Deeply Virtual Compton Scattering from Gauge/Gravity Duality

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work with Miguel S. Costa

Diffraction 2012, Tuesday, September 11, 2012

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Phys. Rev. D **86** (2012) 016009

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- Our goal is to study the strong interaction at strong coupling.
- More specifically, a recent conjecture by Maldacena relating string theory on $AdS_5 \times S_5$ to $\mathcal{N} = 4SYM$ allows us to study QCD at strong coupling.

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$$A(s,t) \sim s^{\alpha(t)}, \quad \alpha(t) = \alpha(0) + \frac{\alpha' t}{2},$$
- In perturbative QCD, the propagation of the Pomeron is given by the BFKL equation.

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- Correspondence works in the limit

$$N_C \to \infty, \quad \lambda = g^2 N_C = R^4/\alpha'^2 \gg 1, \text{fixed}$$

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- At $t = 0$
  Weak coupling:

$$\mathcal{K}(k_\perp, k'_\perp, s) = \frac{s^{j_0}}{\sqrt{4\pi\mathcal{D}\log s}} e^{-(\log k_\perp - \log k'_\perp)^2/4\mathcal{D}\log s}$$

$$j_0 = 1 + \frac{\log 2}{\pi^2}\lambda, \quad \mathcal{D} = \frac{14\zeta(3)}{\pi}\lambda/4\pi^2$$

  Strong coupling:

$$\mathcal{K}(z, z', s) = \frac{s^{j_0}}{\sqrt{4\pi\mathcal{D}\log s}} e^{-(\log z - \log z')^2/4\mathcal{D}\log s}$$

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- Eikonal approximation in AdS space (Brower, Strassler, Tan; Cornalba,Costa,Penedones)

$$A(s,t) = 2is \int d^2 l e^{-i\mathbf{l}_\perp \cdot \mathbf{q}_\perp} \int dz d\bar{z}\, P_{13}(z) P_{24}(\bar{z}) (1 - e^{i\chi(s,b,z,\bar{z})})$$

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- We can study different scattering processes by supplying P_{13} and P_{24}.
- For example, already applied to DIS [Brower, MD, Sarčević,Tan].

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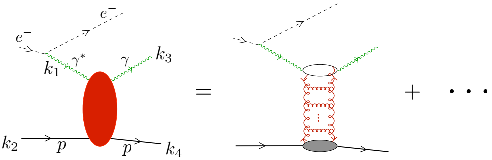

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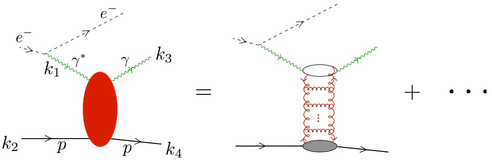

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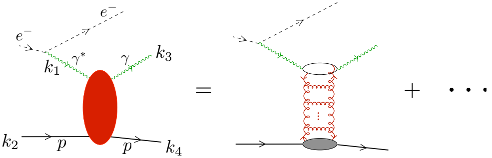

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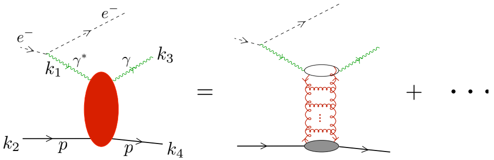

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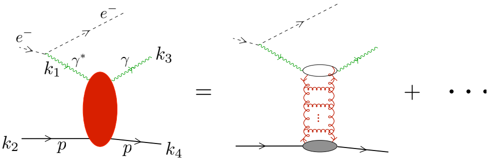

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- the scaling variable

$$x \approx \frac{Q^2}{s}$$

- We are interested in calculating the differential and exclusive cross sections

$$\frac{d\sigma}{dt}(x, Q^2, t) = \frac{|W|^2}{16\pi s^2},$$

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- In this analysis we use

$$\Psi(z) = -C\,\frac{\pi^2}{6}\,z^3\,K_1(Qz),\;\; \Phi(\bar{z}) = \bar{z}^3\,\delta(\bar{z} - z_\star)$$

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- C is the aforementioned normalization, and g_0^2 is related to the coupling of the external states to the pomeron.

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- Similarly, the $t = 0$ result for the hard-wall model can also be written explicitly

$$\chi_{hw}(\tau, t = 0, z, \bar{z}) = \chi(\tau, 0, z, \bar{z}) + \mathcal{F}(\tau, z, \bar{z})\, \chi(\tau, 0, z, z_0^2/\bar{z})\,.$$

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- When $t \neq 0$, we will use an approximation

$$\chi_{hw}(\tau, l, z, \bar{z}) = C(\tau, z, \bar{z})\, D(\tau, l)\, \chi_{hw}^{(0)}(\tau, l, z, \bar{z})$$

- The function

$$\mathcal{F}(\tau, z, \bar{z}) = 1 - 4\sqrt{\pi\tau}\, e^{\eta^2}\, \mathrm{erfc}(\eta)\,, \qquad \eta = \frac{-\log(z\bar{z}/z_0^2) + 4\tau}{\sqrt{4\tau}}$$

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- For the data here analysed, the size of $\mathcal{F}$ will roughly vary between -0.1 and -0.4.

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- We will look at both the differential and total exclusive cross sections.
- We have 52 points for the differential and 44 points for the cross section.

DIS

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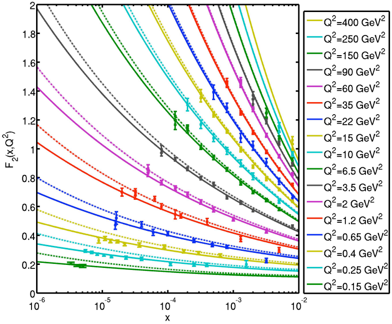

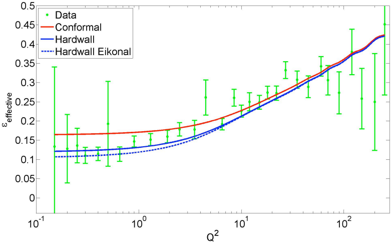

Conformal Pomeron

- Fitting the differential cross section to the data, we get

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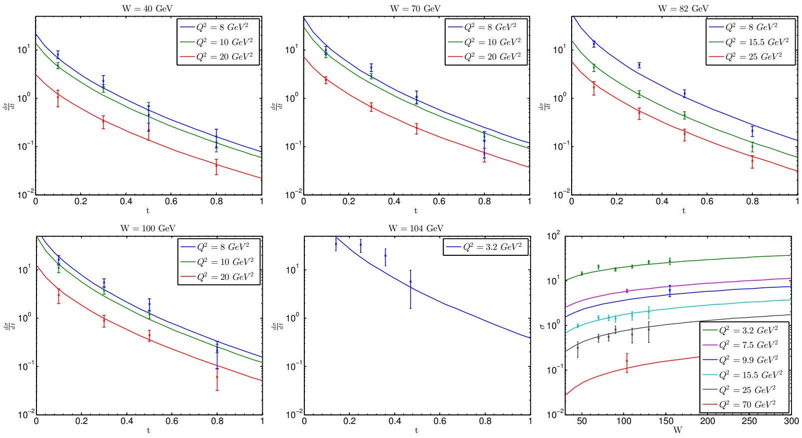
W = 40 GeV
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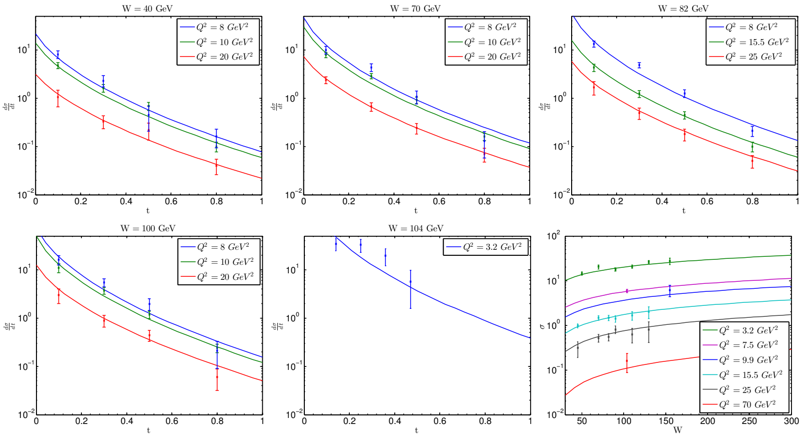
σ
t
W



Running the same fit using the eikonal approximation, instead of just keeping single pomeron exchange, does not improve the fits, due to the fact that the size of χ is small in this kinematical region.

Hard wall pomeron

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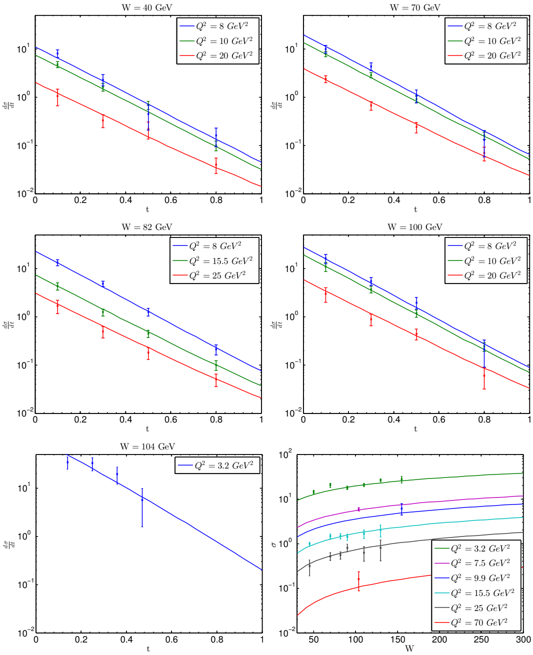
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Outline

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- It might therefore be possible to extend some of the insights we gain even into the weak coupling regime.
- The hard wall model, although a simple modification of AdS, seems to capture effects of confinement well. Interesting to repeat some of the calculations using a different confinement model to identify precisely what features are model independent.

Future work

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- It is also interesting to extend these methods beyond $2 \to 2$ scattering.
- Eventually it would be good to have a single set of parameters that fits several different processes.

Thank you!