analysis, this distribution has been calculated assuming that the scattering of nucleons inside the nucleus is isotropic in the center-of-mass system of the two nucleons. In the calculation we used the above-given values of the probabilities of collision and absorption.

The obtained distribution is of the form:

$$W(\varphi) = A\left(\frac{\cos\varphi \sin 2\varphi}{4} + \frac{\sin^3\varphi}{2} - \frac{\varphi}{2}\cos\varphi\right) + \frac{A}{4}B(\varphi),$$

$$B(\varphi) = \begin{cases} \cos\varphi & 0 \leqslant \varphi \leqslant \pi/2, \\ -\cos\varphi & \pi/2 \leqslant \varphi \leqslant \pi, \end{cases}$$

where φ is the projection of the opening angle between the prongs. The distribution $W(\varphi)$, normalized to the total number of stars, is shown in the figure by the solid curve. It can be easily seen that the calculated distribution fits well the experimental points.

We can thus claim that the obtained preliminary results on the absorption of stopping π mesons in carbon are not in disagreement with the two-nucleon absorption mechanism, and that the absorption probability by a nucleon pair is apparently independent of the energy in the range up to ~200 MeV.[3,4]

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187