Quark Loops and Photons with CGC in pA

Martina Pr. - 1980 to 1980 to all - .

Kenji Fukushima The University of Tokyo ongoing work with Sanjin Benic

Four Steps in HIC

ప్రస్తుతున్న పరిస్థ పరిస్థుత, పరిస్థుత, పరిస్థుత, పరిస్థుత, .

Color Glass Condensate (CGC) $\tau \leq 1/Q_s \sim 0.1$ fm/c

Color Glass + Plasma = Glasma $\tau \lesssim \tau_0 \sim 1 \text{fm/c}$

> **(s) Quark-Gluon Plasma** $\tau \lesssim \tau_f \sim 10 \text{fm/c}$

Hadronization (quarks → hadrons) Lattice $EoS \sim HRG$

Three Keywords in Early Dynamics ම්විතාව, නිම්වාව, නිම්වාව, නිම්වා නිම්වාව, නිම්වාව, නිම්වාව, නිම්වාව, නිම්වාව, නිම්වා

Isotropization Gelis, Epelbaum, Berges, Venugopalan, Schlichting

Complete isotropization is not necessary. Stability of a certain isotropization $(50%)$ is required.

Hydronization Chesler, Yaffe, Janik, Strickland, Heinz

Hydrodynamics would be a better description with more and more dissipative terms.

Anisotropic viscous hydro may work better?

Thermalization Blaizot, McLerran, Liao, Gelis, Berges, Kurkela, Moore

What is seen in experiment is a thermal p_t distribution of hadrons — thermal gluons? Turbulence? BEC? **Photons?**

Issues on Isotropization

*Q***: Is the CSA good to give fast isotropization if the system is NOT expanding?** ³

Issues on Thermalization

RHIC / PHENIX

- * photon puzzle
	- baryons-antibaryons
	- pion Bremsstrahlung (Ralf Rapp)
- * photon elliptic flow

Four Steps in HIC

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Hadronization (quarks → hadrons)

Classical Picture for B

రణించి, రణించబించి, రణించి, రణి

 $\overline{\bm{B}}$

Point-particle approximation:

$$
eB_0 = (47.6 \text{ MeV})^2 \left(\frac{1 \text{ fm}}{b}\right)^2 Z \sinh Y \qquad t_0 = \frac{b}{2 \sinh Y}
$$

"strongest magnetic field in the Universe"
"august 25, 2015 @ INT in Seattle

What I want to do…

కుటించి, మటించి, మటించి, మటించుకొంచి, మటించి, మటించి, మటించి, మటించి, మ

Initial State in High-Energy AA Collisions

Magnetic Fields

Photon Production Quark Pair Production

Anomalous Transport (more direct relevance than hydro/phase diagram)

Expanding CGC

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Longitudinal Fields (*Local Parity Violation***)**

Simulation starts with "negative" pressure: $P_L < 0$

Remark on CGC

"Saturation" is not needed, but just "Scaling"

Scaling variable: $\tau = Q^2/Q_s^2(x)$

Saturation momentum: $Q_s^2(x) = Q_0^2(x/x_0)^{-\lambda}$

Golec-Biernat, Kwiecinski, Stasto, Wuesthoff

"Geometric Scaling"

B-CGC

August 25, 2015 @ INT in Seattle 11 A ugust A \mathcal{L} odd domain realized by parallel *E^z* and *B^z*. The currents

B-CGC

Analytical calculation for uniform fields Current = CP-breaking Schwinger Mechanism

What is new with fields *inhomogeneous* **in space/time?**

B-induced Photons

പ്രദേശങ്ങൾ കണ്ണുകൾ അവരുടെ കണ്ണുകൾ കണ്ണുകൾ കണ്ണുക

Inhomogeneous *B / µ***5 carries energy/momentum**

Reversed Primakoff Effect

q **Fukushima-Mameda (2012)** ²

cf. Basar-Kharzeev-Skokov (2012)

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=

 q_z^2

 $^{2}_{z}+q_{x}^{2}$

x

B-induced Photons

്കുറി, നിര്വാഹി, നിര്വാഹി, നിര്വാനിയില് , നിര്വാഹി, നിര്വാഹി, നിര്വാഹി, .

Inhomogeneous *B / µ***5 carries energy/momentum**

Non-perturbative Formulation color field for time. Finally, one chooses a quark in time. Finally, one chooses a quark in time. Finally, one
The color field for the choose a quark in time. Finally, one chooses a quark in the choose and the chooses a q energy spinor2 pour every of the outcome of an orientation of the outcome of the outco the time evolution of the negative energy spinor in the longitudinal integration. We evaluate Eq. (1) in the 2 dis-Kajantie-Lappi (2005) T , hence the use of \mathcal{T} , hence the use of \mathcal{T} Non-perturbative Formulc the reason for the Jacobian factor ^τdz/[√] τ ² + z² in the 0 100 200 300 q rturbative Formulation delt with a fill pairs of the pell pairs of the pairs of the pairs of the pairs of the p η i (2005) along the positive light η

$$
M_{\tau}(p,q) \equiv \int \frac{\tau dz d^2 \mathbf{x}_T}{\sqrt{\tau^2 + z^2}} \phi_{\mathbf{p}}^{\dagger}(\tau, \mathbf{x}) \gamma^0 \gamma^{\tau} \psi_{\mathbf{q}}(\tau, \mathbf{x}) \quad anticless to
$$

particles

pi (2005)
\n
$$
\frac{2d^{2}x_{T}}{r^{2} + z^{2}} \phi_{P}^{\dagger}(\tau, x) \gamma^{0} \gamma^{\tau} \psi_{q}(\tau, x)
$$
\nAmplitude from *anticless to particles*
\n
$$
\frac{T}{2} \frac{dy_{q}d^{2}q_{T}}{2(2\pi)^{3}} \delta(y - y_{p}) |M_{\tau}(p, q)|^{2}
$$
\n
$$
\psi_{q}(t \rightarrow -\infty, x) = e^{iq \cdot x} v(q)
$$

$$
\frac{dN}{dy} = \int \frac{dy_p d^2 \mathbf{p}_T}{2(2\pi)^3} \frac{dy_q d^2 \mathbf{q}_T}{2(2\pi)^3} \delta(y - y_p) |M_\tau(p, q)|^2
$$

$$
\psi_{\mathbf{q}}(t \to -\infty, \mathbf{x}) = e^{iq \cdot x} v(q)
$$
\n
$$
\phi_{\mathbf{p}}(x) = e^{-ip \cdot x} u(p)
$$

 \overline{a} 3: Dependence of the number of \overline{a} . \mathbf{Im}/\mathbf{c}) \mathbf{v} er \mathbf{y} that \mathbf{v} **Very early (** τ < 0.1fm/c) $\frac{1}{2}$ \mathcal{C} = 0, \mathcal{C} , \mathcal{C}

August 25, 2015 $@$ INT in Seattle $F = 20$ [∼] ¹/(g2µ). ω in I in Seattle in the Wilson control is a set of ω in the Wilson control is a set of ω is 0.2 0.25
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Simple Example simple *fxample* ? ⁺ *^m*² in fig. 5.

In drawing fig. 5 we fixed *m*?, and set the electric field to the value *E* = ⇡*m*² ?*/e*– which is such talks a such talks a such talks a such a sile of the standard expression of the a such talks and
In villar and talks a such talks **Schwinger mechanism in scalar QED**

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Consistency Check

ప్, మత్తున్న, పత్రిం పత్రించి, పత్రించి,

Q **: Is it possible to reproduce the real-time CME for** uniform fields using the GKL formalism? $\mathbf s$ using the OIYL form \hat{y} \hat{y}

A **: of course yes!** \mathbf{f} finitely large momentum contributions *^p^z* ⇠ *[±]*1, but it is unlikely in any experiment that particles \mathcal{L}^{max}

But, unclear whether it is technically feasible? whether it is technical $\begin{bmatrix} 1 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix}$ \mathbf{r} 110 odd domain realized by parallel *E^z* and *B^z*. The currents flow in all the *x*, *y*, and *z* directions; *j^x* is the anomalous Hall

Numerical test with uniform fields without expansion rui uihiol in herus $k \cdot n + \alpha$ we a problem α poul expansion, b worldline formalism on the quantum level, and then \mathbf{r}_i

Consistency Check

normalized by *n*0. The lattice size is *N* = 8 (solid line), 10

Toward B-CGC Simulations

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CGC Background Fields ✔ **(Glasma instability is not needed for the moment)**

Bogoliubov Coefficients (GKL formalism) ✔

Initial Conditions at $\tau = 0^+$?

Toward B-CGC Simulations

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CGC Background Fields ✔ **(Glasma instability is not needed for the moment)**

Bogoliubov Coefficients (GKL formalism) ✔

Initial Conditions at $\tau = 0^+$ ✔ **Gelis-Tanji (2015)**

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What I want to do…

కుటించి, పుటించి, పుటించి, పుటించుకున, పుటించి, పుటించి, పుటించి, పుటించి, పు

Initial State in High-Energy AA Collisions

Magnetic Fields

Photon Production Cuark Pair Production

Anomalous Transport (more direct relevance than hydro/phase diagram)

What I can do… so far… రిపెట్టి, మరోపెట్టి, మరోపెట్టి, మరోపెట్టు మరోపెట్టి, మరోపెట్టి, మరోపెట్టి, మరోపెట్టి, మ **Initial State in High-Energy AA Collisions pA Magnetic Fields Photon Production Quark Pair Production**

Photons from quark loops (for technical simplicity)

Conventional Photons

Compton Scattering Mannihilation

 \boldsymbol{q} γ legg
P

$$
\propto \alpha_e \alpha_s n_q (1 - n_q) n_g \qquad \propto \alpha_e \alpha_s n_q n_{\bar{q}} (1 + n_g)
$$

$$
(q\bar{q} \rightarrow q\gamma)
$$

Conventional Photons

కలిసినాని.. సతిపినాని.. సతిపిన సతిపినాని.. సతిపినాని

Compton Scattering Mannihilation

$$
\propto \alpha_e \alpha_s n_q (1 - n_q) n_g \qquad \propto \alpha_e \alpha_s n_q n_{\bar{q}} (1 + n_g)
$$

$$
(q\bar{q} \rightarrow q\gamma)
$$

Diagrams involving CGC \overline{q} γ g \overline{q} γ g **Compton Scattering Mannihilation** $\propto \alpha_e \alpha_s n_q n_{\bar{q}} \alpha_s^{-1}$ **CGC** ⁵

$$
\propto \alpha_e \alpha_s n_q (1 - n_q) \alpha_s^{-1}
$$

$$
\sim \alpha_e (n_q (1 - n_q))
$$

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 $\sim \alpha_e \overline{n_q} \overline{n_{\bar q}}$

Multiple Scattering

In a certain gauge: $A \sim \rho_A \sim \delta(x^+)$

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Leading-order Processes

Multiple Scattering with CGC

Leading-order Processes

Multiple Scattering with CGC

GJ Formula ^B1(x⊥) [≡] ^Q² ⁰(x[⊥] [−] ^z⊥) [∼] ^Q² " ⁺[∞]

with a collection sies a…sies a −∞ dz−µ²(z−)/2 the saturation scale⁴ (the integral of µ² over the number of the number of color sources per unit of the color sources per unit of the color solution of

$$
\frac{1}{A_\perp} \frac{d\sigma^{q\to q\gamma}}{d^2\mathbf{k}_\perp} = \frac{2\alpha_e}{(2\pi)^4 \mathbf{k}_\perp^2} \int_0^1 dz \frac{1 + (1-z)^2}{z} \int d^2\mathbf{l}_\perp \frac{\mathbf{l}_\perp^2 C(\mathbf{l}_\perp)}{(\mathbf{l}_\perp - \mathbf{k}_\perp/z)^2}
$$

$$
C(\bm{l}_\perp) \equiv \int d^2 \bm{x}_\perp e^{i \bm{l}_\perp \cdot \bm{x}_\perp} e^{-B_2(\bm{x}_\perp)} = \int d^2 \bm{x}_\perp e^{i \bm{l}_\perp \cdot \bm{x}_\perp} \left\langle U(0) U^\dagger(\bm{x}_\perp) \right\rangle_\rho \\ B_2(\bm{x}_\perp - \bm{y}_\perp) \;\; \equiv \;\; Q_s^2 \int d^2 \bm{z}_\perp [G_0(\bm{x}_\perp - \bm{z}_\perp) - G_0(\bm{y}_\perp - \bm{z}_\perp)]^2
$$

August 25, 2015 @ INT in Seattle **Gens-***F* August 25, 2015 @ INT in Seattle **Gelis-Jalilian-Marian (2002)** ₃₀
2015 and Collinear Seattle **Collinear Seattle** Collis-Jalilian-Marian (2002) is quarr
 *i*th $p = 0$ $\begin{bmatrix} 0.25 \\ 0.2 \end{bmatrix}$ \overline{a} 2p[−] $\widetilde{\mathcal{Z}} \leftarrow 0.15 \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix}$ \overrightarrow{A} + crossed diagram \overrightarrow{a} γ \sim \sim \sim \sim 0. (photon emitted first) $\frac{0}{k_1 k_0 c_0}$ $\frac{15}{k_1 k_0 c_0}$ $\frac{20}{k_2 k_0 c_0}$ ities, i.e. singularities that show up when the emitted photon is parallel to the emitted photon is parallel t $\left[\begin{array}{cc} q \end{array} \right]$ γ $\rho_{\rm p} \swarrow \quad \searrow \quad \rho_{\rm A}$ *l~p q k q***+***k* k with $p = 0$ 4π $\begin{array}{c|c} 3 \\ 5 \end{array}$ $\frac{1}{\sqrt{2}}$ $\overline{}$. (23) \blacksquare .
⊿2 + crossed diagram
(photon emitted first) $\sum_{\substack{0 \text{ prime} \ \text$ → + crossed diagram
(photon emitted) **Per one massless quark with** $p = 0$ h*k, |*pAi = *e^f g* ncss quain *d*⁴*y* tr⇥ (*k*?)*G^F* (*x, y*) /*A*(*y*)*G^F* (*y, x*) \sum_{α} $\left| \int_{\mathcal{A}} \mathcal{A} \right|$ <u>*d~p* \times </u> 0 (2⇡)¹² ✓(*^l* $\frac{1}{10}$ $-$ ⁰
 $\frac{1}{5}$ $\frac{10}{15}$ $\frac{15}{5}$ ⁺ *^l* ⁰⁺ + *k*⁺) (*k*?)*G*⁰ *^F* (*l* ? *^k*?)*G*⁰ 0 0.05 0.1 0.15 0.2 0.25 0.3 0 5 10 15 20 25 30 C(k) k/Λ_{OCD} **Gelis-Jalilian-Marian (2002)**

Higher-order Processes

Higher-order Processes

1960 that A. (1960) to 1960 that A.

Should be more and more important as approaching AA

 $\sim \alpha_e \langle (g \rho_{\rm p})^2 \rangle \langle U U^\dagger U U^\dagger \rangle$

 $\sim \alpha_e \langle (g \rho_{\rm p})^4 \rangle \langle U U^\dagger U U^\dagger \rangle$

Interested Regime

ది. పట్టించి, పట్టించి, పట్టిం పట్టించి, పట్టించి

$$
(g\rho_{\rm p})^2 < g\rho_{\rm p} \sim n_q^{\rm (p)}
$$

Benic-Fukushima (2015)

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Interested Regime

ంచి, మతిరించి, మతిరిచి, మతిరి మతిరిచి, మతిరిచి, మతిరిచి, మతిరి

$$
(g\rho_{\rm p})^2 < g\rho_{\rm p} \sim n_q^{\rm (p)}
$$

Lowest-order vanishes due to Furry's theorem

Anomaly sensitive?

Odderon needed?

Benic-Fukushima (2015)

Amplitude (preliminary) \boldsymbol{m} lity UL Z *^k*⁺ 0 *dl*0⁺ 2⇡ $\left[n\right]$ *reliminary p*2 ? \boldsymbol{A} *r* $\n ipl$ (2⇡)⁴*k*² de (preli $\overline{1}$ *^d*²*l*? *l* 2 ?*C*(*l*?) (*l*? *^k*?*/z*)² *.* (4)

⇥ alba a ciba ciba. (*l*0² *^m*² ⁺ *ⁱ*✏)[2*l*0⁺*l* (*p*? ⁺ *^l*?)² *^m*² ⁺ *ⁱ*✏](*l*² *^m*² ⁺ *ⁱ*✏)[(*l*⁰ *^k*)² *^m*² ⁺ *ⁱ*✏] *. A*? *d*²*k*?

Thussies with *p* \sim massless with $p = 0$

$$
\langle \mathbf{k}, \lambda | \mathbf{p} \mathbf{A} \rangle = 2 \sqrt{\alpha_e} \sqrt{\alpha_s} \int \frac{d^2 \mathbf{p}_{\perp} d^2 (\mathbf{l}_{\perp} - \mathbf{l}'_{\perp})}{(2\pi)^4} \frac{\mathcal{T}(\mathbf{k}_{\perp}, \mathbf{p}_{\perp}, \mathbf{l}_{\perp} - \mathbf{l}'_{\perp})}{\mathbf{p}_{\perp}^2} \int \frac{d^2 (\mathbf{l}_{\perp} + \mathbf{l}'_{\perp})}{(2\pi)^2} \int_0^1 dx \frac{x \mathbf{k}_{\perp} - \mathbf{l}'_{\perp}}{(x \mathbf{k}_{\perp} - \mathbf{l}'_{\perp})^2 + \mathbf{l}_{\perp}^2 - \mathbf{l}'_{\perp}^2}
$$

Color matrix
some gauge inv. regularization

$$
\mathcal{T}(\boldsymbol{k}_\perp,\boldsymbol{p}_\perp,\boldsymbol{l}_\perp-\boldsymbol{l}_\perp')\equiv\mathrm{tr}\big[U(-\boldsymbol{p}_\perp-\boldsymbol{l}_\perp+\boldsymbol{l}_\perp')\rho_\mathrm{p}(\boldsymbol{p}_\perp)U^\dagger(-\boldsymbol{l}_\perp+\boldsymbol{l}_\perp'-\boldsymbol{k}_\perp)\big]
$$

Color Average (MV Model) A 110 r age (NIV)

h*T* (*k*?*, p*?*,* ?)*T* (*k*?*, p*⁰ ?*,* ⁰ ?)i ^p(*p*?)⇢*^b* p(*p*⁰ ?)ihtr[*U*(*p*? ?)*t ^aU†*(? *^k*?)]tr[*U*(*p*⁰ ? ⁰ ?)*t b U†*(⁰ ? *^k*?)ⁱ (14)

 $\langle \mathcal{T}(\boldsymbol{k}_\perp, \boldsymbol{p}_\perp, \boldsymbol{\Delta}_\perp) \mathcal{T}(\boldsymbol{k}_\perp, \boldsymbol{p}_\perp', \boldsymbol{\Delta}_\perp') \rangle$ $\langle \phi_p^a(\boldsymbol{p}_\perp)\rho_p^b(\boldsymbol{p}'_\perp)\rangle\langle\mathrm{tr}[U(-\boldsymbol{p}_\perp-\boldsymbol{\Delta}_\perp)t^aU^\dagger(-\boldsymbol{\Delta}_\perp-\boldsymbol{k}_\perp)]\mathrm{tr}[U(-\boldsymbol{p}'_\perp-\boldsymbol{\Delta}'_\perp)t^bU^\dagger(-\boldsymbol{\Delta}'_\perp-\boldsymbol{k}_\perp)]\rangle$ ^p(*p*?)⇢*^b* p(*p*⁰ ?)ihtr[*U*(*p*? ?)*t ^aU†*(? *^k*?)]tr[*U*(*p*⁰ ? ⁰ ?)*t b U†*(⁰ h⇢*a* ^p(*p*?)⇢*^b*⇤ ^p (*p*⁰ ?)ⁱ ⁼ *ab ^g*²*µ*² ^p(2⇡) ²(2)(*p*? *^p*⁰ Γ), c ($-\Gamma$ \sim \sim \sim \sim \sim \sim

Average on p : trivial

$$
\langle \rho_\mathrm{p}^a(\bm{p}_\perp) \rho_\mathrm{p}^{b*}(\bm{p}_\perp') \rangle = \delta^{ab} \, g^2 \mu_\mathrm{p}^2 (2\pi)^2 \delta^{(2)}(\bm{p}_\perp-\bm{p}_\perp')
$$

Average on A : MV model (singlet extracted) α ^t
²

$$
\langle tr[U(\boldsymbol{x}_1)t^a U^{\dagger}(\boldsymbol{x}_2)]tr[U(\boldsymbol{x}_3)t^b U^{\dagger}(\boldsymbol{x}_4)]\rangle
$$
\n
\n= $\frac{\delta^{ab}}{2N_c} \cdot \frac{B_2(\boldsymbol{x}_1-\boldsymbol{x}_4)+B_2(\boldsymbol{x}_2-\boldsymbol{x}_3)-B_2(\boldsymbol{x}_1-\boldsymbol{x}_3)-B_2(\boldsymbol{x}_2-\boldsymbol{x}_4)}{B_2(\boldsymbol{x}_1-\boldsymbol{x}_4)+B_2(\boldsymbol{x}_2-\boldsymbol{x}_3)-B_2(\boldsymbol{x}_1-\boldsymbol{x}_2)-B_2(\boldsymbol{x}_3-\boldsymbol{x}_4)}\times \left(e^{-B_2(\boldsymbol{x}_1-\boldsymbol{x}_4)-B_2(\boldsymbol{x}_2-\boldsymbol{x}_3)}-e^{-B_2(\boldsymbol{x}_1-\boldsymbol{x}_2)-B_2(\boldsymbol{x}_3-\boldsymbol{x}_4)}\right).$

Numerical calculations to be performed…

Technical Remark ogy the correlation function \mathcal{L} and \mathcal{L} bunch of particles and particl *Technical Remark* It is assumed in the MV model that the average h*···*i is accompanied by the Gaus- μ *echnical Kemark*

the specific quantity of our interest in this paper is where the Greek indices are with respect to color in a certain representation *r* of the SU(*N*c) the standard convention, or in other words, the saturation scale *Q*^s related to *µ* up to a logarithmic factor (see Eq. (2.11) for our definition with α and α -and α

$$
\big\langle U(\boldsymbol{x}_{1\perp})_{\beta_1\alpha_1}U(\boldsymbol{x}_{2\perp})_{\beta_2\alpha_2}\cdots U(\boldsymbol{x}_{n\perp})_{\beta_n\alpha_n}\big\rangle
$$

$$
U(\boldsymbol{x}_\perp) = \mathcal{P} \exp\Biggl[-\mathrm{i} g^2 \int_{-\infty}^{+\infty} \!\mathrm{d} x^- \mathrm{d}^2 \boldsymbol{z}_\perp \, G_0(\boldsymbol{x}_\perp\!-\!\boldsymbol{z}_\perp)\, \rho_a(x^-,\boldsymbol{z}_\perp)\, t^a\Biggr] \\ \omega(\rho) = \exp\Biggl[-\int_{-\infty}^{+\infty} \!\mathrm{d} x^- \mathrm{d} \boldsymbol{x}_\perp \, \frac{\rho_a^2(x^-,\boldsymbol{x}_\perp)}{2\mu^2(x^-)}\Biggr]
$$

 $\rho_a(x^-, \mathcal{X}_\perp) \rightarrow o(x^-) \rho_a^{(0)}(\mathcal{X}_\perp)$ very delicate limit the *Fukushima* (2007) \overline{a} @*x*² $\rho_a^{(t)}(x_\perp)$ Very delicate limit ζ is sensitive to ζ of ζ which is sensitive to ζ which is sensitive to ζ $\rho_a(x^-,\bm{x}_\perp) ~\rightarrow~ \delta(x^-)\rho_a^{(t)}$ **The only necessary index in the output follows in the Fukushima (2007)**

Summary

సంఖర్, పరికోరంఖర్, పరికోరంఖర్, పరికోరంఖర్, పరికోరం పరికోరంఖర్, పరికోరంఖర్, పరికోరంఖర్, పరికోరంఖర్, ; **Early-time dynamics Glasma (longitudinal chromo-***E/B***) + U(1)** *B*

Particle production

Quark pair production on P- and CP-odd *E/B* **leading to the CME current**

- **Photons in pA~AA**
- **Loop diagrams become more important**

One loop diagram evaluated

Structure looks quite similar to Bremsstrahlung

*** Introduction of U(1)** *B* *** Color average in a different way?**