PHYSICAL REVIEW D VOLUME 10, NUMBER 9 1 NOVEMBER 1974

Correspondence arguments for wide-angle Compton scattering

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(Received 26 February 1974; revised manuscript received 24 April 1974)

The correspondence principle of Bjorken and Kogut is applied semilocally, using the dominance near threshold of the valence-quark contributions to electroproduction structure functions. The cross section for wide-angle Compton scattering, including normalization, is discussed.

The correspondence principle of Bjorken and Kogut[1] relates the integral over the resonance region of an inclusive cross section extrapolated into the resonance region to the sum of the exclusive cross sections for producing a particle or resonance in the missing-mass channel:

$$\int_R E' \frac{d\sigma}{dq^3}\, dE' \sim \sum_R \frac{1}{E}\frac{d\sigma}{d\Omega} \ , \qquad (1)$$

where R is the resonance region of the missing-mass channel. We have used correspondence to connect inclusive and exclusive processes at large angle,[2] and here we wish to use (1) semilocally to obtain quantitative results. This use of correspondence is very similar to Bloom-Gilman duality[3] for electroproduction, and in fact we use Bloom-Gilman duality to obtain the normalizations.

For correspondence, we are interested in the threshold regions of inclusive cross sections. Experimental results[4] for the electroproduction structure functions for protons and neutrons have indicated that valence-quark contributions are dominant in the threshold region, and so we will neglect contributions from nonvalence quarks.

The cross section for $\gamma p \rightarrow \gamma X$ where the second photon is detected at wide angle in the center-of-mass frame has been calculated in the parton model.[5] The impulse approximation is found to give the dominant contribution, and in the limit,

$$E\frac{d\sigma}{dq^3} = \frac{2\alpha^2(s+u)(s^2+u^2)}{s^2t^2(-u)} \sum_i q_i{}^4 F_2^i\left(\frac{s+u}{-t}\right) , \qquad (2)$$

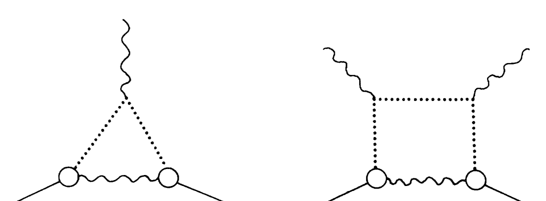

FIG. 1. (a) A model for the form factor. (b) A model for wide-angle Compton scattering.

where q_i is the charge on the ith parton and F_2^i the contribution to the proton's electroproduction structure function from that parton. Using the dominance of valence quarks near threshold, we have

$$\sum q_i{}^4 F_2^i \simeq \frac{16+\rho}{9(4+\rho)} F_2^{ep} \simeq \frac{2(16+\rho)}{9(4+\rho)} F_1^{ep} \ , \qquad (3)$$

where

$$\rho(\omega) = F_2^{\mathfrak{N}}(\omega)/F_2^{\mathcal{P}}(\omega) \qquad (4)$$

has to be determined from experiment. There is some indication[6] that $\rho(1) \simeq 0$, which is active quark dominance[7] where the $\mathcal{P}$ ($\mathfrak{N}$) quark contribution to the proton (neutron) structure function dominates for ω near unity.

Bloom-Gilman duality[3] for electroproduction relates an integral over an electroproduction structure function to an electromagnetic form factor of the proton:

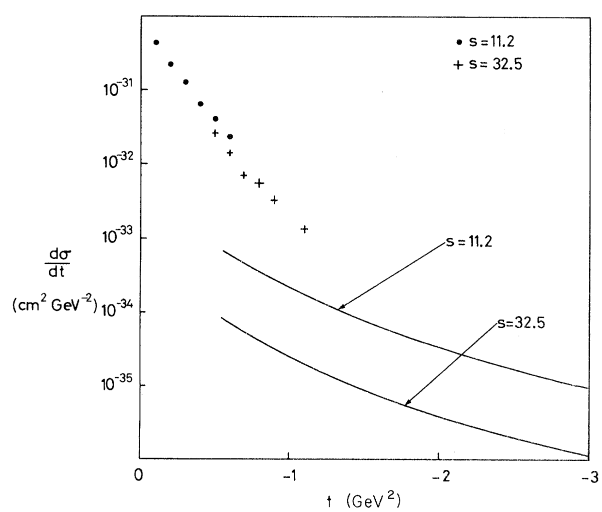

FIG. 2. The cross section for Compton scattering. The points are from Ref. 9, and the curves are from Eq. (6) with $\rho(1) = 0$.

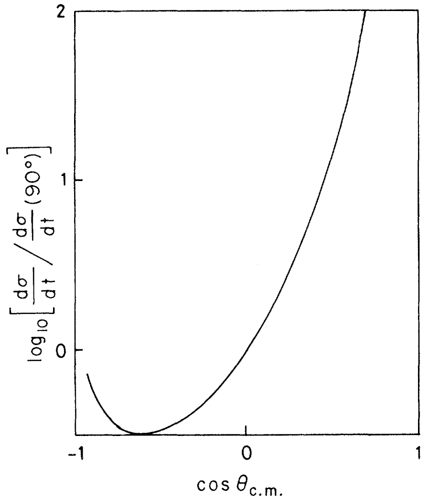

FIG. 3. The angular dependence of wide-angle Compton scattering.

$$\int_1^{1-M^2/q^2} F_1^{ep}(\omega)d\omega = \tfrac{1}{2}G_M^{\,2}(q^2), \tag{5}$$

where M is some mass which need not be specified here.

We now use (1) with the inclusive cross section of (2) and also (3) and (5). Then the cross section for $\gamma p \to \gamma p$ at wide angle is asymptotically

$$\frac{d\sigma}{dt} = \frac{2\pi\alpha^2[16+\rho(1)]}{9[4+\rho(1)]}\,\frac{s^2+u^2}{s^3(-u)}\,G_M^{\,2}(t)\,. \tag{6}$$

It is interesting that a simple covariant model using partons and cores,[8] and $\mathcal{P}$ quark dominance, leads[2] to (6) with $\rho(1)=0$. The model is shown in Fig. 1, where dotted lines are partons and wavy lines are spin-1 cores.

As we have mentioned, active quark dominance gives $\rho(1)=0$ and we use this in what follows. In Fig. 2, we plot (6) at $s=11.2$ and 32.5 for smaller t values. The available data[9] at small t, which seem to be falling exponentially, are plotted for comparison of magnitudes. To do this, we have used

$$G_M(t) = \frac{2.79}{(1-t/0.71)^2}\,. \tag{7}$$

Figure 3 shows the asymptotic form of $[d\sigma/dt(\theta)]/[d\sigma/dt(90°)]$ using $G_M \propto t^{-2}$. Unfortunately the cross section in (6) is probably too small to be measured for some time.

I am pleased to thank Professor J. C. Polkinghorne for his help and encouragement, and the Science Research Council for a grant.

[1]J. D. Bjorken and J. B. Kogut, Phys. Rev. D 8, 1341 (1973).

[2]D. M. Scott, Nucl. Phys. B74, 524 (1974).

[3]E. D. Bloom and F. J. Gilman, Phys. Rev. D 4, 2901 (1971).

[4]D. H. Perkins, lectures given at the Fifth Hawaii Topical Conference in Particle Physics, 1973 (unpublished).

[5]J. D. Bjorken and E. A. Paschos, Phys. Rev. 185, 1975 (1969); R. L. Kingsley, Nucl. Phys. B52, 203 (1973).

[6]A. Bodek, M. Breidenbach, D. L. Dubin, J. E. Elias, J. I. Friedman, H. W. Kendall, J. S. Poucher, E. M. Riordan, M. R. Sogard, and D. H. Coward, Phys. Rev. Lett. 30, 1087 (1973).

[7]R. McElhaney and S. F. Tuan, Phys. Rev. D 8, 2267 (1973); R. W. Fidler, Phys. Lett. 46B, 455 (1973).

[8]J. F. Gunion, S. J. Brodsky, and R. Blankenbecler, Phys. Rev. D 8, 287 (1973), and references therein; P. V. Landshoff and J. C. Polkinghorne, *ibid.* 8, 927 (1973).

[9]R. L. Anderson, D. Gustavson, J. Johnson, I. Overman, D. Ritson, B. H. Wiik, R. Talman, J. K. Walker, and D. Worcester, Phys. Rev. Lett. 25, 1218 (1970).