ELASTIC SCATTERING OF $\pi^{\pm}$ MESONS BY HELIUM NUCLEI AT 300 MEV

M. S. KOZODAEV, R. M. SULIAEV, A. I. FILIPPOV, and IU. A. SHCHERBAKOV

Joint Institute for Nuclear Research

Submitted to JETP editor June 21, 1957

J. Exptl. Theoret. Phys. (U.S.S.R.) 33, 1047-1049 (October, 1957)

In an earlier note[1] we presented some preliminary results of an investigation of the interaction of negative π mesons with helium nuclei. We called attention to the considerable decrease in elastic scattering cross section which takes place at small angles (5 — 15°). This variation in the differential cross section was linked to a possible interference between Coulomb and nuclear scattering.

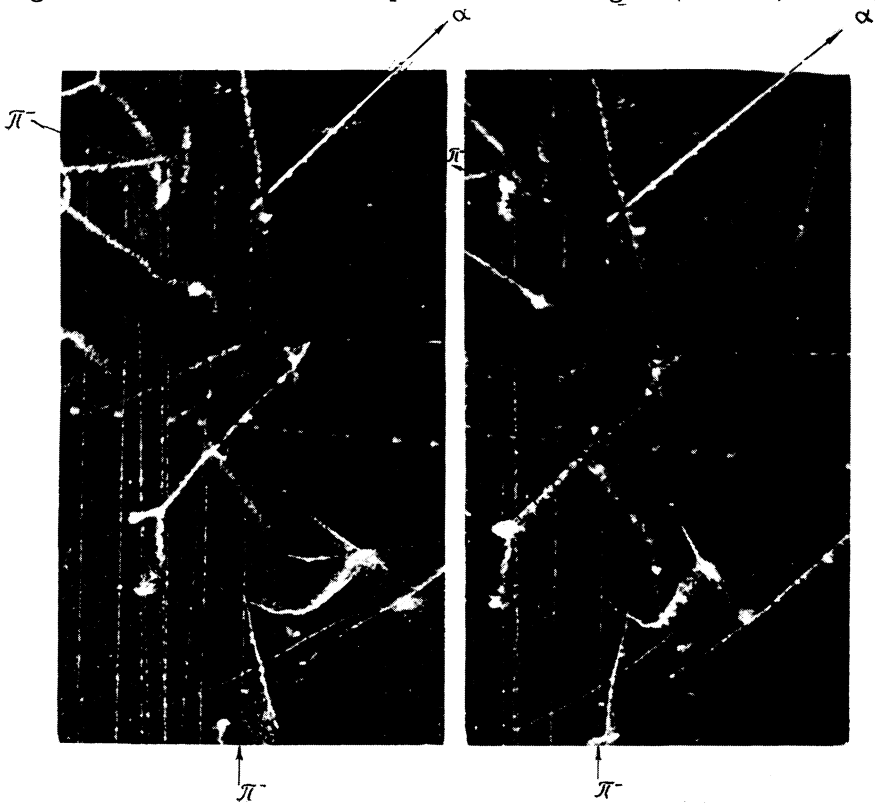

FIG. 1. Photograph of a 300-Mev π^- meson elastically scattered by a helium nucleus at an angle of 9.8°.

The present note describes further experiments on the elastic scattering of π^- and π^+ mesons against helium nuclei near 300 Mev, carried out with a considerably sharpened angular distribution, and verifies the conclusion made about the role of Coulomb interference.

As in the previous experiment, the elastic scattering was studied by means of a diffusion cloud chamber[2] filled with helium at a pressure of 15 atmospheres. The geometry of the outcoming beam of negative π mesons and the experimental setup were described in Refs. 1 and 2. The positive π mesons were generated in a polyethylene target 20 cm thick, which was placed in the path of a 660-Mev proton beam emerging from the synchro-cyclotron. An analyzing magnet selects a monochromatic beam of π^+ mesons which are formed as a result of the reaction $p + p \rightarrow \pi^+ + d$, and they emerge at an angle of 9° to the proton beam. After passing through the analyzing magnet, the beam of π mesons is directed through a collimating slit in the 4 m concrete shielding into the experimental space which contains the diffusion cloud chamber. In order to remove from the meson beam protons which have the same momentum, a 6 cm thick carbon filter was placed in front of the chamber. In the experiment with π^- mesons having an energy of 330 ± 6 Mev, we obtained altogether 24,000 photographs, while π^+ mesons of 273 ± 7 Mev yielded 11,000 photographs.

The elastic scattering of π mesons by helium nuclei were identified by the kinematics of the diverging particles: coplanarity, appropriate angular correlation, and range of the α-particles. For small-angle scattering, coplanarity and angular correspondence can only be crudely determined. In that case, a more reliable criterion is provided by the correspondence between the scattering angle of the mesons and the range of the α-particles. A small-angle region determined by the maximal angle of $\pi - \mu$ decay (5.1° at 300 Mev and 5.9° at 273 Mev) was excluded from consideration. A typical photograph of an elastic scattering event is shown in Fig. 1.

After twice scanning the pictures and analyzing the photographs, we detected 99 cases of elastic scattering of π^- mesons and 76 cases of π^+ mesons. The total absolute cross sections for elastic scattering

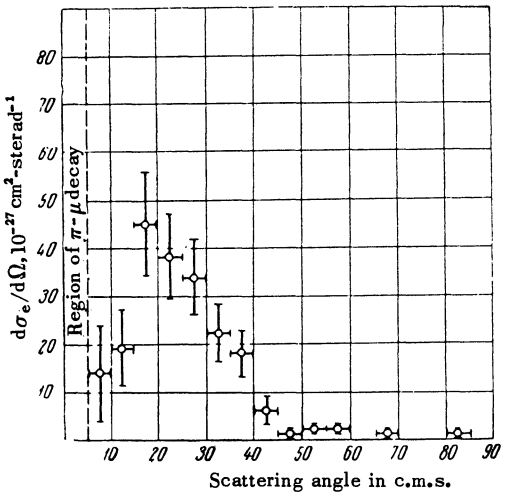

FIG. 2. Angular distribution of 330-Mev π^- mesons elastically scattered by helium nuclei.

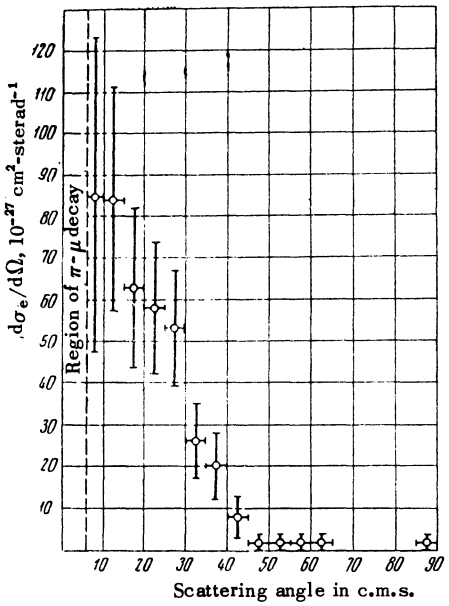

FIG. 3. Angular distribution of 273-Mev π^+ mesons elastically scattered by helium nuclei.

are respectively $(45 \pm 5) \times 10^{-27}$ cm^2 and $(72 \pm 11) \times 10^{-27}$ cm^2. The angular distributions in the center-of-mass system are presented in Figs. 2 and 3. The results show quite definitely the presence of an interference effect between Coulomb and nuclear scattering in the small-angle region. Essentially, the sign of the nuclear scattering amplitude is positive in the energy region under consideration, i.e., the interaction between π mesons and nuclei is repulsive. A calculation of the energy dependence of particles interacting with an average nuclear potential has been carried out using the optical model of the nucleus, and utilizing results on the scattering of π mesons against free nucleons;[3,4] these indicate a change in the sign of the nuclear amplitude in the region of the first resonance maximum, and are thus in agreement with the obtained experimental results.

The authors would like to express their gratitude to L. I. Landus for his interest in this work and for helpful discussion.

APPENDIX

(Received July 25, 1957)

Recently there has been renewed discussion on the possible existence of a non-zero spin for the π meson. This discussion is based on investigations of the angular distribution in $\pi - \mu$ decay.[5,6] In the Laboratory for Nuclear Problems we have tried to settle this question by studying the experimentally-obtained azimuthal distribution of π^+ mesons elastically scattered by nuclei, described in the above communication. Out of 76 cases of elastic scattering, 47 mesons were found scattered to the right and 29 to the left. An analysis of experimental conditions indicated that the observed asymmetry could not be due to systematic error. The probability for such an accidental deviation from isotropic distribution is less than 0.05. Since even such an improbable fluctuation may have occurred during an individual measurement, we are presently carrying out further experiments along this line. In view of the present discussion, however, we have deemed it worth while to announce the results of our preliminary investigations.

No azimuthal anisotropy in the angular distribution was observed in the elastic scattering of negative π mesons.

[1] Kozodaev, Suliaev, Filippov, and Shcherbakov, J. Exptl. Theoret. Phys. (U.S.S.R.) **31**, 701 (1956); Soviet Phys. JETP 4, 580 (1957).

[2] Kozodaev, Suliaev, Filippov, and Shcherbakov, Dokl. Akad. Nauk SSSR **107**, 236 (1956); Soviet Phys. "Doklady" **1**, 171 (1956).

[3] Frank, Gammel, and Watson, Phys. Rev. **101**, 891 (1956).

[4] R. M. Sternheimer, Phys. Rev. **101**, 384 (1956).

[5] F. Bruin and M. Bruin, Physica **23**, 551 (1957).

[6] Lettes, Report at the Conference on the Physics of Cosmic Rays, Italy, (June – July, 1957).

Translated by M. A. Melkanoff
207