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Scaling and Locality with No Pomeron in Electroproduction*

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ABSTRACT

A recent sum rule of Brandt and Ng implies the existence of a pomeron contribution in electroproduction. This is shown to be based on an unrealistic assumption. Therefore the conclusions drawn from it are physically unfounded. In particular, electroproduction need not have a pomeron but still scale in a causal model.

Recently Brandt and Ng[1] have claimed the sum rule $\int_0^1 d\omega\{F_2(\omega) - F_2(0)\}/\omega = 0$ for the electroproduction structure functions $F_2(-q^2/(2m\nu))$. Since $F_2(\omega) \geq 0$, an immediate consequence is that $F_2(0)$ cannot vanish.

This result is based on the following assumptions:

1. Locality, mass spectrum restrictions and crossing symmetry as incorporated in an unsubtracted D-G-S representation[2,3].
2. Scaling and positivity of the electroproduction structure functions.
3. The non-pomeron part of the DGS spectral function should behave as

$$\bar{\sigma}(a,b) \underset{b\to 0}{\to} b^{\varepsilon}, \quad \varepsilon>0,$$

if

$$\nu W_2(\kappa,\nu) \equiv \bar{W}(\kappa,\nu) \underset{A}{\to} \bar{F}(\omega) \sim \omega^{\varepsilon}, \quad \varepsilon>0.$$

A simple derivation of their sum rule is sketched in the appendix.

We construct a simple counter example which satisfies all the physical requirements of positivity, causality, support restrictions, crossing symmetry, scaling and smoothness. The reason it violates the sum rule is that it does not satisfy their assumption (3) on $\bar{\sigma}$ even though it correspnds to $\bar{W} \sim \omega^2$ i.e. $\varepsilon = 2$. We believe that the Brandt-Ng sum rule is physically unfounded, since their assumption (3) is too restrictive and unrealistic. In particular it is possible to have $\bar{F}(\omega) \sim \omega^{\varepsilon}$ with $\bar{\sigma}(a,o)\neq 0$.

Our counter example is the DGS spectral function

$$\bar{\sigma}(a,b) = -2\pi(1-a)e^{-a}\theta(a)\theta(1-b^2)(1-b^2)^2.$$

Clearly

$$\int_0^\infty da\bar{\sigma}(a,b) = 0, \quad \bar{\sigma}(a,b) \underset{b\to 0}{\to} 0(1)$$

$$\bar{F}(\omega) \equiv \nu W_2(\omega) = 4\pi\omega^2(1-\omega^2)\theta(1-\omega^2) \underset{\omega\to 0}{\sim} \omega^2 \qquad \text{ie: } \varepsilon=2$$

$$\int_0^1 \bar{F}(\omega)/\omega \; d\omega = \Pi \neq 0.$$

This shows that the Brandt-Ng sum rule is invalid and there is, therefore, no need for a pomeron.

In configuration space, our example corresponds to

$$\nu W_2(\kappa,\nu) = \kappa\nu\tilde{C}(\kappa,\nu),$$

where the fourier transform of $\tilde{C}$ gives (in the frame, $P\equiv 0$)

$$C(y^2,y_o) = -8\varepsilon(y_o)\theta(y^2) \{ \sin y_o/y_o^3 - 3 \cos y_o/y_o^4 + 3 \sin y_o/y_o^3$$
$$\int_0^\infty da \; a(1-a)e^{-a} \; J_1(\sqrt{ay^2})/\sqrt{ay^2} \; .$$

This clearly has the proper light cone singularity for scaling and corresponds to short-range terms discussed by suri and Yennie[4]. These short-range terms are <u>essential</u> even in the presence of Regge behavior to maintain proper support restrictions.[4]

To sum up, our counter example shows that the Brandt-Ng sum rule is invalid. The trouble with the sum rule arises not from the general physical principles incorporated in (1) and (2), but from the specific assumption (3), which is incorrect. Therefore, the results based on the validity of this sum rule need not be correct. In particular electroproduction may have no contribution from the pomeron but still scale in a causal model.

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APPENDIX

Using the DGS representation, it is easy to show [2,6] that

$$\nu W_2 \equiv \bar{W}(\kappa,\nu) = \kappa\nu \int_{-1}^{1} db \int_{0}^{\infty} da\ \sigma(a,b)\ \delta(\kappa+2b\nu-a)\varepsilon(\nu+b).$$

Scaling then requires that

$$\int_{0}^{\infty} da\ \sigma(a,b) = 0,\quad F_2(\omega) = -\omega/2 \int_{0}^{\infty} da\ a\{\partial/\partial\omega\,\sigma(a,\omega)\}.$$

From this it follows that

$$\int_{0}^{1} d\omega/\omega\ F_2(\omega) = -\tfrac{1}{2} \int_{0}^{\infty} da\ a\{\sigma(a,1) - \sigma(a,o)\}.$$

Mass spectrum condition and smoothness requires $\sigma(a,1) = 0$. In the non-pomeron case (or for the non-pomeron part), Brandt and Ng incorrectly assume that $F(\omega) \to 0$ as $\omega \to 0$ requires $\bar{\sigma}(a,0) = 0$ and they get the sum rule:

$$\int_{0}^{1} d\omega/\omega\ \bar{F}_2(\omega) = 0,$$

where they argue that $\bar{F}_2(\omega) = F_2(\omega) - F_2(0)$.

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