Slope parameter and scaling of differential cross-section of $\Lambda$-p scattering

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MS received 1 January 1986; revised 29 August 1986

Abstract. The claim of Mohapatra and Maharana that $tb(s)$ is a better scaling variable than $t(ln s)^2$ is put to test in the case of $\Lambda$-p scattering, after parametrizing $b(s)$ as $C_1 + C_2(ln s)^{\alpha}$. It was observed that in this case the data also prefer an $\alpha$ value which is close to those obtained by Mohapatra and Maharana for other scattering processes.

Keywords. $\Lambda$-p scattering; slope parameter; scaling; unitarity bound.

PACS No. 13-75

1. Introduction

During the last decade, the scaling phenomenon has been qualitatively well established. Auberson et al (1971) were the first to investigate the scaling of scattering amplitude, $F(s, t)$. While studying the analytic properties of the Pomeranchuk-theorem-violating amplitudes in the high energy limit, they demonstrated that for a sequence $(s_n) \to \infty \lim f(s_n, t(ln s_n)^{-2})$ exists and is a nontrivial function of $t$ where $t = 1(ln s)^2$, and $f(s, t) = F(s, t)/F(s, 0)$. Cornille and Simao (1971) extended the results of Auberson et al (1971) for other forward high energy behaviour of the scattering amplitude and arrived at similar conclusions regarding the scaling of $f(s, t)$. Auberson and Roy (1977) deduced the bounds on slope and curvature of the diffraction peak and further observed that $t = t(ln s)^2$ can be chosen as a scaling variable. Thus in the recent past, there has been a general unanimity over the conclusion that $t = t(ln s)^2$ is a good scaling variable and $b(s)$ is likely to grow as $(ln s)^{\alpha}$.

However, in a recent paper Mohapatra and Maharana (1983) demonstrated that the data of $pp, \bar{p}p, K^\pm p, \pi^\pm p$ scatterings perhaps do not favour such a conclusion. Through the analysis of data they claim that (i) if $b(s)$ is parametrized as $C_1 + C_2(ln s)^{\alpha}$, then the data prefer an $\alpha$ value close to 1.25 instead of 2, and (ii) $tb(s)$ is a better scaling variable than $t(ln s)^{\alpha}$.

In this paper we have tried to test their claim by applying their method of analysis to $\Lambda p$ scattering. We are conscious of the fact that (a) data on $\Lambda p$ scattering are scanty because of the short lifetime (de Swart et al 1970) of $\Lambda$ beam; (b) the available data are

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in the incident momentum range of 0.13 GeV/c to 20 GeV/c only (Hauptman 1974); and (c) \( \frac{d\sigma}{dt}(s, t) \) values are available only up to 6 GeV/c (Hauptman 1974). Though this momentum is not high enough to conclusively show the scaling of \( \frac{d\sigma}{dt}(s, t) \) of \( \Lambda p \) scattering, we assume that it is high enough to test the validity of the claim of Mohapatra and Maharana (1983).

The plan of the paper is as follows: In §2 a brief summary of previous work is given as we are attempting to test the conclusions of the earlier work. Section 3 contains our analysis of data and conclusion.

2. Relevant previous work

Defining

\[
f(s, t) = \frac{d\sigma}{dt}(s, t) / \frac{d\sigma}{dt}(s, 0)
\]

and the slope and curvature, respectively, as

\[
b(s) = \frac{d}{dt} f(s, t)_{t=0},
\]

\[
c(s) = \frac{d^2}{dt^2} \ln f(s, t)_{t=0}.
\]

Maharana (1978), using

\[
w(s) = \ln \frac{s^2}{(d\sigma/dt)(s, 0)}
\]

proved that if

\[
b(s) \approx [w(s)]^\alpha
\]

for \( s \) large and all zeros, \( t_i \), of \( f(s, t) \) lie in a domain \( \text{Im} t_i < \epsilon |t_i|^2 \), \( \epsilon \) being some \( s \)-dependent and arbitrarily small positive number and if

\[
\frac{1}{2} \leq \alpha \leq 2,
\]

then \( \tau = \tau b(s) \) is a scaling variable.

This bound (equation (6)) is important for two reasons: (i) The upper bound for \( \alpha \) is reminiscent of Froissart’s bound and agrees well with the observation of Auberson and Roy (1977). (ii) The lower bound of \( \alpha \) in (6) is of interest in the sense that if the data on various scattering processes favour this then one has to possibly take a second look at the earlier results on scaling and the Froissart’s bound.

3. Analysis of data and conclusion

Keeping in view the findings of Mohapatra and Maharana (1983) we parametrized \( b(s) \) as,