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REMARKS ON p-p ELASTIC SCATTERING AT LARGE MOMENTUM TRANSFERS

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Two sets of experimental data on p-p elastic scattering at large momentum transfers obtained by Allaby et al. [1] and Akerlof et al. [2] suggested the presence of break-points (kinks) in the plot of $\log_{10}(d\sigma/dt)_{cm}$ against $s \sin\theta_{cm}$, break-points which led to speculations about a possible structure of the nucleon. Apart from the fact that the $\exp(-s \sin\theta/g)$ fit cannot satisfy for very high energies the analiticity conditions imposed on the scattering amplitude [3], none of the models proposed till now have been successfull to explain completely this kind of behaviour*.

In view of these difficulties, we have tried to see if the Allaby et al. and Akerlof et al. data definitely ruled out the Orear's formula [5], which is more acceptable from a theoretical point of view and is strongly suggested by the statistical model. To this aim we plotted [6] $\lg(d\sigma/dt)_{cm}$ as given by the Orear's formula against $s \sin\theta_{cm}$, for $\theta_{cm} \approx 90^o$ ($s \sin\theta_{cm} \approx s$).

We arrived at the following conclusions:

a) for $\theta \approx 90^o$ and for large momentum transfers the Orear's formula is able to reproduce quite well all experimental data (see fig. 1).

b) No kinks are therefore suggested to be present, for $\theta \approx 90^o$, in the plot of $\lg(d\sigma/dt)_{cm}$ against $s \sin\theta_{cm} \approx s$ (see fig. 1).

Keeping in mind these results we have tried, by means of a suitable kinematical stitch to the Orear's formula

$$d\sigma/d\Omega \approx (A/s) f(\theta) \exp(-p \sin\theta/T_o) \qquad (1)$$

consisting in an appropriate choice of $f(\theta)$, to fit experimental data at all angles now available. Such choice of $f(\theta)$ is made by a careful comparison of the plot of $\log_{10}(S\, d\sigma/d\Omega)_{Orear}$ against $p \sin\theta_{cm}$ with data given by Allaby et at. [1]. From such a comparison it stands out

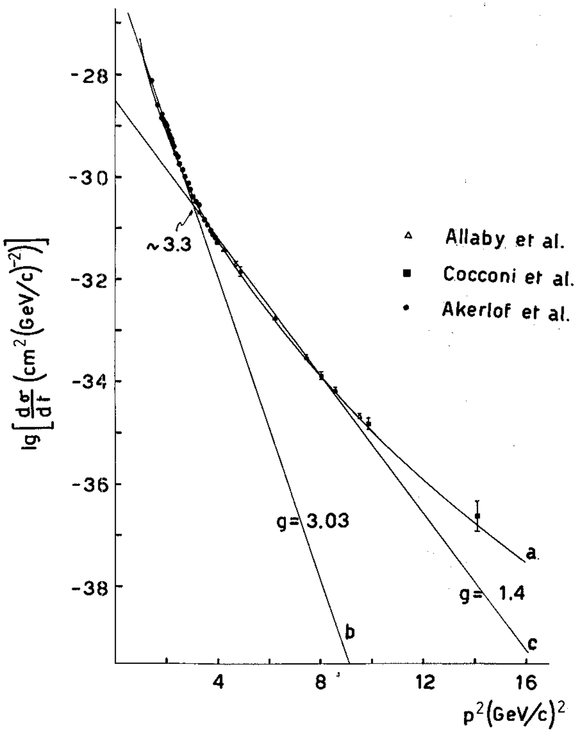

Fig. 1. Logarithmic plot of $(d\sigma/dt)_{cm}$ as a function of p^2, for $\theta \approx 90^o$. The data are from refs. 1, 2 and 7. The curve a represents the Orear fit: $(d\sigma/dt)_{90^o} = (\pi A/p^2 s) \exp(-p_{cm}/b)$. The straight lines b and c result from a fit to the experimental points by $(d\sigma/dt)_{90^o} \approx \exp(-gp^2)$. The values of the slopes of these lines are indicated.

clearly that if one puts $f(\theta) \approx (\sin m\theta)^n$, with $n > 0$, then the experimental points can be reproduced quite reasonably. The choice for m and n cannot be made by looking at the logarithmic plots alone since uninteresting differences in the logarithm can show up significantly in the cross section $d\sigma/d\Omega$. By making minimal choices for m, n we have been able to decide in favour $m = 1$, $n = 4$. The choice $m = \frac{1}{2}$, $n = 2$, although good enough for small values of p_{lab}, was rejected because it gave rather poor results for large values of p_{lab}.

* The models proposed and the related difficulties have been discussed extensively by Bertocchi [4].

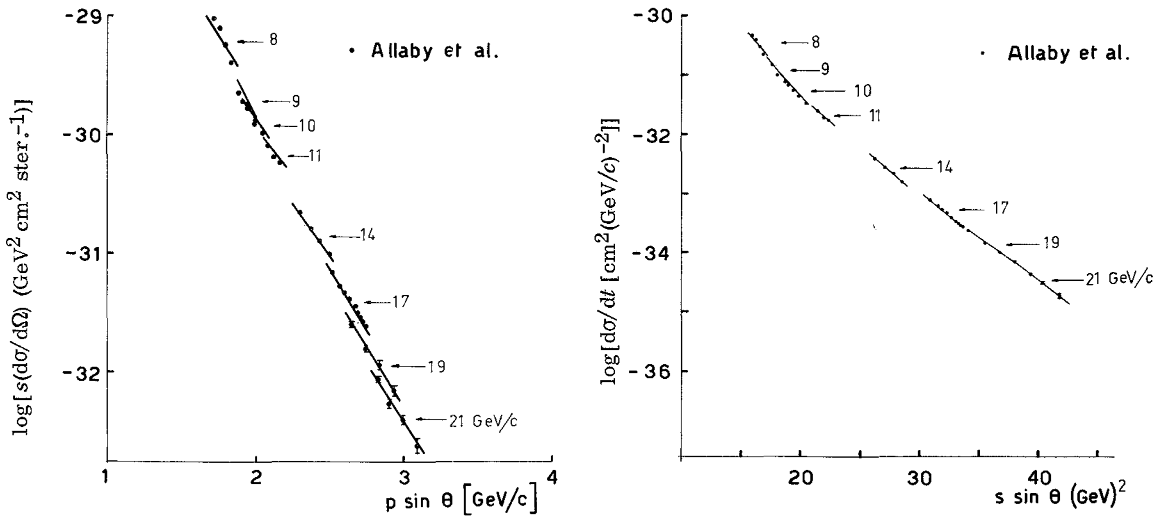

Fig. 2. Logarithmic plots of $s(d\sigma/d\Omega)_{cm}$ as a function of $p\sin\theta$(a), and of $(d\sigma/dt)_{cm}$ as a function of $s\sin\theta$ (b). The data are from Allaby et al. [1]. The curves result from eq. (2).

To obtain a better agreement with experimental data on $d\sigma/d\Omega$ than that afforded by eq. (1), $f(\theta)$ must be weighted with a linear dependence in p; we arrive finally at the formula

$$d\sigma/d\Omega = A' \, (p/s) \, \sin^4\theta \, \exp(-p\sin\theta/T_0) \qquad (2)$$

with

$$A' = 600/2.18 = 275\,\text{mb}\,(\text{str})^{-1}\,(\text{GeV}/c)^{-1}\,(\text{GeV})^2 ,$$

and

$$T_0 = 0.158 \text{ GeV}/c .$$

The p-dependence of $f(\theta, p)$ is not transparent from $\log d\sigma/d\Omega$ but shows up significantly in $d\sigma/d\Omega$. By making use of eq. (2) we plot in fig. 2 $\log_{10}(d\sigma/dt)$ versus $s\sin\theta$ and $\log_{10}(s\, d\sigma/d\Omega)$ versus $p\sin\theta$ respectively. For simplicity we have reported only the data of Allaby et al. However the formula (2) is able to reproduce all experimental data. It is surprising to note, in the plot of $(d\sigma/dt)$ against $s\sin\theta$, that the experimental points can be fitted, to a very good approximation, by a unique curve. That can explain the rather unusual variable $s\sin\theta$ which seemed to fit in a simple way the experimental data. As a result of such good fits we conclude that:

1) An exponential dependence of the form $\exp(-bs\sin\theta)$ cannot be seriously maintained.

2) There are no first order discontinuities in the cross sections.

Finally we point out that the formulae (1) and (2) should be accorded only the importance of stepping stones from which to look for a correct formulation of a future theory of strong interactions at high energies. However it is probably worth while to notice that the behaviour exhibited in (1) and (2) can be justified by using simple models on which we intend to return elsewhere.

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