QCD with Electron Ion Collider (QEIC) II

Report of Contributions

https://indico.cern.ch/e/qeic2

Contribution ID: **1** Type: **not specified**

Imagining Hadrons: Lattice QCD in the EIC Era

Sunday 18 December 2022 14:15 (45 minutes)

To fully realize EIC's goal on 3-dimensional imaging of hadrons complementary lattice QCD results for PDF, GPD, TMD etc. are essential. This talk will provide an overview of some recent progresses in lattice QCD calculations of partonic structures of hadrons.

Author: MUKHERJEE, Swagato

Presenter: MUKHERJEE, Swagato

Contribution ID: **2** Type: **not specified**

Classical and Statistical Physics version of Proton's pressure distribution

Tuesday 20 December 2022 12:00 (30 minutes)

Proton is our stable microscopic platform, allowing four forces - strong, electromagnetic, weak and gravity to act in terms of their respective form factors, where the gravitational form factors describe the hadron's mass, spin, and D term. Recently, in 2018, the D term has been extracted from the experiment and pressure distribution inside the proton is sketched. The shocking part of this results is that the pressure near the center of the proton is crossing the value of neutron star pressure. Present work has attempted to understand this shocking pressure distribution in terms of a simple version of classical and statistical physics. This attempt does not claim about realistic explanation of proton pressure distribution but may be considered as crude visualization to compare
our existing aspects of classical and statistical physics.

Authors: Mr AUNG, Cho Win (IIT Bhilai); Ms WIN, Thandar Zaw (IIT Bhilai); Mr UMAR, Jabed (NISER); Mr SINGH, Deependra (NISER); GHOSH, Sabyasachi

Presenter: GHOSH, Sabyasachi

Contribution ID: **3** Type: **not specified**

Transverse single spin asymmetry at two loops

Monday 19 December 2022 09:15 (30 minutes)

This talk is mostly based on our recent work [1] where we numerically compute transverse single spin asymmetry (SSA) in SIDIS based on a new mechanism suggested in [2]. In this mechanism, the phase required for the asymmetry is generated from higher order diagrams. Specifically in [2] it was demonstrated that with the $g_T(x)$ quark distribution for the transversely polarized proton, a non-zero STSA appears first at two-loops. In our work, we also included an analogous gluon-initiated contribution arising from the $G_{3T}(x)$ distribution. In our framework, both $g_T(x)$ and $G_{3T}(x)$ were considered in the Wilczek-Wandzura (WW) approximation, i.e., as integrals of the quark and gluon helicity distributions respectively. Hence these contributions to the asymmetry can be evaluated unambiguously without inputs from unknown parameters such as dynamical twist-3 distributions. Overall, we are using a collinear framework appropriate for high p_T hadron production, so our results serve as predictions for the planned Electron Ion Collider (EIC). We find that the asymmetry associated with the $\sin(\phi_h - \phi_S)$, $\sin(\phi_S)$ and $\sin(2\phi_h - \phi_S)$ harmonics can reach up to 1-2$\%$ at the EIC. Further I will also discuss our recent calculations [3] which extend this mechanism to hadron and direct photon production in forward pp collisions and present numerical estimates for them. We find that while the SSA for forward hadron production production is rather small, the asymmetry for direct photon production can reach upto 1% in the very forward regions at small values of p_T (1-2 GeV). In general our results for SIDIS and pp collisions should be understood as parts of the respective NLO computations that would be indispensable for a quantitative assessment of SSA.

[1] S. Benić, Y. Hatta, A. K, H-n. Li, Phys. Rev. D 104 (2021), 094027

[2] S. Benić, Y. Hatta, H-n. Li, D.-J. Yang, Phys. Rev. D 100 (2019) 9, 094027

[3] S. Benić, Y. Hatta, A. K, H-n. Li, in preparation

Authors: KAUSHIK, Abhiram (University of Zagreb); LI, Hsiang-nan (Academia Sinica); BENIĆ, Sanjin; Dr HATTA, yoshitaka (BNL)

Presenter: KAUSHIK, Abhiram (University of Zagreb)

Contribution ID: **4** Type: **not specified**

Charmonia production at HERA in CGC model using a holographic AdS/QCD light front wavefunction

We use an anti-de Sitter/Quantum Chromodynamics (AdS/QCD) based holographic light-front wavefunction for the J/ψ meson, in conjunction with the Color dipole model cross-section to investigate the cross-sections data for exclusive J/ψ electroproduction. We have used the updated set of color dipole model parameters fitted to the most recent 2015 high precision HERA data on inclusive Deep Inelastic Scattering (DIS). Our results suggest that the holographic meson light-front wavefunction with color dipole model is able to give a successful description for rate of diffractive J/ψ electroproduction for HERA data at small x in a wide range of Q^2 for the quark mass $m_c = 1.27$ GeV. We also computed the rapidity distributions of J/ψ meson in dipole model proton-lead ultraperipheral coliisions(UPC). Our predictions are in good agrrement with the experimental data of ALICE.

Author: SHARMA, Neetika (Department of Physical Sciences, I K Gujral Punjab Technical University, Kapurthala-144603, Punjab, India.)

Presenter: SHARMA, Neetika (Department of Physical Sciences, I K Gujral Punjab Technical University, Kapurthala-144603, Punjab, India.)

Contribution ID: **5** Type: **not specified**

Angularity event shape for DIS in Soft-Collinear Effective Theory (SCET)

Monday 19 December 2022 14:15 (30 minutes)

One of the classic ways of studying QCD events in high-energy experiments is to measure the Event Shape variables e.g., Thrust, Jet Broadening, Angularity etc. which are observables designed to characterize several properties including the geometric shape of hadron distribution in the event. In this talk, we will discuss a more general global event shape "angularity" for deep inelastic scattering process (DIS), eP -> dijet, in the framework of Soft-Collinear Effective Theory (SCET) and give precision prediction to the DIS angularity cross-section for future Electron-Ion-Collider(EIC) at next-to-next-to-leading log (NNLL) accuracy. The talk is mostly based on our recent publication JHEP11(2021)026.

Angularity is a class of event-shape observables that can be measured in
deep-inelastic scattering (EIC at BNL). With its continuous parameter 'a' one can interpolate angularity between thrust and broadening and further access beyond the region. Providing such a systematic way to access various observables makes angularity attractive in analysis with event shapes. We give the definition of angularity for DIS and factorize the cross-section by using the soft-collinear effective theory. The factorization is valid in a wide range of below and above thrust regions but invalid in broadening limits. It contains an angularity beam function, which is the new result, and we give the expression at O(αs). We also perform large log resummation of angularity and make predictions at various values of 'a' at next-to-next-to-leading log accuracy.

Authors: KANG, Daekyoung (Fudan University); Mr ZHU, Jiawei (Fudan University, Shanghai); MAJI, Tanmay (IIT Hyderabad, Hyderabad, India)

Presenter: MAJI, Tanmay (IIT Hyderabad, Hyderabad, India)

Contribution ID: **7** Type: **not specified**

Accessing linearly polarized gluon TMD in back-to-back J/ψ and jet production at the EIC

Monday 19 December 2022 16:00 (30 minutes)

We present a calculation of the $\cos 2\phi$ azimuthal asymmetry in $e\,p \to e\,J/\psi\,Jet\,X$, where $J/\psi - Jet$ pair is almost back-to-back in the transverse plane, within the framework of the generalized parton model (GPM) and assuming TMD factorization. This probes the Weisz{\"a}ker-Williams type linearly polarized gluon distribution. We calculate the asymmetry using non-relativistic QCD (NRQCD) for the production of J/ψ incorporating both color singlet and color octet contributions. We study the dependence of the asymmetry on the parametrizations of the gluon TMDs used, as well as the impact of TMD evolution on the asymmetry. We present numerical estimates in the kinematical regions to be accessed by
the future EIC.

Authors: PAWAR, Amol; Prof. MUKHERJEE, Asmita (IIT Bombay); Dr SIDDIQAH, Mariyah (IIT Bombay); Dr KISHORE, Raj

Presenter: PAWAR, Amol

Contribution ID: **8** Type: **not specified**

Probing gluon orbital angular momentum through exclusive dijet production at the EIC

Monday 19 December 2022 14:45 (45 minutes)

By considering double spin asymmetry (DSA) in exclusive dijet production in ep collisions, we demonstrate for the first time that the $cos(\phi)$ angular correlation between the scattered electron and proton is a direct probe of the gluon orbital angular momentum and its interplay with the gluon helicity. We also make an estimate of the DSA for typical kinematics of the future Electron Ion Collider.

Authors: BHATTACHARYA, Shohini (Brookhaven National Laboratory); BOUSSARIE, Renaud (CPHT, CNRS, Ecole polytechnique, IP Paris); Dr HATTA, yoshitaka (BNL)

Presenter: BHATTACHARYA, Shohini (Brookhaven National Laboratory)

Contribution ID: **9** Type: **not specified**

Nuclear matter study at sPHENIX experiment

Monday 19 December 2022 16:30 (45 minutes)

We propose in this talk to investigate the QCD dynamics at sPHENIX experiment through two studies:

First, the internal jet structure study provides information about the hadronization process in non-perturbative QCD dynamics. The non-perturbative flavor correlation between pairs of leading and next-to-leading charged hadrons is proposed. The correlation ratio observable r_c for protons, kaons and pions for various kinematic variables is investigated.

Second, the Drell-Yan (DY) process is also discussed as a probe of transport properties of the cold nuclear matter (CNM). The DY events extraction involves a precise knowledge of QCD background participating in the dilepton invariant mass spectrum. A fit of this one, including open-charm, open-bottom, charmonium and bottomonium simulations, is shown. CNM effects are investigated via the rapidity (y) and transverse momentum ($p_\perp$) distributions of the DY dilepton pair.

Author: NAIM, Charles Joseph

Presenter: NAIM, Charles Joseph

Contribution ID: **10** Type: **not specified**

Gluon helicity distributions in the proton from holographic light-front QCD

Monday 19 December 2022 10:15 (30 minutes)

In 1988 the European Muon Collaboration (EMC) at CERN shocked the physics community by announcing that the sum of the spins of the three quarks that make up the proton is much less than the spin of the proton itself, later on which is known so-called "proton spin puzzle". Physicists have been unable to answer a seemingly simple question: where does proton spin come from? How the proton's spin originates from its constituents like quarks and gluons and their interactions, which are regulated by quantum chromodynamics (QCD), is a key issue in nuclear and particle physics. In order to address this issue, the spin sum rules divide the proton's spin into its quark and gluon spin and angular momentum components. The quark and gluon spin components come from the parton distribution functions, while the orbital angular momenta are related to the Generalized Parton Distribution functions (GPDs). So basically in this talk, I will address the individual contributions to the proton spin from all the constituents. In particular, we will look at two different types of decompositions of the proton spin: (1) the non-gauge invariant Jaffee-Manohar decomposition, and (2) the gauge invariant decomposition proposed by Ji.

Author: GURJAR, BHEEMSEHAN (Indian Institute of Technology Kanpur)

Co-authors: Dr MONDAL, Chandan (nstitute of Modern Physics, Chinese Academy of Sciences, Lanzhou 730000, China); Prof. CHAKRABARTI, Dipankar (Indian Institute of Technology Kanpur, India)

Presenter: GURJAR, BHEEMSEHAN (Indian Institute of Technology Kanpur)

Contribution ID: **11** Type: **not specified**

Sum rules for the Graviational Form Factors in light-front dressed quark model

Tuesday 20 December 2022 11:30 (30 minutes)

First, we give a brief overview of the light-front dressed quark model, per se, instead of a proton state, we use a simple composite spin-1/2 state that is a quark dressed with a gluon. It is a perturbative model and has gluonic degrees of freedom. Then we outline the formalism used to evaluate the gravitational form factors (GFFs) of quarks and gluons in a dressed quark model. We use the Hamiltonian framework and choose the light-front gauge such that the two-component formalism eliminates the constraint fields. We calculate the four GFFs and corroborate the sum rules that GFFs satisfy. Of the four GFFs, the D-term as we know is not related to any Poincare generator so it remains unconstrained. This D-term is attributed to information like pressure, shear, and energy distributions. So, we analyze these distributions for a quark state dressed with a gluon at one loop in QCD.

Author: MORE, Jai (INDIAN INSTITUTE OF TECHNOLOGY BOMBAY)

Co-authors: MUKHERJEE, Asmita; NAIR, SREERAJ; Mr SAHA, Sudeep

Presenter: MORE, Jai (INDIAN INSTITUTE OF TECHNOLOGY BOMBAY)

Contribution ID: **12** Type: **not specified**

Towards electron-ion event generation in Pythia

Monday 19 December 2022 11:45 (45 minutes)

General-purpose event generators such as Pythia are programs that model complete particle interactions, including the hard process, parton showers, multiparton interactions, hadronization, etc. The objective of these generators is to provide state-of-the-art predictions for high energy collisions, and are essential for bridging the gap between theoretical models and experimental data. Pythia also includes the Angantyr framework for heavy ion collisions. One of the long-term goals of the Pythia collaboration is to extend this framework to electron-ion collisions.

In this talk, I present our initial work towards this goal. In this first step, we consider vector meson dominance (VMD) processes where the interaction is initiated by a photon that fluctuates into a vector meson, i.e. processes that are essentially hadronic interactions. These interactions will be implemented for both photon-proton, as well as photon-ion via the Angantyr framework, and are relevant for modelling the resolved state of a low-virtuality photon. We compare the results to full photoproduction in photon-proton.

Author: UTHEIM, Marius

Presenter: UTHEIM, Marius

Contribution ID: **13** Type: **not specified**

Exclusive Diffraction with the EPIC detector

Tuesday 20 December 2022 10:15 (45 minutes)

One of the golden measurements at the Electron-Ion Collider (EIC) is to measure the coherent diffractive Vector-Meson (VM) production off heavy nuclei. The measurement is expected to be sensitive to the non-linear gluon dynamics - saturation, and most importantly, it also provides the gluon density distribution of the nucleus. While the measurement was established in the EIC White Paper 10 years ago, it is not until recently that the experimental challenges of this measurement were realized. In this talk, I will discuss the physics motivation, key challenges associated with the measurement, and their potential solutions in the context of electron-gold collisions, including detector resolution and overwhelming background. Full simulations based on the most up-to-date EPIC detector design at the EIC will be presented.

Author: TU, Zhoudunming

Presenter: TU, Zhoudunming

Contribution ID: **14** Type: **not specified**

Quark and gluon spin and orbital angular momentum in the proton : A light-front Hamiltonian approach

Monday 19 December 2022 09:45 (30 minutes)

There is a well-known crisis: one of the fundamental properties of the proton, its spin, is not the same as the sum of its constituent quark spins. The gluon's contribution to the proton spin is nonvanishing and likely sizable. Yet, there remain large uncertainties about the gluon's contribution and resolving this issue is one of the major goals of the upcoming Electron-Ion-Colliders. We address this fundamental issue with a fully relativistic and nonperturbative approach based on a light-front quantized Hamiltonian with Quantum Chromodynamics (QCD) input. From this, we calculate the effects from incorporating a dynamical gluon on the proton's gluon densities, helicity distribution and orbital angular momentum that constitutes the proton spin sum rule. We predict about 26% of the proton's spin is carried by the gluon's helicity and about 1.3% by its orbital angular momentum in low-momentum transfer experiments. Our approach also provides a good quality description of the proton's quark distribution functions following QCD scale evolution.

Author: MONDAL, Chandan

Co-authors: XU, siqi; ZHAO, Xingbo; LI, Yang (University of Science and Technology of China); VARY, James

Presenter: MONDAL, Chandan

Contribution ID: **15** Type: **not specified**

Diffractive Vector Meson production using Sartre with Machine Learning

Monday 19 December 2022 11:15 (30 minutes)

We use Machine Learning with an event-generator (Sar*t*re) for
the process: e
$p \to e'\ p'\ V_M, e\ A \to e'\ A'\ V_M$.
Sar*t*re uses 3-dimensional look-up tables to generate events
in which the first two moments of the Amplitude are stored. In eA collisions the generation of these lookup tables takes many months. I will present a method, using neural networks, which reduces the computing time by up to 90%. This will be important for doing simulations in the ongoing preparations for the electron-ion collider.

Author: SINGH, Jaswant (Indian Institute of Technology New Delhi)

Co-author: TOLL, Tobias

Presenter: SINGH, Jaswant (Indian Institute of Technology New Delhi)

Contribution ID: **16** Type: **not specified**

Probing the gluonic structure of pions with tagged DIS (TDIS)

Tuesday 20 December 2022 09:45 (30 minutes)

Tagged-DIS (TDIS) provides a unique opportunity to study the structure of targets which are not readily available. One can study the longitudinal pion structure in a semi-inclusive measurement by measuring the leading neutrons in the far forward direction in addition to the scattered electron in the usual DIS. Theoretically, in the so-called Sullivan process, the cross section in these events is given as a product of a chiral splitting function (proton to neutron + pion) and the structure function of the (nearly on-shell) exchanged pion. We performed a phenomenological study of the predictions of dipole models in leading neutron DIS at high energy. Our investigations hint toward a universal longitudinal structure of pions and protons at high energy. On the other hand, extending the study to exclusive vector meson production with leading neutrons provides the pathway to investigate the spatial extent of the pion cloud and gluon distribution of pions.

Author: KUMAR, Arjun (Indian Institute of Technology Delhi)

Co-author: TOLL, Tobias

Presenter: KUMAR, Arjun (Indian Institute of Technology Delhi)

Contribution ID: **17** Type: **not specified**

Nucleon-nucleon correlations inside atomic nuclei: review of experimental observations

Tuesday 20 December 2022 12:30 (30 minutes)

There has been a steady flux of new experimental evidences confirming the presence of short-ranged structures inside atomic nuclei, dominated by correlations between pairs of nucleons. The role of these internal nucleon-nucleon correlations has been established using various energetic probes like photons, pions, leptons and hadrons. These correlated structures are essential for understanding the interaction of particles with nuclei and their presence provides an explanation of many specific

nuclear phenomena including backscattered protons, copious deuteron production, sub-threshold particle production, neutrino interactions with nuclei and the EMC effect.

We will highlight a wide range of different experimental studies in this area along with some specific suggetions for experimental observation of 3N correlation in upcoming EIC experiment.

Author: Dr DALAL, Ranjeet (Guru Jambheshwar University of Science and technology, Hisar)

Presenter: Dr DALAL, Ranjeet (Guru Jambheshwar University of Science and technology, Hisar)

Contribution ID: **18** Type: **not specified**

Welcome and inauguration

Sunday 18 December 2022 09:15 (15 minutes)

Contribution ID: **19** Type: **not specified**

Overview of the EIC and the goals of this meeting

Sunday 18 December 2022 09:30 (30 minutes)

Presenter: DESHPANDE, Abhay (Stony Brook University)

Contribution ID: **20** Type: **not specified**

The electron-ion collider – A world wide unique collider to unravel the mysteries of visible matter

Sunday 18 December 2022 10:00 (45 minutes)

Understanding the properties of nuclear matter and its emergence through the underlying partonic structure and dynamics of quarks and gluons requires a new experimental facility in hadronic physics known as the Electron-Ion Collider (EIC). The EIC will address some of the most profound questions concerning the emergence of nuclear properties by precisely imaging gluons and quarks inside protons and nuclei such as their distributions in space and momentum, their role in building the nucleon spin and the properties of gluons in nuclei at high energies. In January 2020 the EIC received CD-0 and Brookhaven National Laboratory was selected as site, and June 2021 CD-1. This presentation will give highlights on the EIC experimental program, introduce the experimental equipment and its integration into the accelerator and give the status of the EIC project, as well what are the next major steps. How contributing to the experimental program will be highlighted.

Presenter: ASCHENAUER, Elke (BNL)

Contribution ID: **21** Type: **not specified**

EIC : Indian Status & possibilities of contribution

Sunday 18 December 2022 12:00 (45 minutes)

Presenters: MOHANTY, Bedanga (NISER); DASGUPTA, Shuddha (NISER)

Contribution ID: **22** Type: **not specified**

EIC Computing, overview and areas where India can contribute

Sunday 18 December 2022 11:15 (45 minutes)

Presenter: DIEFENTHALER, Markus (JLab)

Contribution ID: **23** Type: **not specified**

Discussion

Sunday 18 December 2022 12:45 (20 minutes)

Presenter: DESHPANDE, Abhay (Stony Brook University)

Contribution ID: **24** Type: **not specified**

TBD

Contribution ID: **25** Type: **not specified**

Detailed Project Report Discussion

Sunday 18 December 2022 15:30 (2 hours)

Presenter: MOHANTY, Bedanga (NISER)

Contribution ID: **26** Type: **not specified**

Reception

Contribution ID: **27** Type: **not specified**

Imagining Hadrons: Lattice QCD in the EIC Era

Presenter: MUKHERJEE, Swagato

Contribution ID: **28** Type: **not specified**

Transverse single spin asymmetry at two loops

Presenter: KAUSHIK, Abhiram (University of Zagreb)

Contribution ID: **29** Type: **not specified**

LHeC prospects

Monday 19 December 2022 12:30 (30 minutes)

Presenter: MITRA, Soureek (KIT - Karlsruhe Institute of Technology (DE))

Contribution ID: **30** Type: **not specified**

The initial gluon profile: lessons from exclusive diffraction

Tuesday 20 December 2022 09:15 (30 minutes)

Presenter: TOLL, Tobias

Contribution ID: **31** Type: **not specified**

MC Net Monte Carlo school in India

Tuesday 20 December 2022 14:15 (20 minutes)

Presenter: UTHEIM, Marius

Contribution ID: **32** Type: **not specified**

Concluding Discussion

Tuesday 20 December 2022 14:35 (45 minutes)

Contribution ID: **33** Type: **not specified**

Registration

Sunday 18 December 2022 08:45 (30 minutes)