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COMMENTS ON THE  
BROKEN EXCHANGE-DEGENERATE REGGE POLE MODEL  
FOR  $np$  AND  $p\bar{p}$  CHARGE EXCHANGE\*

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ABSTRACT

We point out that formulas given by Pal on  $np$  and  $p\bar{p}$  CEX for exchange-degenerate and broken exchange-degenerate Regge pole models can be better rationalized by considering  $\pi$  as simultaneously an  $M = 0$  singlet and an  $M = 1$  parity doublet and satisfying threshold behavior.

We have seen that  $np$  and  $p\bar{p}$  CEX (charge-exchange) and charged-pion photoproduction differential cross section produce sharp forward peaks.<sup>1</sup> The pion conspiracy was popular and attractively economical in fitting those processes, it certainly is not unique,<sup>2</sup> and it causes difficulties in other processes via factorization.<sup>3</sup> We want to show here that the factorization difficulties resulting from the conspiracy hypothesis can be avoided if we take into consideration the pion as an  $M = 0$  singlet and an  $M = 1$  parity doublet simultaneously. The  $M = 0$  pion is an evasive one with the usual pion-nucleon coupling constant at the pion pole, and an  $M = 1$  is a parity doublet satisfying the conspiracy relation. An  $M = 0$  pion singlet and an  $M = 1$  parity doublet were considered

simultaneously in np CEX.<sup>4</sup> Only an  $M = 1$  pion parity doublet was considered by Pal<sup>5</sup> in the np and  $p\bar{p}$  CEX broken exchange-degenerate Regge pole model. Now an  $M = 0$  evasive pion should occur in invariant amplitudes  $G_1(s, t, u)_{T=0, 1}$ <sup>6</sup> in the following manner:

$$\begin{aligned}
 G(s, t, u)_{T=0, 1} &= G_2(s, t, w)_{T=0, 1} = G_5(s, t, w)_{T=0, 1} \\
 &= -\frac{g^2}{\pi} \alpha'(t) \Gamma[-\alpha(t)] (1 + e^{-i\pi\alpha(t)}) \left(-\frac{3}{2}, \frac{1}{2}\right) \left(\frac{s}{s_0}\right)^{\alpha(t)}, \\
 G_3(s, t, u)_{T=0, 1} &= G_4(s, t, u)_{T=0, 1} \\
 &= \frac{g^2}{\pi} \alpha'(t) \Gamma[-\alpha(t)] (1 + e^{-i\pi\alpha(t)}) \left(-\frac{3}{2}, \frac{1}{2}\right) \left(\frac{s}{s_0}\right)^{\alpha(t)}
 \end{aligned} \tag{1}$$

for the pion exchange in the t channel, and therefore,

$$\begin{aligned}
 \phi_2(s, t)_{T=0, 1} &= \phi_4(s, t)_{T=0, 1} \\
 &= -\frac{t}{2\sqrt{s}} \frac{g^2}{\pi} \alpha'(t) \Gamma[-\alpha(t)] (1 + e^{-i\pi\alpha(t)}) \left(-\frac{3}{2}, \frac{1}{2}\right) \left(\frac{s}{s_0}\right)^{\alpha(t)}
 \end{aligned} \tag{2}$$

and all other  $\phi_i(s, t)$  are zero. For the pion exchange in the u-channel,

$$\begin{aligned}
 G_1(s, u, t)_{T=0, 1} &= G_4(s, u, t)_{T=0, 1} = G_5(s, u, t)_{T=0, 1} \\
 &= -\frac{g^2}{\pi} \alpha'(u) \Gamma[-\alpha(u)] (1 + e^{-i\pi\alpha(u)}) \left(\frac{3}{2}, \frac{1}{2}\right) \left(\frac{s}{s_0}\right)^{\alpha(u)}
 \end{aligned} \tag{3}$$

$$\begin{aligned}
 G_2(s, u, t)_{T=0, 1} &= G_3(s, u, t)_{T=0, 1} \\
 &= \frac{g^2}{\pi} \alpha'(u) \Gamma[-\alpha(u)] (1 + e^{-i\pi\alpha(u)}) \left(\frac{s}{s_0}\right)^{\alpha(u)} \left(\frac{3}{2}, \frac{1}{2}\right), \quad (4)
 \end{aligned}$$

and therefore

$$\begin{aligned}
 \phi_2(s, u)_{T=0, 1} &= -\frac{u}{2\sqrt{s}} \frac{g^2}{\pi} \alpha'(u) \Gamma[-\alpha(u)] (1 + e^{-i\pi\alpha(u)}) \left(\frac{s}{s_0}\right)^{\alpha(u)} \left(\frac{3}{2}, \frac{1}{2}\right), \\
 \phi_3(s, u)_{T=0, 1} &= \frac{u}{2\sqrt{s}} \frac{g^2}{\pi} \alpha'(u) \Gamma[-\alpha(u)] (1 + e^{-i\pi\alpha(u)}) \left(\frac{s}{s_0}\right)^{\alpha(u)} \left(\frac{3}{2}, \frac{1}{2}\right), \quad (5)
 \end{aligned}$$

and all other  $\phi_i(s, u)$  are zero.

In Ref. 5, the residues were not properly rationalized, and therefore they did not satisfy correct threshold behavior for  $\phi_5(s, t, u)$  only.

Choosing the same invariant amplitudes in Ref. 5 for the t-channel pion exchange, one has conspiracy  $\pi_c$  and its exchange degenerate  $B_c$

$$\begin{aligned}
 \phi_5(s, t)_{T=0, 1} \\
 \frac{\text{large } s}{\text{fixed } t} \sim -\left(-\frac{3}{2}, \frac{1}{2}\right) \frac{\beta(-t)^{1/2} (s+t-4m^2)^{1/2}}{m} \frac{(bs)^{\alpha(t)-1}}{\alpha(0)\Gamma[\alpha(t)] \sin \pi \alpha(t)} \quad (6)
 \end{aligned}$$

instead of

$$\phi_5(s, t)_{T=0, 1} \frac{\text{large } s}{\text{fixed } t} \sim -\left(-\frac{3}{2}, \frac{1}{2}\right) \beta_t \left(1 + \frac{s}{2}\right)^{1/2} \frac{m(bs)^{\alpha(t)-1}}{\sin \pi \alpha(t) \alpha(0)\Gamma[\alpha(t)]}$$

In Ref. 5, it does not satisfy correct threshold behavior  $\propto (-t)^{1/2}$  for small  $t$ . For the  $u$ -channel pion exchange, one has

$$\phi_5(s, u)_{T=0, 1} \underset{\text{fixed } u}{\text{large } s} \sim - \left(\frac{3}{2}, \frac{1}{2}\right) \beta(-u)^{1/2} \frac{(s+u-4m^2)^{1/2}}{m} \frac{(bs)^{\alpha(u)-1}}{\alpha(0) \Gamma[\alpha(u)] \sin \pi \alpha(u)}. \quad (7)$$

It satisfies the correct threshold behavior  $\propto (-4)^{1/2}$  for small  $u$ .

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#### FOOTNOTE AND REFERENCES

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