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Thermalization beyond the Bottom-Up Picture

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Starting with the initial condition of a Color Glass Condensate we investigate thermalization of a QGP in expanding 1+1 Bjorken geometry, with inelastic $gg \leftrightarrow ggg$ collisions with pQCD calculated crossections included. Our main focus lies on comparison of thermalization process with the Bottom-Up scenario[1]. We observe a mismatch with the Bottom-Up picture, since no significant increase of particle number due to production of soft particles during early evolution of the system can be observed. Thermalization occurs over the whole range of transversal momenta on approximately equal timescales $\tau \sim 1\ fm/c$. Early themalization is observed in simulations with LHC relevant parameters: after approximately 0.75 fm/c the system exhibits quasi-hydrodynamical behavior. Shear viscosity and ratio to entropy density are calculated applying standard dissipative hydrodynamics in Bjorken geometry. The calculated ratio $\frac{\eta}{s}$ lies close to the AdS/CFT limit.

References

[1] R. Baier, A.H. Mueller, D. Schiff, D.T. Son, *Phys. Lett. B*, **502**, (2001) 5158.

PARTICLE MULTIPLICITIES AND NUCLEAR MODIFICATION FACTORS AT THE LHC FROM NON-LINEAR QCD EVOLUTION

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At high energies QCD enters a novel regime, the Color Glass Condensate, characterized by high partonic densities, coherence phenomena and non-linear saturation effects. I will briefly review the recent progress attained in this field after the calculation of running coupling corrections to the kernel of the small-x BK-JIMWLK evolution equations [1,2,3] via all order resummation of $\alpha_s\, N_f$ contributions. Next I will concentrate on the phenomenological applications to the physics of ultra-relativistic heavy ion collisions that arise from our en-

hanced knowledge of the small-x dynamics, focusing in the expectations for the LHC. I will discuss multiparticle production in A-A collisions: It was shown in [4] that the inclusion of running coupling corrections in the evolution of the unintegrated nuclear gluon distributions suffice to describe the collision energy and pseudorapidity dependence of the multiplicity densities in Au-Au collisions at the highest RHIC energies, yielding the following prediction for midrapidity multiplicities in Pb-Pb collisions at the LHC:

$$\frac{dN_{ch}^{Pb-Pb}}{d\eta}(\sqrt{5.5}\,\text{TeV}, \eta = 0) \approx 1290 \div 1480\,,$$

which is significantly smaller than previous theoretical expectations and closer to the empirical extrapolations from lower energies data.
Finally I will discuss the expectations for the nuclear modification factor, $R_{pPb}(p_t, y)$ in proton-lead collisions at the the LHC, as well as its dependence on rapidity and particle species based on the use of running coupling small-x dynamics and a proper consideration of fragmentation functions [5].

References

[1] I. Balitsky, *Phys. Rev. D*, **75**, 1 (2008).
[2] Y. V. Kovchegov and H. Weigert, *Nucl. Phys. A* **789**, 260 (2007).
[3] J. L. Albacete and Y. V. Kovchegov, *Phys. Rev. D*, **75**, 125021 (2007).
[4] J. L. Albacete, arXiv:0707.2545 [hep-ph]. Accepted for publication in *Phys. Rev. Lett.*.
[5] J. L. Albacete, in preparation.

Measuring gluon shadowing with prompt photons at RHIC and LHC

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The possibility to observe the nuclear modification of the gluon distribution at small-x (gluon shadowing) using high-$p_\perp$ prompt photon production at RHIC and at LHC is discussed. The per-nucleon ratio, $\sigma(p+\text{A} \to \gamma + X)/(A \times \sigma(p+p \to \gamma + \text{X}))$, is computed for both inclusive and isolated prompt photons in perturbative QCD at NLO using different parametrizations of nuclear parton densities, in order to assess the v isibility of the shadowing signal. The production of isolated photons turns out to be a promi sing channel which allows for a reliable extraction of the gluon density, R_G^{A}, and the structure function, $R_{F_2}^{\text{A}}$, in a nucleus over that in a proton. Moreover, the production ratio of prompt photons at forward-over-ba ckward rapidity in p–A collisions provides an estimate of R_G^{A} (at small x) over $R_{F_2}^{\text{A}}$ (at large x), without the need of p–p reference data at the same energy.

References
[1] F. Arleo and T. Gousset, *0707.2944*, submitted to Phys. Lett. **B**.

EQUATION OF STATE AND THERMALIZATION OF THE HOT DENSE MATTER IN A MULTI-PHASE TRANSPORT MODEL

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Transport models are important tools for studying dynamics of relativistic heavy ion collisions. In particular, a multi-phase transport model has been successful in correlating many experiment observables. It is interesting to study the thermal properties of the hot matter in these models. Within the framework of a multi-phase transport model, we study the equation of state and pressure anisotropy of the hot dense matter produced in central relativistic heavy ion collisions. We find that their dynamical evolution depends strongly on the non-equilibrium expansion dynamics in the collisions as well as the hadronization scheme and scattering cross sections used in the model. Furthermore, our results indicate that only partial thermalization is achieved in the produced matter as a result of its fast expansion.

References
[1] B. Zhang, L. W. Chen, and C. M. Ko, "Equation of state of the hot dense matter in a multi-phase transport model," arXiv:0705.3968 [nucl-th].

COLD NUCLEAR MODIFICATIONS AT RHIC AND LHC

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Modifications of the parton distribution function (PDF) in the nuclear environment are of great interest and importance for precise perturbative QCD calculations. These modifications were first measured in electron-nucleus collisions. In relativistic heavy-ion collisions, they contribute to the deviation from unity of the nuclear modification factor, $R_{AA'}(p_T)$, in various ranges of transverse momentum, p_T. Since the modifications are generally in the $10 - 30\%$ range, a good understanding of the associated uncertainties is critical in order to draw solid conclusions from recent RHIC data.
We use Hirai – Kumano – Nagai [1,2] (HKN) nuclear parton distributions in our pQCD-improved parton model [3] to evaluate systematic errors in the calculated nuclear modification factor resulting from uncertainties in the nuclear PDFs at RHIC and the LHC. At RHIC, the measured nuclear modification factor appears to be inconsistent with the pQCD model result for $p_T \geq 10$ GeV/c even when the systematic uncertainties in the nuclear PDFs are accounted for. On the other hand, the slopes of the calculated $R_{dAu}(p_T)$ are similar to the slopes of the PHENIX pion and photon data[4,5]. The inclusion of a small final-state energy loss can reduce the discrepancy with the data. At LHC, without final-state effects, we predict an enhancement of $R_{dPb}(p_T)$ in the transverse momentum range 10 GeV/c $\geq p_T \geq 100$ GeV/c.

References

[1] M. Hirai, S. Kumano, T.-H. Nagai, and K. Sudoh *Phys.Rev.* **D75**, (2007) 094009.
[2] M. Hirai, S. Kumano, and T.-H. Nagai, *arXiv:0709.3038 [hep-ph]*, (2007)
[3] B.A. Cole, G.G. Barnaföldi, P. Lévai, G. Papp, and G. Fai, *arXiv:hep-ph/0702101*, (2007)
[4] S.S. Adler *et al.*, [PHENIX], *Phys.Rev.Lett*, **98**, (2007) 172302.
[5] T. Isobe *et al.*, [PHENIX], *arXiv:nucl-ex/0701040*, (2007); D. Peressounko *et al.*, [PHENIX], *arXiv:nucl-ex/0609037*, (2006).

Parton rearrangement and fast thermalization in heavy-ion collisions at RHIC and LHC energies

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We have investigated the implications of parton rearrangement processes on the dynamics of ultra-relativistic heavy-ion collisions. A microscopic transport model, namely the quark gluon string model (QGSM) which has been extended for a locally density-dependent partonic rearrangement and fusion procedure served as the tool for this investigations. The model emulates effectively the dynamics of a strongly coupled quark plasma and final hadronic interactions.

We demonstrate that dynamical parton rearrangement which occurs in the very dense medium created in ultra-relativistic heavy-ion reactions during the early stages drives the system to fast kinetic equilibrium. Moreover, this mechanism improves significantly on the theoretical description of measured directed and elliptic flow, i.e., v_1 and v_2, distributions and their pseudorapidity dependence in Au+Au collisions at top RHIC energy of $\sqrt{s_{\rm NN}} = 200$ GeV. The shape of $v_2(\eta)$ is found to be closely related to fast thermalization. Furthermore, we present predictions for the pseudorapidity dependence of the azimuthal anisotropy parameters v_1 and v_2 of charged hadrons produced in central and semiperipheral Pb+Pb reactions at a LHC energy of $\sqrt{s_{\rm NN}} = 5.5$ TeV. Our simulation results, e.g., an increasing magnitude of v_2 at LHC conditions by about 10-20%, suggest in comparison with results of other transport models and hydrodynamical calculations that the hydrodynamical limit will be reached at this collision energy.

References

[1] J. Bleibel, G. Burau, A. Fäßler, and C. Fuchs, *Phys. Rev. C* **76**, (2007) 024912.
[2] J. Bleibel, G. Burau, and C. Fuchs, "Anisotropic flow in Pb+Pb collisions at LHC from the quark gluon string model with parton rearrangement", submitted to *Phys. Lett. B*

EARLY EVOLUTION OF TRANSVERSALLY THERMALIZED PARTONS

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Following our recent papers [1,2], we introduce and discuss the hydrodynamic description of transversally thermalized matter, possibly formed at the early stages of ultra-relativistic heavy-ion collisions. The formalism is based on the thermodynamically consistent approach with all thermodynamic variables referring to two-dimensional objects, the so-called transverse clusters, which are identified with the particles having the same rapidity. The resulting hydrodynamic equations for a single cluster have the form of the two-dimensional hydrodynamic equations of the perfect fluid. Since the clusters do not perform any work in the longitudinal direction, their energy is completely transformed and used to generate strong radial and elliptic flows. With a suitable choice of the initial and final temperatures one is able to describe the measured hadron spectra and the elliptic flow coefficient v_2.

The idea of purely transverse equilibration has been analyzed previously by Heinz and Wong in [3] with the conclusion that it cannot be realistic since it does not lead to the large elliptic flow found in the corresponding 3-dimensional hydrodynamic calculations. Our conclusions differ substantially from those reached in [3] because of at least two reasons: Firstly, we compare the results of our model calculations to the present data rather than to other hydrodynamic calculations. Secondly, we use a different technical implementation of the concept of transverse thermalization and longitudinal free-streaming.

References
[1] A. Bialas, M. Chojnacki, and W. Florkowski, arXiv:0708.1076 [nucl-th].
[2] M. Chojnacki and W. Florkowski, arXiv:0710.5871 [nucl-th].
[3] U. Heinz and S. M. H. Wong, Phys. Rev. **C66** (2002) 014907.

Gluon saturation and the high energy limit of hadronic cross sections

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At very high energies we expect that the hadronic cross sections satisfy the Froissart bound, which is a well-established property of the strong interactions. In this energy regime we also expect the formation of the Color Glass Condensate, characterized by gluon saturation and a typical momentum scale: the saturation scale Q_s. In this contribution we show that if a saturation window exists between the nonperturbative and perturbative regimes of Quantum Chromodynamics (QCD), the total cross sections satisfy the Froissart bound. Furthermore, we show that our approach allows us to describe the high energy experimental data on $pp/p\bar{p}$ total cross sections. Our first results on this subject were published in [1]. The present contribution contains new (yet unpublished) material.

References
[1] F. Carvalho, F.O. Durães, V.P. Gonçalves and F.S. Navarra, e-Print: arXiv:0705.1842 [hep-ph].

TWO-PARTICLE DISTRIBUTION IN AA COLLISIONS IN THE CGC FRAMEWORK

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We evaluate the 2-particle spectrum resulting from the collision of two heavy ions in the Color

Glass Condensate framework. Our approach provides an explicit expression for the Leading Order 2-particle correlation function in terms of classical fields and quantum fluctuations about the classical field. We report on preliminary results on 1-loop corrections to the 2-particle spectrum and the insight they provide into high energy factorization in QCD. The implications of these results for correlated particle production at RHIC and the LHC are discussed.

The glasma initial state at the LHC

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We present results from numerical classical Yang-Mills calculations of the initial stage Glasma color field configurations in a relativistic heavy ion collision. We compute the initial gluon multiplicity and transverse energy from RHIC to LHC energies. The initial conditions for the classical field computation are taken from a dipole model parametrization tested on HERA data. This enables us to perform a computation where all the parameters, including the normalization and the value of the saturation scale, are fixed from DIS data. By using a suitable parametrization of the dipole cross section we can study the influence of DGLAP and BK evolution on bulk properties of heavy ion collisions at both fixed and running coupling.

Review of Forward Physics

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The forward region of heavy ion collisions offers a unique regime to test QCD. Measurements at high rapidity are sensitive to the low x structure of the nucleus and to the dynamics of the color fields created by the collision. Does the matter expand from a standing start or is it dragged behind the receding nuclei? How rapidly does it thermalize? How long do different parts of the system stay in causal contact? How are jet quenching and quark recombination modified in a system with such strong time dilation affects? Recent data from all four of the RHIC experiments is starting to paint a picture of the system at several stages of its evolution. I will review these data and attempt to link them to the questions listed above. Finally I will sketch recent theoretical work and the exciting opportunities afforded by new detectors at RHIC and LHC.

AZIMUTHAL CORRELATIONS OF FORWARD DIJETS IN D-AU COLLISIONS

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Studying correlations of forward dijets in proton-nucleus collisions will further test the Color Glass Condensate (CGC) picture of the nuclear wavefunction at small-x. I will focus on correlations in azimuthal angle. They were measured in the first d-Au run at RHIC and the second run will provide the opportunity to turn the qualitative CGC estimations into a quantitative description, as was done in the case of single particle production at forward rapidities. I will derive forward inclusive dijet production in the scattering of a dilute hadron p off an arbitrary dense target A, whose partons with small fraction of momentum x_A are described by a CGC. This is of relevance for measurements of two-particle correlations $pA\to h_1h_2X$ with h_1 and h_2 detected in the proton direction.
While this process is probing small$-x$ partons in A, only high-momentum valence partons of p contribute to the scattering, and with RHIC kinematics, the dominant partonic subprocess is $qA\to qgX$. This two-particle spectrum can be expressed in terms of correlators of Wilson lines. Computing the correlators with a Gaussian CGC wavefunction allows to include (in the large$-N_c$ limit) both multiple scattering and non-linear QCD evolution at small$-x$ (so-called Balitsky-Kovchegov evolution). The cross-section for the production of the quark-gluon dijet (with respective transverse momenta $q_\perp$ and $k_\perp$ and rapidities $y_q>0$ and $y_k>0$) reads:

$$\frac{d\sigma^{pA\to qgX}}{d^2k_\perp d^2q_\perp dy_k dy_q}\propto\frac{\alpha_S C_F}{4\pi^2}x_p q(x_p,\Delta^2)\sum_{\lambda\alpha\beta}\left|I^\lambda_{\alpha\beta}(z,k_\perp-\Delta;x_A)-\psi^\lambda_{\alpha\beta}(z,k_\perp-z\Delta)\right|^2 F(x_A,\Delta^2)$$

$$\text{with}\qquad \begin{array}{l}1/z-1=|q_\perp|\;e^{y_q-y_k}/|k_\perp|\\ \Delta=k_\perp+q_\perp\end{array}\qquad,\qquad \begin{array}{l}\sqrt{s}\;x_p=|k_\perp|e^{y_k}+|q_\perp|e^{y_q}\\ \sqrt{s}\;x_A=|k_\perp|e^{-y_k}+|q_\perp|e^{-y_q}\end{array}\;.$$

The dilute hadron contributes via the quark distribution function $q(x_p,\Delta^2)$. By contrast, the CGC cannot be described only by its (unintegrated) gluon distribution function $F(x_A,\Delta^2)$: the so-called k_T-factorization framework is not applicable (it would if there was no other x_A dependence). As the valence quark emits the virtual gluon via lowest-order pQCD Bremsstrahlung (the associated wavefunction is $\psi^\lambda_{\alpha\beta}$ where λ, α and β are polarization and spin indices) it interacts coherently with the dense small$-x$ gluons in A, which modifies the $q\to qg$ splitting and yields the factor $\sum_{\lambda\alpha\beta}\left|I^\lambda_{\alpha\beta}(x_A)-\psi^\lambda_{\alpha\beta}\right|^2$. Details can be found in [1].
Considering the correlations in azimuthal angle, we obtain that the perturbative back-to-back peak of the azimuthal angle distribution (which we recover for very large momenta) is reduced by initial state saturation effects. As the momenta decrease closer to the saturation scale ($Q_s\simeq 2$ GeV), the angular distribution broadens. But at RHIC energies, saturation does not lead to a complete disappearance of the back-to-back peak.

References

[1] Cyrille Marquet, *Nucl. Phys.* **A**, in press, arXiv:0708.0231.

QUARK STRUCTURE OF NUCLEONS INSIDE THE COLLIDING NUCLEI:

THE ROLE OF INITIAL STATE INTERACTIONS

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Quark structure of nuclei is analyzed in the framework of the Strongly Correlated Quark Model (SCQM) of nucleon structure. Proposed by the author, this model demonstrates the interconnection between constituent and current quark models and leads to the representation of constituent quarks as solitons [1]. According to the model three quarks inside nucleons oscillate around the origin in correlated motion. Derived interquark potential explicitly demonstrates that relativistic (current) quark configurations are located at the origin of oscillation and constituent (non–relativistic) quark ones are at maximal displacements, respectively. Putting aside the mass and charge differences of valence quarks one can say that inside nucleons three quarks, surrounded by condensate of sea quarks and gluons, oscillate along the bisectors of equilateral triangle with spins perpendicular to the plane of oscillation. Quarks inside nuclei are arranged according to $SU(3)_{color} \otimes SU(2)_{flavor} \otimes SU(2)_{spin}$ and the nucleons being colorless quark clusters. Applying the above mechanism of quark – quark interactions to the quarks of the adjacent (bound) nucleons inside nuclei we demonstrate that these interactions lead nucleon–nucleon correlation. Nucleon–nucleon correlations are arranged in such a way that they form lattice–like nuclear structure. Such a nucleon arrangement brings together shell, liquid-drop and cluster characteristics, as found in the conventional models, within a single theoretical framework [2].
In bound nucleons inside nuclei relativistic quark states, which correspond to small quark configurations, are suppressed and constituent quark configurations are dominating. This rearrangement of quark states inside nuclei results in modification of the structure of the bound nucleons which appears as observable "EMC–effect" and Color Trasparency Breaking in quasielastic proton–proton scattering in large angle proton–nucleus collisions. In relativistic and ultra–relativistic nucleus–nucleus collisions which were realized at SPS and RHIC this modification is one of the sources of J/ψ and high p_t-jets suppression. This suppression comes from the initial state interactions as far as small quark configurations states inside bound nucleons are suppressed.

References

[1] G. Musulmanbekov in Frontier of Fundamental Physics 4, Ed. B. G. Sidharth, Kluwer Acad./Plenum Pub., 2001, p.109.
[2] N.D. Cook, J. Phys. G: Nucl. Part. Phys., **23** (1997) 1109 and references therein.

Effects of CGC on J/ψ production in nucleus-nucleus collisions

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We calculate the production of J/ψ in Au-Au collisions at RHIC by taking into account gluon saturation effects in the nuclei. The new J/ψ production mechanism, provided by gluon saturation and CGC formation [1], gives a stronger suppression at forward rapidity, as a function of the centrality, than at midrapidity, in agreement with recent RHIC data. We compare our results with RHIC data and give predictions for LHC energies.
Work in preparation.

References

[1] D. Kharzeev and K. Tuchin, Nucl. Phys. A **770** (2006) 40 [arXiv:hep-ph/0510358].

Thermal Equilibrium in Relativistic Heavy-Ion Collisions.

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The scattering rates of quarks and gluons has been evaluated perturbatively and compared with the expansion rate of a radially expanding quark gluon plasma (QGP). Similar study for the hadronic phase has been been performed. Although the experimental results from RHIC needs very small thermalization time it is observed that the system remains out of equilibrium with the perturbative inputs. The sensitivity of the results on various input parameters will be presented.

Chemical equilibration of QGP enforcing baryon number conservation

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Parton equilibration for a thermally equilibrated but chemically non-equilibrated quark-gluon-plasma is presented. Parton equilibration is studied enforcing baryon number conservation. Process like quark flavour interchanging is also considered. The degree of equilibration is studied comparatively for the various reactions / constraints that are being considered.

Initial conditions and space-time scales in relativistic heavy ion collisions.

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The space-time picture of the hadron emission versus initial energy density and transverse flow profiles is analyzed within hydro-kinetic model for A+A collisions. The model treats the formation of hadronic spectra as a result of continues process of particle liberation which is analyzed within Boltzmann equations in generalized relaxation time approximation [1]. It accounts for the particle escape probability and back reaction of particle emission on hydrodynamic evolution [2]. We study which type of initial conditions and equation of state (EoS) are preferred in view of current RHIC data. It is found that observed relatively small increase of interferometry radii with energy (so called RHIC HBT puzzle) is caused by

- developing of the initial transverse flows at early pre-thermal partonic stage [3]. The formation of such flows is calculated within Color Glass Condensate picture;
- relatively hard EoS corresponding to cross-over, not first order phase transition, between hadron and quark-gluon matter at top RHIC energies;
- earlier emission of hadrons, as compare with sudden freeze-out picture based on Landau/Cooper-Frye prescription, because escape probability accounts for whole particle trajectory in rapidly expanding surrounding, but not mean free pass at freeze-out temperature.

Within the hydro-kinetic picture of the evolution the successful description of the hadronic spectra and interferometry radii for RHIC energies is done and corresponding predictions for central nucleus-nucleus collisions at LHC energies is presented [4].

References
[1] Yu.M. Sinyukov, S.V. Akkelin and Y. Hama, *Phys. Rev. Lett.*, **89**, (2002), 052301.
[2] S.V. Akkelin, Y.Hama, Iu. Karpenko, Yu.M. Sinyukov, prepared for publication (2007).
[3] M.Gyulassy, Iu.Karpenko, A.V.Nazarenko, Yu.M.Sinyukov, *Braz. Journ. of Phys.*, **37**, (2007), 1031.
[4] Yu.M. Sinyukov , S.V. Akkelin, Iu.A. Karpenko. *arXiv: 0706.4066*, (2007) (Contributed to the Workshop on Heavy Ion Collisions at the LHC: Last Call for Predictions, Geneva, Switzerland, 14 May - 8 Jun 2007, to be published in Journal of Physics G, 2007).

What can we learn from Polarization probes in heavy ion collision?

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We discuss the information that can be deduced from a measurement of particle (hyperon or vector meson) polarization in ultrarelativistic nuclear collisions. We describe the sensitivity of polarization to initial conditions, in particular with regard to the initial longitudinal distribution of matter, focusing on "Firestreak" and Bjorken/BGK models. We also show that the polarization observable is sensitive to all details and stages of the system's evolution, as well as the mean free path. We suggest that an experimental investigation covering production plane and reaction plane polarizations, as well as the polarization of jet-associated particles in the plane defined by the jet and particle direction, can help in disentangling the factors contributing to this observable. Scans of polarization in energy and rapidity might also point to a change in the system's properties.

References

[1] B. Betz, M. Gyulassy and G. Torrieri, In press, P.R.C., arXiv:0708.0035 [nucl-th].

Gluon Number Fluctuations in Small x Physics

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The effect of gluon number uctuations (Pomeron loops) in small x physics is studied in the xed coupling case. We nd that the gluon number uctuations play a important role on describing the DIS data. Also the values of the parameters, like the saturation exponent and the diusion coecient, turn out reasonable and agree with values obtained from numerical simulations of toy models which take into account uctuations. This outcome seems to indicate the evidence of geometric scaling violations, and a possible implication of gluon number uctuations, in the DIS data. However, we cannot exclude the possibility that the scaling violations may also come from the diusion part of the solution to the BK-equation, instead of gluon number uctuations.

References

[1] M. Kozlov, A.I. Shoshi, and W.C. Xiang, JHEP, 10, (2007) 20.
[2] A.H. Mueller and A.I. Shoshi, Nucl. Phys. B 692 (2004) 175.
[3] A.H. Mueller, A.I. Shoshi and S.M.H. Wong,Nucl. Phys. B715 (2005) 440.

GLUON RECOMBINATION IN HIGH PARTON DENSITY QCD

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We argue that the collinear factorization of the fragmentation functions in high energy hadron and nuclear collisions breaks down at transverse momenta $k_T \leq Q_s/g$ due to high parton densities in the colliding hadrons and/or nuclei. We then argue that gluon recombination, which is basically the merging of two classical elds, should dominate in that k_T regime. We calculate, at next-to-leading order in projectile parton density and to all orders in target

parton density, the double-inclusive cross-section for production of a pair of gluons in the scalar $J^{PC} = 0^{++}$ channel. We then generalize our results to AuAu collisions at RHIC energy. Using the low energy theorems of QCD we nd the inclusive cross-section for π-meson and baryon production. Finally, we compare our results for baryon to meson ratio with the experimental data from RHIC.

References

[1] Y. Li and K. Tuchin, Phys. Rev. D, 75, (2007) 074022. [2] Y. Li and K. Tuchin, to be submitted.

Regge behaviour of distribution functions and the leading and next-to-leading order gluon distribution from Dokshitzer-Gribov-Lipatov-Altarelli-Parisi evolution equation at low-x

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Evolution of gluon distribution function from Dokshitzer-Gribov-Lipatov-Altarelli- Parisi evolution equation in leading and next-to-leading order at low-x are presented assuming the Regge behaviour of quarks and gluons at this limit. We compare our results of gluon distribution function with MRST 2001, MRST 2004 and GRV 1998 parameterizations and show the compatibility of Regge behaviour of quark and gluon distribution functions with perturbative quantum chromodynamics at low-x.

Solution of non-singlet Dokshitzer-Gribov-Lipatov-Alterelli-Parisi Parisi evolution equation in next-next-to-leading order at small-x by method of characteristics

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The non-singlet structure functions have been obtained by solving Dokshitzer-Gribov-Lipatov-Alterelli-Parisi (DGLAP) evolution equations in next-next-to-leading order (NNLO) at the small-x limit. Here a Taylor series expansion has been used and then the method of characteristics has been applied to solve the evolution equations. Results are compared with the Fermilab experiment E665 data and New Muon Collaboration (NMC) data.