this increases further the inverted population and the generation power [3].

We note also that at CO_2+N_2 working pressures on the order of 6 Torr, as follows from Fig. 1, $T_2 \simeq 1000°K$. At this temperature the population of the lower laser vibrational level is one-tenth the population of the CO_2 ground level, and at a CO_2 concentration close to 10^{17} cm^{-3} the population at the lower laser level will be on the order of 10^{16} cm^{-3} (owing to the Boltzmann population at the gas temperature), and this can greatly decrease the inversion of the lower laser leve relative to the upper one.

[1] N. N. Sobolev and V. V. Sokovikov, ZhETF Pis. Red. 4, 303 (1966), JETP Lett 4, 204 (1966).

[2] N. N. Sobolev and V. V. Sokovikov, ibid. 5, 122 (1967), transl. p. 99.

[3] T. J. Bridges and C. N. Patel, Appl. Phys. Lett. 7, 244 (1965)

[4] G. Moeller and J. D. Ridgen, ibid. 7, 274 (1965).

[5] C. N. Patel et al., ibid. 7, 290 (1965).

[6] K. F. Herzfeld, Disc. Faraday Soc. No. 33, 22 (1962).

[7] L. O. Hocker et al. Phys. Rev. Lett. 17, 233 (1966). T. L. Cottrell et al. Trans. Faraday Soc. 62, 2655 (1966). P. V. Slobodskaya, Opt. Spektrosk. 22, 29 (1967).

[8] T. L. Cottrell and J. C. Courbay, Molecular Energy Transfer in Gases, Butterworth, 1961.

[9] M. J. Weber and T. F. Deutsch, IEEE, J. Quantum Electronics, QE-2, 369 (1966).

REAL PART OF THE ELASTIC π^-p SCATTERING AMPLITUDE IN THE COULOMB INTERFERENCE REGION AT 3.48 AND 6.13 GeV/c

A. A. Nomofilov, I. M. Sitnik, L. A. Slepets, L. P. Strunov, and L. S. Zolin
Joint Institute for Nuclear Research

Submitted 16 May 1967
ZhETF Pis'ma 6, No. 3, 546-550 (1 August 1967)

Several recent papers [1] are devoted to a check on the dispersion relations. The present communication deals with the same problem.

We measured the real part of the nuclear amplitude of elastic π^-p scattering, using the effect of the interference of the Coulomb and nuclear interactions in the squared 4-momentum transfer interval $1.22 \times 10^{-3} \leq -t \leq 4.22 \times 10^{-3}$ $(GeV/c)^2$ 10^{-2} $(GeV/c)^2$. An analysis of the experimental data (see Fig. 1) with the aid of the Bethe formula [2] derived within the framework of nonrelativistic quantum mechanics yields values $\alpha_B = (ReA_{nuc}/ImA_{nuc}) = -(0.17 \pm 0.7)$ at 3.48 GeV/c and $\alpha_B = -(0.22 \pm 0.09)$ at 6.13 GeV/c. Reduction of the same data in accord with the Solov'ev formula, derived on the basis of relativistic quantum field theory [3], yields the values shown in Fig. 3: $\alpha_S = -(0.12 \pm 0.07$ and $\alpha_S = -(0.17\ 0.09)$ at 3.48 and 6.13 GeV/c, respectively.

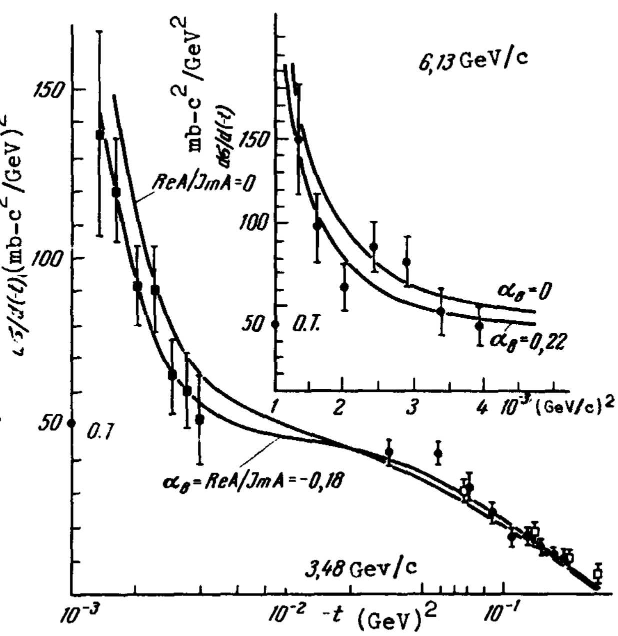

Fig. 1. Differential elastic π^-p scattering cross section at 3.48 GeV/c (■ - our data, □ - data of [11], o - from data of [8]) and 6.13 GeV/c (● - our data).

Good χ^2 were obtained by using the formulas of Bethe and Solov'ev.

The scattering was registered by a method based on recoil protons [1, 4, 5]. We scanned twice 60,000 photographs obtained at 3.48 and 6.13 GeV/c. Some 10,000 events selected in accordance with preliminary criteria were processed, About 5% of this mass of essentially elastic events fell in our interference t-interval. The single-scanning efficiency was 90 - 95%.

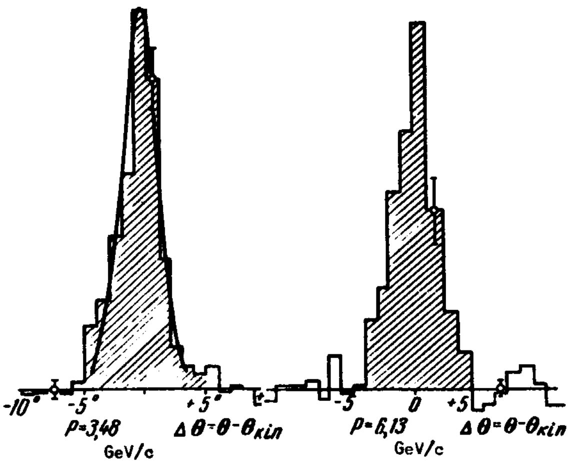

Fig. 2. Recoil-proton distribution with respect to the deviation from the momentum-angle kinematic line.

The elastic events were separated from the background by momentum-angle kinematics. Figure 2 shows the distribution of the events by deviation from the kinematic line, with the background subtracted.

The background level was 11 - 12% of the height of the elastic peak, which contained 355 events at 3.48 GeV/c and 224 events at 6.13 GeV/c satisfying the selection criteria (stopping in the gas of the chamber, recoil-proton momentum $35 \leq p \leq 65$ MeV/c, projection on the plane of the frame 1 cm). The main source of the background recoil protons were the neutrons constantly present near the working accelerator. The recoil proton momentum was determined with great accuracy from its range in the chamber gas. We have therefore obtained good resolution with respect to t, namely $\Delta t = 1 \times 10^{-4}$ (GeV/c)^2. We note that in this method the resolution with respect to t does not change when the energy of the incident particle is increased. The condition $A_{Coul} \sim A_{nuc}$, which is needed for the observation of the interference, is likewise practically independent of the energy and is only a function of t. All this makes it possible to use this procedure at much higher energies.

The absolute measurement of the pion flux was made with a nuclear emulsion covering the entire beam, and with an integrating electronic system measuring the flux in each pulse. The beam of 3.48-GeV/c π^- mesons had a momentum scatter $\Delta p/p = 1.5\%$ and contained $(7 \pm 1)\%$ muons and $(2.4 \pm 0.3)\%$ electrons. The 6.13-GeV/c beam had $\Delta p/p = 2.2\%$ and 6% of muons and electrons. The The K^- and $\tilde{p}$ content could be neglected. The value of $n_\pi n_H L$ was determined accurate to 3% (n_π - pion flux, n_H - hydrogen density, L - length of working region of the chamber). For the momentum-transver interval selected by us, the effective cross section was $\Delta\sigma = 0.244 \pm 0.017$ mb for 3.48 GeV/c and (0.219 ± 0.019) mb for 6.13 GeV/c. To calculate $\mathrm{Im}A_{nuc}(0°)$ we used the values of $\sigma^{tot}_{\pi^- p}$ from [6]. The angular dependences of the real and imaginary parts of the nuclear amplitude were assumed to be the same and were taken from [7, 8]. When the angular dependence of A_{nuc} is varied, the values of α change little [1]. In our experiment, the main error in the detrmination of α was statistical.

As seen from Fig. 3, the results of calculation by means of the dispersion relation and the values obtained in our experiment are in good agreement. It was shown in [10] that experiment agrees with the dispersion relations for πp scattering at energies up to several hundred MeV. It is shown in [1] that the experimental data on the charge exchange $\pi^- p \to \pi^0 n$ agree with the dispersion relations for π^--meson energies up to 18 GeV.

Just as in [1] and in the paper delivered by us at the 13th International Conference on High-energy Physics at Berkeley [1], we conclude that there is no indication that the dispersion relations are violated for forward πp scattering, at least for energies up to 6 GeV.*

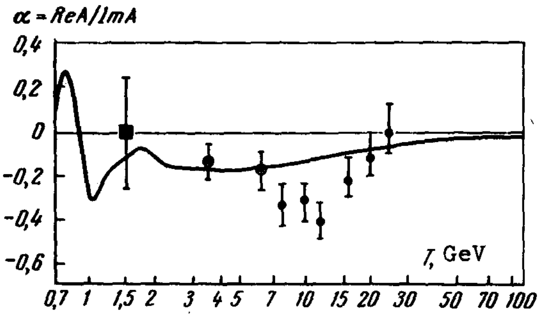

Fig.1. Ratio of real and imaginary parts of the nuclear amplitude of forward $\pi^- p$ scattering vs. pion energy in the l.s. Theoretical curve - from [9]. ⊙ - our data, ● - data of [1], ■ - from data of [12].

We are grateful to the late Academician V. I. Veksler and to Professor I. V. Chuvilo for interest in the experiment, to V. A. Nikitin, V. A. Sviridov, and N. N. Govorun for direct participation in the first stage of the experiment, and to all thowe who took part in the exposure of the chamber and to the reduction of the material. We are particularly grateful to N. I. Pavlov, L. P. Zinov'ev, S. V. Fedukov, N. I. Malashkevich, A. G. Muryzin, L. N. Belyaev, V. S. Grigorashenko, and B. D. Omel'chenko for good organization of the computer operation and the operation of the electrophysical equipment.

[1] D. I. Blokhintsev and G. I. Kolerov, Nuovo Cimento 34, 163 (1964); A. A. Logunov, Nguyen Van Hieu, JINR Preprint R-2873, Dubna, 1966; K. L. Foley, R. S. Gilmore, R. S. Jones, S. I. Lindenbaum, W. A. Love, S. Ozaki, E. H. Willen, R. Yamada, and L. C. L. Yuan, Phys. Rev. Lett. 14, 862 (1965); B. Lautrup and P. Olesen, Phys. Lett. 17, 62 (1965); G. Hohler and J. Baacke, Phys. Lett. 18, 181 (1965); J. Hamilton, Phys. Lett. 20, 687 (1965); G. Hohler, J. Baacke, and R. Strauss, Phys. Lett. 21, 223 (1966); A. A. Nomofilov, I. M. Sitnik, L. A. Slepets, L. N. Strunov, and L. S. Zolin, Phys. Lett. 22, 350 (1966) and Preprint E-13267, JINR, 1967; L. Van Hove, Rapporteur paper at 13th Internat. Conf. in Berkeley, 1966, p. 3.

[2] H. Bethe, Annals of Phys. 3, 190 (1958).

[3] L. D. Solov'ev, Zh. Eksp. Teor. Fiz. 49, 292 (1965), Sov. Phys. JETP 22, 205 (1966).

[4] V. A. Nikitin, A. A. Nomofilov, V. A. Sviridov, L. A. Slepets, I. M. Sitnik, and L. N. Strunov, Yad. Fiz. 2, 183 (1965), Sov. J. Nuc. Phys. 1, 127 (1965).

[5] N. N. Govorun, I. V. Popova, L. A. Smirnova, T. V. Ryl'tseva, V. A. Nikitin, A. A. Nomofilov, V. A. Sviridov, L. A. Slepets, I. M. Sitnik, and L. N. Strunov, PTE No. 4, 44(1966)

[6] A. Citron, W. Galbraith, T. F. Kycia, B. A. Leontic, P. H. Phillips, A. Rousset, and P. H. Sharp, Phys. Rev. 144, 1101 (1966).

[7] S. Brandt, V. T. Cocconi, D. R. O. Morrison, A. Wroblewski, P. Fleury, G. Kayas, F. Muller, C. Pelletier, Phys. Rev. Lett. 10, 413 (1963).

[8] Aachen-Birmingham-Bonn-Hamburg(I.C.)-Munchen Collaboration, Nuovo Cimento 31, 729 (1964).

[9] V. S. Barachenkov, Phys. Lett. 19, 699 (1966).

[10] N. P. Klepikov, V. A. Meshcheryakov, S. N. Sokolov, Preprint D-584, JINR, Dubna, 1960; H. I. Schnitzer and G. Salzman, Phys. Rev. 113, 1153 (1963).

[11] M. S. Ainutdinov, S. M. Zombkovskii, A. A. Pletnikov, Ya. M. Selektor, and V. N. Shulyachenko, Zh. Eksper. Teor. Fiz. 47, 100 (1964), Soviet Phys. JETP 20, 69 (1965).

[12] Saclay-Orsay-Bari-Bologna Collaboration, Nuovo Cimento 29, 515 (1963).

*After finishing this paper, we learned that the authors of [1] repeated their measurements of $\pi^{\pm}p$ and pp scattering in the Coulomb interference region for 8 - 26 GeV. By reducing their data with the aid of the Solov'ev formula, they now obtained full agreemeent between the experimental values of α and calculations based on the dispersion relations. Thus, the entire aggregate of experimental data is now in agreement with dispersion-relation calculations.