INTERACTION OF 78-Mev π^+ MESONS IN PROPANE

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The interaction of π^+ mesons of 78 ± 3 Mev with hydrogen and carbon was studied in a bubble chamber. The scattering cross sections on hydrogen and carbon and the absorption cross section in carbon were determined. The prongs of the stars formed in the absorption of a meson go predominantly forward. This points to the existence of quasi-elastic collisions of the mesons in the nucleus prior to their absorption.

WE have investigated the interaction of π^+ mesons with hydrogen and carbon at the synchrocyclotron of the Joint Institute of Nuclear Research by means of a small propane bubble chamber.[1] The energy of the π^+ mesons and the admixture of positrons and μ mesons to the beam, η, were determined by range measurements in polyethylene. These values were obtained: $E_{\pi^+} = (78 \pm 3)$ Mev; $\eta = (25 \pm 2)\%$. In 2852 stereoscopic pictures we found 400 interactions. The scanning efficiency was 0.90 ± 0.03. The results are given in Table I. The scattering from hydrogen and carbon was investigated for scattering angles $\theta \geq 41°$. The cross sections agree with the known values contained in the literature (see, e.g., the review article by Barkov and Nikol'skii[2]).

The experimental value of the cross section for reaction (4) (Table I) includes the process of exchange scattering and absorption of the mesons. Taking into account that the exchange scattering cross section of π^- mesons on hydrogen at 79 Mev equals 15 mb,[2] one has $\sigma_{abs} = 180 \pm 20$ mb and a mean free path $\lambda_{abs} = (7.6 \pm 0.9) \times 10^{-13}$ cm.

The mean number of prongs of the stars is $\bar{f} = 2.50 \pm 0.18$. Comparison with the data of different investigations[4,5] shows that this distribution depends very little on the energy of the π^+ mesons (Table II).

Among the two-prong stars 36 of the 92 events have an angle between the emitted protons of > 140° which allows to classify them as due to absorbtion of the meson by an n-p pair. If one takes into account the collisions of the protons in the nucleus and one considers that capture of mesons by an n-n pair is 2 — 3 times less probable than by an n-p pair,[6] it follows from the experimental data that approximately in 70% of the cases mesons are absorbed by nucleon pairs. This agrees well with the estimates obtained by different authors.[7,8]

The angular distribution of the prongs (see Table II) has a forward-backward asymmetry with respect to the incoming π^+ beam: about 30% more prongs go forward than backward. The asymmetry coefficient $\xi = 2(N_{\rightarrow} - N_{\leftarrow})/(N_{\rightarrow} + N_{\leftarrow})$ decreases with increasing number of prongs in the star. (Here $N_{\rightarrow}$ and $N_{\leftarrow}$ is the number of prongs going forward and backward respectively).

The similarity of the experimental conditions and of the analysis between the present work and Ref. 4 allows also to determine the weighted mean value of the asymmetry coefficient. It is also given in Table II.

A large contribution to the anisotropy of single prong stars certainly is due to protons leaving the nucleus as a result of the exchange scattering process ($\pi^+ + n \rightarrow \pi^0 + p$). The anisotropy of the other stars and the character of its dependence on the prong number must be connected with the meson absorption mechanism. The appearance of a large isotropic "background" (more than 30% of the total number of prongs) of low energy prongs (E < 15 Mev) indicates that the mesons sometimes are absorbed by a large cluster of nucleons or by the nucleus as a whole. The overall anisotropy of the prongs can be explained by quasi-elastic collisions of the meson in the nucleus before its absorption. This has been already suggested in Ref. 4. It should be mentioned that any reasonable assumptions concerning the meson absorption mechanism must also lead to an anisotropy of the emitted particles and fragments (the meson-nucleus system contains forward momentum). However, no other assumption (e.g., absorption of the meson by the nucleus as a whole) can yield an anisotropy in the distribution of the emitted protons. Evidently, the angular distribution of the residual nuclei could

Table I. Cross section of π^+ mesons of 78 Mev with hydrogen and carbon

Reaction	Number of events	σ_{exp}, mb	Remarks	σ, mb
(1) $\pi^+ + p \rightarrow \pi^+ + p$	72	36± 5	$\theta_{\pi+} \geqslant 41°$ (lab syst.)	$\sigma_{el}(0° - 180°) = 39 \pm 6$ [3]
(2) $\pi^+ + C \rightarrow \pi^+ + C$ (3) $\pi^+ + C \rightarrow \pi^+ + A + f$ prongs $f = 0,1,2,...$	177	166±14	$\theta_{\pi+} \geqslant 41°$ (lab syst.)	
Absorption and exchange scattering: (4) $\pi^+ + C \rightarrow A + f$ prongs $f = 1,2,...$	201	195±20	$\sigma(\pi^+ \rightarrow \pi^0) = 15$ mb [2]	$\sigma_{abs} = 180 \pm 20$

Table II. Distribution of the prong number and asymmetry coefficient

	Number of prongs in star							E_{π^+}, Mev	Reference
	1	2	3	4	5	6	7		
Number of stars	17	45 (+8) *	35	14	2	1	1	250—270	[5]
	9 (+14) *	66 (+18) *	58 (+5) *	32	8	—	—	~50	[4]
	24	92	56	21	6	2	—	78	[**]
Asymmetry coefficient ξ	0.50 ± 0.30	0.26 ± 0.12	0.18 ± 0.13	0.14 ± 0.18	0.14 ± 0.31	—	—	78	[**]
	0.90 ± 0.23	0.44 ± 0.10	0.46 ± 0.09	0.28 ± 0.10	0.28 ± 0.20	—	—	50—80	[4] and [**]

*The error is due to the uncertainty in the prong number.
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give additional evidence concerning the meson absorption mechanism.

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