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

\[ A(\xi, t) = \int dx \ H(x, \xi; t) \left( \frac{1}{\xi - x - i0} - \frac{1}{\xi + x - i0} \right) \quad \text{“known”} \]

- 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–$\xi$ 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 $\text{Im} A$ $\rightarrow$ $\text{Re} A$
Polynomiality

\[
\int_{-1}^{1} dx \ x^n \ H(x, \xi) = c_0^{(n)} + c_2^{(n)} \xi^2 + \ldots + c_{n+1}^{(n)} \xi^{n+1}
\]

Polynomial of degree \( n + 1 \) in \( \xi \)

- \( \xi \)-dependence constrained by polynomiality condition (\( \rightarrow \) Lorentz invariance)
  - Intriguing!
  - Generate GPDs from “more primary” functions
Double distribution parametrization

\[ P^+ \rightarrow \Delta^+ \quad f(\alpha, \beta) \]

- Basic idea: Spectral representation of matrix element w. independent \( P^+, \Delta^+ \)
  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 \( x \rightarrow \xi？ \)
  - QCD evolution external
  - Not natural at small \( x \)

\[
H(x, \xi) = \int \int d\alpha d\beta f(\alpha, \beta)_{\beta=x-\xi \alpha}
+ D(x/\xi)
\]

[Radyushkin 97; Polyakov, CW 99; alt. formulation: Belitsky, Müller 00]
\textit{s and \(t\)-channel view, duality}

- \textbf{Hadronic amplitudes}
  - Intermediate state? \(s\)-channel view
  - Resonance, \(q\) + spectator \(s\)-channel view
  - Exchanged object? \(t\)-channel view
  - Regge trajectory, \(q\bar{q}\) pair \(t\)-channel view

- \textbf{Duality: Equivalence of \(s\)- and \(t\)-channel representations}
  \cite{Veneziano; Dolen, Horn, Schmid 70's}

\[
\sum_A A \rightarrow \sum_A A \\
\sum_B B \\
\sum_A A = \sum_B B
\]

\textbf{string amp.} \hspace{1cm} \textbf{cf. quark model}
Dual parametrization

\[
H(x, \xi) = K_0 Q_0(x) \leftarrow q, \bar{q} \\
+ K_2 Q_2(x) \sim \xi^2 \\
+ \ldots
\]

Terms of increasing order in $\xi^2$

cf. Regge: Leading + daughter trajectories

$Q_0(x), Q_2(x)$ “forward–like,” DGLAP

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

→ Talk by V. Guzey

[Polyakov, Shuvaev 02]
• More rigorous approach: Conformal expansion
  – NLO DVCS evolution diagonalized using conformal symmetry
  – Uses $J$–plane analyticity to formalize partial–wave expansion
    and clarify connection with Regge theory

  [Belitsky et al. 97; Müller, Schäfer 05]  → 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]  → individual talks
Dispersion relations

\[ A(\xi, t) = \int dx \, H(x, \xi; t) \times \left( \frac{1}{\xi - x - i0} - \frac{1}{\xi + x - i0} \right) \]

Analytic properties:
\[ \text{Re } A \leftrightarrow \text{Im } A \quad (x = \xi) \]

- 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]

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

→ Talk by M. Vanderhaeghen