Aspects of GPDs

- Unified description of nucleon structure probed in
  - Inclusive DIS
  - Elastic form factors
  - Hard exclusive processes

- Access to operators not available in standard electroweak interactions
  - EM Tensor, $J_q$

- Quark/gluon imaging of nucleon
  - 2D “tomography"
  - 3D imaging

Q: What can measurements of hard exclusive processes contribute to our knowledge of GPDs?
GPDs: Distinguish three regions

→ Interest for nucleon structure
→ Experimental access
→ Theoretical understanding

\[
x + \xi \quad x - \xi
\]

I) \( \xi = 0 \) Transverse quark imaging (“tomography”)

II) \( x = \xi \) “Stopping” of fast quark

III) \( x \neq \xi \) 3D imaging, sum rules
1) GPDs at $\xi = 0$: Transverse parton imaging

- **Input**: PDFs, Formfactors
- **Correlation $x \leftrightarrow t$**
  - $x \to 1$: pQCD
  - Small $x$: Regge, DGLAP evolution
  - Intermediate $x$: Lattice
- **Interesting**: Transverse spin, etc.

Theory well understood; No direct access at large $x$ ($\xi, t_{\text{min}} \neq 0$)

Small $x \to$ tomorrow
II) GPDs at $x = \xi$: Stopping of fast quark

- Probed by $\text{Im}(\text{DVCS})$ at leading twist

- Overlap of very different configurations in nucleon wave function
  - Role of vacuum structure?
  - Hard–soft separation, QCD evolution?

Directly accessible in experiment
Challenge for theory:
Can we relate it to PDF/formfactor?
III) GPDs at \( x \neq \xi \): General case

- Needed for 3D imaging, Ji's angular momentum sum rule
  \[
  \int dx \ x \ [H_q(x, \xi) + E_q(x, \xi)]_{t=0} = 2J_q
  \]

- Probed by \( \text{Re}(\text{DVCS}) \) at leading twist

- Two–component structure: "Meson exchange" contributions for \(-\xi < x < \xi\)

Challenging for both experiment and theory!
From electroproduction data to GPDs

GPD parametrizations

Sensitivity?

Leading-twist observables

Higher twist
Target mass
L/T

Data

2D/3D Imaging
Sum rules $J_q$

$\text{Im}(\text{Amp}) \sim H(x = \xi, t)$

$\text{Re}(\text{Amp}) \sim \int dx \frac{H(x, \xi, t)}{x \pm \xi}$

$(e, e' \gamma)$ cross section, target/beam spin asymmetry

$(e, e' \text{ meson})$ cross section and response fns $(L/T)$
GPD Parametrizations
GPD parametrizations: Requirements

- PDF, formfactor as limits
- Polynomiality: $\int dx \, x^n \, H(x, \xi) = \text{Pol}_{n+1}(\xi)$
- Non-perturbative dynamics at $x \to \xi$
- "Meson exchange" contributions at $-\xi < x < \xi$
- Correlation $x \leftrightarrow t$ dependence
## GPD parametrizations: Overview

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<td>Spectral representation symmetric in $P$, $\Delta$; Polynomiality</td>
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1) Radyushkin 96; Polyakov, CW 99; Belitsky, Müller 00; Goeke, Polyakov, Vanderhaeghen, 2001
2) Polyakov, Shuvaev 02; Polyakov, Guzey 06
3) Müller, Schäfer 05
GPD parametrizations: Questions

- Do we understand the $x \rightarrow \xi$ behavior?
  
  How do measurements of $H(x = \xi) \sim \text{Im(DVCS)}$ constrain GPDs elsewhere?

- Sensitivity of $\text{Re(DVCS)}$ to parameters?

- What can lattice calculations of moments contribute?