Scattering of π^- mesons of 7-8 GeV energy on
nucleons, with large momentum transfers

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In studying elementary particle scattering processes at high energies, of considerable interest is the case of large momentum transfers of the colliding particles as a result of the interaction.

Examples of such processes are reactions in which the particles are scattered through angles close to 180° in the centre-of-mass system. In particular, studies of such reactions may confirm the ideas set out in the work of Gell-Mann and Zachariasen[1], one of the consequences of which is that scattering with large momentum transfers must not disappear at high energies. In addition, as pointed out by I.Ya. Pomeranchuk (see, for example, reference 2), the vertex in diagram 1 may contribute significantly to the scattering of π^+ mesons with protons through an angle of 180° in the centre-of-mass system at high energies. The angular distribution of the scattered π^+ mesons, defined by this diagram, must have a maximum at 180° in the centre-of-mass system with a width of about 30° (for π^- mesons with momenta of 7-8 GeV/c), corresponding to backwards scattering of π^+ mesons in the lab. system. The cross-section for such a process can be estimated from $d\sigma/d\Omega$ (180°) = 0.5 mb/sterad. The total cross-section here for backwards scattering of π^+ mesons with momenta of 7-8 GeV/c in the lab. system should be about 0.5 mb.

We studied the following backwards scattering reactions in the lab. system for π^- mesons with nucleons,

$$\pi^- + n \to \pi^- + n \qquad (1)$$

$$\pi^- + p \to \pi^- + p \qquad (2)$$

$$\pi^- + p \to \pi^0 + n \ . \qquad (3)$$
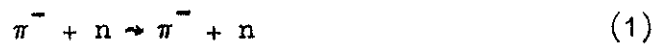
Reaction (1) is an isotopically conjugate analogue of the π^+ meson scattering reaction with protons considered above. It follows that the peculiarity already noted must also obtain in this case[2]. It is also obvious that the diagram given (Fig. 1) will also give a contribution to the cross-section for reaction (3). Indeed, for the scattering of π^- mesons with protons (2), it will not obtain because of charge

conservation.

The events were studied in photographs obtained with the 24 litre propane bubble chamber placed in a magnetic field of 13,700 oersted. The incident π^--meson beam was of momentum 7-8 GeV/c.

Two independent observers studied about 30,000 photographs in order to find events corresponding to reaction (3). Those events were recorded in which the π^- meson disappeared. The efficiency of finding such events was about 95%. As a result, 579 cases of pion disappearance were selected, which were accompanied by $\sim$ 230 γ quanta. Amongst these, only in three cases did the γ quanta have an emission angle $\vartheta \gtrsim 90°$ in the lab. system. An upper limit for the cross-section for reaction (3) can be obtained from this, since at least one γ quantum should be emitted backwards from the decay of the π^0 meson in the case of backwards scattering of the π^0 meson in the lab. system. From this we obtain

$$\sigma_3 (\gtrsim 90°) \lesssim 0.1 \text{ mb.}$$

In order to find events corresponding to reactions (1) and (2) nearly 6,000 photographs were scanned twice. Those cases were recorded in which there was a negative relativistic particle having an emission angle $\vartheta \gtrsim 90°$ in the lab. system (1), and the analogous case with an accompanying emission of a charged particle forward (2). The efficiency of finding these events was close to 100%.

As a result, four events were found, which did not contradict the kinematics of reaction (1). With the assumption that the carbon nucleus behaves itself effectively as a single quasi-free neutron[3], an estimate for the upper limit of the cross-section for this reaction was obtained

$$\sigma_1 (\gtrsim 90°) \lesssim 0.06 \text{ mb.}$$

This result agrees with the analogous estimate obtained by Bayukov, Leksin et al.[2,4] with π^- meson momenta of 2.8 GeV/c.

Together with this, three cases were found which did not contradict the kinematics for an elastic scattering reaction backwards in the lab. system of π^- mesons with protons. This corresponds to the cross-section

$$\sigma_2 (\gtrsim 90°) \lesssim 0.02 \text{ mb.}$$

The estimates for the cross-sections obtained in this way for the processes (3), and especially (1), are significantly less than those calculated for the diagram (Fig. 1), and this apparently indicates that the diagram given should be modified by another possible diagram. Furthermore, the cross-sections for all of the three scattering processes studied are equal in order of magnitude, within the framework of the estimates given, i.e., there is no difference between those processes in which this diagram contributes and those for which it is impossible.

References

1) M. Gell-Mann, F. Zachiariasen, preprint (1961).

2) Yu.D. Bayukov, G.A. Leksin, D.A. Sychkov, Ya.Ya. Shalamov, V.A. Shebanov ITEP preprint 61-6 (1961), JETP (in print).

3) B.P. Bannik et al., JETP (in print).
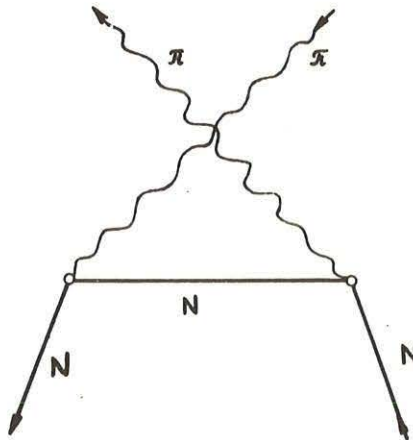
4) Yu.D. Bayukov et al., ITEP (1961) preprint.

Рис 1