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The Pomeron-f Identity and Vector Meson Production

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ABSTRACT

The Pomeron-f identity scheme proposed by Chew and Rosenzweig is shown to fail badly when compared to vector meson production data. In contrast, a standard exchange degenerate ω-f model is satisfactory.

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Chew and Rosenzweig[1] (CR) have proposed a scheme in which the highest lying Reggeon trajectory is actually the f meson trajectory, with intercept $\alpha_0 \approx 0.96$. In this scheme there is no tensor trajectory that is exchange degenerate (EXD) with the ω, and there is no separate Pomeron trajectory in contrast to most previous Regge-pole models. Subsequently, Stevens, Chew, and Rosenzweig[2] (SCR) have shown that moderate energy ($p_{LAB} \leq 30$ GeV/c) data for meson-baryon and baryon-baryon total cross sections are compatible with such a Pomeron-f identity scheme, and explicit calculations by Tsou[3] within the dual unitarization program have given strong quantitative support to the Pomeron-f identity, especially regarding the t-dependence. It is therefore of interest to test the Pomeron-f identity in reactions other than elastic scattering. It is shown below that the Pomeron-f identity, as formulated by CR, fails badly when compared to vector meson production data.

In pseudoscalar meson elastic scattering reactions, both SU(3) octet and singlet components of tensor trajectories couple, whereas only octet couplings of vector trajectories are allowed. However, if a vector meson is produced (e.g. $\pi^- p \rightarrow \rho^- p$), then only the octet component of the tensor trajectory can couple and both octet and singlet components of the vector trajectories couple. In the CR scheme, the Regge couplings of interest here become

$$\gamma_{\pi\rho}^{A_2} = 2g \qquad \gamma_{KK^*}^{f} = g(\cos\theta_+ - \sqrt{2}\sin\theta_+)$$

$$\gamma_{\pi\rho}^{\omega} = 2g\cos\theta_- \qquad \gamma_{KK^*}^{f'} = g(-\sin\theta_+ - \sqrt{2}\cos\theta_+)$$

$$\gamma_{KK^*}^{\omega} = g(\cos\theta_- + \sqrt{2}\sin\theta_-)$$

$$\gamma_{KK^*}^{\phi} = g(-\sin\theta_- + \sqrt{2}\cos\theta_-) \quad .$$

Here g is the π-ρ-A_2 coupling constant, and $\theta_+(\theta_-)$ is the amount of rotation of f-f' (ω - ϕ) away from ideal mixing. At t=0 the value $\theta_+ = 20.3^\circ$ is determined fairly precisely by means of the $\sigma_T(\pi^- p) - \sigma_T(K^- p)$ total cross section difference. The value $\theta_- = -33.7^\circ$ was obtained by SCR, while Tsou obtained $\theta_- = -45^\circ$ in the dual unitarization calculation. The angles $\theta_\pm$ are t-dependent and the values

$$\theta_+(t) = 20.3^\circ - 15.0^\circ\, t$$

$$\theta_-(t) = -45.0^\circ + 9.7^\circ\, t$$

are used in the following. The trajectories shown in Fig. 1 were determined using the intercepts α_0 of SCR and the (approximate) t-dependence calculated by Tsou. The results presented below are not sensitive to the precise values used for α_ω, α_ϕ, $\alpha_{f'}$, and θ_-.

Lacking a planar theory for baryons, it is necessary to resort to a reasonable guess to obtain the Reggeon-baryon couplings. The following values were used:

$$\gamma^{f}_{NN} = \beta^{f} \cos\theta_{+} \qquad \gamma^{\omega}_{NN} = \beta^{\omega} \cos\theta_{-}$$

$$\gamma^{f'}_{NN} = -\beta^{f} \sin\theta_{+} \qquad \gamma^{\phi}_{NN} = -\beta^{\omega} \sin\theta_{-} \quad .$$

Reggeon exchange amplitudes of the form

$$A^{R}(s, t) = -\sqrt{-t}\ \gamma^{R}_{PV}\gamma^{R}_{NN} e^{bt}\Gamma(1 - \alpha_{R})(e^{-i\pi\alpha_{R}} + \tau)\left(\frac{s}{s_0}\right)^{\alpha_R}$$

were used. The values $\beta^{f} = 5.27$ and $\beta^{\omega} = 8.33$ are taken from SCR. With $s_0 = 1\ \mathrm{GeV}^2$ and $b = 1.62\ \mathrm{GeV}^{-2}$ to give correct t-dependence, the only remaining parameter g is obtained by normalizing to the differential cross section that isolates ω exchange[4] in $\pi p \to \rho N$ at 16 GeV/c,

$$\frac{d\sigma}{dt}(\omega) = \frac{1}{2}\left[\frac{d\sigma}{dt}(\pi^{+}p \to \rho^{+}p) + \frac{d\sigma}{dt}(\pi^{-}p \to \rho^{-}p) - \frac{d\sigma}{dt}(\pi^{-}p \to \rho^{0}n)\right] \quad .$$

The value obtained is $g = 1.06$ when $d\sigma/dt$ is normalized as

$$\frac{d\sigma}{dt} = \frac{0.3893}{q^2 s} \left| \sum_{R} A^{R} \right|^2 \quad .$$

Normalizing in this manner to the phenomenological ω exchange amplitude precludes any question concerning ω-baryonium mixing effects.[5] I have checked that these parameters also predict fairly well the amount of A_2 exchange[6] in $\pi^{-}p \to \rho^{0}n$.

The model now makes definite normalized predictions for the reaction $K^-p \to K^{*-}(890)\,p$ (ref. 7). The results shown in Figs. 2 and 3 show that the CR model fails badly in both normalization and especially energy dependence of the integrated cross section. In contrast, a simple standard model based on ω-f EXD and also normalized to ω exchange in $\pi p \to \rho N$ is found to agree well with the $K^*(890)$ production data. Also, the phase of the strong production amplitude near $t = 0$ for the reaction $K^+A \to K^{*+}(890)A$ on nuclei has been measured to be real,[8] in agreement with ω-f EXD.

One might now wonder whether these considerations also cause trouble in the f-dominated Pomeron model as originally formulated by Carlitz, Green, and Zee[9] (CGZ). In this model the Pomeron couples like

$$P \propto \frac{\beta_{fac}}{\alpha_{P_0} - \alpha_f}\, g_{P_0P_0f}\, B_{P_0}(s,\, t)\, g_{P_0P_0f}\, \frac{\beta_{fdb}}{\alpha_{P_0} - \alpha_f} \quad ,$$

where P_0 is the primitive Pomeron. The f - f' mass difference induces an apparent octet component in the output Pomeron. Indeed, Irving[10] has found that with a specific model for tensor meson couplings, the f-dominated Pomeron couples only half as strong to single helicity flip vertices as to zero helicity flip vertices. It is possible that the forced production of high mass resonances and hence t_{min} effects in the dual unitarization calculations can account in part for the smaller coupling of the Pomeron to π-A_2.

In conclusion, the simple Pomeron-f identity and quark coupling scheme proposed by Chew and Rosenzweig seems to be definitely ruled out by vector meson production data. A standard ω-f EXD model does adequately describe the data.[11] It remains to be seen if the CGZ scheme can naturally account for the tensor meson production data.

The CR scheme was chosen on the basis of simplicity. Veneziano[12] has suggested an alternate scheme in which there exist distinct Pomeron and f trajectories. It is possible that the vector meson production date could be accommodated within such a scheme, although the model has not yet been formulated in a testable form.

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FIGURE CAPTIONS

Fig. 1: The I = 0 natural parity trajectories $\alpha(t)$ (from Ref. [2, 3]).

Fig. 2: Data (Antipov, Ref. [7]) for the differential cross section for $K^- p \rightarrow K^{*-}(890)p$ at p_{LAB} = 25 GeV/c and the predictions of the CR and EXD models.

Fig. 3: Data (Ref. [7]) for the integrated cross section for $K^- p \rightarrow K^{*-}(890)p$ and the predictions of the CR and EXD models.

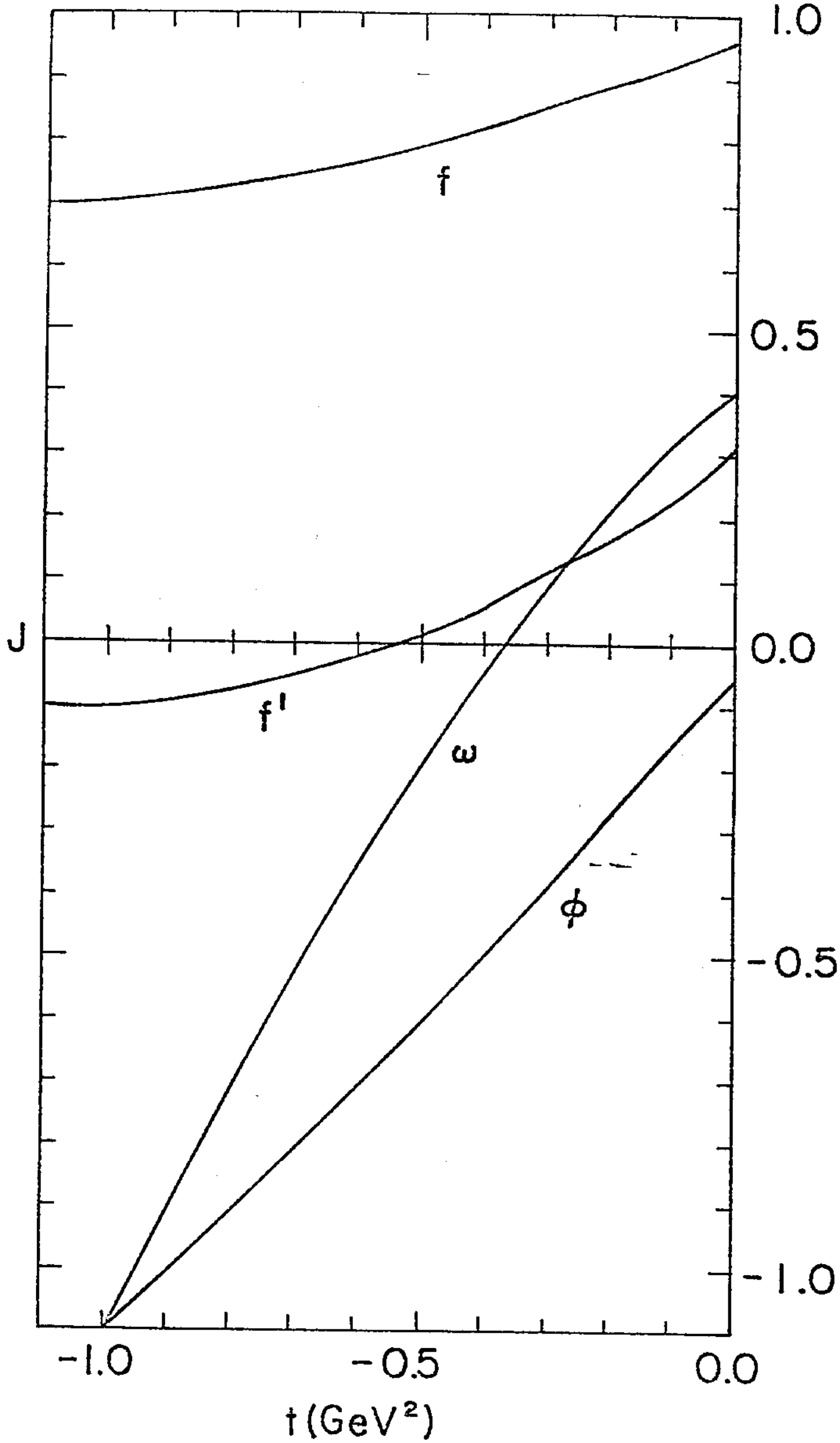
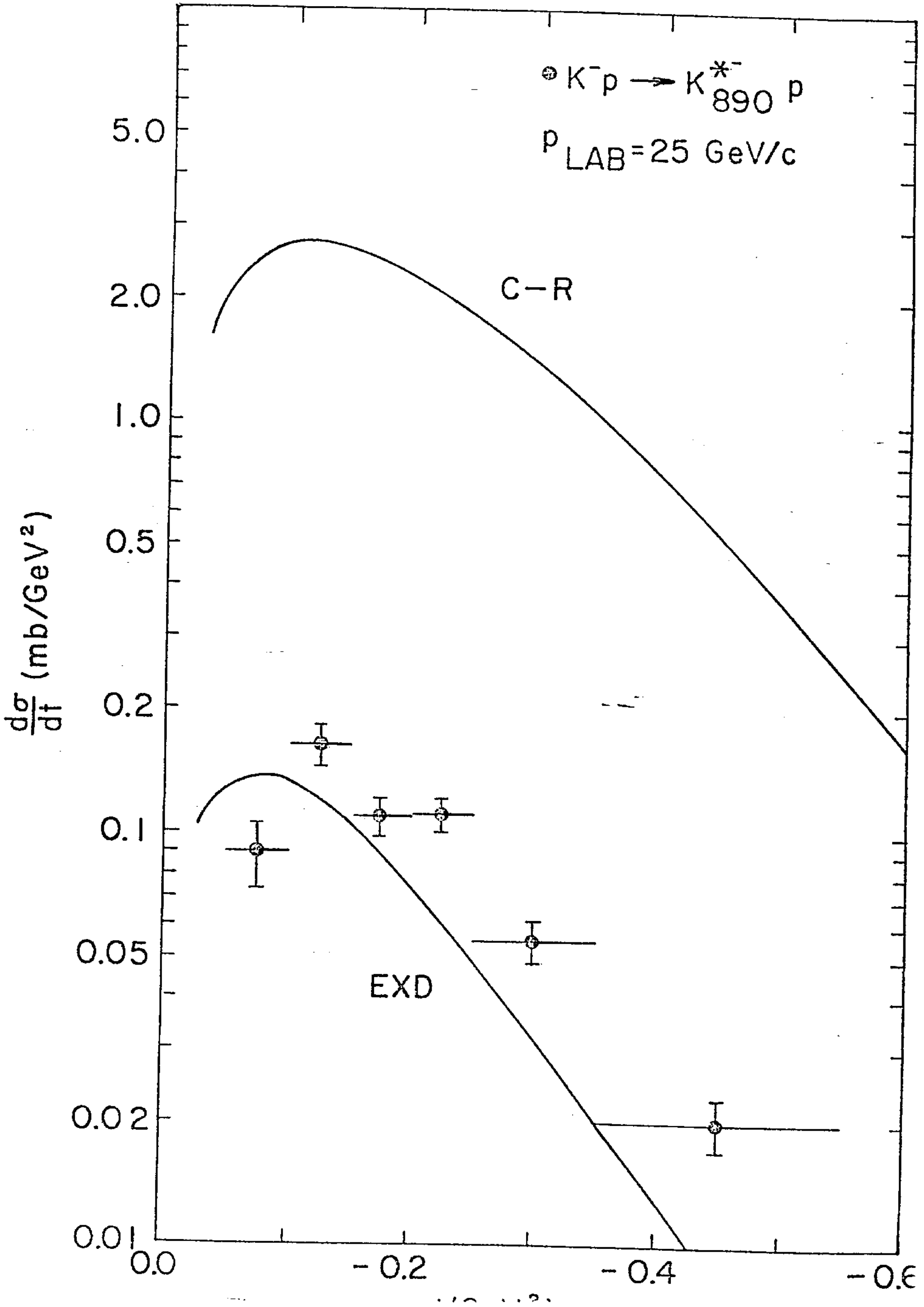
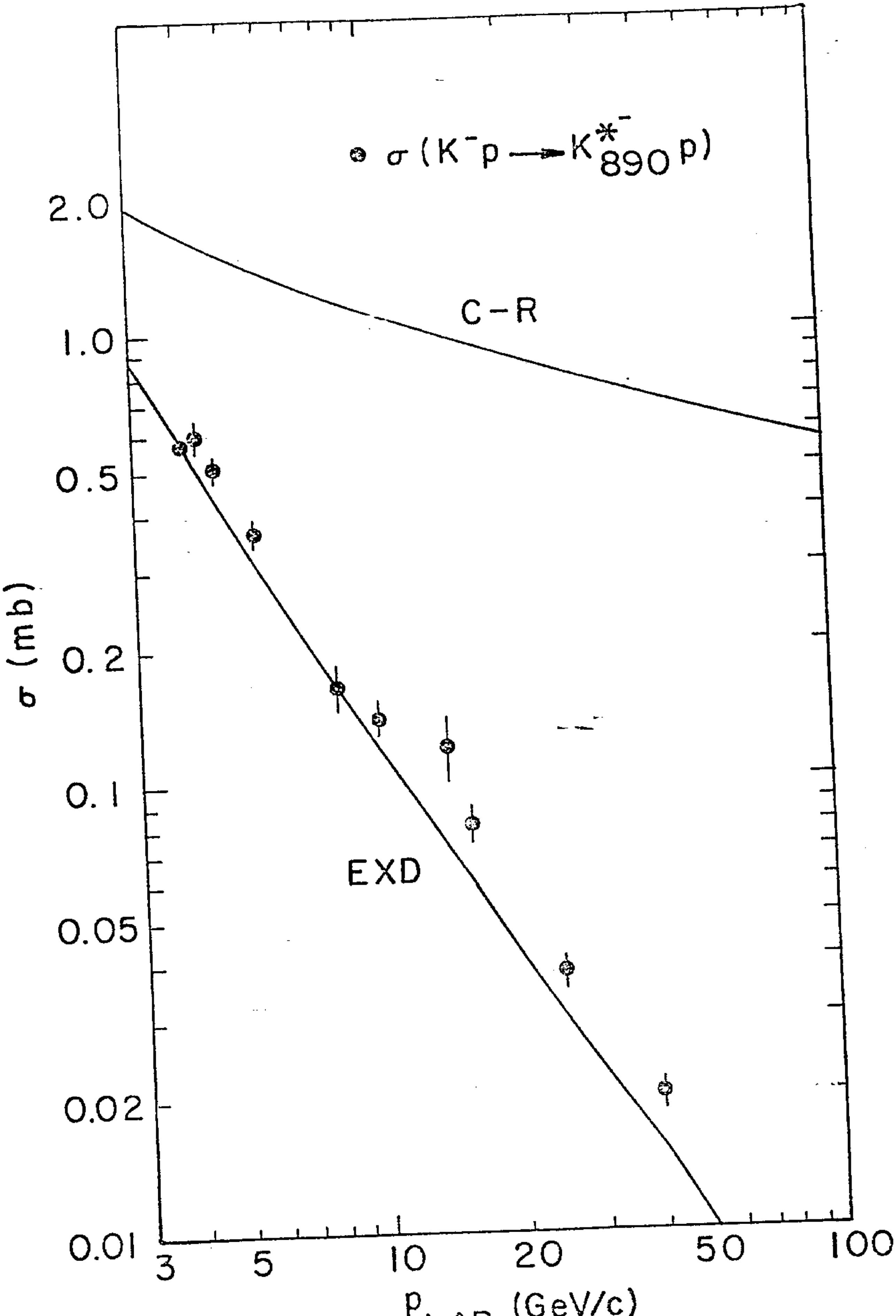


Fig. 1



K⁻p → K*⁻ 890 p
p LAB = 25 GeV/c
C−R
EXD
dσ/dt (mb/GeV²)
5.0
2.0
1.0
0.5
0.2
0.1
0.05
0.02
0.01
0.0
−0.2
−0.4
−0.6



σ(K⁻p → K*⁻890 p)
C-R
EXD
2.0
1.0
0.5
0.2
0.1
0.05
0.02
0.01
σ (mb)
3
5
10
20
50
100
p LAB (GeV/c)

Fig. 3