Evolution and Gaussian truncation of Small-x TMDs

Based on: hep-ph:2603.15243 - JHEP 08 (2026) 029 and hep-ph:2608.30687

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REF 2026, October 19 - 23, Santiago de Compostela

Overview

Motivations

- TMD distributions and phenomenology.
- Evolution and the large N_c limit.
- MV-initial condition - Gaussian approximation and N_c dependence.

Operators and the Gaussian truncation

- Operator definitions and relation to irreps.
- The Gaussian truncation.

Numerical evaluations and Gaussian truncation

- Dipoles and evolution, Casimir Scaling.
- Evaluations of Ω^{ω}_{ag} vs GT prediction.
- Implications for TMDs: the quark-gluon cases $\mathcal{F}_{qg}$.

Outlooks

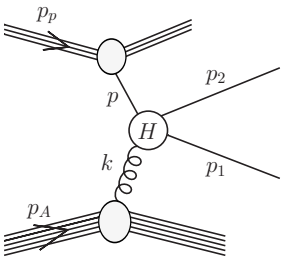


Figure: Inclusive forward di-jet production in p+A collision, figure from [Marquet-Petreska-Roiesnel 2016].

In the TMD factorization, one can write the formula for forward dijet production [Marquet-Petreska-Roiesnel 2016] [Kotko-Kutak-Marquet-Petreska-Sapeta 2015] [Dominguez-Marquet-Xiao-Yuan 2011] as:

$$\frac{d\sigma^{pA\to\text{dijets}+X}}{dy_1 dy_2 d^2p_{1t} d^2p_{2t}} = \frac{\alpha_s^2}{(x_1 x_2 s)^2} \sum_{a,c,d} x_1 f_{a/p}(x_1,\mu^2) \sum_i H^{(i)}_{ag\to cd}(z,P_t)\ \mathcal{F}^{(i)}_{ag}(x_2,k_t) \frac{1}{1+\delta_{cd}}\,, \quad (1)$$

- Encoding of universal features / non-perturbative domain.

Motivations - Evolution and the large N_c limit

Consider the dipole operator

$$\hat{S}_{\underline{x}\underline{y}} = \frac{1}{N_c}\mathrm{tr}\left(V_{\underline{x}}V^{\dagger}_{\underline{y}}\right), \qquad V_{\underline{x}} = P\exp\left\{ig\int_{-\infty}^{\infty} dt\ \alpha^a(t,\underline{x})t^a_F\right\}, \qquad t = x^{\pm}, \quad \alpha = A^{\mp}. \tag{2}$$

Evolution equations: Action of JIMWLK Hamiltonian on the dipole operator:

$$\frac{d}{dY}\langle\hat{S}_{\underline{x}\underline{y}}\rangle = \frac{\alpha_s N_c}{2\pi^2}\int \mathrm{d}^2\underline{w}\ \frac{(\underline{x}-\underline{y})^2}{(\underline{x}-\underline{w})^2(\underline{w}-\underline{y})^2}\left[\langle\hat{S}_{\underline{x}\underline{z}}\hat{S}_{\underline{z}\underline{y}}\rangle - \langle\hat{S}_{\underline{x}\underline{y}}\rangle\right] \tag{3}$$

The BK equation for the dipole:

$$\frac{d}{dY}\langle\hat{S}_{\underline{x}\underline{y}}\rangle = \frac{\alpha_s N_c}{2\pi^2}\int \mathrm{d}^2\underline{w}\ \frac{(\underline{x}-\underline{y})^2}{(\underline{x}-\underline{w})^2(\underline{w}-\underline{y})^2}\left[\langle\hat{S}_{\underline{x}\underline{z}}\rangle\langle\hat{S}_{\underline{z}\underline{y}}\rangle - \langle\hat{S}_{\underline{x}\underline{y}}\rangle\right] \tag{4}$$

Remarks:

- Subtle difference: $\langle\hat{S}_{\underline{x}\underline{z}}\hat{S}_{\underline{z}\underline{y}}\rangle$ vs $\langle\hat{S}_{\underline{x}\underline{z}}\rangle\langle\hat{S}_{\underline{z}\underline{y}}\rangle$.
- Big implications: JIMWLK equation (equivalently the Balitsky hierarchy) is not closed system of equations!
- JIMWLK large-N_c limit and finite N_c corrections?

Motivations - Evolution and the large N_c limit

Acting with JIMWLK hamiltonian on the dipole minus the rhs of the BK equation, introduces the following:

$$\Delta_{\underline{x},\underline{y};\underline{z}} = \langle \hat{S}_{\underline{x}\underline{z}} \hat{S}_{\underline{z}\underline{y}} \rangle - \langle \hat{S}_{\underline{x}\underline{z}} \rangle \langle \hat{S}_{\underline{z}\underline{y}} \rangle \tag{5}$$

Observations:

- Expected to be of the order $\mathcal{O}(1/N_c^2) \overset{N_c=3}{\longrightarrow} \mathcal{O}(10\%)$
- Observed to be of the order $\mathcal{O}(1\%)$ in numerical simulations instead!
  [Rummukainen-Weigert 2004] [Kovchegov-Kuokkanen-Rummukainen-Weigert 2009]
- Conclusion reached for any distributions that can be expressed out of the **dipole expectation value** $\langle \hat{S}_{\underline{x}\underline{y}} \rangle$ **without large** $1/N_c$ **corrections**.
- A related study has been performed in the context of the quadrupole operator.
  [Dumitru-Jalilian-Marian-Lappi-Schenke-Venugopalan 2011]
  and more recently [Lappi-Triantafyllopoulos 2026]

$\Rightarrow$ What about distributions with **large** $1/N_c$ **corrections**?

Motivations - Initial condition in [Cougoulic-Korcyl-Stebel 2026]

In the previous episode...
Baseline: $N_c = 3$.

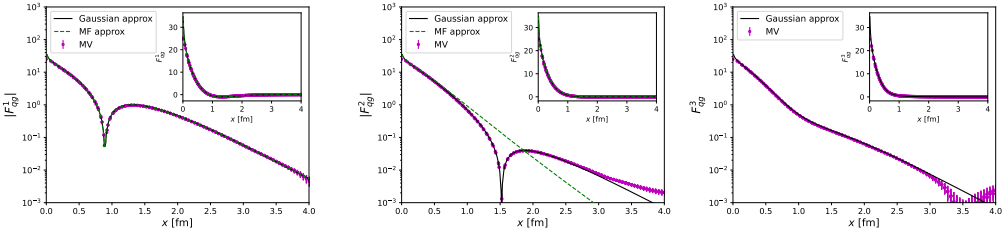


Figure: Evaluation of quark-gluon TMD distributions for $SU(3)$. The magenta data points are obtained from MV-model simulations. The black plain lines show the computed Gaussian approximations. The green dashed lines show results from [Caucal and al. 2025] where the mean-field approximation has been used. The mean-field (MF) curve for $\mathcal{F}^{(1)}_{qg}$ agrees with the Gaussian approximation and the data because of the exact scaling of this distribution.

- Good agreement between data and both approximations (Gaussian and Mean-field) at small separation.
- Deviation between approximation observed in the tail. Numerical simulations show the range of validity of the mean-field approximation.
- Operator's definitions in the next slides.

Motivations - Initial condition in [Cougoulic-Korcyl-Stebel 2026]

In the previous episode...

N_c-dependence.

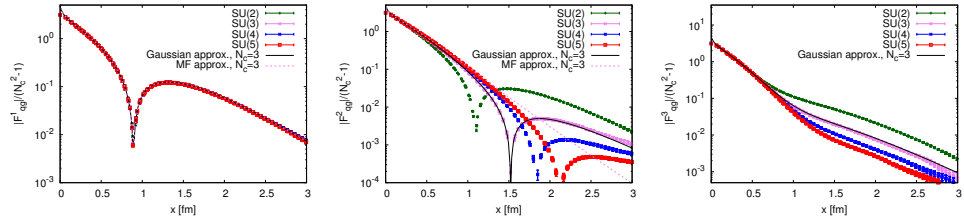


Figure: (N_c^2-1)-normalized quark-gluon TMD distributions for different values of N_c together with the Gaussian and mean-field approximations for $N_c = 3$.

- Exact N_c-scaling of $\mathcal{F}_{qg}^{(1)}/(N_c^2-1)$.
- $\mathcal{F}_{qg}^{(2)}/(N_c^2-1)$ node depends on N_c, such that at $N_c \to \infty$ it *moves* toward $r \to \infty$.
- Clearly observe the N_c-ordering of the tails.

$\Rightarrow$ Good understanding of the N_c-dependence in the initial contribution.

$\longrightarrow$ Time to study the evolution for the baseline $SU(3)$.

Operators and the Gaussian truncation

Operator's definitions

Following the nomenclature from [Marquet-Petreska-Roiesnel 2016] and [Bury-Kotko-Kutak 2019]
Quark - Gluon sector:

$$\hat{\mathcal{F}}_{qg}^{(1)}(\underline{x},\underline{y}) = \mathsf{tr}\left[(\partial_i V_{\underline{x}}^\dagger)(\partial_i V_{\underline{y}})\right] \tag{6a}$$

$$-N_c\,\hat{\mathcal{F}}_{qg}^{(2)}(\underline{x},\underline{y}) = \mathsf{tr}\left[(\partial V_{\underline{x}})V_{\underline{x}}^\dagger(\partial V_{\underline{y}})V_{\underline{y}}^\dagger\right]\mathsf{tr}\left[V_{\underline{y}}V_{\underline{x}}^\dagger\right] \tag{6b}$$

$$-\hat{\mathcal{F}}_{qg}^{(3)}(\underline{x},\underline{y}) = \mathsf{tr}\left[(\partial V_{\underline{x}})V_{\underline{x}}^\dagger\left[V_{\underline{y}}V_{\underline{x}}^\dagger\right](\partial V_{\underline{y}})V_{\underline{y}}^\dagger\right] \tag{6c}$$

Gluon - Gluon sector:

$$N_c\hat{\mathcal{F}}_{gg}^{(1)}(\underline{x},\underline{y}) = \mathsf{tr}\left[(\partial_i V_{\underline{x}}^\dagger)(\partial_i V_{\underline{y}})\right]\mathsf{tr}\left[V_{\underline{x}}V_{\underline{y}}^\dagger\right] \tag{7a}$$

$$-N_c\hat{\mathcal{F}}_{gg}^{(2)}(\underline{x},\underline{y}) = \mathsf{tr}\left[(\partial_i V_{\underline{y}})V_{\underline{x}}^\dagger\right]\mathsf{tr}\left[(\partial_i V_{\underline{x}})V_{\underline{y}}^\dagger\right] \tag{7b}$$

$$-\hat{\mathcal{F}}_{gg}^{(3)}(\underline{x},\underline{y}) = \mathsf{tr}\left[(\partial_i V_{\underline{x}})V_{\underline{x}}^\dagger(\partial_i V_{\underline{y}})V_{\underline{y}}^\dagger\right] \tag{7c}$$

$$-\hat{\mathcal{F}}_{gg}^{(4)}(\underline{x},\underline{y}) = \mathsf{tr}\left[V_{\underline{x}}^\dagger(\partial_i V_{\underline{x}})V_{\underline{y}}^\dagger(\partial_i V_{\underline{y}})\right] \tag{7d}$$

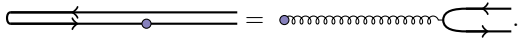
$$-\hat{\mathcal{F}}_{gg}^{(5)}(\underline{x},\underline{y}) = \mathsf{tr}\left[V_{\underline{y}}V_{\underline{x}}^\dagger(\partial_i V_{\underline{y}})V_{\underline{y}}^\dagger V_{\underline{x}}V_{\underline{y}}^\dagger(\partial_i V_{\underline{x}})V_{\underline{x}}^\dagger\right] \tag{7e}$$

$$-N_c^2\hat{\mathcal{F}}_{gg}^{(6)}(\underline{x},\underline{y}) = \mathsf{tr}\left[(\partial_i V_{\underline{x}})V_{\underline{x}}^\dagger(\partial_i V_{\underline{y}})V_{\underline{y}}^\dagger\right]\mathsf{tr}\left[V_{\underline{x}}V_{\underline{y}}^\dagger\right]\mathsf{tr}\left[V_{\underline{y}}V_{\underline{x}}^\dagger\right] \tag{7f}$$

$$-N_c\hat{\mathcal{F}}_{gg}^{(7)}(\underline{x},\underline{y}) = \mathsf{tr}\left[V_{\underline{x}}V_{\underline{y}}^\dagger(\partial_i V_{\underline{x}})V_{\underline{x}}^\dagger(\partial_i V_{\underline{y}})V_{\underline{y}}^\dagger\right]\mathsf{tr}\left[V_{\underline{y}}V_{\underline{x}}^\dagger\right] \tag{7g}$$

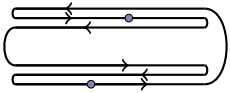
Operator's definitions - Birdtracks

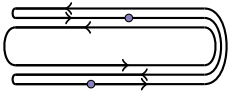
Introduce a birdtrack [Cvitanovic 2008] representation for WLs and (transverse) derivatives:

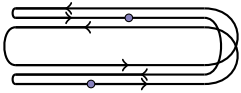
$$\mathcal{B}^i = (\partial^i V)V^\dagger =$$  (8)

- Belongs to the adjoint irrep. Convenient to express forward staples.

Quark - Gluon sector:

$$-\hat{\mathcal{F}}^{(1)}_{qg} =$$  (9a)

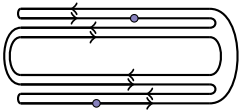
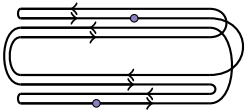
$$-N_c\,\hat{\mathcal{F}}^{(2)}_{qg} =$$  (9b)

$$-\hat{\mathcal{F}}^{(3)}_{qg} =$$  (9c)

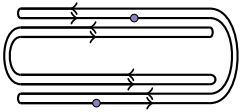
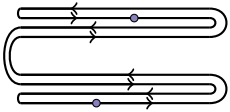
- Top lines are at position $\underline{x}$, bottom lines are at position $\underline{y}$.
- Left (resp. right) vertical lines are contractions of WLs at $\pm\infty$.

Gluon-Gluon sector

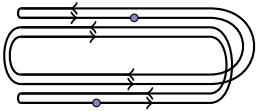
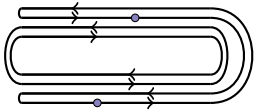
$$-N_c\hat{\mathcal{F}}^{(1)}_{gg} = \quad -N_c\hat{\mathcal{F}}^{(2)}_{gg} = \tag{10a}$$

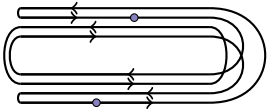
$$-N_c\hat{\mathcal{F}}^{(3)}_{gg} = \quad -\hat{\mathcal{F}}^{(4)}_{gg} = \tag{10b}$$

$$-\hat{\mathcal{F}}^{(5)}_{gg} = \quad -N_c^2\hat{\mathcal{F}}^{(6)}_{gg} = \tag{10c}$$

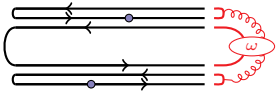
$$-N_c\hat{\mathcal{F}}^{(7)}_{gg} = \tag{10d}$$



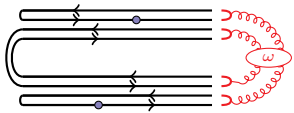
- Only seven out of all possible ways of contracting at $+\infty$ are of interest to us.

Operator's definitions - Relation to irreducible representations

Introduce the following operators:

$\hat{\Omega}^{\omega}_{qg} = 2 \times$ 

, $\quad 8 \otimes \bar{3} = \bar{15} \oplus 6 \oplus \bar{3}$ (11)

$\hat{\Omega}^{\omega}_{gg} = 4 \times$ 

, $\quad 8 \otimes 8 = 27 \oplus 0 \oplus (10 + \bar{10}) \oplus 8_s \oplus 8_a \oplus 1$ (12)

Remark:

- QG-sector, 3 irreps $\Leftrightarrow$ 3 TMD distributions.
- GG-sector: Full vector space at $+\infty$ has dimension 10 for $N_c > 3$.
  Combine $10 + \bar{10}$ (symmetry and charge).
  Focus only on hermitian part, ie drop the transitions $8_a \leftrightarrow 8_s$.
  Use Fierz identity at $-\infty$. Grand total of 7 contributions $\Leftrightarrow$ 7 TMD distributions.

Relate TMD distribution $\hat{\mathcal{F}}$ to irrep operators $\hat{\Omega}$:

$$\hat{\mathcal{F}}_{ag} = M^{-1}_{ag} \cdot \hat{\Omega}_{ag} \quad \Longrightarrow \quad \mathcal{F}_{ag} = M^{-1}_{ag} \cdot \Omega_{ag}, \qquad a = \{q, g\}. \tag{13}$$

where M are matrices that only depend on N_c and are explicitly computed. (Appendix)

The Gaussian truncation

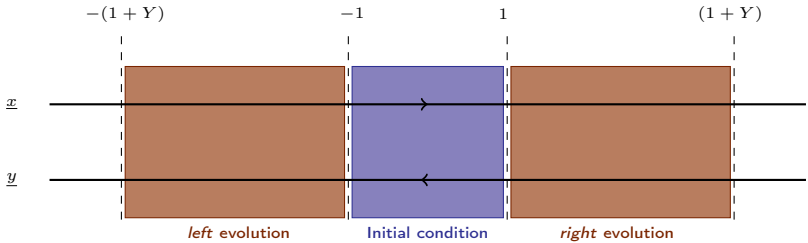


Figure: Region of interest for the evaluation of a fundamental dipole $\langle \hat{S}_{\underline{x}\,\underline{y}} \rangle_Y$ using the symmetric Gaussian truncation. The inner blue area represents the support for the initial condition according to the MV-model. The external brown areas represent the support for the evolution in the Gaussian truncation.

Using the Gaussian ansatz:

- Interactions are instantaneous $\longrightarrow$ $\left\langle \alpha(t_x)\alpha(t_y) \right\rangle \propto \delta(t_x - t_y)\gamma^t_{\underline{x}\underline{y}}$.
- Keystone: the two point function denoted $\gamma^t_{\underline{x}\underline{y}}$.
- Assume invariance under translation and rotation: $\gamma_r = \gamma_{\underline{x}\underline{y}}$.

Why using GT?

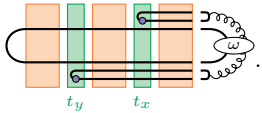
- Truncate the Balitsky hierarchy.
- Easily recover coincidence limits in the GT.
- To Recover the two-point function: the simplest case is to use the dipole (e.g. BK).

Some remarks:

- Initial condition: Gaussian ansatz already in the MV-model.
- Postulated for the evolution, in particular before the saturation regime.
- Picture of a longitudinal profile with a *time*-dependence.

Apply to the operator $\hat{\Omega}_{ag}$:

$$\Omega_{qg} \equiv \langle \hat{\Omega}_{qg} \rangle^{\text{(Gaussian)}} = 2 \times$$



(14)

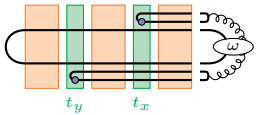
- Integrated over $t_{x/y}$.
- Orange: usual eikonal interaction $\left\langle \alpha_{\underline{u}} \alpha_{\underline{v}} \right\rangle \quad \longrightarrow \quad \gamma_r$
- Green: involves either $\left\langle (\partial\alpha)_{\underline{u}} \alpha_{\underline{v}} \right\rangle$ or $\left\langle (\partial\alpha)_{\underline{u}} (\partial\alpha)_{\underline{v}} \right\rangle \quad \longrightarrow \quad \nabla_r^i \gamma_r$ or $\nabla^2 \gamma_r$.

And similar for the GG-sector.

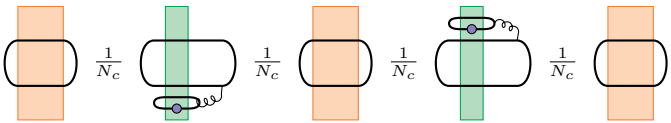
The Gaussian truncation - Topologies of interest

Unequal time contribution

$$\Omega_{qg}^{(a)}\Big|_{t_x>t_y} = 2 \times$$



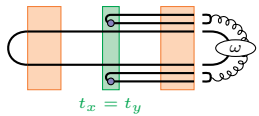
$$= \frac{2}{C_F} \times$$



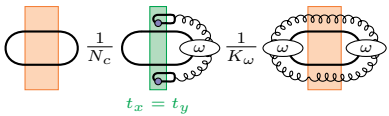
(15)

Equal time contribution

$$\Omega_{qg}^{(b)} = 2 \times$$



$$= 2 \times$$



(16)

Remarks

- Two distinct cases: $\Omega_{ag}^{(a+b)}$ and $\Omega_{ag}^{(b)}$ depending on irrep $\omega \Rightarrow$ two calculations for 10 TMDs!
- Longitudinal profile dependence: $t_{x/y}$ integrals are not trivial (initial condition and evolution).
- Dependence on $\gamma_r(t)$, not only $\Gamma_r = \int dt\ \gamma_r(t)$.

Numerical evaluations and Gaussian truncation

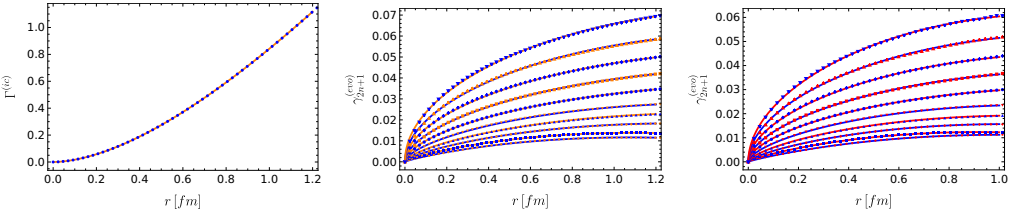


Figure: Left: IC fundamental dipole; Center: fundamental dipole evolution; Right: adjoint dipole evolution.

Initial condition:

$$S_r^{R,Y=0}\Big|_{\text{fit}} = e^{-C_R \Gamma_r^{(\text{ic fit})}}, \qquad \text{where} \qquad \Gamma_r^{(\text{ic fit})} = \frac{\mu_{\text{fit}}^2}{m_{\text{fit}}^2}\big[1 - m_{\text{fit}} r K_1(m_{\text{fit}} r)\big]. \tag{17}$$

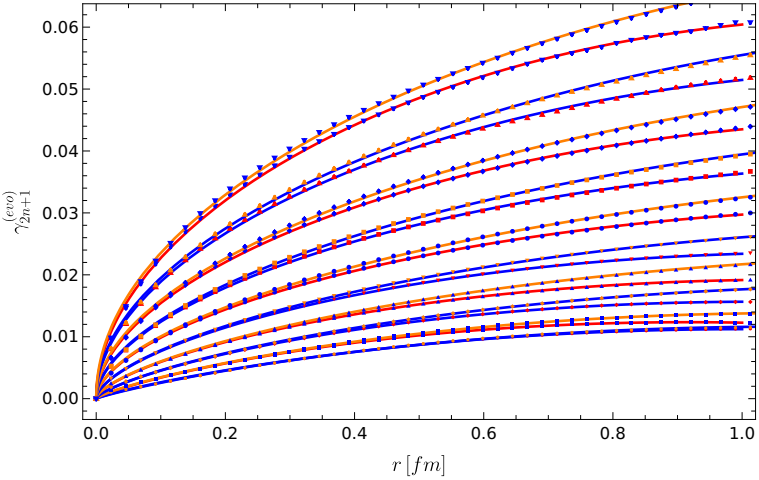
- Initial condition fulfills Casimir scaling.
  i.e. adjoint dipole gives the same result: $\mu_{\text{fit}} = 0.87; \quad m_{\text{fit}} = 0.20$.

Rapidity evolution: Range $Y \in (0, 1/\alpha_s) \Rightarrow$ Discr. $Y_n = n \times Y/20$.

$$\gamma_r^{(evo),n} = \frac{-1}{2\delta Y\ C_R} \ln\left(\frac{S_r^{R,n+1}}{S_r^{R,n}}\right), \qquad \gamma_r^{(evo),n}\Big|_{\text{fit}} = b_n r^2 + c_n r^{\delta_n}. \tag{18}$$

- Increase in rapidity $\Leftrightarrow$ curve goes up.

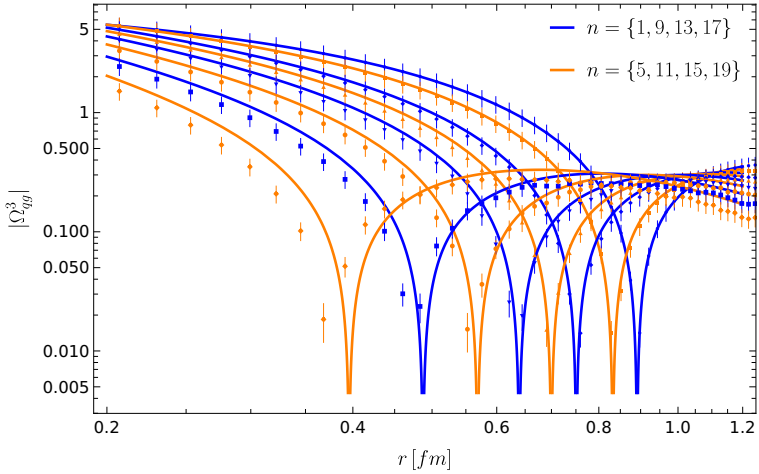
Numerical evaluations and Gaussian truncation - Casimir scaling



- Fundamental dipole (blue - orange) / Adjoint dipole (blue - red).
- Increase in rapidity $\Leftrightarrow$ curve goes up.

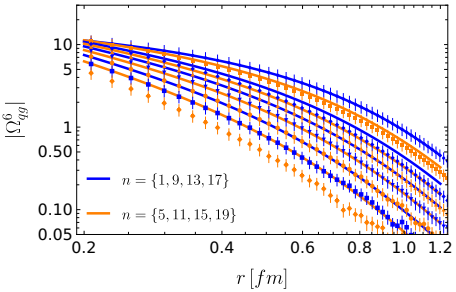
$\Longrightarrow$ Start of the evolution: agrees with Casimir scaling.
End of the evolution: mild breaking of Casimir scaling.

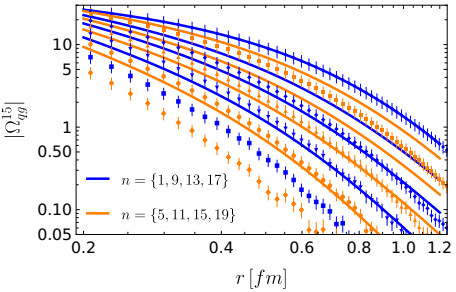
Numerical evaluations and Gaussian truncation - Ω_{qg}



- GT prediction: obtained by fitting the dipole then taking the Laplacian.
- Correct functional behavior of the GT prediction.
- Slightly slower than the data
  $\Rightarrow$ Simultaneous fit with the dipole $\Rightarrow$ BK with Automatic Differentiation?

Numerical evaluations and Gaussian truncation - Ω_{qg}

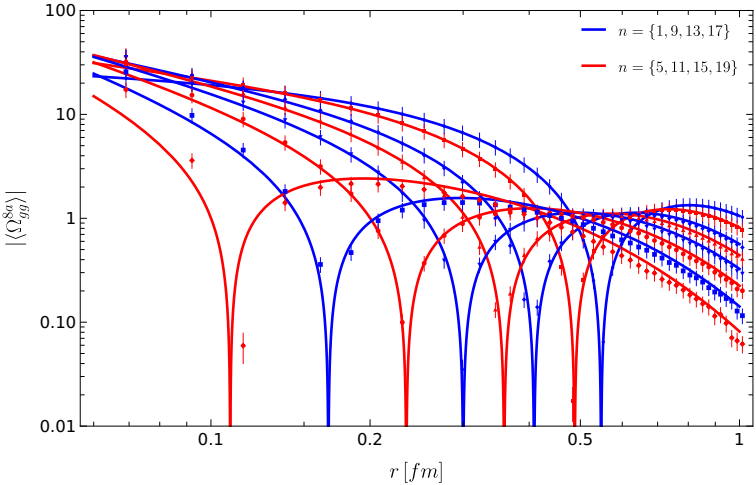




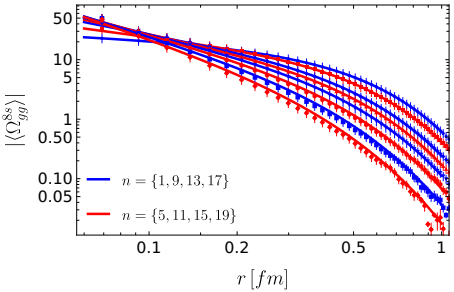
- Functional form is correct for both irrep 6 and 15.
- GT prediction slower than data for both cases.
- Discrepancy is larger for irrep 15 than 6 and agreement with irrep 3.

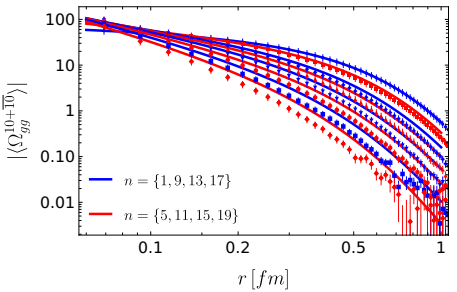
Hints to a systematic correction depending on the irrep involved?

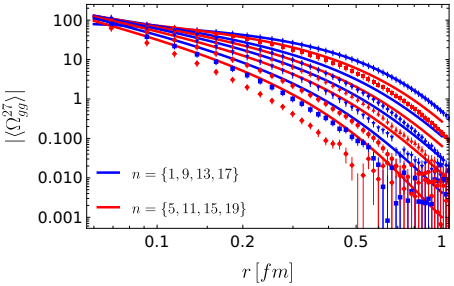
Numerical evaluations and Gaussian truncation - Ω_{gg}

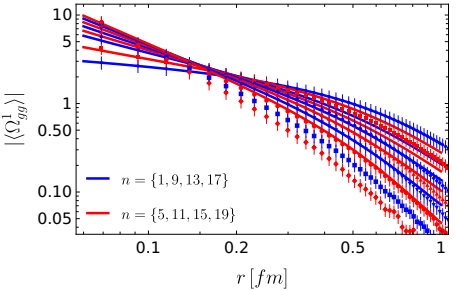


- GT prediction: obtained by fitting the dipole then taking the Laplacian.
- Correct functional behavior of the GT prediction.
- Good description of the node location over the full range in rapidity.





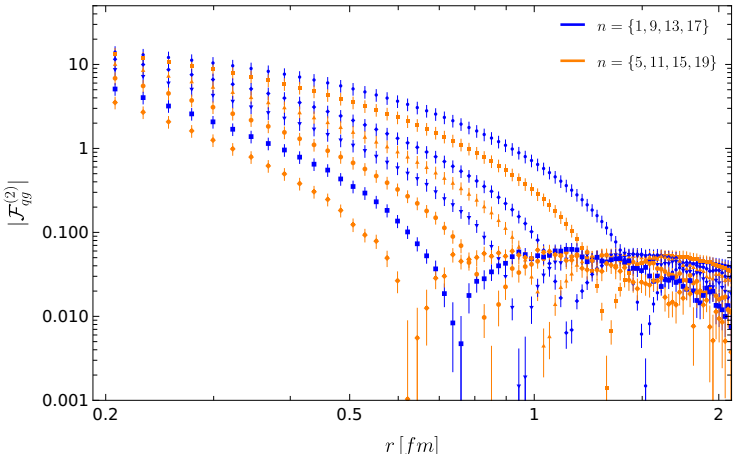




- Functional form is correct for all irrep.
- Evolution speed is correct for the irrep 8_s! GT formula: only dependence on $\Gamma_r = \int dt \gamma_r^t$.
- Irreps $\{27, 10 + \overline{10}, 1\}$: GT prediction is slower than the data.

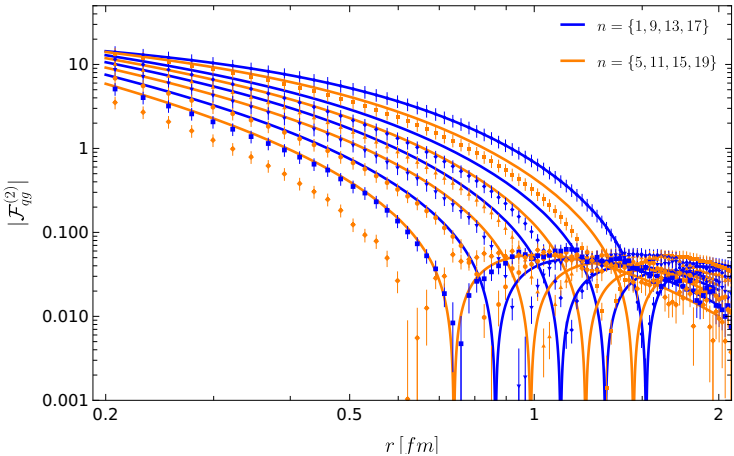
$\Rightarrow C_1 < C_A$ and $Dim(1) < Dim(Adj)$: Why is GT for singlet (i.e. WW) slower than the data?

Numerical evaluations and Gaussian truncation - Implications for TMDs $\mathcal{F}_{qg}^{(2)}$

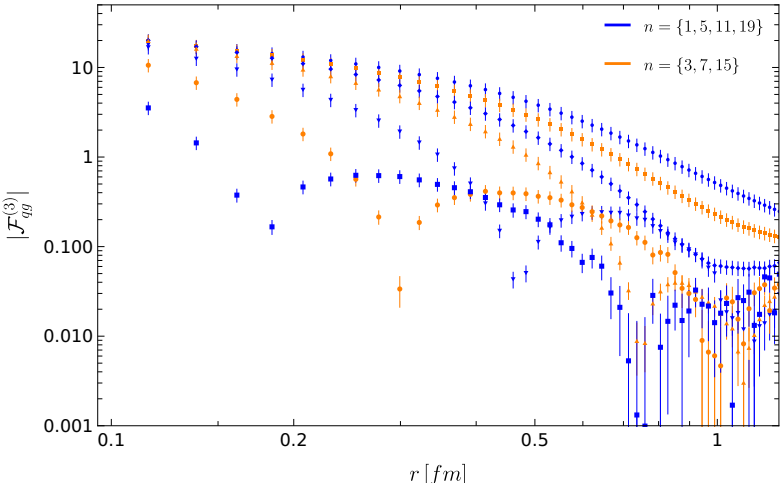


- Functional form of the GT prediction is acceptable <u>but</u> too slow!
- Follows from $\mathcal{F}_{qg}^{(2)} = -\frac{1}{3}\sum_{\omega=3,6,15}\Omega_{qg}^{\omega}$.
  $\Rightarrow$ GT(Ω_{qg}) is slower than data for irreps 6 and 15 $\Rightarrow$ GT($\mathcal{F}_{qg}^{(2)}$) slower than data.

Numerical evaluations and Gaussian truncation - Implications for TMDs $\mathcal{F}_{qg}^{(2)}$

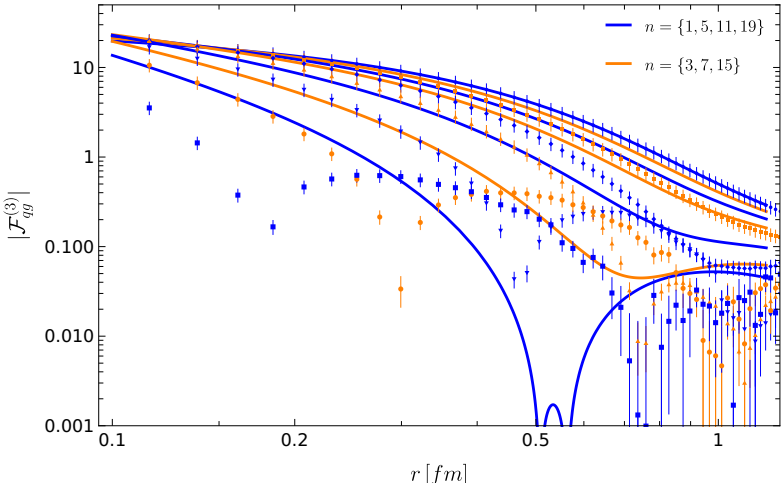


- Functional form of the GT prediction is acceptable but too slow!
- Follows from $\mathcal{F}_{qg}^{(2)} = -\frac{1}{3}\sum_{\omega=3,6,15}\Omega_{qg}^{\omega}$.
  $\Rightarrow$ GT(Ω_{qg}) is slower than data for irreps 6 and 15 $\Rightarrow$ GT($\mathcal{F}_{qg}^{(2)}$) slower than data.



- Data: a node appears around the rapidity $n \in (5, 7)$.
- GT functional form is clearly wrong: dip instead of a node, and evolution is slower than data.

Numerical evaluations and Gaussian truncation - Implications for TMDs $\mathcal{F}_{qg}^{(3)}$



- Data: a node appears around the rapidity $n \in (5, 7)$.
- GT functional form is clearly wrong: dip instead of a node, and evolution is slower than data.

Outlooks

Summary

- We observe some mild Casimir scaling breaking between *fun* and *adj* dipoles.
- Good agreement for Ω^{ω}_{ag} for $\omega = 3$ and $\omega = \{8_a, 8_s\}$.
- For other irreps: Ω^{ω}_{ag} GT predictions are slower than the JIMWLK evolution data.
- For all but the singlet case, systematic discrepancy scales with the dimension / charge of the irrep.
- Quark-Gluon sector TMDs - GT vs data: $\mathcal{F}^{(1)}_{qg}$ agrees, $\mathcal{F}^{(2)}_{qg}$ functional form is alright but too slow, $\mathcal{F}^{(3)}_{qg}$ fails to reproduce data.
- Similar situation in the Gluon-Gluon sector (not shown here).
- TMDs are linear combinations of Ω's and full agreement cannot be reached without understanding the previous Ω_{ag} in the GT.

Prospects

- Introduce the rapidity evolution using JIMWLK equation in the range $N_c \in \{2, 3, 4, 5\}$.
- Momentum representation: cross section / evolution speed.

Appendix

$$\hat{\mathcal{F}}_{ag} = M_{ag}^{-1} \cdot \hat{\Omega}_{ag} \quad \Longrightarrow \quad \mathcal{F}_{ag} = M_{ag}^{-1} \cdot \Omega_{ag}, \qquad a = \{q, g\}. \tag{19}$$

QG-sector

$$M_{qg}^{-1} = \begin{pmatrix} -\frac{N_c^2-1}{N_c} & 0 & 0 \\ -\frac{1}{N_c} & -\frac{1}{N_c} & -\frac{1}{N_c} \\ \frac{1}{N_c} & 1 & -1 \end{pmatrix} \tag{20}$$

GG-sector

$$M_{gg}^{-1} = \begin{pmatrix} -\frac{N_c^2-1}{N_c^2} & -\frac{1}{2} & -\frac{N_c^2-4}{2N_c^2} & 0 & 0 & 0 & -\frac{1}{N_c^2} \\ -\frac{N_c^2-1}{N_c^2} & \frac{1}{2} & -\frac{N_c^2-4}{2N_c^2} & 0 & 0 & 0 & -\frac{1}{N_c^2} \\ 0 & 0 & 0 & 0 & 0 & 0 & -1 \\ -(N_c^2-1) & 0 & 0 & 0 & 0 & 0 & 0 \\ -1 & 1 & -1 & 1 & -1 & -1 & 0 \\ -\frac{1}{N_c^2} & -\frac{1}{N_c^2} & -\frac{1}{N_c^2} & -\frac{1}{N_c^2} & -\frac{1}{N_c^2} & -\frac{1}{N_c^2} & -\frac{1}{N_c^2} \\ \frac{1}{N_c^2} & 0 & \frac{2}{N_c^2} & 0 & -\frac{1}{N_c} & \frac{1}{N_c} & -\frac{1}{N_c^2} \end{pmatrix} \tag{21}$$

Fit parameters

n	b_n	c_n	δ_n
1	-0.0073	0.018	0.84
2	-0.0075	0.020	0.82
3	-0.0074	0.021	0.78
4	-0.0067	0.022	0.74
5	-0.0060	0.024	0.71
6	-0.0055	0.025	0.66
7	-0.0051	0.027	0.64
8	-0.0050	0.029	0.62
9	-0.0054	0.031	0.60
10	-0.0058	0.034	0.58
11	-0.0043	0.037	0.56
12	-0.0053	0.041	0.55
13	-0.0051	0.045	0.54
14	-0.0048	0.048	0.53
15	-0.0056	0.053	0.52
16	-0.0053	0.057	0.51
17	-0.0069	0.062	0.50
18	-0.0069	0.068	0.50
19	-0.0076	0.073	0.49

(a) Quark-gluon sector

n	b_n	c_n	δ_n
1	-0.0088	0.020	0.88
2	-0.0094	0.021	0.84
3	-0.0098	0.022	0.80
4	-0.0091	0.023	0.76
5	-0.0084	0.024	0.72
6	-0.0082	0.025	0.68
7	-0.0079	0.027	0.65
8	-0.0073	0.029	0.62
9	-0.0079	0.031	0.61
10	-0.0082	0.033	0.58
11	-0.0066	0.036	0.56
12	-0.0080	0.040	0.56
13	-0.0074	0.044	0.54
14	-0.0074	0.048	0.53
15	-0.0090	0.052	0.53
16	-0.0103	0.057	0.52
17	-0.0103	0.062	0.51
18	-0.0108	0.067	0.51
19	-0.0135	0.074	0.51

(b) Gluon-gluon sector