SMALL ANGLE PROTON-PROTON SCATTERING AT 7.85 GeV/c

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The experiment reported here was designed to measure the absolute values of the forward differential cross-sections at 7.85 GeV/c in the nuclear-Coulomb interference region. The experimental lay-out is shown in Fig. 1. The momentum analysed beam, momentum 7.85 GeV/c and momentum spread ± 50 MeV/c base width, was focused to give an essentially parallel beam of protons of intensity 1 to 2×10^3 protons per pulse. The momentum and direction of the protons which were incident on the liquid hydrogen target were determined in the first magnetic spectrometer consisting of counters *C1-3*, sonic spark chambers *S1-3* and the first bending magnet. The momentum and direction of the scattered protons were determined in the second spectrometer consisting of the counters *C5* Left and Right, *C6* Left and Right, the sonic spark chambers *S4-6* and the second bending magnet. The incoming flux of protons was given by the coincidence counters *C1-3* and the trigger for the spark chambers cwas provided by the coincidences between *C1-3* and the left counters (*C5*, *C6*) and right counters (*C5*, *C6*).

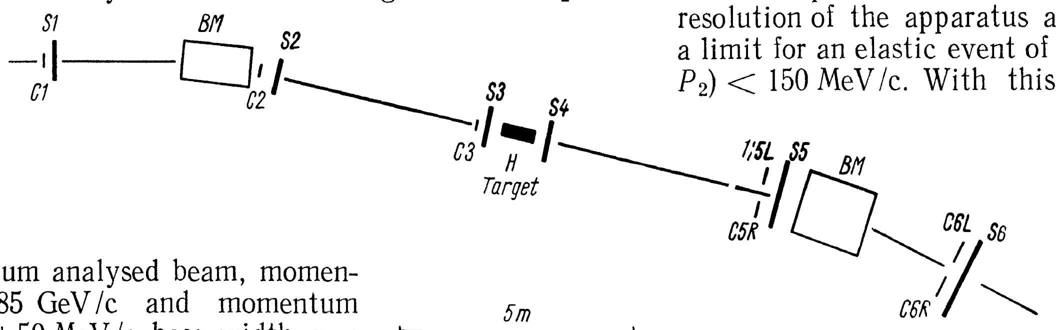

Fig. 1. Geometrical lay-out.

The position of the sparks in the central spark chambers, *S2-5*, was used to measure the scatteringangle, θ_{lab} and the origin of the scattering. The resolution obtained on the latter was sufficient to separate clearly those scattered events coming from the liquid hydrogen target from those coming from the vacuum windows and spark chambers. When this information was used the background was only 10% of the hydrogen effect. The selection of elastic events was made using the difference between the measured momentum, P_1 of the incident particle and the measured momentum, P_2 of the scattered particle. The momentum resolution of the apparatus allowed a limit for an elastic event of $(P_1 - P_2) < 150$ MeV/c. With this limit the inelastic contamination was quite negligible. The absolute scale of the cross-section was obtained from the coincidence counts recorded on scalers and the angular distribution of the cross-section from the events in the sonic spark chambers.

The differential cross-sections are plotted in Fig. 2 against the laboratory scattering angle θ_{lab}; the solid line is the differential cross section expected from a purely imaginary amplitude given by the optical theorem with the addition of Coulomb scattering. The difference, $\Delta d\sigma/d\omega$, between this prediction and the experimental cross-section corrected for angular resolution (± 0.4 mrad) is plotted against θ^{-2} in Fig. 3. The imaginary part of the nuclear amplitude has been taken as $(\sigma_t k/4\pi)\, e^{-4t}$ where σ_t was the total cross-section equal to 40.0 mb $\pm$ 0.6 mb measured during this experiment using the same target and beam, k is the laboratory wave number and the form factor e^{-4t} is taken from larger angle data, t being the square of the four momentum transfer in GeV^2. Over the angular range in this experiment the nuclear amplitude varied by 5%. The Coulomb amplitude has been taken as wholly real, given by

$$\mathrm{Re}\, C = -\frac{2e^2\theta^{-2}}{p\beta c} e^{-4t}.$$

The results displayed in Fig. 3 show a significant θ^{-2} dependence. The assumption of no θ^{-2} dependence produces a x^2 of 37 for the 20 points (i. e. a probability $\sim 1\%$). If the θ^{-2} dependence arises from an interference between a real part of the nuclear amplitude ReN, assumed constant in this angular range, and the real part of the Coulomb amplitude and if the imaginary part of the nuclear amplitude is given by the optical theorem, then:

$$\Delta \frac{d\sigma}{d\omega} = (\mathrm{Re}\, N)^2 + 2\mathrm{Re}\, N \times \mathrm{Re}\, C,$$

i. e. (1)

$$\Delta \frac{d\sigma}{d\omega} = A + B\theta^{-2}.$$

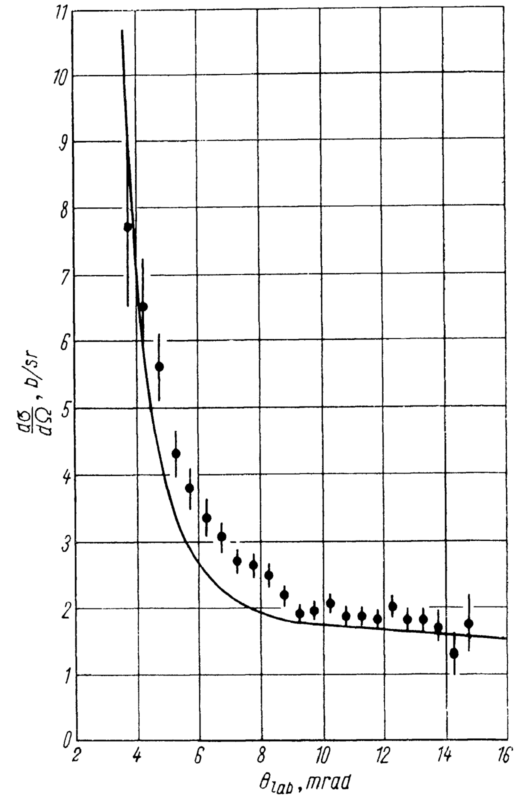

Fig. 2. Angular distribution of the differential crosssection plotted against laboratory scattering angle.

The value of B obtained from a least squares fit implies a ratio of Re N/J_mN = —0.32 ± 0.07. The contribution to the interference from the imaginary parts of the Coulomb and nuclear amplitudes would be much smaller and of opposite sign to that from the real parts with this value of Re N.

If the forward scattering amplitude is spin independent, then A and B are related as in equation (1), with $A = (\mathrm{Re}\, N)^2$. The value obtained for A from the least squares fit was 0.08 ± ± 0.10b/sr to be compared with the valur $(\mathrm{Re}\, N)^2 = 0.16$b/sr.

The results hare consistent terefore with an interpretation of the proton-proton forward scattering amplitude at 7.85 GeV/c having an imaginary part given by the optical theorem for spinless particles, together with a real part equal to 32% of imaginary part and interfering constructively with the Coulomb amplitude.

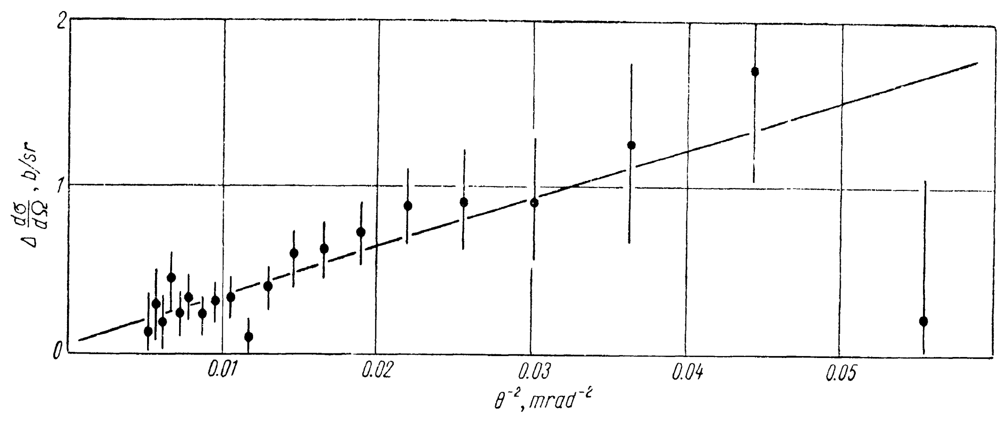

Fig. 3. The difference between the experimental values of the differential cross-section and those predicted for a purely imaginary amplitude given by the optical theorem with the addition of Coulomb scattering.