ELASTIC 180° SCATTERING OF π^+ MESONS BY PROTONS AT HIGH ENERGIES

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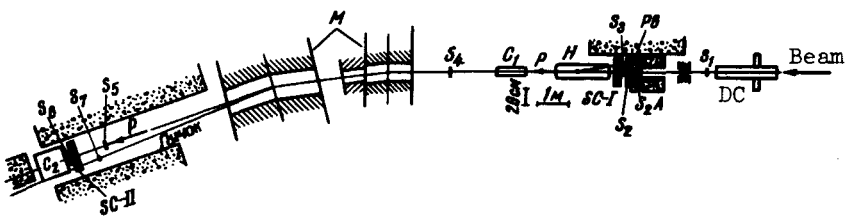
The differential cross sections for elastic π^+p scattering in a small solid angle about 180° were measured at π^+-meson l.s. momenta 3.15, 4.10, and 4.85 GeV/c at the High Energy Laboratory of the Joint Institute for Nuclear Research. The results for 3.15 GeV/c have already been published [1]. In this paper we present the results for 4.10 and 4.85 GeV/c and compare the data obtained at all three energies.

Measurements at different energies were made with the same setup, already described in [1], from which the figure is taken.



Setup for the measurement of elastic π^+p scattering at an angle close to 180°. S_1 - S_7 - scintillation counters, DC - differential gas-filled Cerenkov counter, C_1, C_2 - threshold gas-filled Cerenkov counters, H - hydrogen target, SC I, SC II - spark chambers, M - magnetic spectrometer.

The ratio of the number of elastic π^+-meson backward-scattering events registered by the apparatus to the total number of obtained photographs decreased with increasing energy (1:4.4, 1:11, and 1:40 at 3.15, 4.10, and 4.85 GeV/c, respectively). This was due not only to the decrease in the measured cross section, but to a deterioration of the background conditions as a result of the smaller spatial separation of the recoil protons from the beam particles (cf. the figure). It was therefore required to apply more rigorous criteria for the selection of the backward elastic-scattering events than in [1]. The same criteria were used for a second reduction of the data at 3.15 GeV/c.

In scanning the film from the spark chamber SC I, we selected for further processing photographs showing, besides the track due to the incident beam particle, also a track whose continuation in the direction of the hydrogen target can cross the continuation of the beam track. Lines were drawn through the coordinates of these tracks and the distance of the

closest approach δ of these lines, the coordinate of this point, and the angle ϵ at which this minimum distance is seen from the SC I chamber were calculated. The distribution of the events relative to ϵ was Gaussian with half-width $\sim 1.2 \times 10^{-2}$ rad, corresponding to the value expected for backward $\pi^+ p$ scattering (owing to the Coulomb scattering of the back-scattered π^+ meson in the hydrogen and the error in the measurements of the track angles in SC I). Track pairs were assumed to intersect if $\epsilon < 3 \times 10^{-2}$ rad. All others were discarded. We also eliminated cases when the tracks intersected outside the liquid-hydrogen volume. Distributions of the events selected in this manner were then plotted with respect to the momenta of the particles registered in spark chamber SC II. These distributions show a distinct peak corresponding to the momentum of the recoil protons from the elastic πp backward scattering (the width of this peak is determined by the energy spread of the primary beam and by the resolution of the magnetic spectrometer, and amounts to approximately 2% at 4.10 and 4.85 GeV/c). The events of this peak were classified as elastic π^+ backward scattering (the correction for the random entry of the particle in this region of the chamber SC II with $\epsilon < 3 \times 10^{-2}$ rad was 1.7%, 3.7%, and 6.4% for 3.15, 4.10, and 4.85 GeV/c, respectively).

The effective c.m.s. solid angle of the setup, calculated by the Monte Carlo method with account of the Coulomb scattering of the particles, was 3.87×10^{-3} sr for 4.10 GeV/c and 3.04×10^{-3} sr for 4.85 GeV/c.

In calculating the effective cross sections, corrections were introduced for the nuclear interaction of the primary and back-scattered π^+ mesons and the recoil proton in the hydrogen target and in the counters, for the muon contamination of the beam, for decay of the scattered pion, for the efficiency of the scintillation counters and the electronic circuitry, and for the efficiency of the spark chambers.

Data on elastic scattering of π^+ mesons by protons near 180°

π^+ meson l.s. momentum	θ_{cms} angle interval, deg.	Range of $\cos\theta_{mcs}$	Range of u, $(GeV/c)^2$	$(d\sigma/d\Omega)_{cms}$, $\frac{\mu b}{sr}$	$(d\sigma/du)$, $\frac{\mu b}{GeV/c}$	Reference
3.15	177 - 180	-0.998 - -1.000	0.109 - 0.104	99 ± 12	244 ± 29	This work
4.10	177 - 180	-0.998 - -1.000	0.086 - 0.081	74 ± 11	136 ± 20	This work
4.85	177 - 180	-0.998 - -1.000	0.074 - 0.068	37 ± 12	56 ± 18	This work
4.00	143 - 180	-0.800 - -1.000	0.088 - -0.562	19 ± 5	36 ± 9	[2]
	90 - 180	0 - -1.000	0.088 - -3.252	6.4 ± 1.3	12 ± 2.4	

The table lists the values obtained for the differential cross sections, including the 3.15-GeV/c data reduced by using the foregoing selection criteria. The errors listed in the table include the statistical error and the uncertainty in the corrections.

The same table shows for comparison the data for 4.0 GeV/c, obtained with the aid of a liquid-hydrogen chamber [2].

In our earlier paper [1] we deduced the existence of a narrow peak of appreciable mag-

nitude in the differential cross section of elastic $\pi^+ p$ backward scattering at 3.15 GeV/c. From the data in the table we see that a narrow peak exists near 180° for 4.0 GeV/c. Indeed, the value of $(d\sigma/d\Omega)^{4.1}_{180°}$ exceeds by one order of magnitude the average cross section for scattering into the back hemisphere, and is almost 4 times as large as the cross section for the $\cos\theta_{cms}$ interval from -0.8 to -1.0 at 4.0 GeV/c. There is a peak in the backward π^+ scattering also for 4.85 GeV/c, with $(d\sigma/d\Omega)^{4.85}_{180°}$ exceeding by several times the value of $(d\sigma/d\Omega)^{4.00}_{90+180°}$, which in turn should be larger than $(d\sigma/d\Omega)^{4.85}_{90+180°}$.

The existence of a peak in elastic $\pi^+ p$ backward scattering in a rather broad energy interval above 3 GeV shows that this peak is not connected with the appearance of any resonance, but is characteristic of the process of elastic scattering at high energies. [1)]

The differential backward-scattering cross section at 4.0 GeV/c, obtained in [2], together with the value of $(d\sigma/d\Omega)^{4.1}_{180°}$ from that reference, is well described by a relation of the type

$$d\sigma/d\Omega = A \exp\{p_\perp/0.32\},$$

where $p_\perp$ is the perpendicular momentum transfer in GeV/c.

The value of $(d\sigma/d\Omega)_{180°}$ decreases rapidly in the energy interval measured by us. However, since measurements at different energies were made at different values of the square of the momentum transfer u, this decrease in the cross section is accompanied by a simultaneous change in two parameters, the energy and the square of the momentum transfer u.

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[1] Savin, Vovenko, Gus'kov, Likhachev, Lyubimov, Matulenko, and Stavinsky, Phys. Lett. 17, 68 (1965).

[2] Aachen-Berlin-Birmingham-Bonn-Hamburg-London-Munchen Collaboration. Phys. Lett. 10, 248 (1964).

1) The measurements were made at energies higher than 3.0 GeV to avoid a possible influence of the isobar production on the backward elastic scattering.

CONCENTRATION AND TEMPERATURE DEPENDENCES OF THE SPIN-LATTICE RELAXATION TIMES IN RUBY AT HELIUM TEMPERATURES. RELAXATION IN ZERO MAGNETIC FIELD.

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A rather strong dependence of the spin-lattice relaxation time T_1 in ruby on the con-