Generalized Parton Distribution for Non Zero Skewness

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Introduction

In the theory of strong interactions the main open question is how the nucleon and other hadrons are built from quarks and gluons, the fundamental degrees of freedom in QCD. An essential tool to investigate hadron structure is the study of deep inelastic scattering processes, where individual quarks and gluons can be resolved. The parton densities extracted from such processes encode the distribution of longitudinal momentum and polarization carried by quarks, antiquarks and gluons within a fast moving hadron. They have provided much to shape our physical picture of hadron structure. In the recent years, it has become clear that appropriate exclusive scattering processes may provide such information encodeded in the general parton distributions (GPDs). Here, we investigate the GPD for deep virtual compton scattering (DVCS) for the non zero skewness. We investigate the GPDs by expressing them in terms of overlaps of light front wave functions (LFWFs). We represent a spin 1/2 system as a composite of spin 1/2 fermion and spin 1 boson with arbitrary masses.

Generalized Parton Distribution

The DVCS process $\gamma^* + p \to \gamma + p$ has become subject of considerable interest. The generalized parton distributions H,E are defined through matrix elements of bilinear vec-

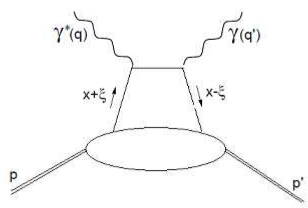

FIG. 1: Diagram for DVCS

tor currents on the light cone as

$$\int \frac{dy^-}{8\pi} e^{\frac{ixP^+y^-}{2}} \langle P^{'}|\bar{\psi}(0)\gamma^+\psi|P\rangle|_{y^+,y^\perp=0} = \frac{1}{2\bar{P}^+}U(P^{'})[H(x,\zeta,t)\gamma^+ + E(x,\zeta,t)\frac{i}{2M}\sigma^{+\alpha}(-\Delta_\alpha)]U(P). \quad (1)$$

Here, we take skewness to be non zero. For non zero-skewness ζ there are diagonal parton number conserving contributions in the kinematical regions $\zeta < x < 1$ and $\zeta - 1 < x < 1$. If we consider a spin 1/2 target state consisting of a spin 1 particle and a spin 1/2 particle, these contributions can be expressed in terms of the 2-particle LFWFs as

$$H(x,\zeta,t) = \int \frac{d^2k_\perp}{16\pi^3}[\psi^{\uparrow *}_{+\frac{1}{2}+1}(x,\vec{k}^{'}_\perp)\psi^{\uparrow}_{+\frac{1}{2}+1}(x,\vec{k}_\perp) + \psi^{\uparrow *}_{+\frac{1}{2}-1}(x,\vec{k}^{'}_\perp)\psi^{\uparrow}_{+\frac{1}{2}-1}(x,\vec{k}_\perp) + \psi^{\uparrow *}_{\frac{-1}{2}+1}(x,\vec{k}^{'}_\perp)\psi^{\uparrow}_{\frac{-1}{2}+1}(x,\vec{k}_\perp)], \quad (2)$$

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where

$$\vec{k}'_{\perp} = \vec{k}_{\perp} - (1-x)\vec{\Delta}_{\perp}. \quad (3)$$

Here, $\psi^{\uparrow^*}_{\lambda_1\lambda_2}(x, \vec{k}'_{\perp})$ is the lowest (two-particle) Fock component of the hadron LFWF with helicity up and down, i = 1, 2 are the intrinsic helicities of the internal particles.

Calculations

The GPDs can be calculated in the simulated models of hadron LFWFs. The two-particle wave function for spin-up electron can be expressed as

$$\psi^{\uparrow}_{+\frac{1}{2}+1}(x, \vec{k}_{\perp}) = -\sqrt{2}\frac{-k^1 + ik^2}{x(1-x)}\varphi, \quad (4)$$

$$\psi^{\uparrow}_{+\frac{1}{2}-1}(x, \vec{k}_{\perp}) = -\sqrt{2}\frac{k^1 + ik^2}{(1-x)}\varphi, \quad (5)$$

$$\psi^{\uparrow}_{\frac{-1}{2}+1}(x, \vec{k}_{\perp}) = -\sqrt{2}(M - \frac{m}{x})\varphi, \quad (6)$$

$$\psi^{\uparrow}_{\frac{-1}{2}-1}(x, \vec{k}_{\perp}) = 0, \quad (7)$$

where, $\varphi(x, \vec{k}_{\perp}) = \frac{e}{\sqrt{1-x}}\frac{1}{M^2 - \frac{\vec{k}_{\perp}^2 + m^2}{x} - \frac{\vec{k}_{\perp}^2 + \lambda^2}{1-x}}$. Here, we assigned a mass M to the external electrons and a different mass m to the internal electron lines and a mass λ to the internal photon lines. The idea behind this is to model the structure of a composite fermion state with mass M by a fermion and a vector diquark constituent with respective masses m and λ. We differentiate the $\varphi(x, \vec{k}_{\perp})$ w.r.t M^2. We take $\varphi(x, \vec{k}_{\perp}) = N\frac{e}{\sqrt{1-x}}\frac{1}{\left(M^2 - \frac{\vec{k}_{\perp}^2 + m^2}{x} - \frac{\vec{k}_{\perp}^2 + \lambda^2}{1-x}\right)^2}$, where N is the normalization constant. The GPD in this model when the target helicity is not flipped (helicity non-flip) for non zero skewness using Feynmann parametrization becomes:

$$H(x,\zeta,t) = \frac{e^2}{16\pi^3}[\frac{\sqrt{1-\zeta}x(1-x)(x-\zeta)}{(1-\zeta)^2} + \frac{(x-\zeta)^2x^2(1-x)}{(1-\zeta)^2}]I_1 + [\frac{\sqrt{1-\zeta}x(1-x)(x-\zeta)}{(1-\zeta)^2} + \frac{(x-\zeta)^2x^2(1-x)}{(1-\zeta)^2}]I_2 + [\frac{\sqrt{1-\zeta}x(1-x)(x-\zeta)}{(1-\zeta)^2} + \frac{(x-\zeta)^2x^2(1-x)}{(1-\zeta)^2}][M^2x(1-x) - m^2(1-x) + \frac{M^2(x-\zeta)(1-x)}{(1-\zeta)^2} - \lambda^2x - (1-x)^2\Delta_{\perp}{}^2 - \frac{m^2(1-x)}{1-\zeta} - \frac{\lambda^2(x-\zeta)}{1-\zeta}] + 2(M(x-\zeta) - m(1-\zeta)) \left(\frac{(Mx-m)(x-\zeta)x(1-x)^3\sqrt{1-\zeta}}{(1-\zeta)^4}\right) I_3 \quad (8)$$

where

$$D = \frac{m^2(1-x)(1-\alpha\zeta) + \lambda^2(x-\zeta) + \alpha\lambda^2\zeta(1-x)}{1-\zeta} + M^2(1-x)\left(\frac{-x+\zeta(1-\alpha)+\alpha x\zeta(2-\zeta)}{(1-\zeta)^2}\right) + \Delta_{\perp}^2(1-x)^2(1-\alpha)\left(\frac{\zeta^2 - 2\zeta + \alpha}{(1-\zeta)^2}\right)$$

$$I_1 = \pi\int_0^1 \frac{\alpha d\alpha}{D^2}$$

$$I_2 = \pi\int_0^1 \frac{(1-\alpha)d\alpha}{D^2}$$

$$I_3 = \pi\int_0^1 \frac{\alpha(1-\alpha)d\alpha}{D^3} \quad (9)$$

Summary and Conclusion

We have investigated the GPDs for non zero skewness. We check the analyticity of the result by taking $\zeta = x$ and found H(x,x)=0 in the DGLAP region.

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