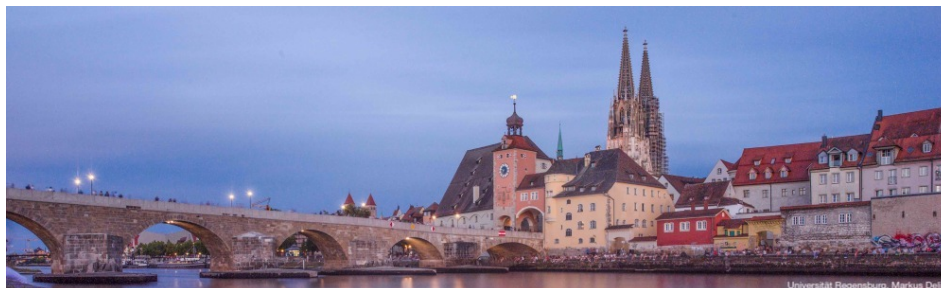


# LaMET 2023



## Report of Contributions

Contribution ID: 2

Type: **talk**

## Matching Factors for Quasi-GPDs with Hybrid Renormalization

*Wednesday 26 July 2023 14:00 (30 minutes)*

I will present the one-loop result of the matching kernels between the quasi-GPDs in hybrid renormalization and GPDs in the MS-bar scheme. We will also show the effect of the matching to modeled functions of GPDs.

**Author:** CHEN, Jiunn-Wei

**Presenter:** CHEN, Jiunn-Wei

Contribution ID: 3

Type: **talk**

## Factorization for lattice qTMD distributions at NNLO

*Tuesday 25 July 2023 16:00 (30 minutes)*

The determination of parton distributions with lattice simulations is a promising and rapidly growing direction in the physics of strong interactions. In particular, TMD factorization can be applied to a certain class of operators that can be computed within the lattice QCD approach. These are equal-time correlators usually called quasi-transverse-momentum dependent (qTMD) distributions. In this talk, I discuss the factorization theorem for qTMD distributions in terms of physical TMDPDFs and soft factors and present the computation of the next-to-next-to-leading order coefficient function.

**Authors:** DEL RÍO GARCÍA, Óscar (Complutense University of Madrid); VLADIMIROV, Alexey (Universidad Complutense de Madrid)

**Presenter:** DEL RÍO GARCÍA, Óscar (Complutense University of Madrid)

Contribution ID: 4

Type: **talk**

## TMDs and Quasi PDFs in Parton Model Approach

*Wednesday 26 July 2023 13:30 (30 minutes)*

The parton model is a well-known intuitive framework for first, exploratory studies of hadronic high energy reactions. The parton model can also be used to study nonperturbative properties of hadrons like structure functions and PDFs. The Wandzura-Wilczek relation is an example for that. The parton model approach has been (under the name “covariant parton model”) extended to describe TMDs and recently also quasi PDFs and some of the gravitational form factors of the proton. We review the recent progress with focus on the field theoretical foundations and the pure-spin vs mixed-spin state versions of the model. We also discuss the theoretical consistency of the approach, and demonstrate the validity of sum rules for quasi PDFs in this approach.

**Authors:** ASLAN, Fatma (University of Connecticut); SCHWEITZER, Peter; TANDOGAN, Asli (University of Connecticut)

**Presenter:** SCHWEITZER, Peter

Contribution ID: 5

Type: **talk**

## Ultraviolet renormalized quasi PDFs

Parton distribution functions (PDFs),  $f(x)$ , encode important nonperturbative information on the hadron structure as a function of light-cone momentum fraction  $x$  which can be extracted from experimental measurements of cross sections. The quasi parton distribution functions (qPDFs) of hadron momentum  $P_z$ ,  $\tilde{f}(\tilde{x}, P_z)$ , introduced in the large-momentum effective field theory (LaMET) approach, provide an alternative method to access the same nonperturbative information from lattice QCD calculations. PDFs and qPDFs could be related through an infra-red, collinear and ultraviolet (UV) safe matching coefficient that is calculable perturbatively with the corrections suppressed by the inverse power of  $P_z$ . However, there are challenges that must be overcome to uniquely determine such a matching coefficient. Although, PDFs and qPDFs contain the same nonperturbative physics at the leading power in  $1/P_z$ , the perturbative UV divergences of the qPDFs are different from that of PDFs, and more explicitly, the integration of  $\tilde{x}$  of  $\tilde{f}(\tilde{x}, P_z)$  or the first  $\tilde{x}$ -moment of qPDFs could lead to a divergence with a UV origin. To address this issue, we introduce a UV renormalization scheme for qPDFs so that the first moment of qPDFs is finite and the  $\tilde{x}$ -dependence of the matching coefficient is well defined for all values of  $\tilde{x}$ .

**Authors:** ASLAN, Fatma Pinar; Dr QIU, Jianwei (Jefferson Lab)

**Presenter:** ASLAN, Fatma Pinar

Contribution ID: 6

Type: **talk**

## A novel approach for calculating GPDs from asymmetric frames

*Wednesday 26 July 2023 17:00 (30 minutes)*

Recently, significant progress has been made in improving the efficiency and computational speed of lattice QCD calculations associated with Generalized Parton Distributions (GPDs). These advancements are a result of employing asymmetric frames, which differ from the commonly used symmetric frames, and introducing flexibility in the distribution of transferred momentum. A key element of our approach involves utilizing a Lorentz covariant parameterization for the matrix elements in terms of Lorentz-invariant amplitudes. This enables us to establish connections between matrix elements in different frames. Furthermore, we utilize the amplitude-based approach to propose an alternative definition of quasi-GPDs. This alternative definition not only maintains frame independence but also holds the potential for reduced power corrections when matching with light-cone GPDs. We thoroughly explore the interpretations of these new definitions, carefully examining the intricacies involved, and addressing the important issue of uniqueness/non-uniqueness in their formulation. In this presentation, we discuss these theoretical advancements, focusing specifically on the axial-vector GPDs  $\tilde{H}$  and  $\tilde{E}$ .

**Authors:** BHATTACHARYA, Shohini; CICHY, Krzysztof; Prof. CONSTANTINOU, Martha; GAO, Xiang (Argonne National Lab); METZ, Andreas; MILLER, Joshua (Temple University); MUKHERJEE, Swagato; STEFFENS, Fernanda; ZHAO, Yong

**Presenter:** BHATTACHARYA, Shohini

Contribution ID: 7

Type: **talk**

## Progress in Lattice calculations for the Boer-Mulders function of the pion

*Tuesday 25 July 2023 13:00 (30 minutes)*

We focus on the Boer-Mulders function of the pion and for now use the CLS ensemble X650 ( $a = 0.098$  fm,  $m_\pi = 338$  MeV) to study this quantity. Here, preliminary results of the ongoing work are shown, including extractions of the bare matrix elements and the rectangular Wilson loop. A main goal of the current work is to determine the largest momentum  $P^z$  at which we still see a sufficient signal.

**Author:** WALTER, Lisa

**Presenter:** WALTER, Lisa

Contribution ID: 8

Type: talk

# Unpolarized Transverse-Momentum-Dependent Parton Distributions of the Nucleon from Lattice QCD

*Tuesday 25 July 2023 13:30 (30 minutes)*

We present a first calculation of the unpolarized proton's isovector transverse-momentum-dependent parton distribution functions (TMDPDFs) from lattice QCD, which are essential to predict observables of multi-scale, semi-inclusive processes in the standard model. We use a  $N_f = 2 + 1 + 1$  MILC ensemble with valence clover fermions on a highly improved staggered quark sea (HISQ) to compute the quark momentum distributions in large-momentum protons on the lattice. The state-of-the-art techniques in renormalization and extrapolation in correlation distance on the lattice are adopted. The one-loop contributions in the perturbative matching kernel to the light-cone TMDPDFs are taken into account, and the dependence on the pion mass and hadron momentum is explored.

Our results are qualitatively comparable with phenomenological TMDPDFs, which provide an opportunity to predict high energy scatterings from the first principles.

**Author:** ZHANG, Qi-An

**Presenter:** ZHANG, Qi-An



Contribution ID: 9

Type: **talk**

## Quasi PDFs in the Covariant Parton Model

*Monday 24 July 2023 14:30 (30 minutes)*

The Covariant Parton Model is an appealing quark model framework that has been applied successfully to the description of structure functions, PDFs, and TMDs at the leading and subleading twist levels. In this contribution, the first application of the covariant parton model to quasi-PDFs is presented. Numerical results are presented and compared to lattice QCD results.

**Authors:** TANDOGAN, Asli (University of Connecticut); ASLAN, Fatma (University of Connecticut); SCHWEITZER, Peter

**Presenter:** TANDOGAN, Asli (University of Connecticut)

Contribution ID: 10

Type: talk

## Transversity PDFs of the proton from lattice QCD with physical quark masses

*Wednesday 26 July 2023 13:00 (30 minutes)*

We present a lattice QCD calculation of the transversity isovector- and isoscalar-quark parton distribution functions (PDFs) of the proton utilizing a perturbative matching at next-to-leading-order (NLO). Additionally, we determine the isovector and isoscalar tensor charge for the proton. The calculations are performed using a single ensemble of  $N_f = 2 + 1$  highly-improved staggered quarks simulated with physical-mass quarks and a lattice spacing of  $a = 0.076$  fm. The Wilson-clover action, with the gauge links after one iteration of HYP smearing and physical quark masses, is used in the valence sector. The leading-twist OPE approximation is then utilized to extract the lowest four Mellin moments and the PDFs.

**Authors:** GAO, Xiang (Argonne National Lab); Dr HANLON, Andrew (Brookhaven National Laboratory)

**Co-authors:** KARTHIK, Nikhil (Brookhaven National Laboratory); MUKHERJEE, Swagato; PETRECKZY, Peter; SHI, Qi; Prof. SYRITSYN, Sergey (Stony Brook University); ZHAO, Yong

**Presenter:** SHI, Qi

Contribution ID: 11

Type: talk

## Proton GPDs from Lattice QCD

*Wednesday 26 July 2023 17:30 (30 minutes)*

The few calculations of  $x$ -dependent GPDs performed in lattice QCD use the symmetric frame, where the momentum transfer is evenly divided between the momentum of the initial and final hadron states. To obtain the GPDs for several values of the momentum transfer in a computationally efficient method, we employ an asymmetric frame developed in PRD 106 (2022) 11, 114512. The kinematic setup we use allows all momentum transfer to be assigned to the initial state. The calculation uses an  $N_f = 2 + 1 + 1$  ensemble of twisted mass fermions with a clover improvement. The light quark masses provide a pion mass of about 260 MeV. This talk will cover the implementation of the asymmetric frame and the extraction of twist-2 GPDs for the proton with unpolarized quarks ( $H$  and  $E$ ), as well as the helicity ( $\tilde{H}$ ) case, both at zero skewness.

**Authors:** METZ, Andreas; SCAPELLATO, Aurora; STEFFENS, Fernanda; DODSON, Jack; MILLER, Joshua; CICHY, Krzysztof; Prof. CONSTANTINOU, Martha; BHATTACHARYA, Shohini; MUKHERJEE, Swagato; GAO, Xiang (Argonne National Lab); ZHAO, Yong

**Presenter:** MILLER, Joshua

Contribution ID: 12

Type: **not specified**

## Moments of proton GPDs from the OPE of nonlocal quark bilinears up to NNLO

*Wednesday 26 July 2023 15:00 (30 minutes)*

We present a lattice QCD determination of Mellin moments of unpolarized generalized parton distributions (GPDs) of the proton from an analysis of the quasi-GPD matrix elements within the short-distance factorization framework. We perform our calculation on an  $N_f=2+1+1$  twisted mass fermions ensemble with a clover improvement at lattice spacing  $a = 0.093$  fm and a pion mass of  $m_\pi = 260$  MeV. Focusing on the zero-skewness case, the quasi-GPDs are calculated from the  $\gamma_0$  definition, as well as a recently proposed Lorentz-invariant definition. We utilize data on both symmetric and asymmetric kinematic frames, which allows us to obtain the Mellin moments for several values of the momentum transfer,  $-t$ , in the range 0.17 to 2.77 GeV<sup>2</sup>. We use the ratio scheme for GPDs, i.e. renormalization group invariant ratios with leading-twist factorization formula and perturbatively calculated matching coefficients up to the next-next-to-leading order (NNLO) to extract Mellin moments of GPDs.

**Authors:** METZ, Andreas; STEFFENS, Fernanda; MILLER, Joshua (Temple University); CICHY, Krzysztof; Prof. CONSTANTINOU, Martha; PETRECZKY, Peter; BHATTACHARYA, Shohini; MUKHERJEE, Swagato; GAO, Xiang (Argonne National Lab); ZHAO, Yong

**Presenter:** GAO, Xiang (Argonne National Lab)

Contribution ID: 13

Type: talk

## $x$ -dependence of nucleon PDFs from two-current matrix elements

*Monday 24 July 2023 16:00 (30 minutes)*

We use the operator product expansion (OPE) to relate hadronic Euclidean two current matrix elements to parton distribution functions (PDFs) resolving the dependence on the parton momentum fraction  $x$ . We are following the ansatz proposed by [arXiv:1709.03018]. In our calculation, we consider the valence quark PDFs for the proton. This requires the evaluation of a connected proton four-point function for small quark distances. Our simulation is performed on  $n_f = 2 + 1$  CLS gauge ensemble with extension  $32^3 \times 96$ , coupling  $\beta = 3.4$ , and pseudo-scalar masses  $m_\pi = 355$  MeV and  $m_K = 441$  MeV, where we include proton momenta up to  $|\vec{p}| = 1.57$  GeV. The results are converted to the  $\overline{\text{MS}}$ -scheme at the scale  $\mu = 2$  GeV. In order to extract the PDF, the data is fitted in Fourier space based on a standard parameterization of the PDF.

**Author:** ZIMMERMANN, Christian

**Presenter:** ZIMMERMANN, Christian

Contribution ID: 15

Type: **not specified**

## Parton Distributions from Boosted Fields in the Coulomb Gauge

*Monday 24 July 2023 16:30 (30 minutes)*

In this talk, we will discuss a new method to calculate parton distribution functions (PDFs) from correlations of boosted quarks and gluons in the Coulomb gauge.

Compared to the widely used quasi-PDFs defined from gauge-invariant Wilson-line operators, such correlations offer advantages including absence of linear power divergence, enhanced long-range precision, and accessibility to larger off-axis momenta. We verify the validity of this method at next-to-leading order in perturbation theory and use it to calculate the pion valence quark PDF on a lattice with spacing  $a = 0.06$  fm and valence pion mass  $m_\pi = 300$  MeV.

Our result agrees with that from the gauge-invariant quasi-PDF at similar precision, achieved with only half the computational cost through a large off-axis momentum  $|\vec{p}| \sim 2.2$  GeV.

**Authors:** LIU, Wei-yang (Stony Brook University); GAO, Xiang (Argonne National Lab); ZHAO, Yong

**Presenter:** ZHAO, Yong

Contribution ID: 16

Type: **talk**

## Connecting Euclidean to lightcone correlations: From forward to non-forward kinematics

*Monday 24 July 2023 14:00 (30 minutes)*

According to large momentum effective theory (LaMET), the parton observables can be extracted from lattice calculations of quasi-observables through a perturbative matching relation. In this talk, I present a unified framework for the perturbative factorization connecting Euclidean correlations to light-cone correlations. We derive the flavor singlet and non-singlet matching kernel for the generalized distribution functions (GPDs), parton distribution functions (PDFs) and distribution amplitudes (DAs) at one-loop level, including the unpolarized, longitudinally and transversely polarized cases. Our results provide a manual for extracting all leading-twist GPDs, PDFs as well as DAs from lattice simulations of Euclidean correlations, following the state-of-the-art renormalization and matching strategy, either in coordinate or in momentum space factorization approach.

**Authors:** Ms YAO, Fei (BNU); ZHANG, Jianhui (CUHK-shenzhen); JI, Yao (TUM)

**Presenter:** Ms YAO, Fei (BNU)

Contribution ID: 17

Type: talk

## Leading Power Accuracy in Lattice Calculations of Parton Distributions

*Monday 24 July 2023 15:00 (30 minutes)*

In lattice-QCD calculations of parton distribution functions (PDFs) via large-momentum effective theory, the leading power (twist-three) correction appears as  $\mathcal{O}(\Lambda_{\text{QCD}}/P^z)$  due to the linear-divergent self-energy of Wilson line in quasi-PDF operators. For lattice data with hadron momentum  $P^z$  of a few GeV, this correction is dominant in matching, as large as 30% or more. We show how to eliminate this uncertainty through choosing the mass renormalization parameter consistently with the resummation scheme of the infrared-renormalon series in perturbative matching coefficients. An example on the lattice pion PDF data at  $P^z = 1.9$  GeV shows an improvement of matching accuracy by a factor of more than  $3 \sim 5$  in the expansion region  $x = 0.2 \sim 0.5$ .

**Author:** Dr ZHANG, Rui (University of Maryland)

**Co-authors:** HOLLIGAN, Jack Edward; JI, Xiangdong; SU, Yushan (University of Maryland)

**Presenter:** Dr ZHANG, Rui (University of Maryland)



Contribution ID: 18

Type: talk

## A journey through the heavy-light Sudakov universality class in LaMET: from quasi-TMDPDF at large $P_z$ to quark quasi-PDF in the threshold limit

*Tuesday 25 July 2023 17:30 (30 minutes)*

In this talk we will provide a survey of three fundamental objects: quasi-TMDPDF, quasi-LFWF amplitudes and perturbative quark quasi-PDF that appears naturally in the application of LaMET to lattice calculation of various parton distribution functions. We demonstrate how factorization works for the three objects in the corresponding scaling limits, in a way that shares the common maximally-conformal ingredient (or hard kernel): the **universal** heavy-light Sudakov form factor. We show how the physical TMDPDF/LFWF amplitudes can be extracted by combining the quasi-TMD quantities together with an auxiliary space-like form factor. Finally, we explain how the NNLO heavy-light Sudakov form factor can be extracted through the threshold limit of quasi-PDF matching kernel (or perturbative quark quasi-PDF).

**Authors:** JI, Xiangdong; LIU, Yizhuang (Jagiellonian University); SU, Yushan (University of Maryland)

**Presenter:** LIU, Yizhuang (Jagiellonian University)

Contribution ID: 19

Type: **talk**

## Multiparton distributions from lattice QCD

*Tuesday 25 July 2023 17:00 (30 minutes)*

Multiparton distributions, among which the double parton distributions (DPDs) are the simplest and most important ones, play an important role in describing multiparton scattering processes in hadron collisions. In this talk, I'll discuss how they can be directly computed from correlations of equal-time nonlocal Euclidean operators on the lattice in the large hadron momentum limit.

**Author:** ZHANG, Jianhui**Presenter:** ZHANG, Jianhui

Contribution ID: 20

Type: **talk**

## Collins-Soper kernel from lattice QCD with NNLO and NNLL LaMET matching

*Tuesday 25 July 2023 15:00 (30 minutes)*

This work presents a determination of the quark Collins-Soper kernel from quasi-TMDs using lattice QCD and LaMET. The kernel is extracted in the range of transverse momentum scales  $240 \text{ MeV} < q_T < 1.6 \text{ GeV}$  for hadron momenta  $P < 2.2 \text{ GeV}$ , using quark masses corresponding to a close-to-physical value of the pion mass. An analysis of LaMET matching, including for the first time next-to-next leading order accuracy and next-to-next leading logarithmic resummations, indicates perturbative convergence for  $q_T$  less than  $550 \text{ MeV}$  and increasing sensitivity to the associated power corrections in  $q_T$  at larger transverse momenta.

**Authors:** AVKHADIEV, Artur; WAGMAN, Michael; SHANAHAN, Phiala; ZHAO, Yong

**Presenter:** AVKHADIEV, Artur

Contribution ID: 21

Type: talk

## Perturbative study of renormalization and mixing for asymmetric staple-shaped Wilson-line operators on the lattice

*Monday 24 July 2023 13:30 (30 minutes)*

We present one-loop perturbative results of the renormalization functions for a complete set of nonlocal quark bilinear operators containing an asymmetric staple-shaped Wilson line, using a family of improved lattice actions. This study is relevant for the nonperturbative investigations regarding the renormalization of the unpolarized, helicity and transversity transverse-momentum dependent parton distribution functions (TMDPDFs) in lattice QCD. We employ a number of different versions of regularization-independent ( $\overline{\text{RI}}'$ ) renormalization prescriptions which address the power and logarithmic divergences of such non-local operators, the pinch-pole singularities at infinite Wilson-line lengths, as well as the mixing among operators of different Dirac structures, as dictated by discrete symmetries. All cancelations of divergences and admixtures are confirmed by our results at one-loop level. We compare all the different prescriptions and we provide the conversion matrices at one-loop order which relate the matrix elements of the staple operators in  $\overline{\text{RI}}'$  to the reference scheme  $\overline{\text{MS}}$ .

**Authors:** Mr SPANOUEDES, Gregoris (University of Cyprus); PANAGOPOULOS, Haralambos (University of Cyprus); Prof. CONSTANTINOU, Martha

**Presenter:** Mr SPANOUEDES, Gregoris (University of Cyprus)

Contribution ID: 22

Type: **talk**

## TMDPDFs in twisted mass lattice QCD

*Tuesday 25 July 2023 14:30 (30 minutes)*

Advancements in LaMET have made it possible to extract the transverse momentum dependent parton distribution functions (TMDPDFs) from first principles calculations. In this work, we calculate the two main ingredients necessary, the quasi-beam function and the soft function. We investigate the non-perturbative renormalization of these objects. Finally, we present results for the TMDPDF in twisted mass lattice QCD.

**Authors:** SEN, Aniket; LIU, Chuan (Peking University); ALEXANDROU, Constantia; STEFFENS, Fernanda; Dr SPANOUEDES, Gregoris (University of Cyprus); Mr TARELLO, Jacopo; JANSEN, Karl (DESY); CICHY, Krzysztof; Prof. CONSTANTINOU, Martha; BACCHIO, Simone; FENG, Xu

**Presenter:** SEN, Aniket

Contribution ID: 23

Type: **talk**

## Toward a precision calculation of generalized parton distribution functions.

*Wednesday 26 July 2023 16:00 (30 minutes)*

Generalized parton distribution functions (GPDs) describe the longitudinal momentum distribution within a hadron among its constituent partons as well as information about the momentum in the transverse direction. We calculate unpolarized and helicity GPDs using 2+1+1 flavors of highly improved staggered quarks in ensembles generated by the MILC collaboration at  $a=0.09$  fm with a physical pion mass using the method of large-momentum effective theory (LaMET). We use boosting momentum  $\sim 1.7$  GeV for multiple  $\xi = 0$  and  $\xi = 0.25$  with multiple transfer momenta renormalized in the hybrid scheme. In addition, we study the effects of systematic errors by applying leading renormalon resummation and renormalization group resummation in the matching process.

**Authors:** LIN, Huey-Wen; HOLLIGAN, Jack Edward

**Presenter:** HOLLIGAN, Jack Edward

Contribution ID: 24

Type: **not specified**

## Moments from local and non-local operators

*Wednesday 26 July 2023 14:30 (30 minutes)*

I will discuss the relation between lattice computation of PDF moments from local and non-local operators. Consistency between the two approaches provide important constraints on LaMET calculations of partons on lattice.

**Author:** JI, Xiangdong**Co-author:** Mr SU, Yushan (University of Maryland)**Presenter:** JI, Xiangdong

Contribution ID: 25

Type: talk

## Chiral-even axial twist-3 GPDs of the proton from lattice QCD

Wednesday 26 July 2023 16:30 (30 minutes)

We present the first lattice-QCD calculation of the proton's twist-3 axial quark GPDs using the LaMET approach. The lattice computation is performed using one ensemble of  $N_f = 2 + 1 + 1$  maximally twisted mass fermions with a clover term at a single lattice spacing of 0.093 fm and a pion mass of 260 MeV, employing three proton boosts up to 1.67 GeV. The light-cone GPDs are defined in the symmetric frame, at  $-t = 0.69, 1.38$  and  $2.76 \text{ GeV}^2$  and at zero skewness. We extract the leading combinations with twist-2 helicity GPDs,  $\tilde{H} + \tilde{G}_2$  and  $\tilde{E} + \tilde{G}_1$ . We also isolate  $\tilde{G}_2$  and calculate the suppressed GPD  $\tilde{G}_4$ , while  $\tilde{G}_3$  is confirmed to vanish at zero skewness. We also present several consistency checks, including the local limit of the twist-3 GPDs and the Burkhardt-Cottingham-type and Efremov-Teryaev-Leader-type sum rules.

**Authors:** BHATTACHARYA, Shohini; CICHY, Krzysztof; Prof. CONSTANTINOU, Martha; DODSON, Jack; METZ, Andreas; SCAPELLATO, Aurora; STEFFENS, Fernanda

**Presenter:** CICHY, Krzysztof



Contribution ID: 26

Type: **talk**

## Investigating nucleon's elastic, resonance, and DIS structures from hadronic tensor in lattice QCD

*Monday 24 July 2023 17:00 (30 minutes)*

The excitation of nucleons to resonance structures via electromagnetic interactions is crucial for enhancing our comprehension of strong interactions within the realm of quark confinement. Moreover, accurate characterization of various resonance structures is also essential for maximizing the discovery potential of neutrino oscillation experiments. In this presentation, we present preliminary determinations of the nucleon's elastic and transition form factors, utilizing the hadronic tensor. Furthermore, we discuss how the hadronic tensor formalism enables access to  $x$ -dependent structure functions and allows for the numerical investigation of higher-twist contributions in deep inelastic scattering.

**Author:** SUFIAN, Raza (Brookhaven National Lab)

**Co-authors:** WANG, Bigeng; LIANG, Jian; Prof. LIU, Keh-Fei; KHAN, Tanjib; YANG, Yi-Bo

**Presenter:** SUFIAN, Raza (Brookhaven National Lab)

Contribution ID: 27

Type: talk

## Transverse-Momentum-Dependent Wave Functions of Pion from LaMET

Tuesday 25 July 2023 14:00 (30 minutes)

We present a first lattice QCD calculation of the transverse-momentum-dependent wave functions (TMDWFs) of the pion using large-momentum effective theory. Numerical simulations are based on one ensemble with 2+1+1 flavors of highly improved staggered quarks action with lattice spacing  $a = 0.121\text{ fm}$  from the MILC Collaboration, and one with 2 +1 flavor clover fermions and tree-level Symanzik gauge action generated by the CLS Collaboration with  $a = 0.098\text{ fm}$ . As a key ingredient, the soft function is first obtained by incorporating the one-loop perturbative contributions and a proper normalization. Based on this and the equal-time quasi-TMDWFs simulated on the lattice, we extract the light-cone TMDWFs. The results are comparable between the two lattice ensembles and a comparison with phenomenological parametrization is made. Our studies provide a first attempt of *ab initio* calculation of TMDWFs which will eventually lead to crucial theory inputs for making predictions for exclusive processes under QCD factorization.

**Author:** HUA, Jun (South China Normal University)

**Presenter:** HUA, Jun (South China Normal University)

Contribution ID: 28

Type: talk

## Double Parton Distributions off and on the lattice

*Tuesday 25 July 2023 16:30 (30 minutes)*

The HL-LHC program will be sensitive to significantly smaller effects of BSM physics than probed so far. This implies that the quantitative understanding of non-perturbative Standard Model “backgrounds” has to be improved correspondingly. In this context Multiple Parton Interactions (MPIs) are a major concern. Theory efforts to improve their understanding focus on the simplest case, Double Parton Interactions, which are parameterized by Double Parton Distributions (DPDs) [1]. Jianhui Zhang will present a talk on LaMET evaluations of DPDs [2], see also [3], while I plan to present some general introduction, analytic results [4] and lattice results for DPD moments [5].

[1] M. Diehl, D. Ostermeier and A. Schäfer, JHEP **03** (2012), 089, [arXiv:1111.0910]

[2] J. H. Zhang, [arXiv:2304.12481]

[3] M. Jaarsma, R. Rahn and W. J. Waalewijn, [arXiv:2305.09716]

[4] M. Diehl et al., Eur. Phys. J. C **80** (2020) 468 [arXiv:2001.10428]

[5] G. S. Bali, et al., JHEP **09** (2021), 106 [arXiv:2106.03451]

**Author:** SCHAEFER, Andreas

**Presenter:** SCHAEFER, Andreas

Contribution ID: 29

Type: **talk**

## Lattice Constraints on the Fourth Mellin Moment of the Pion LCDA using the HOPE Method

*Monday 24 July 2023 17:30 (30 minutes)*

The light-cone distribution amplitude (LCDA) of the pion carries information about the parton momentum distribution and is an important theoretical input into various predictions of exclusive measurements at high energy, including the pion electromagnetic form factor. We provide constraints on the fourth Mellin moment of the LCDA using the heavy quark operator product expansion (HOPE) method.

**Authors:** GREBE, Anthony (Fermilab); Dr KANAMORI, Issaku (R-CCS, RIKEN); Dr PERRY, Robert (Univerisity of Barcelona); DETMOLD, Will (Massachusetts Institute of Technology); ZHAO, Yong; LIN, C.-J. David (National Yang Ming Chiao Tung Univiersity)

**Presenter:** Dr PERRY, Robert (Univerisity of Barcelona)