DETERMINATION OF THE SLOPE OF THE POMERANCHUK-TRAJECTORY FROM HIGH ENERGY ELASTIC SCATTERING *

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Recently, new light has been shed on the theory of elementary particles by the hypothesis that the concept of singularities in the complex angular momentum variable [1] (Regge-poles) also applies to a relativistic quantized theory [2]. In particular, the assumption is made that particles (including resonances) which differ only by their mass and spin values lie on the same trajectory in the Chew-Frautschi diagram [3]. Up to now, there is only one pair of particles fulfilling these suppositions, the nucleon and its third resonance N^{+++} with mass 1680 MeV and spin-parity $\frac{5}{2}^+$. This leads to a slope of its trajectory of about $\frac{1}{50}\mu^2$ (μ being the pion mass).

On the other hand, high energy elastic scattering is correlated to the slope of the Pomeranchuk-trajectory [1,2] by means of

$$A(s,t) \sim C(t)\, s^{1+at} \,, \tag{1}$$

where $A(s,t)$ is the (imaginary) elastic amplitude, $\alpha(t) = 1+at$ is the Pomeranchuk-trajectory, approximated by a straight line of slope a for small $|t|$.

It should be mentioned that a high energy behaviour of this type is also a consequence of a model in the strip approximation to the Mandelstam representation proposed by Amati et al. [4]. Furthermore, this model provides successive approximations to the form factor of the diffraction scatter-

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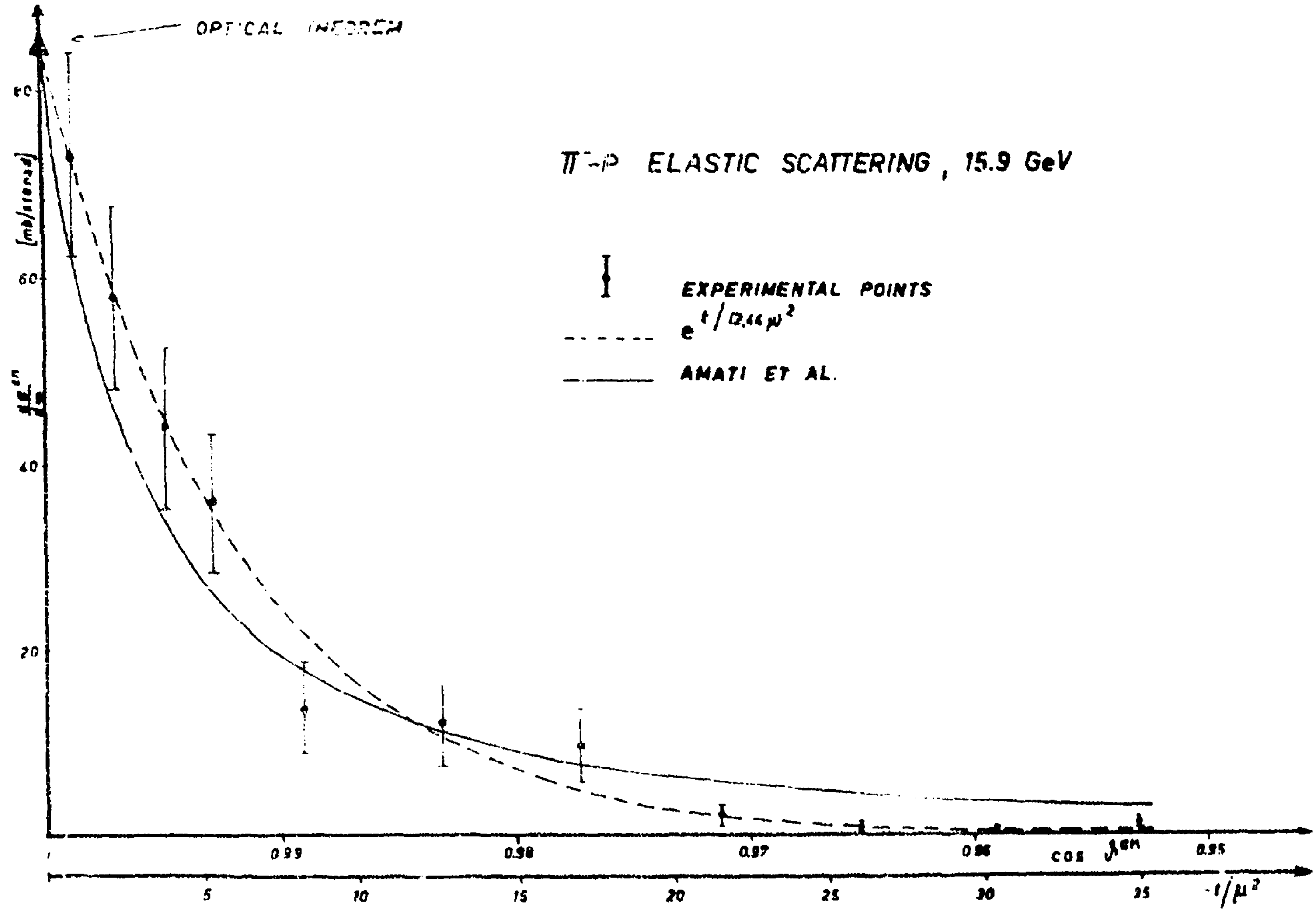

Fig. 1. 16 GeV π^-p differential elastic cross-section. The broken line is a fit corresponding to equation (3), the solid line corresponds to Amati et al., equation (2).

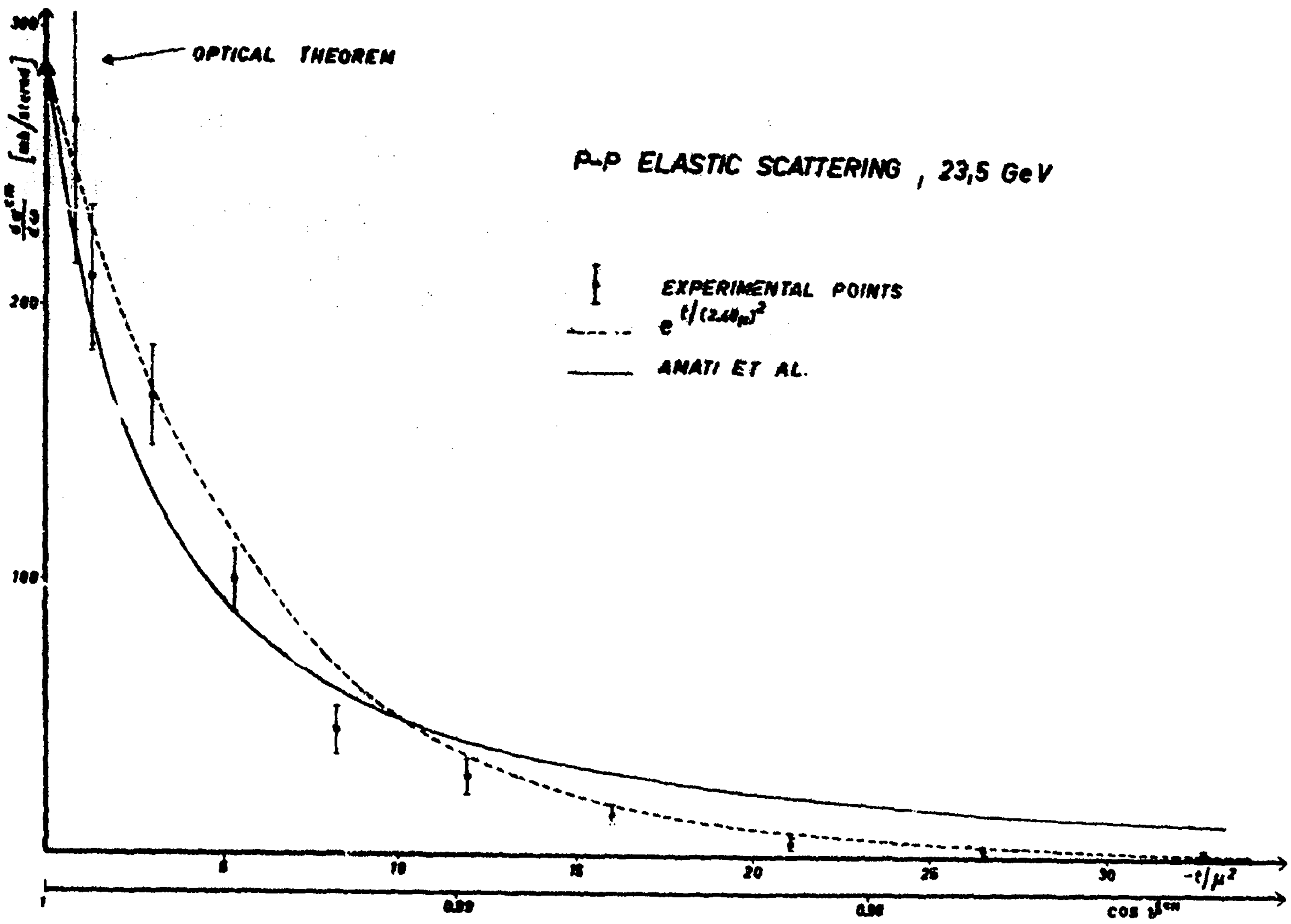

Fig. 2. 24 GeV pp differential elastic cross-section. The broken line is a fit corresponding to equation (3), the solid line corresponds to Amati et al., equation (2).

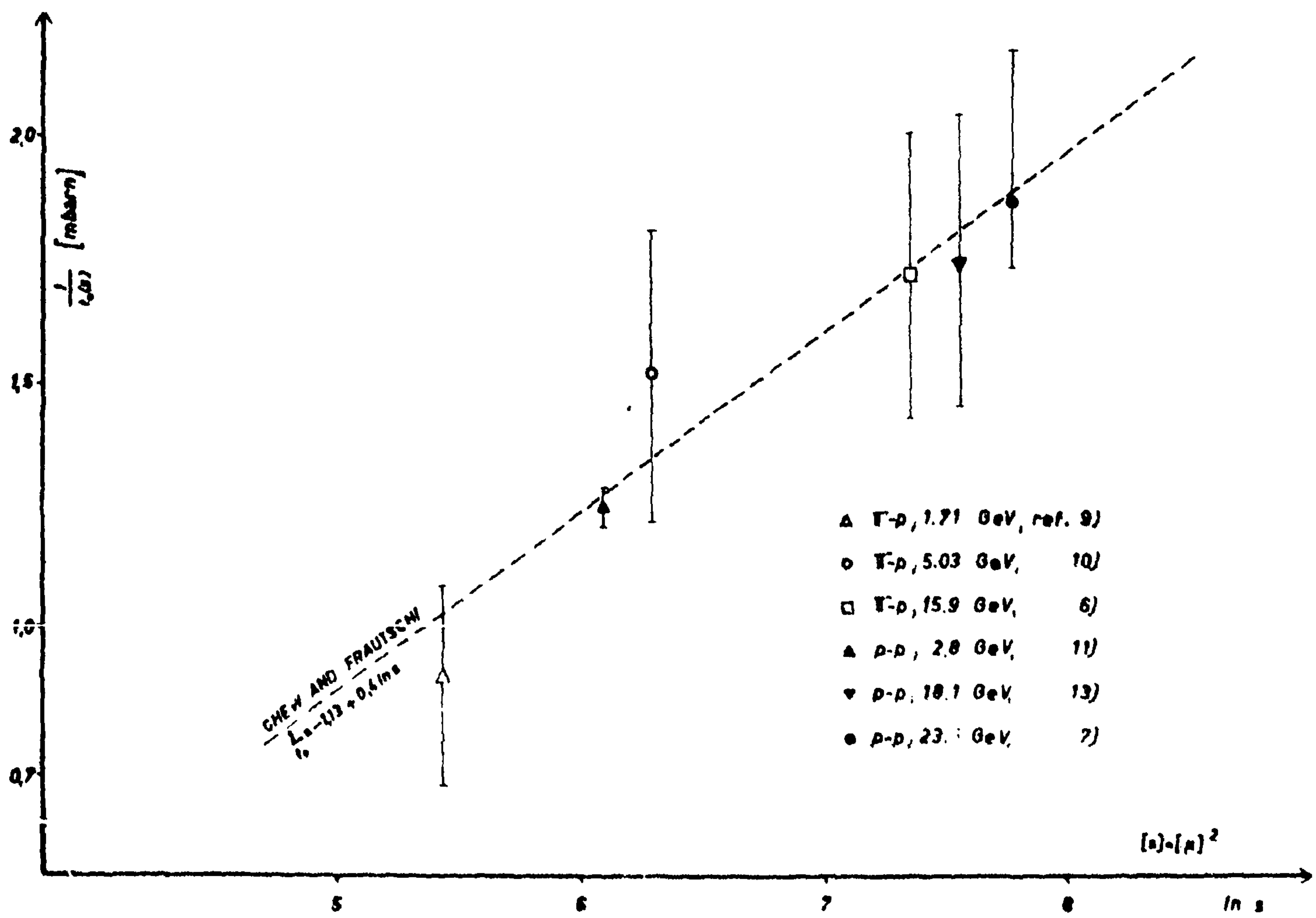

Fig. 3. π^-p and pp scattering at various energies; the diagram gives the data in the form given by equation (5). The broken line corresponds to the slope of the Pomeranchuk-trajectory of $\frac{1}{50}\mu^2$, predicted by Chew and Frautschi.

ing amplitude. In the first step, the form factor is given by [4])

$$\frac{A(s,t)}{A(s,o)} = F(x) = \frac{1}{x\sqrt{1+x^2}} \log\left(x+\sqrt{1+x^2}\right), \quad (2)$$

where

$$x^2 \equiv \frac{|t|}{+4\mu^2}.$$

As a consequence of the Regge-type behaviour (1) the differential elastic-cross-section at high energies should decrease exponentially from the optical point * (diffraction peak).

$$\frac{d\sigma}{d\Omega} \sim e^{-2t/t_0(s)}. \quad (3)$$

In (3), $t_0(s)$ should be asymptotically independent of the particular process.

The elastic scattering of 16 GeV π^--mesons and 24 GeV protons on protons (corresponding to an energy of 5.6 GeV and 6.9 GeV in the CM system, respectively) has been studied with bubble chamber and emulsion techniques [5,6]).

Results are plotted in fig. 1 and 2 where the exponential points are fitted with an exponential normalized to the optical point as in (3), such that the integrated elastic cross-section coincides with the measured value. It actually turns out that t_0 = 2.44 for π^-p and 2.40 for pp scattering, thus verifying what has been said after eq. (3). Moreover, the parameterless curve $F(x)^2$ due to Amati et al. [4]) is shown in fig. 1 and 2, normalized again to the optical point **.

Assuming the behaviour (3) to be valid, one now has a means to establish the slope of the Pomeranchuk-trajectory. Expanding $C(t)$ in (1) into a power series

$$C(t) = 1 + \delta t + O(t^2) \quad (4)$$

leads, combined with (3), to

$$\frac{1}{t_0(s)} = \frac{1}{32\pi}\frac{\sigma_{tot}^2}{\sigma_{el}} = \delta + \alpha \log s. \quad (5)$$

In fig. 3 the data of the quoted experiments are combined with the results of other authors (see table). The broken line corresponds to the slope of $\frac{1}{50}\mu^2$, predicted by Chew and Frautschi [3]). In addition one obtains an estimate for δ to be -1.13. It should explicitly be pointed out that the points of this diagram correspond to different physical processes.

* It should at least be an exponential tail, since $C(t)$ is supposed to be a smoothly varying function.

** This leads to a too high value of $d\sigma/dt$ for large $|t|$, the difference being due to the higher order corrections in $F(x)$.

Table 1
Experimental values for elastic and total cross sections at various energies.

	σ_{el} (mb)	σ_{tot} (mb)
1.71 GeV π^-p	11.1 ± 2.3 [7])	31.4 ± 1.6 [7])
5.03 GeV π^-p	5.6 ± 0.5 [8])	29.1 ± 2.9 [8])
15.9 GeV π^-p	4.2 ± 0.5 [5])	26.8 ± 1.1 [5])
2.75 GeV pp		
2.85 GeV pp	14.87 ± 0.27 [9])	43.3 ± 0.6 [10])
2.9 GeV pp		
18.1 GeV pp	9 ± 1.4 [11])	39.7 ± 1.5 [12])
23.5 GeV pp	8.3 $^{+1.2}_{-0.7}$ [6])	39.7 ± 1.5 [12])

In conclusion one might say that the hypothesis of Regge-poles, though not on a very good footing from the theoretical point of view seems to be very appealing when compared with the experiment.

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