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AGK rules in QCD

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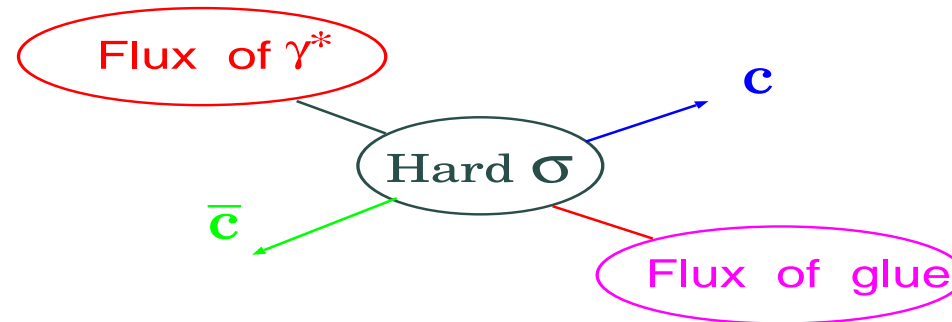
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- ★1973: Abramovsky-Gribov-Kancheli unitarity rules for multipomeron amplitudes
 - ★ Unitarity: opening a new channel affects all previous inelastic channels & diffraction & elastic scattering
 - ★ Nuclear targets: testing ground for multipomeron exchanges
- (Bertocchi & Treleani & Capella & Kaidalov, 1976)
- ★ QCD: inelastic interaction = color flow from beam to target
 - ★ Classification of final states by color excitation of the target nucleus
 - ★ Projectile parton and color flow-dependent nonlinear factorization for final states
 - ★ Important QCD modifications of AGK-73

pQCD factorization theorems

Example: open charm in $ep \rightarrow c \bar{c} X$



- Forward dijets: $x_\gamma = z_+ + z_- \approx 1$, jet-jet decorrelation momentum $\Delta = \mathbf{p}_+ + \mathbf{p}_-$

$$\frac{d\sigma_N(\gamma^* \rightarrow c\bar{c})}{dzd^2\mathbf{p}_+d^2\Delta} = \frac{\alpha_S(\mathbf{p}^2)}{2(2\pi)^2} f(\Delta) |\Psi(z, \mathbf{p}_+) - \Psi(z, \mathbf{p}_+ - \Delta)|^2 .$$

$$f(\boldsymbol{\kappa}) = \frac{4\pi}{N_c} \cdot \frac{1}{\kappa^4} \cdot \frac{\partial G_N(x, \boldsymbol{\kappa})}{\partial \log \kappa^2}$$

- ★ A linear functional of the unintegrated glue.
- ★ The dijet momentum Δ probes the unintegrated gluon momentum.

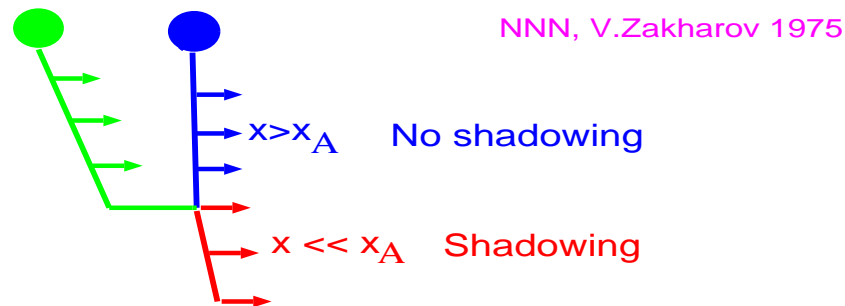
- ★ Back to 1973-74: Lorentz-contracted ultrarelativistic nucleus:

$$R_A \rightarrow R_A \frac{m_N}{p_N} < \lambda = \frac{1}{k_z} = \frac{1}{xp_N}.$$

- ★ Spatial overlap of partons from many nucleons if

$$x \lesssim x_A = 1/R_A m_N$$

parameter \implies FUSION & NUCLEAR SHADOWING.



★ Nuclear parton density (if it can be meaningfully defined!) is a nonlinear functional of the free nucleon parton density: the same sea is shared by many nucleons.

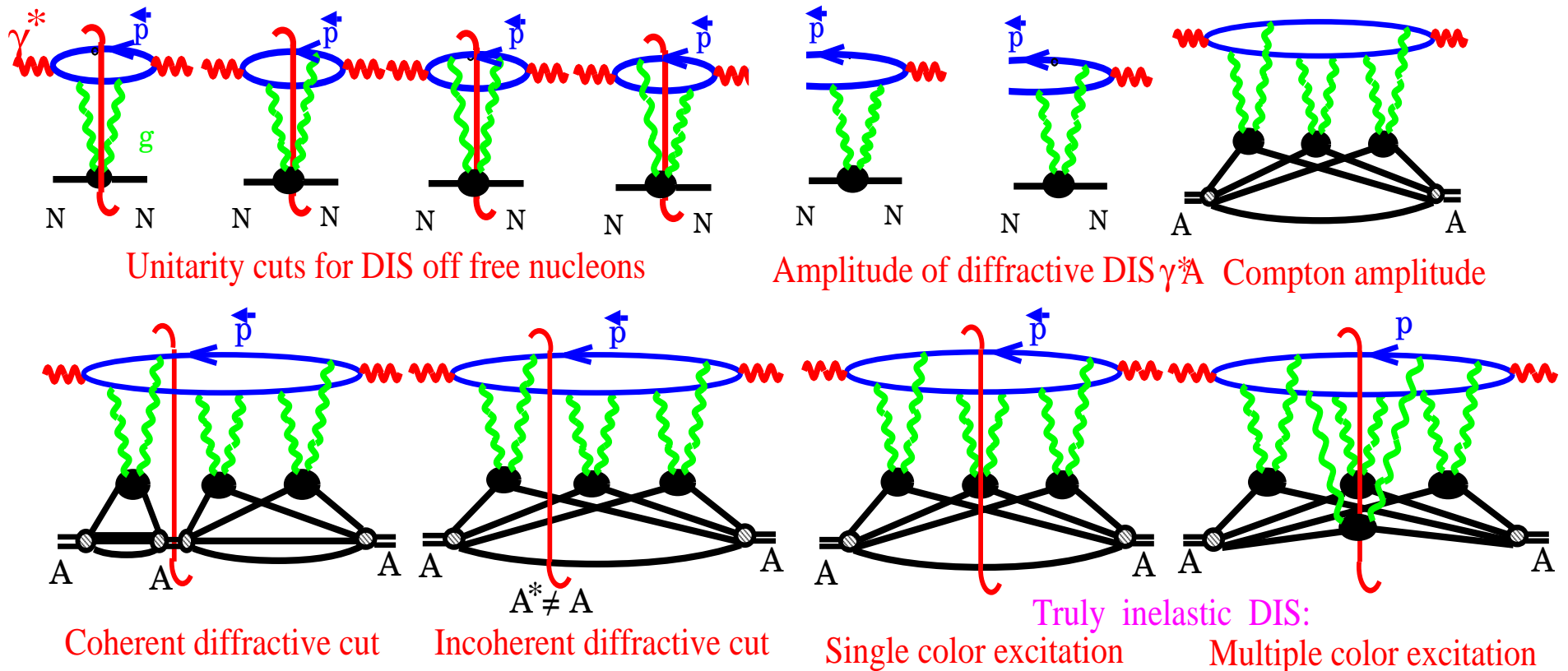
- ★ Must describe all nuclear observables!
- ★ Major strategy of this talk: shadowing from unitarity for dipole amplitudes.

Coherent diffractive and truly inelastic DIS

Color dipole is coherent over whole nucleus for $x \lesssim x_A$: \implies Glauber–Gribov formalism (NNN, Zakharov (91)):

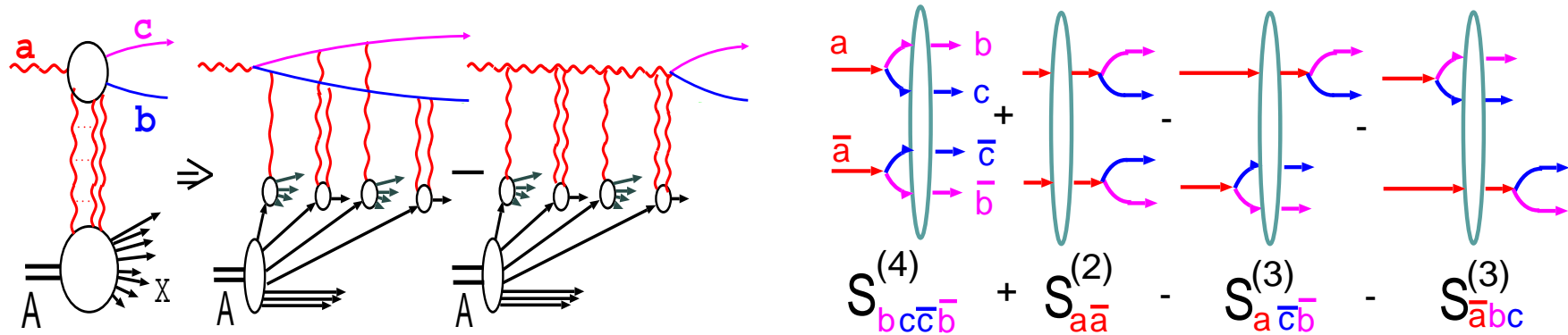
$$\sigma_A(\mathbf{r}) = 2 \int d^2\mathbf{b} \Gamma_A(\mathbf{b}, \mathbf{r}) = 2 \int d^2\mathbf{b} [1 - \exp(-\frac{1}{2}\sigma(\mathbf{r})T(\mathbf{b}))]$$

★ The unitarity content of DIS



Production processes as excitation of beam Fock states $a \rightarrow bc$

Zakharov (87), NNN, Zakharov, Piller (95), NNN, Schäfer, Zakharov, Zoller (03)



- ★ Interactions after and before the virtual decay interfere destructively.
- ★ Apply closure over the nucleon & nucleus excitations
- ★ Hermitian conjugated S -matrix = S -matrix for an antiparticle!

$$S_a S_b^\dagger = S_{a\bar{b}}$$

- ★ Partial cross sections with color-excitation of ν nucleons (ν cut pomerons in the Abramovsky-Gribov-Kancheli language)
- ★ Requires evaluation of specific intermediate states in $S^{(n)}$: well developed technique is available (NNN, Schafer, Zakharov (05))

Non-Abelian evolution and master formula for non-diffractive dijets

NNN, Zakharov, Piller (95), NNN, Schäfer, Zakharov, Zoller (03)

$$\frac{d\sigma(a^* \rightarrow bc)}{dz_b d^2\mathbf{p}_b d^2\mathbf{p}_c} = \frac{1}{(2\pi)^4} \int d^2\mathbf{b}_b d^2\mathbf{b}_c d^2\mathbf{b}'_b d^2\mathbf{b}'_c \times \exp[-i\mathbf{p}_b(\mathbf{b}_b - \mathbf{b}'_b) - i\mathbf{p}_c(\mathbf{b}_c - \mathbf{b}'_c)]$$

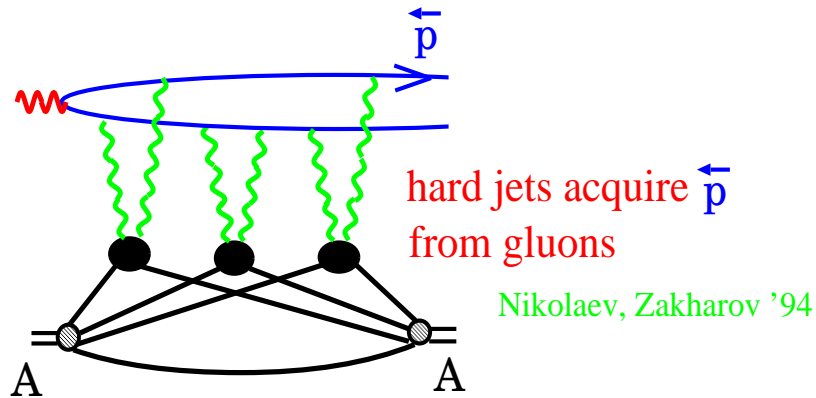
$$\Psi(z_b, \mathbf{b}_b - \mathbf{b}_c) \times \Psi^*(z_b, \mathbf{b}'_b - \mathbf{b}'_c)$$

$$\{S_{\bar{b}\bar{c}cb}^{(4)}(\mathbf{b}'_b, \mathbf{b}'_c, \mathbf{b}_b, \mathbf{b}_c) + S_{\bar{a}a}^{(2)}(\mathbf{b}', \mathbf{b}) - S_{\bar{b}\bar{c}a}^{(3)}(\mathbf{b}, \mathbf{b}'_b, \mathbf{b}'_c) - S_{\bar{a}bc}^{(3)}(\mathbf{b}', \mathbf{b}_b, \mathbf{b}_c)\}.$$

★ Coupled-channel non-Abelian evolution:

- DIS: $\gamma^* \rightarrow q\bar{q}$: $\implies \underbrace{1}_1 + \underbrace{8}_{N_c^2}$
- Open charm: $g \rightarrow c\bar{c}$: $\implies \underbrace{1}_{1 (N_c \text{ suppressed})} + \underbrace{8}_{N_c^2}$
- Forward dijets: $q \rightarrow qg$: $\implies \underbrace{3}_{N_c} + \underbrace{6 + 15}_{N_c \times N_c^2}$
- Central dijets: $g \rightarrow gg$: $\implies \underbrace{1}_{1 (N_c \text{ suppressed})} + \underbrace{8_A + 8_S}_{N_c^2} + \underbrace{10 + \overline{10} + 27 + R_7}_{N_c^2 \times N_c^2}$

★ Universality classes depending on color excitation



Diffractive DIS off nuclei defines collective nuclear glue

- ★ Diffractive hard dijets from pions: $\pi N \rightarrow Jet_1 + Jet_2$, $\mathbf{p}_{Jet_2} = -\mathbf{p}_{Jet_1} \gg \frac{1}{R_N}$:

$$M_{diff,N}(\mathbf{p}) \propto \int d^2\mathbf{r} \sigma(\mathbf{r}) \exp(i\mathbf{p} \cdot \mathbf{r}) = -f(\mathbf{p})$$

- ★ Diffraction off nuclei (NNN, Schäfer, Schwiete'01):

$$M_{diff,A}(\mathbf{p}) \propto \int d^2\mathbf{r} \Gamma_A(\mathbf{b}, \mathbf{r}) \exp(i\mathbf{p} \cdot \mathbf{r})$$

- ★ Nuclear profile function (partial amplitude)

$$\Gamma_A(\mathbf{b}, \mathbf{r}) = 1 - S_A(\mathbf{b}, \mathbf{r}) = \int d^2\boldsymbol{\kappa} \phi(\mathbf{b}, \boldsymbol{\kappa}) \{1 - \exp[i\boldsymbol{\kappa} \cdot \mathbf{r}]\}$$

- ★ Optical thickness $T(\mathbf{b}) = \int dz n_A(\mathbf{b}, z)$ - a new large dimensional scale.

Collective glue of overlapping nucleons

- Nuclear S -matrix for the dipole: $S_A(\mathbf{b}, \mathbf{r}) = \exp[-\frac{1}{2}\sigma(\mathbf{r})T(\mathbf{b})]$

$$\Phi(\mathbf{b}, \boldsymbol{\kappa}) = \frac{1}{(2\pi)^2} \int d^2\mathbf{r} S_A(\mathbf{b}, \mathbf{r}) \exp(-i\mathbf{r}\boldsymbol{\kappa}) = \phi(\mathbf{b}, \boldsymbol{\kappa}) + w_0(\mathbf{b})\delta(\boldsymbol{\kappa})$$

- Nuclear glue per unit area in the impact parameter space: unitarity interpretation as an expansion quasielastic qA scattering in ν -fold quasilestic νN scattering

$$\phi(\mathbf{b}, \boldsymbol{\kappa}) = \sum_{j=1}^{\infty} w_j(\mathbf{b}) f^{(j)}(\boldsymbol{\kappa})$$

- Probability to find j overlapping nucleons: boundary condition for evolution

$$w_j(\mathbf{b}) = \frac{\nu_A^j(\mathbf{b})}{j!} \exp[-\nu_A(\mathbf{b})], \quad \nu_A(\mathbf{b}) = \frac{1}{2}\sigma_0 T(\mathbf{b})$$

- Collective glue of j overlapping nucleons:

$$f^{(j)}(\boldsymbol{\kappa}) = \int \prod_i^j d^2\boldsymbol{\kappa}_i f(\boldsymbol{\kappa}_i) \delta(\boldsymbol{\kappa} - \sum_i^j \boldsymbol{\kappa}_i), \quad f^{(0)}(\boldsymbol{\kappa}) \equiv \delta(\boldsymbol{\kappa})$$

- Antishadowing of hard, $\kappa^2 \gtrsim Q_A^2$, glue per bound nucleon
(NNN,Schäfer, Schwiete '00):

$$f_A(\mathbf{b}, x, \kappa) = \frac{\phi(\mathbf{b}, \kappa)}{\nu_A(\mathbf{b})}$$

$$= f(x, \kappa) \left[1 + \frac{\gamma^2}{2} \cdot \frac{\alpha_S(\kappa^2)G(x, \kappa^2)}{\alpha_S(Q_A^2)G(x, Q_A^2)} \cdot \frac{Q_A^2(\mathbf{b})}{\kappa^2} \right].$$

- γ = exponent of the large- κ^2 tail

$$f(\kappa) \sim \alpha_S(\kappa^2)/(\kappa^2)^\gamma$$

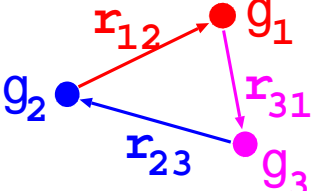
- Antishadowing \implies the Cronin effect.
- Plateau for softer collective glue

$$\phi(\mathbf{b}, \kappa) \approx \frac{1}{\pi} \frac{Q_A^2(\mathbf{b})}{(\kappa^2 + Q_A^2(\mathbf{b}))^2},$$

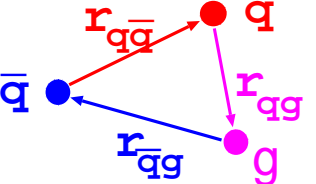
- Width of the plateau (saturation & higher twist scale, independent of auxiliary soft $\sigma_0(x)$)

$$Q_A^2(\mathbf{b}, x) \approx \frac{4\pi^2}{N_c} \alpha_S(Q_A^2)G(x, Q_A^2)T(\mathbf{b}).$$

The origin, and inevitability of the nonlinear k_{\perp} -factorization



$$\sigma^{(3)} = \frac{C_A}{2C_F} \left(\sigma(r_{31}) + \sigma(r_{23}) + \sigma(r_{12}) \right)$$



$$\sigma^{(3)} = \frac{C_A}{2C_F} \left(\sigma(r_{qg}) + \sigma(r_{\bar{q}g}) - \sigma(r_{q\bar{q}}) \right) + \sigma(r_{q\bar{q}})$$

★ Glauber-Gribov multiple scattering theory for the dilute-gas nucleus:

$$S_i(\mathbf{b}_c', \mathbf{b}_b', \mathbf{b}_c, \mathbf{b}_b) = \exp\left\{-\frac{1}{2}\sum_i(\mathbf{b}_c', \mathbf{b}_b', \mathbf{b}_c, \mathbf{b}_b)T(\mathbf{b})\right\}$$

★

$$\begin{aligned} S_{123} &= \exp\left\{-\frac{C_A}{4C_F}\sigma(r_{12})T(\mathbf{b})\right\} \exp\left\{-\frac{C_A}{4C_F}\sigma(r_{13})T(\mathbf{b})\right\} \exp\left\{-\frac{C_A}{4C_F}\sigma(r_{23})T(\mathbf{b})\right\} \\ &= \int d^2\boldsymbol{\kappa}_1 d^2\boldsymbol{\kappa}_2 d^2\boldsymbol{\kappa}_3 \Phi(\mathbf{b}, \boldsymbol{\kappa}_1) \Phi(\mathbf{b}, \boldsymbol{\kappa}_2) \Phi(\mathbf{b}, \boldsymbol{\kappa}_3) \exp(i\boldsymbol{\kappa}_1 r_{12} + i\boldsymbol{\kappa}_2 r_{13} + i\boldsymbol{\kappa}_3 r_{23}) \end{aligned}$$

★ The multiparton S -matrix is a nonlinear functional of the collective nuclear glue!

Dijets: Universality class of coherent diffraction

- ★ Coherent distortion of dipole WF in slice $[0, \beta]$ of the nucleus:

$$\Psi(\beta; z, \mathbf{p}) = \int d^2\boldsymbol{\kappa} \Phi(\beta; \mathbf{b}, x, \boldsymbol{\kappa}) \Psi(z, \mathbf{p} + \boldsymbol{\kappa})$$

$$\exp\left[-\frac{1}{2}\beta\sigma(x, \mathbf{r})T(\mathbf{b})\right] = \int d^2\boldsymbol{\kappa} \Phi(\beta; \mathbf{b}, x, \boldsymbol{\kappa}) \exp(i\boldsymbol{\kappa}\mathbf{r})$$

- ★ Diffractive DIS:

$$\frac{(2\pi)^2 d\sigma_A(\gamma^* \rightarrow Q\bar{Q})}{d^2\mathbf{b}dzd^2\mathbf{p}d^2\boldsymbol{\Delta}} = \delta^{(2)}(\boldsymbol{\Delta}) |\Psi(1; z_g, \mathbf{p}) - \Psi(z_g, \mathbf{p})|^2,$$

- ★ Exactly back-to-back dijets

- ★ $q \rightarrow qg$: net color charge of the incident parton

$$\frac{(2\pi)^2 d\sigma_A(q^* \rightarrow qg)}{d^2\mathbf{b}dzd^2\mathbf{p}_gd^2\boldsymbol{\Delta}} = \delta^{(2)}(\boldsymbol{\Delta}) S_{abs}(2\nu_A(\mathbf{b})) |\Psi(1; z_g, \mathbf{p}_g) - \Psi(z_g, \mathbf{p}_g)|^2.$$

- ★ Intranuclear attenuation of the incident quark wave (Bj's gap survival):

$$S_{abs}(2\nu_A(\mathbf{b})) = \exp[-2\nu_A(\mathbf{b})]$$

Dijets: Universality class of dijet in higher color representation from partons in lower representation: black $q \rightarrow qg|_{6+15}$

$$\begin{aligned}
 & \left. \frac{d\sigma(q^* \rightarrow qg)}{d^2\mathbf{b}dzd^2\Delta d^2\mathbf{p}} \right|_{6+15} = \frac{1}{(2\pi)^2} T(\mathbf{b}) \int_0^1 d\beta \\
 & \times \int d^2\boldsymbol{\kappa} d^2\boldsymbol{\kappa}_1 d^2\boldsymbol{\kappa}_2 d^2\boldsymbol{\kappa}_3 \delta(\boldsymbol{\kappa} + \boldsymbol{\kappa}_1 + \boldsymbol{\kappa}_2 + \boldsymbol{\kappa}_3 - \Delta) \\
 & \times \underbrace{\Phi(\beta; \mathbf{b}, \boldsymbol{\kappa}_3)}_{\text{Quark ISI}} \underbrace{f(\boldsymbol{\kappa}) |\Psi(\beta; z, \mathbf{p} - \boldsymbol{\kappa}_1) - \Psi(\beta; z, \mathbf{p} - \boldsymbol{\kappa}_1 - \boldsymbol{\kappa})|^2}_{\text{Hard Excitation}} \\
 & \times \underbrace{\Phi(1 - \beta; \mathbf{b}, \boldsymbol{\kappa}_1)}_{\text{Quark FSI}} \underbrace{\Phi\left(\frac{C_A}{C_F}(1 - \beta); \mathbf{b}, \boldsymbol{\kappa}_2\right)}_{\text{Gluon FSI}}
 \end{aligned}$$

★ $\gamma^* \rightarrow q\bar{q}|_8$: the same as $q \rightarrow qg|_{6+15}$ modified for vanishing ISI

★ $g \rightarrow gg|_{10+\bar{10}+27+R_7}$: the same as $q \rightarrow qg$ subject to two modifications:

(i) Quark FSI/ISI \implies Gluon FSI/ISI

(ii) C_A/C_F : collective glue is a color matrix in color space.

Dijets: Universality class of dijets in the same lower color representation as the beam parton: $q \rightarrow qg|_3$

$$\left. \frac{d\sigma(q^* A \rightarrow qg)}{d^2\mathbf{b} dz d^2\mathbf{\Delta} d^2\mathbf{p}} \right|_3 = \frac{1}{(2\pi)^2} \phi(\mathbf{b}, \mathbf{\Delta}) |\Psi(1; z, \mathbf{p} - \mathbf{\Delta}) - \Psi(z, \mathbf{p} - z\mathbf{\Delta})|^2$$

★ $\Psi(z, \mathbf{p} - z\mathbf{\Delta})$ = probability amplitude for the qg state in a physical quark - driving term of quark jet fragmentation

★ Color triplet dijets: nearly linear-factorizable fragmentation of the multiply-scattered quark subject to a coherently nuclear-distorted $\Psi(1; z, \mathbf{p} - \mathbf{\Delta})$:

$$|\underbrace{\Psi(z, \mathbf{p} - \mathbf{\Delta})}_{in-vacuum} - \Psi(z, \mathbf{p} - z\mathbf{\Delta})|^2 \implies |\underbrace{\Psi(1; z, \mathbf{p} - \mathbf{\Delta})}_{in-nucleus \ distorted} - \Psi(z, \mathbf{p} - z\mathbf{\Delta})|^2$$

Interpretation: nuclear modification of the fragmentation function

★ WF distortions always by uncut pomerons

★ More universality classes: $g \rightarrow q\bar{q}|_8$, $g \rightarrow gg|_{8_A+8_S}$, $g \rightarrow gg|_{8_S}$

Nonlinear evolution for collective glue in the dipole basis

★ Impact of the $a\bar{a}g$ Fock state on the $a\bar{a}$ scattering matrix, the 1st iteration:

$$\begin{aligned} \delta S_{a\bar{a}}(x, \mathbf{b}_a, \mathbf{b}_{\bar{a}}) &= \int_{x/x_0}^1 dz_g \int d^2 \boldsymbol{\rho} \Psi_{a\bar{a}g}^* \Psi_{a\bar{a}g} \\ &\times [S_a(x_0, \mathbf{b}_a) S_a^\dagger(x_0, \mathbf{b}_{\bar{a}}) S_g(x_0, \mathbf{b}_g) - S_{a\bar{a}}(x_0, \mathbf{b}_a, \mathbf{b}_{\bar{a}})]. \end{aligned} \quad (1)$$

★ The linear approximation is the dipole form of the BFKL eqn. (NNN B.G.Zakharov (1993))

★ Recall the classic momentum space form

$$\frac{\partial f(x, \mathbf{p})}{\partial \log \frac{1}{x}} = \mathcal{K}_0 \int d^2 \boldsymbol{\kappa} [2K(\underline{\mathbf{p}}, \mathbf{p} - \boldsymbol{\kappa}) f(x, \boldsymbol{\kappa}) - f(x, \mathbf{p}) K(\boldsymbol{\kappa}, \boldsymbol{\kappa} - \mathbf{p})] = (\mathcal{K}_{BFKL} \otimes f)(x, \mathbf{p})$$

★ The nonlinear case for the quark-antiquark dipole is the BK "equation" (Balitsky (1966), Kovchegov (1999)):

$$\star K(\mathbf{p}, \mathbf{p} + \mathbf{q}) = |\psi(\mathbf{p}) - \psi(\mathbf{p} + \mathbf{q})|^2$$

★ Infrared regularization

$$\psi(\mathbf{p}) = \frac{\mathbf{p}}{\mathbf{p}^2 + \mu^2}$$

The nonlinear case for the initial gg dipole (NNN, W.Schaefer (2006))

★ Large N_c : gluon-gluon dipole interacts as two uncorrelated overlapping quark-antiquark dipoles

$$\begin{aligned}
 \delta S_{gg}(\mathbf{b}; x, \mathbf{r}) &= \int_x^1 dz_g \int d^2 \boldsymbol{\rho} |\Psi_{ag}(z_g, \boldsymbol{\rho}) - \Psi_{ag}(z_g, \boldsymbol{\rho} + \mathbf{r})|^2 \\
 &\times \{S[\mathbf{b}; \sigma_{ggg}(x_0)] - S[\mathbf{b}; \sigma_{gg}(x_0)]\} \\
 &= \int_x^1 dz_g \int d^2 \boldsymbol{\rho} |\Psi_{ag}(z_g, \boldsymbol{\rho}) - \Psi_{ag}(z_g, \boldsymbol{\rho} + \mathbf{r})|^2 \\
 &\times \{S[\mathbf{b}; \sigma_g(x_0, \boldsymbol{\rho})]S[\mathbf{b}; \sigma_g(x_0, \boldsymbol{\rho} + \mathbf{r})]S[\mathbf{b}; \sigma_g(x_0, \mathbf{r})] - S[\mathbf{b}; \sigma_{gg}(x_0, \mathbf{r})]\}.
 \end{aligned}$$

- ★ Higher nonlinearity compared to the initial quark-antiquark dipole
- ★ Not a closed form equation.
- ★ Only an approximation for small number of iterations $\lesssim \nu_A(\mathbf{b})$.
- ★ Inapplicable to the free-nucleon case.

Evolution of the collective glue in the momentum space

- ★ BK for quark-antiquark dipoles in the momentum space (NNN, W.Schaefer (1966))

$$\frac{\partial \phi(\mathbf{b}, x, \mathbf{p})}{\partial \log(1/x)} = \mathcal{K}_{BFKL} \otimes \phi(\mathbf{b}, x, \mathbf{p}) + \mathcal{Q}[\phi](\mathbf{b}, x, \mathbf{p}), \quad (2)$$

- ★ The nonlinear term: the real emission resembles coherent diffraction

$$\mathcal{Q}_{real}[\phi](\mathbf{b}, x, \mathbf{p}) = -\mathcal{K}_0 \left| \int d^2\mathbf{q} [\psi(\mathbf{p}) - \psi(\mathbf{p} + \mathbf{q})] \phi(\mathbf{b}, x, \mathbf{q}) \right|^2$$

It defines a triple pomeron vertex in the evolution eqn. Only undistorted ψ 's make it entirely different from the ones in incoherent dijet production!

- ★ The nonlinear term: the virtual emission

$$\mathcal{Q}_{virt}[\phi](\mathbf{b}, x, \mathbf{p}) = \phi(\mathbf{b}, x, \mathbf{p}) \int d^2\mathbf{q} \phi(\mathbf{b}, x, \mathbf{q}) [\omega(\mathbf{p}) - \omega(\mathbf{p} + \mathbf{q})]$$

The nonlinear renormalization of the intercept of a collective glue

- ★ Glue for the gluon-gluon dipoles evolves as a convolution of the glue for quark-antiquark dipoles:

$$\Phi_{gg}(\mathbf{b}, x, \mathbf{p}) = (\Phi \otimes \Phi)(\mathbf{b}, x, \mathbf{p}). \quad (3)$$

Triple-pomeron (?) regime of diffraction off nucleons

- ★ Forward diffraction into large-mass $q(\mathbf{p}), \bar{q}, g(\mathbf{q})$, $\beta = Q^2/(Q^2 + M_{q\bar{q}g}^2)$

$$\left. \frac{\partial}{\partial \log \frac{1}{\beta}} \frac{d\sigma_N^D}{dz d^2\mathbf{p} d^2\mathbf{q} dt} \right|_{t=0} = \frac{1}{16\pi(2\pi)^4} \cdot \left(\frac{C_A}{2C_F} \right)^2 \cdot 4\alpha_S C_F P_{q\gamma}(z) \left| \int d^2\boldsymbol{\kappa} f(x_{\mathbf{P}}, \boldsymbol{\kappa}) H_{ij}^N(\boldsymbol{\kappa}, \mathbf{q}, \mathbf{p}) \right|^2, \quad (4)$$

- ★ Try a triple-pomeron reinterpretation?

$$\begin{aligned} H_{ij}^N(\boldsymbol{\kappa}, \mathbf{q}, \mathbf{p}) &= \psi_i(\mu^2, \mathbf{q}) \{ [\psi_j(\varepsilon^2, \mathbf{p} + \mathbf{q}) - \psi_j(\varepsilon^2, \mathbf{p})] \\ &+ + [\psi_j(\varepsilon^2, \mathbf{p} - \boldsymbol{\kappa} + \mathbf{q}) - \psi_j(\varepsilon^2, \mathbf{p} - \boldsymbol{\kappa})] \} \\ &- \{ \mathbf{q} \rightarrow \mathbf{q} + \boldsymbol{\kappa} \}, \end{aligned} \quad (5)$$

- ★ $\psi_j(\varepsilon^2, \mathbf{p})$ from the $\gamma^* \rightarrow q\bar{q}$, where $\varepsilon^2 = z(1-z)Q^2 = m_q^2$
- ★ $H_{ij}^N(\boldsymbol{\kappa}, \mathbf{q}, \mathbf{p})$ does not admit factorization into the photon impact factor and triple-pomeron vertex.

Triple-pomeron regime of diffraction off heavy nuclei

$$\frac{\partial}{\partial \log \frac{1}{\beta}} \frac{d\sigma_A^D}{dz d^2\mathbf{b} d^2\mathbf{p} d^2\mathbf{q}} = \frac{1}{(2\pi)^4} 4\alpha_S C_F P_{q\gamma}(z) \times \left| \int d^2\boldsymbol{\kappa}_1 d^2\boldsymbol{\kappa}_2 \Phi(\mathbf{b}, x_{\mathbb{P}}, \boldsymbol{\kappa}_1) \Phi(\mathbf{b}, x_{\mathbb{P}}, \boldsymbol{\kappa}_2) H_{ij}^A(\boldsymbol{\kappa}_1, \boldsymbol{\kappa}_2, \mathbf{q}, \mathbf{p}) \right|^2,$$

$$H_{ij}^A(\boldsymbol{\kappa}_1, \boldsymbol{\kappa}_2, \mathbf{q}, \mathbf{p}) = \psi_i(\mu^2, \mathbf{q}) [\psi_j(\varepsilon^2, \mathbf{p} - \boldsymbol{\kappa}_1 + \mathbf{q}) - \psi_j(\varepsilon^2, \mathbf{p} - \boldsymbol{\kappa}_1)] - \{\mathbf{q} \rightarrow \mathbf{q} + \boldsymbol{\kappa}_1 + \boldsymbol{\kappa}_2\} \quad (6)$$

- ★ Only undistorted ψ' s, but
- ★ Diffraction neither off free-nucleons nor heavy nuclei admits a simple reinterpretation in terms of a diffractive pomeron: there is a strong entanglement of the photon impact factor and a triple-pomeron coupling
 - ★ No semblance of the "diffractive triple vertex" in the evolution of the collective nuclear glue: still another breaking of the old AGK rules
- ★ Possible recovery of a triple-pomeron reinterpretation in the restricted LLQ^2 regime?

Summary and further applications:

- Nuclear collective glue is an observable defined by coherent diffraction
- Nonlinear k_{\perp} -factorization: explicit quadratures for all observables in terms of the collective
- Expansion of nuclear unintegrated glue in terms of *collective glue of overlapping nucleons and coherent nuclear gluons*.
- *A non-abelian* intranuclear evolution of color dipoles.
- Incoherent multiproduction off nuclei: the universality class-dependent AGK rules
- Coherent diffraction does not factorize into the photon impact factor and triple-pomeron vertex
- Distinct cut and uncut and evolution-defined multipomeron vertices in QCD.
- Further complications with coherent distortions of multipomeron vertices.
- A beauty of AGK-73 is lost in nonabelian QCD