New developments in GPD parametrization and DVCS analysis

C. Weiss (JLab), GPD Working Group meeting, JLab, 6–7 Aug 08

- GPD analysis of leading–twist DVCS observables

$$A(\xi, t) \;=\; \int dx\; H(x, \xi; t) \left(\frac{1}{\xi - x - i0} - \frac{1}{\xi + x - i0} \right) \qquad \text{"known"}$$

  - GPD parametrizations
  - Accessible information?
  - Dispersion relations

- Development of DVCS MC generator

Major directions

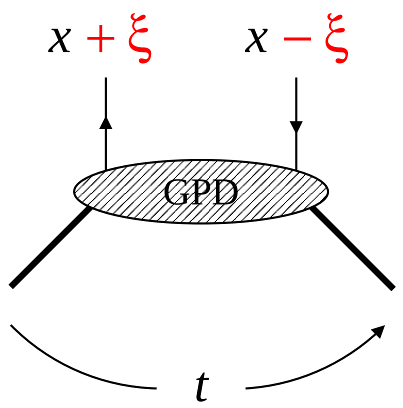
- Handle skewness $\xi \neq 0$
  - Polynomiality constraint
  - Reduction to $\xi = 0$ $\rightarrow$ transverse imaging
  - Small–ξ expansion $\rightarrow$ Regge–like behavior, HERA/EIC energies

- Diagonalize QCD evolution

- Relate GPD parameters to nucleon structure: J_q *etc.*
  Incorporate lattice data

- Work directly with LT amplitudes:
  Dispersion relations ImA $\rightarrow$ ReA

Polynomiality



$$\int_{-1}^{1} dx\ x^n\ H(x, \xi)$$

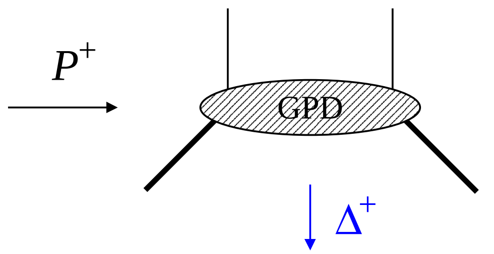
Spin–n operator

$$= \ c_0^{(n)} + c_2^{(n)}\ \xi^2 + \ldots + c_{n+1}^{(n)}\ \xi^{n+1}$$

Polynomial of degree $n+1$ in ξ

- ξ–dependence constrained by polynomiality condition ($\rightarrow$ Lorentz invariance)
  - Intriguing!
  - Generate GPDs from "more primary" functions

Double distribution parametrization



$f(\alpha, \beta)$

$$H(x,\xi) \;=\; \iint\limits_{\beta = x - \xi\alpha} d\alpha\, d\beta\; f(\alpha, \beta)$$

$$+ \quad D(x/\xi)$$

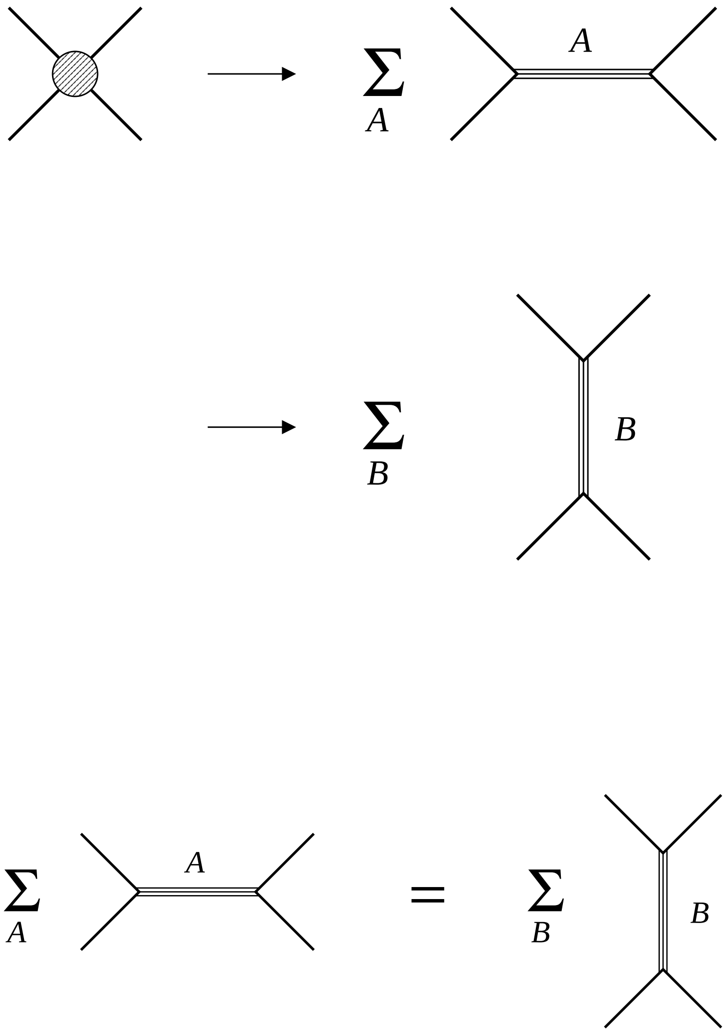
[Radyushkin 97; Polyakov, CW 99;
alt. formulation: Belitsky, Müller 00]

- Basic idea: Spectral representation of matrix element w. independent P^+, Δ^+

  in GPD: $\Delta^+ = -2\xi P^+$

- In practice
  - Widely used for $\xi \sim 0.1 - 0.5$
    [Goeke, Polyakov, Vanderhaeghen 01]
  - Nucleon structure?
    Physics of $x \to \xi$?
  - QCD evolution external
  - Not natural at small x

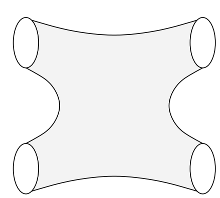
s and t–channel view, duality



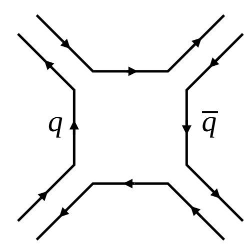
- Hadronic amplitudes

Intermediate state? Resonance, q + spectator	s–channel view
Exchanged object? Regge trajectory, $q\bar{q}$ pair	t–channel view

- Duality: Equivalence of s– and t–channel representations
  [Veneziano; Dolen, Horn, Schmid 70's]

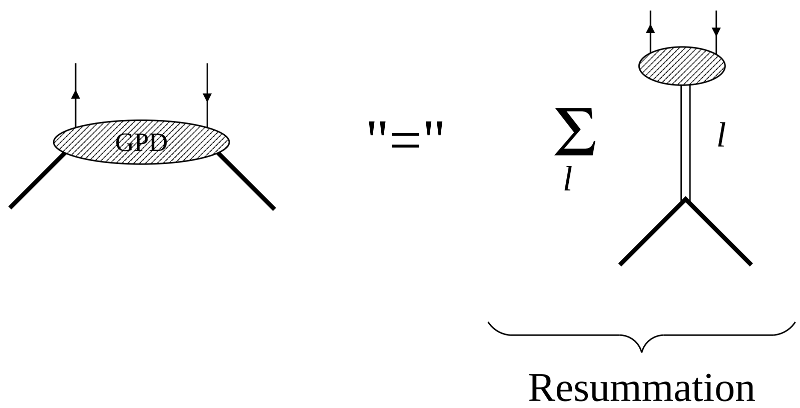


string amp.



cf. quark model

Dual parametrization



$$
\begin{aligned}
H(x,\xi) \quad &= \quad K_0\, Q_0(x) \quad \leftarrow q, \bar{q} \\
&+ \quad K_2\, Q_2(x) \qquad \sim \xi^2 \\
&+ \quad \ldots
\end{aligned}
$$

Terms of increasing order in ξ^2
cf. Regge: Leading + daughter trajectories

$Q_0(x), Q_2(x)$ "forward–like," DGLAP

[Polyakov, Shuvaev 02]

- Basic idea: t–channel representation of GPD (partial wave expansion)
- LO QCD evolution diagonalized
  x^n moments $\rightarrow$ $C_n^{3/2}(x)$ moments
- In practice
  - LO QCD evolution "automatic"
  - Natural high–energy expansion (small ξ)
  - Nucleon structure: Controled angular momentum of $q\bar{q}$ pair
  - Unclear if effective at large ξ

$\boxed{\rightarrow \text{ Talk by V. Guzey}}$

- More rigorous approach: Conformal expansion
  - NLO DVCS evolution diagonalized using conformal symmmetry
  - Uses J–plane analyticity to formalize partial–wave expansion and clarify connection with Regge theory

  [Belitsky et al. 97; Müller, Schäfer 05]

  $\boxed{\rightarrow \text{Talk by D. Müller}}$

- Applications of dual/conformal parametrization
  - HERA DVCS data well described
  - HERMES, JLab asymmetries and cross sections: "Minimal model" . . . is it unique?

  [Belitsky et al 01; Kumericki et al. 06;
  Guzey, Polyakov 06; Guzey, Teckentrup 06;
  Polyakov, Vanderhaeghen 08]

  $\boxed{\rightarrow \text{individual talks}}$

Dispersion relations

$$
\begin{aligned}
A(\xi, t) \;\; &= \;\; \int dx \, H(x, \xi; t) \\
\times & \left(\frac{1}{\xi - x - i0} - \frac{1}{\xi + x - i0} \right)
\end{aligned}
$$

Analytic properties:
Re $A \;\; \leftrightarrow \;\;$ Im $A \;\; (x = \xi)$

[Frankfurt et al. 97;
Teryaev 05; Anikin, Teryaev 07;
Kumericki, Müller, Passek–Kumericki 07;
Diehl, Ivanov 07]

- Basic idea: Use s–channel dispersion relation (fixed–t) to calculate Re A from Im A in a model–independent way

  D–term appears as subtraction constant

- Applied to JLab Hall A DVCS cross sections
  [Polyakov, Vanderhaeghen 08]

$\rightarrow$ Talk by M. Vanderhaeghen