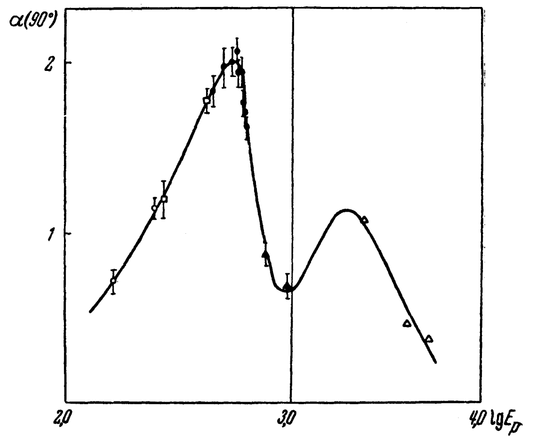


FIG. 2. The energy dependence of $\alpha(90°)$ for the states with the isotopic spin $T = 1\frac{1}{2}$. □ —according to Ref. 2, O—according to Ref .3, ●—according to Ref. 4, ▲—according to Ref. 5, Δ—according to Ref. 6.

In addition to this latter peculiarity, at present a maximum is also known for the states of a pion and and a nucleon with an isotopic spin of $T = 1/2$, which is observed at the pion energy of ~ 800 mev in a laboratory system of coordinates, or at a total energy of ~ 600 mev in a center-of-mass system. The hypotheses of Dyson[7] and of Brueckner[8] clarify the causes of the appearance ofthis second maximum, however its nature has not yet been established, If this second maximum appears as a result of a strong interaction between a pion and a nucleon, then one would expect to find peculiarities in the interaction between two protons in the same energy region. Initial data on the value $\alpha(90°)$ at energies higher than one bev indicate the presence of this predicted peculiarity, namely: as is evident from Fig. 2, in the energy region (1.5 – 2) bev the value $\alpha(90°)$ undergoes non-monotonic change. The total energy in a center-of-mass system corresponding to this region is equal to 600–700 mev.

The states of a two nucleon system with $T = 0$ cannot experience the effect of strong interaction between a pion and a nucleon in the state s with $T = 3/2$, since $T_{\pi N} = 3/2$ and $T_N = 1/2$ can produce only the states with $T = 2$ and $T = 1$. Therefore, the dependence curves of $\alpha(90°)$ for the states of two nucleons with $T = 0$ should not possess any of the peculiarities which can be observed for $T = 1$. Although the experimental data substantiate this prediction, they do not permit us to draw such a conclusion with complete certainty.

The maximum of the dependence of the total cross section of the interaction between a pion and a nucleon in the states with $t = 1/2$ at total energy in a center-of-mass system of ~ 600 mev should appear in the processes of the elastic scattering of a nucleon on a nucleon in the states with $T = 1$ and $T = 0$. This permits us to draw the conclusion that the dependence curve of $\alpha(90°)$ for the states of two nucleons with $T = 0$, beginning with the energy (0.8–1.0) bev, should reproduce almost completely the corresponding curve for the states of two nucleons with $T = 1$.

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## Interaction between Negative Pions and Helium Nuclei at 330 mev Energy

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At present there exist few investigations devoted to the interaction between pions and nuclei at energies higher than 200 mev. In particular, very little data have been obtained on the interaction between pions and the simplest nuclei. Below we will describe the results of the study of the interaction between negative pion and helium nuclei at 330 mev energy.

For the observation of simple interactions we have used a diffusion chamber of 270 mm in diameter which was filled with helium at a pressure of

14 atm. The results are based on an analysis of 97 events of interaction obtained from an examination of approximately 13,000 photographs.

In the collisions of fast mesons with $\alpha$-particles the following main processes are possible:

$$\pi^- + He^4 \rightarrow \begin{cases} \pi^- + He^4 - \text{elastic scattering} & (1) \\ \pi^- + (2p,\ 2n) - \text{inelastic scattering with no change in charge} & (2) \\ \pi^0 + (1p,\ 3n) - \text{scattering with change of charge} & (3) \\ (1p,\ 3n) - \text{nonradiative capture} & (4) \end{cases}$$

The nucleons in these reactions may be emitted as deuterons, tritons, $He^3$ nuclei and free nucleons. At a given energy of pions processes of meson production are also possible.

In the reactions enumerated the events of elastic scattering at angles larger than 10° can be easily identified from the general kinematic conditions. The identification of elastic scattering at smaller angles presents considerable difficulties, since the resulting fissioning nuclei ($\alpha$-particles) have a very short path. It is possible, however, with a sufficient degree of certainty, to assume for the events of elastic scattering in the region of small angles any sharp deviation of the particles from its initial direction, since the overwhelming majority of inelastic processes, capable of serving as a main source of errors, is accompanied by visible tracks of the products of splitting. The lower limit of the registration angle of the elastic scattering is given by the maximum angle of $(\pi - \mu)$–disintegration equal to 5.1° at 330 mev energy.

The events of inelastic scattering with no change in charge were identified by the presence among the reaction products of a single track with ionization approximating the minimum. We did not succeed in identifying individually any events of exchanged interaction [reactions (3) and (4)]. The exception was the absorption of pions by the $(p-p)$–pairs, when as a result of interaction a single fast proton is emitted. The criterion for the selection of such events was the approximate agreement between the angle of emission of the proton and the ionization produced by it, which follows from the requirements of the conservation of energy and momentum.

In the reactions of meson production we identified only the events of the production of charged $\pi$-mesons the ionization of which approximates the minimum.

The cross sections (in the units $10^{-27}$ cm$^2$) obtained in the various processes are as follows:

| | | |
|---|---|---|
| Total cross section of interaction ($\sigma_t$) | 150 ± 15 | (97) |
| Inelastic processes ($\sigma_t$) | 99 ± 12 | (64) |
| Elastic scattering ($\sigma_t$) | 51 ± 9 | (33) |
| Absorption with change in charge ($\sigma_\alpha + \sigma_{ex}$) | 31 ± 7 | (20) |
| Inelastic scattering with no change in charge ($\sigma_i$) | 65 ± 10 | (42) |
| Absorption by $(p-p)$–pair ($\sigma_{\alpha(pp)}$) | 3 ± 2 | (2) |
| Meson production ($\sigma_\pi$) | 3 ± 2 | (2) |

The figures on the brackets indicate the number of the corresponding events of interaction. In both observed events of meson production creation of positive mesons was taking place.

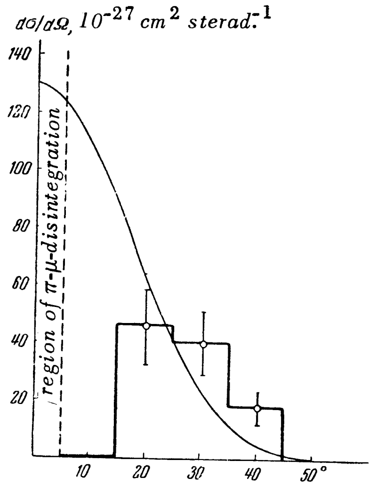
From experiments on the interaction between mesons of lower energies and complex nuclei[1,2], it is known that in the nonradiative absorption of pions by nuclei essentially only a pair of nucleons participate. Therefore, we may consider that at the energy of 330 mev the absorption of pions will all the more be accomplished essentially by pairs of nucleons. Taking into account this condition and assuming that the absorption by the $(p-p)$–pair and by the $(n-p)$–pair proceeds with equal probability, it is possible to evaluate the total cross section of the absorption of pions by helium nuclei from the cross section of the absorption by the $(p-p)$–pair. This was found to equal $9 \times 10^{-27}$ cm$^2$. In conformity with this, the cross section of the scattering with a change in charge (recharge?) will then be equal to $22 \times 10^{-27}$ cm$^2$.

Among the events of inelastic scattering with no change in charge we have observed three events of quasi-elastic scattering on protons and 21 events of quasi-elastic scattering of neutrons with no secondary scattering of mesons or nucleons in the same nucleus. The first were identified from the relationships between the angles of the scattering of mesons and of one of the particles of fissioning approximating the scattering on free nucleons. The second group of events was characterized by the emission of an $H^3$ fissioning nucleus with a comparatively short path and a momentum of the nucleons in the $\alpha$-particle; moreover neither the direction of emission of the nucleus, nor the magnitude of its momentum depend on the scattering angle of the meson.

The mean differential cross sections of the inelastic scattering for the three ranges of angles in the units $10^{-27}$ cm$^2$ /sterad in a laboratory system of coordinates are as follows:

| 0—60° | 60—120° | 120—180° |
|---|---|---|
| 7.9 ± 2.0 | 2.5 ± 0.8 | 4.5 ± 1.5 |

The angular distribution of the elastic scattering in a center-of-mass system is given in the Figure. Attention is drawn to the fact that not a single event of elastic scattering was observed in the angle range 5–15°. Above it was noted that the identification of elastic scattering events at small angles is associated with considerable difficulties, therefore it would be natural to assume that the latter state of affairs may be due to omissions in the analysis. In order for the differential cross section in the region 5 –15° to remain at the level $50 \times 10^{-27}$ cm$^2$/sterad, one would expect to find here 5–6 events on the basis of the existing statistical material. A thorough second examination of 40% of all the photographs did not disclose a single event of elastic scattering (additional to the first analysis). The small statistical material does not provide the possibility of drawing a completely definite conclusion regarding the course of the angular distribution in this region, however it appears probable that in the region of small angles the differential cross sections of the elastic scattering change non-monotonically.




The general character of the angular distribution of elastic scattering can be qualitatively described within the frame of the optical model of a nucleus. The calculated angular distribution is shown by the solid curve in the Figure. The mean free path of the $\pi$-mesons and the mean potential inside the nucleus $V_0$, used in these calculations, were determined from the total cross sections of the elastic and inelastic scattering and for a nucleus of radius $R = (\hbar/\mu c)\, A^{1/3}$ were found to be $(2.7 \pm 0.3) \times 10^{-13}$ cm and $(32 \pm 8)$ mev respectively. The angular distribution obtained in terms of the optical model shows considerable deviation from experimental data only in the region of small angles.

If non-monotonic change in the differential cross sections of elastic scattering in the region of small angles actually takes place, then for its explanation one may draw on the interference between the coulombic and the nuclear interaction. In this case it would be necessary to consider that the amplitudes of the coulombic and nuclear scatterings of the negative pions on nuclei have different signs, in contrast to the results for low energies (less than 200 mev) where the signs of the corresponding amplitudes are the same.[2]

The calculations of the energy dependence of the mean potential inside the nucleus, carried out in the investigations[3,4] on the basis of the properties of the scattering of pions on free nucleons, are in agreement with this fact.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## Note on Waves in a Homogeneous Magnetoactive Plasma

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WITHIN recent years there appeared a number of articles by Piddington[1-3] devoted to a consideration of the properties of normal waves propagated in a homogeneous plasma situated in a magnetic field $H_0$. In these works the calculation of thermal motion is made by the approximation method based on equations for mean particle velocities. Such a quasi-hydrodynamic method of investigation is not new; it has been repeatedly used in the analysis of similar problems by other authors (see, for example, Refs. 4 and 5). But at the same time it should be noted that many of the problems touched