EINN2025

Monday 27 October 2025 - Saturday 1 November 2025

Book of Abstracts

Contents

3

Moments of parton distributions functions from Lattice QCD

Author: Dimitra Pefkou[1]

[1] *UC Berkeley*

Corresponding Author: dpefkou@berkeley.edu

The parton distribution functions (PDFs) are crucial to the understanding of the internal structure of hadrons, and their precise determination is necessary for searches of BSM physics in collider experiments. Directly accessing PDFs in Lattice QCD calculations is impossible due to the Euclidean space-time geometry. Mellin moments of PDFs are defined in terms of local operators that can be computed in Lattice QCD, but suffer from power divergent mixing beyond a certain order due to the reduced symmetry of the hypercubic lattice. Recently, a method was proposed [1] to use gradient flow in order to circumvent this mixing and access moments of PDFs of any order. In this talk, I will discuss the implementation of this method, and present results on moments of PDFs of hadrons using four stabilized Wilson fermion ensembles generated by the OpenLat [2] initiative.

[1] A. Shindler Phys.Rev.D 110 (2024) 5, L051503, 2311.18704
[2] https://openlat1.gitlab.io

5

Measurements of the nuclear dipole resonance with MAGIX at MESA

Author: Tyler Kutz[1]

[1] *Johannes Gutenberg University Mainz*

Corresponding Author: tkutz@uni-mainz.de

Nuclear multipole resonances have long been studied as a source of information on bulk nuclear properties. The nuclear dipole response has received much experimental and theoretical attention due to the proposed correlation between the pygmy dipole resonance (PDR) and the nuclear equation of state. Such a connection interprets the PDR in neutron-rich nuclei as the oscillation of the neutron skin against the symmetric nuclear core, correlating the strength of the PDR with the neutron skin thickness and nuclear symmetry energy. However, this connection remains model-dependent and controversial, and alternative interpretations of the PDR have been argued for. Additional experimental and theoretical efforts are required to clarify the situation.

Using electron scattering to excite nuclear resonances is complementary to experiments using real photons or hadronic probes. The MAGIX experiment, under construction at the MESA facility at JGU Mainz, is excellently suited for such measurements. MESA will deliver an electron beam with energies up to 105 MeV. Using a pair of magnetic spectrometers, MAGIX will reconstruct scattered electrons with high resolution ($\delta_p/p = 10^{-4}$) across a wide range of scattering angles. These capabilities will allow high-precision measurements of dipole resonances in a range of nuclei, further elucidating the connection of the dipole response to nuclear structure.

6

Investigating the coupling effects using Quasi-elastic scattering for 14N+176Yb system

Authors: Abhishek Yadav[1]; Gobind Ram[2]; Manoj Kumar Sharma[2]

[1] *Amity Institute of Nuclear Science and Technology, Amity University*

[2] *University of Lucknow, Lucknow, India*

Corresponding Authors: gobindram777@gmail.com, manojamu76@gmail.com, abhishekyadav117@gmail.com

The fusion barrier studies at energies around the Coulomb barrier have been a topic of great interest. At these energies, the coupling between relative motion and internal degrees of freedom of colliding heavy ions is strongly affected, which results in a number of distributed barriers instead of a single barrier (Bfus) [1-6]. A barrier distribution (BD) can be extracted experimentally from the fusion excitation function {σfus(E)} using the relation Dfus =d2/dE2 (Eσfus) [3]. The extracted BD contains the fingerprint of the reaction dynamics. This is because the nature and strengths of the several couplings involved in the interaction give distinct peaks in the barrier distribution. Further, it was suggested that the same information can also be extracted from the cross-section of quasi-elastic scattering (QE) (as the total flux is conserved) measured at large angles using the prescription Dqel= d/dE(dσqel /dσR), as an alternative representation of fusion BD [5]. In the present work, the QE measurements have been performed for the 14N+ 176Yb system, which will be translated into BD.
The experiment has been performed in the GPSC at the IUAC, New Delhi, employing the HYTAR detecting system, comprising 13 ΔE-E hybrid telescopes, where ΔE were gas ionization chambers and E detectors were passivated implanted planar silicon (PIPS) detectors [7]. Beam energy was varied in steps of 3 MeV ranging from 20% below to 20% above the barrier. Four telescope detectors, each at an angle of 1730, were arranged in a symmetrical cone geometry to measure the back-scattered quasi-elastic events. Two monitor detectors were placed at ±100 for beam monitoring and normalization purposes. The QE-excitation functions have been obtained, and the experimental BD for the 14N+ 176Yb system has been derived, as shown in Fig.1. In order to understand the observed nature of the experimentally deduced BD, theoretical calculations have been performed using the CCFULL code. As can been seen from Fig.1, the experimental BD significantly deviates from the one one-dimensional barrier penetration model (shown as a dotted curve), which reveals the presence of structural effects involved in the interaction of the 14N projectile with the 176Yb target. To gain a concrete understanding of these effects, the deformations of the interacting nuclei have been included in the CCFUL calculations. The analysis concludes that target deformation plays an important role in the interaction process. Further, the analysis of the data and results will be presented.

References:

[1] G. Kaur et al., Phys. Rev. C 94, 034613 (2016).
[2] Md. Moin Shaikh et al., Phys. Rev. C 91, 034615 (2015).
[3] N. Rowley, G.R. Satchler, and P.H. Stelson, Phys. Lett. B254, 25 (1991).
[4] M. Dasgupta et al., Annu. Rev. Nucl. Part. Sci. 48, 401 (1998).
[5] H. Timmers et al., Nucl. Phys. A 584, 190 (1995).
[6] K. Hagino, N. Rowley, and A. T. Kruppa, Comp. Phys. Comm. 123, 143 (1999).
[7] Akhil Jhingan et al., Nuclear Inst. and Methods in Physics Research, A 903, 326 (2018).

7

Analyzing Fermionic Dark Matter Scenarios with the HESS J1731-347 Compact Object

Authors: Jose Manuel Alarcón[1]; Yaiza Cano[1]

[1] *Universidad de Alcalá de Henares*

Corresponding Authors: jmanuel.alarcon@uah.es, ycano01@ucm.es

In this presentation I will show how we can constrain Dark Matter (DM) scenarios with the supernova remnant HESS J1731-347. We assume the compact object to be an admixture of DM and Neutron Star, and presume the former to behave as a free Fermi gas. For the Neutron Star we use recently calculated regulator-independent equations of state for neutron stars obtained from first principles. Using the two-fluid formalism we analyze the impact of the DM contribution to the mass and radius of the compact object in terms of the DM particle mass and the DM fraction. This allows us to constrain different scenarios for fermonic DM behaving as a free Fermi gas.

8

Proton charge radius extraction from muon scattering at MUSE using dispersively improved chiral effective field theory

Authors: Christian Weiss[None]; Fernando Gil Dominguez[1]; Jose Manuel Alarcón[2]

[1] *UESTC*

[2] *Universidad de Alcalá de Henares*

Corresponding Authors: fgildominguez@uestc.edu.cn, weiss@jlab.org, jmanuel.alarcon@uah.es

The MUSE experiment at the Paul Scherrer Institute will measure low-energy muon-proton elastic scattering (muon momenta: 115–210 MeV) to determine the proton charge radius. This talk discusses the prospects for extracting the radius using dispersively improved chiral effective field theory (DIχEFT), which connects the proton's charge distribution to the form factor behavior while allowing data up to $Q^2 \sim 0.1$ GeV^2 to be used. We examine the sensitivity of the μp cross section to the proton radius, theoretical uncertainties in the predictions, and the two-photon exchange correction. The optimal kinematics for radius extraction at MUSE are found at 210 MeV and $Q^2 \sim 0.05$-0.08 GeV^2. We compare muon and electron scattering in the same kinematics and provide predictions for both μp and ep cross sections as functions of the proton radius.

9

Nucleon electromagnetic and weak form factors

Author: Fernando Alvarado[1]

[1] *GSI*

Corresponding Author: f.alvarado@gsi.de

Nucleon electroweak form factors contain relevant details about hadronic structure and strong interactions in the nonperturbative regime. This information is encoded in their dependence on the momentum transferred to the nucleon by external probes but also in their quark-mass dependence, which is accessible by Lattice QCD (LQCD) simulations.

In our study we rely on relativistic chiral perturbation theory (ChPT) in two flavors with explicit Delta(1232) degrees of freedom. For the electromagnetic isovector form factors we also employ dispersion theory to account for rho-dominated isovector pion-pion interaction and its quark-mass dependence in the t-channel nonperturbatively and beyond NLO in ChPT. With this framework we explore how LQCD data are described in both the Q2 and mpi dimensions simultaneously. Furthermore, we have performed an NNLO calculation of the nucleon axial form factor, extracting relevant low-energy constants from a combined set of recent LQCD results from different collaborations.

10

The MAGIX Experiment at MESA

Author: Sebastian Stengel[1]

[1] *Johannes Gutenberg University Mainz, Institute for Nuclear Physics*

Corresponding Author: sestenge@uni-mainz.de

At the new high-intensity, low-energy electron accelerator MESA, the MAGIX experiment will enable high-precision scattering studies focused on the structure of hadrons and few-body systems, dark sector searches, as well as investigations of reactions relevant to nuclear astrophysics.

MAGIX features a fully windowless scattering chamber housing an internal gas jet target that can be operated with a variety of different gases, two high-precision magnetic spectrometers, and sophisticated detector systems positioned at the spectrometers'focal planes. This setup, in combination with MESA's high-intensity electron beam, ensures an exceptionally clean experimental environment, in which background effects like multiple scattering or energy straggling are drastically reduced.

The focal plane detectors include a tracking detector realized by a time projection chamber, as well as a trigger veto system composed of plastic scintillation detectors and passive lead absorbers. Additionally, a recoil detector system based on silicon strip detectors can be installed inside the scattering chamber to detect nuclear recoil particles in coincidence with the scattered electrons.

This contribution presents a detailed overview of the sophisticated experimental setup of MAGIX, including a glimpse at its rich and versatile physics program.

11

Constraining the GPD E: Deeply Virtual Compton Scattering off the neutron with CLAS12 at Jefferson Lab

Author: Adam Hoballah Hobart[1]

[1] *IJCLab CNRS-IN2P3*

Corresponding Author: ajhobart@jlab.org

A key step toward a better understanding of the nucleon structure is the study of Generalized Parton Distributions (GPDs). GPDs are nowadays the object of an intense effort of research since they convey an image of the nucleon structure where the longitudinal momentum and the transverse spatial position of the partons inside the nucleon are correlated. Moreover, GPDs give access, via Ji's sum rule, to the contribution of the orbital angular momentum of the quarks to the nucleon spin. Deeply Virtual Compton scattering (DVCS), the electroproduction of a real photon off the nucleon at the quark level, is the golden process directly interpretable in terms of GPDs of the nucleon. The GPDs are accessed in DVCS mainly through the measurements of spin-dependent asymmetries. Combining measurements of asymmetries from DVCS experiments on both the neutron and the proton will allow performing the flavor separation of relevant quark GPDs via linear combinations of proton and neutron GPDs. This talk will give an overview of experiments aiming to constrain the GPD E, one of the least know GPDs. Focus will be directed towards the recently published neutron-DVCS measurements from the CLAS12 experiment at Jefferson Lab with the upgraded ~11 GeV CEBAF polarized electron beam. In particular, details on the measurement of Beam Spin Asymmetries from neutron-DVCS will be presented. The impact of the measurement on the extraction of the Compton form factor (CFF) E related to the GPD E of the neutron will be discussed. Further discussion will motivate the foreseen measurements with the CLAS12 experiment on a transversly polarized proton target aiming to extract the CFF E of the proton.

12

New physics searches in low-energy precision experiments

Authors: Aleksandr Pustyntsev[1]; Marc Vanderhaeghen[2]

[1] *Johannes Gutenberg University of Mainz*

[2] *University Mainz*

Corresponding Authors: apustynt@uni-mainz.de, marcvdh@kph.uni-mainz.de

Various extensions of the Standard Model give rise to BSM particles with masses in the MeV to sub-GeV range. Such particles are often associated with dark matter, the strong CP problem and the $(g-2)_\mu$ anomaly. In this work, we examine the experimental constraints on such particles that can be derived from near-future high-precision experiments, including the MESA facility and the JLab program utilizing polarized positrons, alongside recent measurements of $(g-2)_l$. Special focus is placed on lepton couplings, which remain weakly constrained within this mass range.

13

The DNA of nuclear models: How does AI predict nuclear masses?

Author: Sokratis Trifinopoulos[1]

[1] *CERN*

Corresponding Author: sokratis.trifinopoulos@cern.ch

Obtaining high-precision predictions of nuclear masses, or equivalently nuclear binding energies, E_b, remains an important goal in nuclear-physics research. Recently, many AI-based tools have shown promising results on this task, some achieving a precision that surpasses the best human models. However, the utility of these AI models remains in question given that predictions are only useful where measurements do not exist, which inherently requires extrapolation away from the training (and testing) samples. Since AI models are largely \textit{black boxes}, the reliability of such an extrapolation is difficult to assess. We present an AI model that not only achieves cutting-edge precision for E_b, but does so in an interpretable manner. For example, we find that (and explain why) the most important dimensions of its internal representation form a double helix, where the analog of the hydrogen bonds in DNA here link the number of protons and neutrons found in the most stable nucleus of each isotopic chain. Furthermore, we show that the AI prediction of E_b can be factorized and ordered hierarchically, with the most important terms corresponding to well-known symbolic models (such as the famous liquid drop). Remarkably, the improvement of the AI model over symbolic ones can almost entirely be attributed to an observation made by Jaffe in 1969. The end result is a data-driven model of nuclear masses that is fully interpretable.

14

Overview of Recent Developments for TMDs

Author: Daniel Pitonyak[1]

[1] *Lebanon Valley College*

Corresponding Author: pitonyak@lvc.edu

In this talk I will review the current status of transverse momentum dependent (TMD) physics and related phenomena, including both unpolarized and polarized observables. Such studies give us insight into the 3-dimensional structure of hadrons. The focus of the talk will be on recent developments in theory and phenomenology regarding the extraction of TMD parton distribution functions and fragmentation functions (TMDs). The talk will also cover connections of TMDs to aspects of high-energy physics, lattice QCD, and AI/ML.

15

New Results on 2N and 3N Short-Range Correlations

Author: Nadia Fomin[None]

Corresponding Author: nfomin@utk.edu

The existence of two-nucleon short-range correlations (2N SRCs) has been well established by a series of experiments at SLAC and Jefferson Lab. The inclusive measurements showed a universal behavior in A/D cross section ratios of quasielastic scattering at x>1 and moderate Q2 yielding a constant value. In these kinematics mean field contributions fall off rapidly and 2N SRC contributions dominate. In even higher x-values (x>2), it was argued that contributions from 3N SRCs might dominate. Existing experimental searches for 3N SRCs have yet to provide unambigious and significant evidence for them. A recent 12 GeV Jefferson Lab experiment measured the quasi-elastic scattering off various nuclei in the kinematic region that is sensitive to the 3N SRCs. This talk will discuss the state of the field and present new results on 2N and 3N SRCs.

16

Progress of Polarizabilities from Lattice QCD

Author: Xu Feng[1]

[1] *Columbia University*

Corresponding Author: pkufengxu@gmail.com

I will discuss a lattice QCD calculation of the nucleon electric polarizabilities at the physical pion mass. Our findings reveal the substantial contributions of the Nπ states to these polarizabilities. Without considering these contributions, the lattice results fall significantly below the experimental values, consistent with previous lattice studies. This observation has motivated us to compute both the parity-negative Nπ scattering up to a nucleon momentum of ~ 0.5 GeV in the center-of-mass frame and corresponding Nγ* ⟶ Nπ matrix elements using lattice QCD. Our results confirm that incorporating dynamic Nπ contributions is crucial for a reliable determination of the polarizabilities from lattice QCD. This methodology lays the groundwork for future lattice QCD investigations into various other polarizabilities.

17

Status of the DarkMESA Experiment

Author: Mirco Christmann[1]

[1] *University of Mainz*

Corresponding Author: chrmirco@uni-mainz.de

At the Institute for Nuclear Physics in Mainz, the new electron accelerator MESA will be operational shortly. The high-power beam dump of the P2 experiment (150 MeV, 150 μA) is ideally suited for a parasitic dark sector experiment –DarkMESA.

The experiment is designed for the detection of Light Dark Matter (LDM), which in the simplest model couples to a massive vector particle, the dark photon γ'. It can potentially be produced in the beam dump by a process analogous to photon Bremsstrahlung and may then decay into Dark Matter (DM) particle pairs $\chi\bar{\chi}$. A fraction of them scatter off electrons or nuclei in the DarkMESA detectors.

This contribution discusses the extension of the simulation framework through the integration of additional models. The current status and first results of the Phase A setup will be shown. Beyond the use of a traditional calorimeter, the possibility of utilizing an opaque liquid scintillator for Phase B is under investigation. First simulation results, initial steps in prototype development, and exclusion limits obtained in co-operation with the NuDoubt^{++} collaboration are presented.

18

Lattice Determination of Parton Distributions Through Neural Network

Authors: Min-Huan Chu[1]; Jakub Wagner[2]; Krzysztof Cichy[3]; Martha Constantinou[4]; Pawel Sznajder[5]

[1] *Adam Mickiewicz University, Poznań*

[2] *National Centre for Nuclear Research*

[3] *Adam Mickiewicz University, Faculty of Physics*

[4] *Temple University*

[5] *National Centre for Nuclear Research, Warsaw*

Corresponding Authors: jakub.wagner@fuw.edu.pl, marthac@temple.edu, pawel.sznajder@fuw.edu.pl, kcichy@amu.edu.pl, minhuan.chu@amu.edu.pl

We propose a framework for the reconstruction of parton distribution functions (PDFs) and generalized parton distributions (GPDs) from lattice QCD, utilizing artificial neural networks (ANNs). Our approach combines two complementary methodologies: the Large Momentum Effective Theory (LaMET) and the short-distance operator expansion (SDE). To determine ANN-based PDFs and GPDs, we achieve a joint reconstruction that incorporates quasi-matrix elements from LaMET and matched Ioffe-time distributions derived from SDE. Our framework successfully recovers PDFs and GPDs from mock data and is applied for actual lattice QCD data. It mitigates the individual limitations inherent in LaMET and SDE, while leveraging the ANN architecture to enable a robust reconstruction.

19

From Anomaly to Agreement: The Muon g–2 Puzzle in Light of Recent Theory and Experiment

Author: Simone Bacchio[None]

Corresponding Author: s.bacchio@gmail.com

The anomalous magnetic moment of the muon, a_μ, has long been a precision benchmark for testing the Standard Model, with persistent tensions between experiment and theoretical predictions driving intense activity over the past five years, particularly since 2020 with the publication of the first White Paper by the Muon $g-2$ Theory Initiative. This talk reviews the evolution of this puzzle in light of the latest White Paper, released earlier this year, which incorporates state-of-the-art first-principles determinations and effectively eliminates the discrepancy with experiment, confirming the Standard Model at the sub-ppm level. A key development has been the replacement of dispersive evaluations of the hadronic vacuum polarization with high-precision lattice QCD results, enabled by major methodological and computational advances. Nonetheless, residual tensions persist, most notably between lattice QCD and dispersive approaches, the latter still undergoing extensive reanalysis by multiple groups. I will summarize the current theoretical landscape, highlight the advances in lattice QCD that reshaped the comparison with experiment, and discuss the open issues and prospects for further scrutiny of a_μ as a probe of new physics.

20

The Jefferson Lab 22 GeV Upgrade

Author: Patrizia Rossi[1]

[1] *Jefferson Lab*

Corresponding Author: rossi@jlab.org

The Continuous Electron Beam Accelerator Facility (CEBAF) at Jefferson Lab has been delivering the world's highest intensity and highest precision multi-GeV electron beams for more than 25 years. The Nuclear Physics community has resourcefully exploited these advanced accelerator facility for studies of the fundamental interactions and this research has impacted the entirety of Nuclear Physics, as well as High Energy Physics and Astrophysics. A potential energy upgrade of CEBAF from the current 12 GeV to 22 GeV and a positron beam are under technical development and a physics program is being developed. Precision measurements in the valence quark region requiring high luminosity are clearly the purview of CEBAF. With the 22 GeV upgrade some important thresholds would be crossed and an energy window which sits between JLab at 12 GeV and EIC will be available. In this presentation the impact on scientific reach of such an energy upgrade will be discussed.

21

Electromagnetic Form Factors of the Nucleon with Dispersively Improved Chiral Effective Field Theory

Author: Jose Manuel Alarcon[1]

[1] *University of Alcalá*

Corresponding Author: jmanuel.alarcon@uah.es

In this talk, I will show how effective field theory can be combined with dispersion theory to provide a representation of the nucleon's electromagnetic form factors that incorporates the correct analytical structure and the dynamics of QCD at low energy. As an application, I will present how this approach contributes to the determination of the proton's charge and magnetic radii, as well as its predictions for the MUSE experiment.

22

Generalized Parton Distribution Functions of the Pion and Kaon from Lattice QCD

Authors: Joseph Torsiello[1]; Krzysztof Cichy[2]; Martha Constantinou[1]; Joshua Miller[None]

[1] *Temple University*

[2] *Adam Mickiewicz University*

Corresponding Authors: marthac@temple.edu, tuq13693@temple.edu, tuo90295@temple.edu, krzysztof.cichy@gmail.com

We present a first-principles determination of the unpolarized GPDs of the pion and kaon from lattice QCD using a Twisted Mass N_f = 2+1+1 ensemble reproducing a pion mass of 260 MeV, and a kaon mass of 540 MeV. Using boosted meson states and gauge-invariant nonlocal quark bilinears, we compute off-forward matrix elements over a range of meson momenta, momentum transfers t, focusing on zero skewness. In particular, our data incorporate meson momentum up to 2 GeV, and momentum transfer squared up to 2.5 GeV^2. For the reconstruction of the x dependence, we use the Large Momentum Effective Theory (LaMET), which matches the lattice data to the light-cone GPDs. As a byproduct, we also test the validity of the kinematic range by comparing the energy of the meson to the continuum dispersion relation.

23

Noise Reduction for DarkMESA in the Search for Light Dark Matter

Author: Christian Stoß[None]

Co-authors: Achim Denig [1]; Mirco Christmann [2]

[1] *JGU Mainz*

[2] *University of Mainz*

Corresponding Authors: denig@kph.uni-mainz.de, chrmirco@uni-mainz.de, chstoss@uni-mainz.de

The existence of dark matter remains one of the most significant open questions in particle physics. The DarkMESA experiment aims to search for light dark matter (LDM) in an unexplored mass and coupling regime. This parasitic beam dump experiment will be located downstream of the P2 experiment at the new MESA accelerator in Mainz. It is planned to operate for 10,000 hours in extracted beam mode, using a $150\mu A$ electron beam with an energy of $150MeV$.
In the simplest model of LDM, the dark matter particle χ couples to a massive vector particle, the dark photon γ'. In this framework, electrons in the beam dump can produce γ' via a Bremsstrahlung-like process. If kinematically allowed, these dark photons then decay into χ
$Bar\chi$ pairs. If LDM exists within the targeted parameter space, a fraction of the produced LDM will scatter off electrons or nuclei in one of the calorimeter's Cherenkov crystals, generating a measurable signal. Given the low probability of such an event, dark counts can significantly overlay the interesting signal.
This contribution focuses on cooled SiPMs in coincidence as a possible readout method to drastically reduce dark counts to a negligible level. This allows an initial estimate to determine the minimum energy emitted in the detector up to which LDM particles can be detected.

24

The Future Program of PRad and Dark Sector Searches at JLab

Author: Patrick Achenbach[1]

[1] *Jefferson Lab*

Corresponding Author: patricka@jlab.org

The PRad-II and X17 Experiments are planned to run in Jefferson Lab's Hall B in 2026. The common experimental setup includes a large-volume vacuum system, two planes of GEM tracking detectors for improved vertex and angle reconstruction, and a high-resolution calorimeter (HyCal). These experiments strive to give definite answers to long-standing questions in hadron physics. PRad-II is addressing the discrepancy in elastic electron-proton scattering at momentum transfers between 0.01 and 0.06 GeV^2 that are seen between the world's most complete data set taken with focusing magnetic spectrometers on the one side and the data set from the first proton charge radius experiment at Jefferson Lab (PRad).
PRad-II will provide a measurement of the proton electric form factor at momentum transfers down to $Q^2 \approx 10^{-5}$ GeV^2 and improve the overall precision on the proton charge radius by about a factor of three compared to PRad. The X17 experiment is searching for a hypothetical light boson with a mass of about 17 MeV/c^2 that has been discussed to explain some anomalous nuclear transition data. The HyCal could be re-used in the mid-term future as one of the calorimeter blocks for the Beam Dump eXperiment (BDX), an electron-beam thick-target experiment aimed to search for the existence of light Dark Matter particles in the MeV−GeV mass region at Jefferson Lab. BDX will be able to lower the exclusion limits by one to two orders of magnitude in the parameter space of dark-matter coupling versus mass.

25

Progress for x-dependent GPDs from Lattice QCD

Author: Krzysztof Cichy[1]

[1] *Adam Mickiewicz University, Faculty of Physics*

Corresponding Author: kcichy@amu.edu.pl

In this talk, we discuss the recent progress in lattice QCD determinations of generalized parton distributions. The recently developed framework of asymmetric frames of reference, now complete for the vector, axial vector and tensor cases, allows for cost effective calculations of GPDs across a broad range of kinematics. This makes the prospects of their full mapping realistic in the near future, although requiring careful quantification of all systematic effects. We show a selection of our recent results and discuss future prospects, involving also synergy with phenomenology and experiment.

26

Unpolarized twist-two GPD and the trace anomaly

Author: Ignacio Castelli[None]

Corresponding Author: tuq07932@temple.edu

We present a one-loop perturbative study of unpolarized twist-two generalized parton distributions (GPDs) for external on-shell gluon states. A finite quark mass ⊠ is kept throughout: it serves as an infrared regulator and, crucially, enables an explicit realization of the full trace-anomaly relation. By taking second Mellin moments, we extract the associated gravitational form factors (GFFs) in QED and QCD and verify the matching implied by the energy–momentum tensor operator identity, including the gluonic trace term. Particular attention is given to anomaly-induced "anomaly-pole" structures. The analysis complements our previous work on polarized twist-two GPDs and the axial anomaly, providing a unified picture of anomaly effects in partonic correlators.

27

Development of a Liquid Scintillator Veto Prototype for the DarkMESA and NuDoubt++ Experiments

Author: Michail Kontogoulas[1]

[1] *Institute for Nuclear Physics, Johannes Gutenberg University Mainz*

Corresponding Author: mikontog@students.uni-mainz.de

In the ongoing search for light dark matter, the DarkMESA and NuDoubt^{++} experiments have combined their efforts to probe a new region of parameter space. DarkMESA is a forthcoming electron beam dump experiment to be located in the new MESA accelerator facility in Mainz, designed to detect light dark matter particles mediated by a hypothetical dark photon γ' with the use of a Pb_2F crystal calorimeter. The NuDoubt^{++} experiment will utilize an opaque liquid scintillator detector to investigate neutrinoless double beta decay ($0\nu\beta\beta$), a yet-to-be-confirmed beyond Standard Model (BSM) decay process. Due to the expected rarity of these interactions, exceptional background rejection is crucial for identifying potential events. Therefore, both experiments plan to use passive and active shielding layers against cosmic radiation and, for DarkMESA, additional beam-related backgrounds.

This contribution will focus on the development of a liquid scintillator veto prototype for use in both experiments. The prototype will feature a hexagonal geometry with an active volume of approximately $0.351\,\mathrm{m}^3$, filled with a linear alkylbenzene (LAB) scintillator, doped with $0.2\mathrm{wt.}\%$ Gadolinium to enhance neutron detection. The inner walls will be overlaid with a highly reflective coating to improve photon collection efficiency. The scintillator will be read out by seven 5-inch PMTs mounted on the top surface of the volume. A comparative analysis will be presented, comparing simulation results with initial tests of the prototype to evaluate veto efficiency, with particular emphasis on neutron rejection, given their significance as a background in dark matter searches.

28

Generalized Parton Distributions of the proton from Lattice QCD: Transversity case

Author: Joshua Miller[None]

Co-authors: Andreas Metz [1]; Fernanda Steffens [2]; Krzysztof Cichy [3]; Martha Constantinou [4]; Peter Petreczky ; Shohinni Bhattacharya

[1] *Department of Physics, Temple University, Philadelphia*

[2] *DESY - Zeuthen*

[3] *Adam Mickiewicz University, Faculty of Physics*

[4] *Temple University*

Corresponding Authors: marthac@temple.edu, metza@temple.edu, tuo90295@temple.edu, fsteffens@uol.com.br, kcichy@amu.edu.pl, sde24001@uconn.edu

With the upcoming Electron-Ion Collider, interest in proton tomography has greatly increased due to experiments, like DVCS are able to be conducted. A large set of functions that gives a great amount of information about the structure are Generalized Parton Distribution functions (GPDs). Recently, the x-dependence of GPDs has been extracted from lattice QCD. Utilizing a novel method that gives access to a wide range for the kinematic parameters (PRD 106 (2022) 11, 114512), we extract the transversity GPDs for the proton: H_T, E_T, $\tilde{H}_T$, and $\tilde{E}_T$. Calculations are done in zero-skewness with an $N_f = 2+1+1$ ensemble of twisted mass fermions with a clover improvement. The quark masses give a pion mass of roughly 260 MeV.

29

Subtracted dispersion relations formalism for virtual Compton scattering off the proton

Author: Matteo Ronchi[1]

Co-authors: Barbara Pasquini [2]; Igor Danilkin [3]; Marc Vanderhaeghen [3]

[1] *Johannes Gutenberg University*

[2] *University of Pavia*

[3] *Johannes Gutenberg University of Mainz*

Corresponding Authors: ronchima@uni-mainz.de, danilkin@uni-mainz.de, vandma00@uni-mainz.de, barbara.pasquini@unipv.it

In this work, we propose the formalism of subtracted dispersion relations for virtual Compton scattering (VCS) off a proton target as a tool for extracting generalized polarizabilities (GPs) of the proton. This approach offers advantages over the one based on unsubtracted dispersion relations used so far in interpreting the data, particularly in reducing the model dependence.
In this framework, the GPs appear as input parameters which can be determined by a direct fit to

the experimental data for VCS.
To achieve this improvement, we evaluate the dispersion integrals in the momentum transfer t. To evaluate these integrals on the positive values of t (right-hand cut), the unitarity relation in the t-channel has been used by saturating it with the contribution of two-pion intermediate states. This has been done using recently available data on the $\gamma\gamma^* \to \pi\pi$ and $\pi\pi \to N\bar{N}$ processes.
On the other hand, to evaluate the integral on the negative values of t (left-hand cut), we approximate the left-hand cut discontinuity by the spectral function for the $\Delta(1232)$-resonance excitation in s- and u-channel for the VCS process.
We then present first results for VCS observables obtained within this framework.

30

First Determination of the Collins–Soper Kernel using Lattice QCD in a Neural Network TMD fit

Authors: Chiara Bissolotti[1]; Artur Avkhadiev[2]; Matteo Cerutti[3]; Phiala Shanahan[2]; Valerio Bertone[4]; Yong Zhao[1]; Simone Rodini[None]

[1] *Argonne National Laboratory*

[2] *MIT*

[3] *CEA Paris-Saclay*

[4] *CEA Paris-Sclay*

Corresponding Authors: valerio.bertone@cern.ch, matteocerutti996@gmail.com, rodini.simone.luigi@gmail.com, cbissolotti@anl.gov

We present the first proof of concept extraction using neural networks (NNs) of the unpolarized transverse-momentum distributions (TMDs) at next-to-next-to-next-to-leading logarithmic (N^3LL) accuracy. By offering a more flexible and adaptable approach, NNs overcome some of the limitations of traditional functional forms, providing a better description of data.
Moreover, we present the first joint study of the Collins–Soper kernel combining inputs from lattice QCD and TMD phenomenology. Using recent continuum-extrapolated lattice calculations of the kernel at 3 values of the lattice spacing, we assess their impact on a recent phenomenological extraction based on Neural Network parametrizations. We perform both Bayesian reweighing and, for the first time, a direct global fit including the 21 lattice data alongside about 500 experimental measurements. We
find that the inclusion of the lattice points shifts the central value of the non-perturbative parameter by 5\% and reduces its uncertainty by 30\%, highlighting the potential of lattice inputs to improve TMD extractions.

31

Baryon resonances from lattice QCD

Author: Fernando Romero-Lopez[1]

[1] *Uni Bern*

Corresponding Author: fernando.romero-lopez@unibe.ch

Lattice QCD calculations have now reached the maturity required to determine the properties of hadronic resonances from first principles. In this talk, I will review recent progress on baryon resonances, with particular emphasis on the $\Lambda(1405)$, the $\Delta(1232)$, and two-nucleon systems. I will also outline the path toward exploring higher-lying resonances in QCD, highlighting recent advances that open the way to the study of three-hadron resonances.

32

Experimental Manifestation of the Neutron - Electron Interaction in Solids via Measurement it Dependence on the Distance between Nucleons

Author: Vladimir G Plekhanov[None]

Corresponding Author: vgplekhanov@gmail.com

Experimental Manifestation of the Neutron - Electron Interaction in Solids via Measurement it Dependence on the Distance between Nucleons

V.G. Plekhanov

Fonoriton Sci. Lab., Garon Ltd, Estonia
Abstract. Yet, the energy scale associated with new physics (NP) is unknown and therefore the experimental program for physics beyond Standard Model (SM) should be as broad as possible. Colliders are one of the main tools to study elementary particles and the LHC is pushing forward the energy frontier. A complementary and vital role is played by low energy experiments. In broader context atomic and nuclear physics probes have been used for this goal. In this way the isotope shift spectroscopy may probe spin - independent couplings of light bosons fields to electrons and neutrons. The discovery of the neutron by Chadwick in 1932 may be viewed as the birth of the strong nuclear interaction In 1935 Yukawa have tried to develop a theory of nuclear forces. The most important feature Yukawa'forces is they have a small range (~10-15 m). However, up to present time phenomenological Yukawa potential can not be directly verified experimentally. We should remind that the strong nuclear interaction - the heart of Quantum Chromodynamics (QCD) which is the part of the Standard Model (SM). According to SM the nuclear force is a result of the strong force binding quarks to form protons and neutrons. Residual part of it holds protons and neutrons together to form nuclei. There are common place in nuclear and high energy physics that the strong force does not act on leptons. Our report is devoted to study the strong nuclear interaction via measuring the low - temperature (2 K) photoluminescence spectra of LiH (Eg ~ 4.992 eV) (without strong interaction in hydrogen nucleus) and LiD (Eg ~ 5.095 eV) (with strong interaction in deuterium nucleus) single crystals.
The uniqueness of the LiH and LiD compounds is that they differ in only one neutron, i.e. lithium ions, electron and proton are the same for them and, therefore they have the same gravitational, weak and electromagnetic interactions. The additions of a neutron to hydrogen nucleus, generates according to Yukawa, a strong interaction between a prooton and a neutron, the effect on which on electron is manifested in the isotope shift (0.103 eV) of the zero - phonon photoluminescence line of free excitons in LiD crystals (see fig. 4 in Ref. 1). Using the experimentally observed isotopic shift within the framework of the dipole - dipole magnetic interaction, the strong interaction coupling constant was calculated to be 2.4680.

Reference

V.G. Plekhanov, Atomic Energy 131, 121 (2022)

33

Dispersive analysis of two photon reactions

Author: Igor Danilkin[1]

Co-author: Marc Vanderhaeghen [1]

[1] *Johannes Gutenberg University of Mainz*

Corresponding Authors: danilkin@uni-mainz.de, vandma00@uni-mainz.de

We perform a coupled-channel dispersive analysis of $^{(*)(*)} \to \pi\pi/\pi\eta/K\bar{K}$ using a modified Muskhelishvili–Omnès framework that enforces analyticity and unitarity, modeling the left-hand cut with pion/kaon and vector-meson pole terms. Both unsubtracted and subtracted forms are studied, the latter incorporating Adler-zero constraints. The S-wave $\pi\pi/K\bar{K}_{I=0}$ and $\pi\eta/K\bar{K}_{I=1}$ channels describe the $f_0(500)$, $f_0(980)$, and $a_0(980)$, while the D-wave is anchored by the $f_2(1270)$ and $a_2(1320)$ resonances. As an application to $(g-2)_\mu$, we obtain dispersive HLbL rescattering estimates from scalar channels with improved precision over narrow-width models. A new two-photon Monte Carlo generator in development at Mainz will also be briefly presented.

34

Design of a luminosity monitor for the P2 parity violating experiment at MESA

Author: Tobias Rimke[1]

Co-authors: Boris Gläser [1]; Frank Maas [2]; Jayanta Naik [1]; Maarten Bonnekamp [3]; Malte Wilfert [1]; Michael Gericke [4]; Moran Neher [5]; Rahima Krini [1]; Sebastian Baunack [1]; Siddharth Thakker [1]

[1] *Institut für Kernphysik Uni Mainz*

[2] *Helmholtz-Institut Mainz*

[3] *IRFU, CEA, Universite Paris-Saclay, Gif-sur-Yvette, France*

[4] *Department of Physics and Astronomy, University of Manitoba, Winnipeg, Canada*

[5] *P2 Kollaboration - Johannes Gutenberg-Universität Mainz*

Corresponding Authors: maas@uni-mainz.de, torimke@uni-mainz.de, neher@uni-mainz.de

The P2 experiment at the future MESA accelerator in Mainz plans to measure the weak mixing angle $\sin^2(\theta_W)$ in parity violating elastic electron-proton scattering. The aim of the experiment is a very precise measurement of the weak mixing angle with an accuracy of 0.14% at a low four-momentum transfer of $Q^2 = 4.5 \cdot 10^{-3}\ \mathrm{GeV}^2$. In order to achieve this accuracy, it is necessary to monitor the stability of the electron beam and the liquid hydrogen target. Any helicity correlated fluctuation of the target density leads to false asymmetries.

Therefore, it is planned to install a luminosity monitor in forward direction close to the beam axis. The motivation and challenges for designing an air Cherenkov luminosity monitor will be discussed. Furthermore, I show the current prototype design with results from promising tests run with the electron beam of the Mainz MAMI accelerator and detailed simulation studies.

35

DVCS with polarized targets and CLAS12

Author: Silvia Niccolai[1]

[1] *IPN Orsay*

Corresponding Author: silvia@jlab.org

Generalized Parton Distributions (GPDs) are nowadays the object of an intense effort of research, in the perspective of understanding nucleon structure. They describe the correlations between the longitudinal momentum and the transverse spatial position of the partons inside the nucleon and they can give access to the contribution of the orbital momentum of the quarks and gluons to the nucleon spin.
Deeply Virtual Compton scattering (DVCS), the electroproduction on the nucleon, at the partonic level, of a real photon, is the process more directly interpretable in terms of GPDs of the nucleon. Depending on the target nucleon (proton or neutron) and on the DVCS observable extracted (cross

sections, target- or beam-spin asymmetries, ⋯), different sensitivity to the various GPDs for each quark flavor can be exploited.
This talk will provide an overview on new, promising, DVCS-related experimental results, obtained at in Hall B at Jefferson Lab on longitudinally polarized hydrogenated and deuterated ammonia targets, with a 10.5-GeV electron beam, using the CLAS12 spectrometer. The future CLAS12 experiment to measure DVCS with a transversally polarized ammonia target will also be presented.

36

Study of the Λ → pℓν¯ℓ semileptonic decay in lattice QCD

Authors: Andreas Konstantinou[1]; Simone Bacchio[None]

[1] *University of Cyprus*

Corresponding Authors: antreas9@windowslive.com, s.bacchio@gmail.com

We present the first lattice QCD determination of the Λ → N vector and axial-vector form factors, which are essential inputs for studying the semileptonic decay Λ → pℓν¯ℓ. This channel provides a clean, heoretically controlled avenue for extracting the CKM matrix element |Vus| from the baryon sector. Our analysis uses a gauge ensemble with physical light, strange, and charm quark masses and yields the most precise determination to date of the full set of transition form factors —including second-class contributions—as well as the associated couplings, radii, and the ratio of muon-toelectron decay rates, an observable sensitive to possible non-standard scalar and tensor interactions.
We compare our non-perturbative results with next-to-next-to-leading order expansions in the small parameter δ = (mΛ − mN)/mΛ ≈ 0.16. We find that the common phenomenological approximation of neglecting the q2-dependence of the form factors leads to a ~ 4% deviation in the decay rate.
This underscores the critical importance of precise, fully non-perturbative form factor inputs for achieving the sub-percent precision targets of upcoming experimental programs.

37

Investigations of the integrating readout system of the P2 experiment at MESA

Author: Moran Neher[1]

Co-authors: Boris Gläser [1]; Frank Maas [2]; Jayanta Kumar Naik [1]; Maarten Bonnekamp [3]; Malte Wilfert [1]; Michael Gericke [4]; Rahima Krini [1]; Sebastian Baunack [1]; Siddarth Thakker [1]; Tobias Rimke [1]

[1] *Institut für Kernphysik, JGU Mainz*

[2] *Helmholtz-Institut Mainz*

[3] *IRFU, CEA, Universite Paris-Saclay*

[4] *University of Manitoba*

Corresponding Authors: mgericke@physics.umanitoba.ca, torimke@uni-mainz.de, neher@uni-mainz.de, maas@uni-mainz.de

The P2 experiment aims for a high precision measurement of the weak mixing angle, a fundamental parameter of the Standard Model. The weak mixing angle will be extracted from the parity-violating asymmetry in elastic electron-proton scattering at low momentum transfer, with an expected raw asymmetry of $A_{\text{raw}} = 0.2403 \times 10^{-7}$. The central component of the detector system is an integrating Cherenkov ring detector, which measures the rates of scattered electrons. These rates depend on the helicity of the electron beam and give rise to the production of Cherenkov light.

The detector modules are developed in collaboration with the University of Manitoba. They consist of a photomultiplier tube, the P2 voltage divider and pre-amplifier and the P2 sampling ADC. In this poster, the P2 experiment is introduced and a test setup for the readout system, emulating an asymmetric light signal down to $\mathcal{O}(10^{-7})$, is presented.

38

Design of the liquid hydrogen target for the P2 parity violating experiment at MESA

Author: Jayanta Kumar Naik[1]

Co-authors: Boris Gläser [2]; Frank Maas [3]; Maarten Bonnekamp [4]; Malte Wilfert [2]; Michael Gericke [5]; Moran Neher [6]; Rahima Krini [2]; Sebastian Baunack [2]; Siddharth Thakker [2]; Tobias Rimke [2]

[1] *Johannes Gutenberg University of Mainz*

[2] *Institut für Kernphysik Uni Mainz*

[3] *Helmholtz-Institut Mainz*

[4] *IRFU, CEA, Universite Paris-Saclay, Gif-sur-Yvette, France*

[5] *Department of Physics and Astronomy, University of Manitoba, Winnipeg, Canada*

[6] *P2 Kollaboration - Johannes Gutenberg-Universität Mainz*

Corresponding Authors: jnaik@uni-mainz.de, maas@uni-mainz.de, neher@uni-mainz.de, torimke@uni-mainz.de

The P2 experiment aims to precisely measure the weak mixing angle $\sin^2\theta_W$ through parity-violating electron-proton scattering at low momentum transfer. This is projected to achieve a relative precision of 0.14% for $\sin^2\theta_W$. A crucial component of the experiment is a 60 cm long liquid hydrogen (lH_2) target. It is designed to handle a heat load of 4000 W while maintaining a density reduction below 2% and density fluctuations below 10 ppm. One of the important aspects of this is the design of the internal conical flow diverter in the lH_2 target cell.

In this poster, simulation results for the design of the conical flow diverter are presented. Along with this, the P2 experiment is introduced, and the current design of the lH_2 target cell is explained.

39

Nucleon axial, tensor, and scalar charges and σ-terms in lattice QCD

Authors: Christos Iona[1]; Constantia Alexandrou[2]; Giannis Koutsou[3]; Gregoris Spanoudes[4]; Jacob Finkenrath[5]; Simone Bacchio[None]; Yan Li[6]

[1] *University of Cyprus and The Cyprus Institute*

[2] *University of Cyprus & Cyprus Institute*

[3] *The Cyprus Institute*

[4] *University of Cyprus*

[5] *CERN*

[6] *University of cyprus*

Corresponding Authors: g.koutsou@cyi.ac.cy, gspano01@ucy.ac.cy, j.finkenrath@cern.ch, yan.li@cyi.ac.cy, s.bacchio@gmail.com, alexand@ucy.ac.cy, ciona001@ucy.ac.cy

We determine the nucleon axial, scalar and tensor charges at the continuum limit by analyzing three $N_f = 2+1+1$

twisted mass fermion ensembles with all quark masses tuned to approximately their physical values. We include all contributions from valence and sea quarks. We use the Akaike Information Criterion to evaluate systematic errors due to excited states and the continuum extrapolation. For the nucleon isovector axial charge we find $g_A^{u-d} = 1.250(24)$, in agreement with the experimental value. We compute the axial, tensor and scalar charges for each quark flavor. The axial charge provides crucial information on the intrinsic spin carried by quark in the nucleon and the the latter two provide input for experimental searches of physics beyond the standard model. Moreover, we extract the nucleon σ-terms and find $\sigma_{\pi N} = 41.9(8.1)$ MeV, for the strange $\sigma_s = 30(17)$ MeV and for the charm $\sigma_c = 82(29)$ MeV. We also present preliminary results on the isovector quantities using a fourth ensemble at smaller lattice spacing.

40

Two-photon exchange effects in muonic hydrogen

Author: Panagiotis Kalamidas[None]

Corresponding Author: pakalami@uni-mainz.de

Motivated by the expected improvement in the experimental determination of the μH Lamb shift measurement, I will present an updated fit of the unpolarised nucleon structure functions from available data in the nucleon resonance region in combination with Regge fits to the high-energy and deep inelastic region. The evaluation of the structure functions in the resonance region is building upon earlier work describing the resonance electrocouplings from exclusive data. The new fits of exclusive data will be a crucial part of a new parametrisation of the nucleon inelastic structure functions valid in a broad kinematic range. For the high-energy region, we start from the Regge-like parametrisation used for the structure functions $F_{1,2}$ in previous studies. The resonance and Regge regions are connected through analytic parametrisations constrained from inclusive electron scattering data from JLab. In this poster, I will present first results on the new parametrisation of nucleon unpolarised structure functions which will lead to updated data-driven evaluations of the two-photon exchange effects in the μH Lamb shift.

41

First measurement of the DVCS beam spin asymmetry in the Sullivan process

Author: Elouan Ferrand[1]

Co-author: Maxime DEFURNE [2]

[1] *CEA/Irfu/DPhN*

[2] *CEA-Saclay*

Corresponding Authors: mdefurne@jlab.org, elouan.ferrand@cea.fr

Deeply Virtual Compton Scattering (DVCS) is a powerful tool to investigate the internal structure of hadrons in terms of Generalized Parton Distributions (GPDs). The Sullivan process, involving the exchange of a virtual pion from the proton's meson cloud, offers a unique opportunity to access the three-dimensional structure of the pion at high energies. Since the pion plays a central role in QCD dynamics, being the lightest hadron and the Goldstone boson associated with chiral symmetry breaking, unraveling its structure is of fundamental importance for our understanding of hadronic matter.

This work aims at measuring, for the first time, the DVCS beam spin asymmetry (BSA) in the Sullivan process, using data collected with the CLAS12 experiment at Jefferson Lab with a 10.6 GeV electron beam on a proton target. These preliminary results demonstrate the feasibility of this novel

measurement, thereby improving our understanding of the Sullivan process and validating this approach as a tool to probe the pion's internal dynamics. This first measurement paves the way for an exploration of the pion structure through its GPDs, and sets the stage for future studies at Jefferson Lab and at the upcoming Electron-Ion Collider.

42

Unpolarised Generalised Parton Distributions on lattice QCD at physical mass

Author: Gabriele Pierini[1]

[1] *The Cyprus Institute, TU Berlin*

Corresponding Author: g.pierini@cyi.ac.cy

We present a lattice QCD analysis of unpolarised generalised parton distributions (GPDs) of the proton. Our calculations are done on an ensamble with Nf = 2 + 1 + 1 (degenerate light quarks, strange and charm quarks) twisted mass fermions at physical mass with a clover improvement and lattice spacing a = 0.08 fm. We use Large Momentum Effective Theory (LaMET) to anlayse and match the quasi-GPDs to their light-cone distributions in the asymmetric kinematic frame. Our analysis has been performed with several values of the momentum transfer −t, from 0 to 1.2 GeV^2 at zero-skewness and boost up until 1.7 GeV. We check the convergence in our matched light-cone distributions for large boosts, both in the standard definition and in the Lorentz-Invariant one. We use the quasi-GPDs to define the pseudo-GPDs in order to extract the Mellin moments. We compute and compare them to direct calculations of the moments from lattice QCD as well as to the phenomenology.

43

Dalitz-plot decomposition of $e^+e^- \to J/\psi\,\pi\,\pi$ process from 4.1271 to 4.3583 GeV employing dispersive analysis

Authors: Igor Danilkin[1]; Marc Vanderhaeghen[1]; Viktoriia Ermolina[1]

[1] *Johannes Gutenberg University of Mainz*

Corresponding Authors: vermolin@uni-mainz.de, vandma00@uni-mainz.de, danilkin@uni-mainz.de

We analyze the processes $e^+e^- \to \gamma^* \to J/\psi\,\pi\,\pi\,(K\bar{K})$ and $e^+e^- \to \gamma^* \to h_c\,\pi\,\pi$ using the recently proposed Dalitz-plot decomposition approach, based on the helicity formalism for three-body decays. Within a Lagrangian-based toy model, we validate key aspects of this approach, namely the factorization of the overall rotation for all decay chains and spin alignments, as well as crossing symmetry between final states. In analyzing the experimental data, we describe the subchannel dynamics through a dispersive treatment of $\pi\pi/K\bar{K}$ interactions, reproducing the $f_0(500)$ and $f_0(980)$ pole structures. Using recent $e^+e^- \to J/\psi\,\pi\,\pi$ data in the 4.1271-4.3583 GeV range, we reproduce invariant mass spectra that reveal both $Z_c(3900)$ and $Z_c(4020)$ states and discuss prospects for further constraints on the $Y(4220)$ and $Y(4320)$.

44

x-dependence of hadron GPDs at physical pion mass from the lattice

Author: Huey-Wen Lin[1]

[1] *Michigan State University*

Corresponding Author: hwlin@pa.msu.edu

Generalized Parton Distributions (GPDs) provide a unified framework for exploring the three-dimensional structure of hadrons, encoding correlations between spatial and momentum distributions as well as spin and orbital angular momenta of quarks and gluons. Lattice QCD offers a first-principles approach to access these nonperturbative quantities, but long-standing challenges have limited calculations to low moments. Recent developments in large-momentum effective theory (LaMET) and related approaches have enabled direct studies of the full Bjorken-x dependence of parton distributions, opening new opportunities for lattice inputs to global analyses.
In this talk, I will review the progress of lattice QCD calculations of parton distributions, with an emphasis on generalized parton distributions. I will highlight results on pion and nucleon GPDs at the physical pion mass and discuss recent advances in renormalization and matching, as well as systematic effects and strategies for controlling them. Together, these developments mark an exciting era where lattice QCD inputs can play a decisive role in unraveling the three-dimensional structure of hadrons.

45

Searching for Physics Beyond the Standard Model at the EIC

Author: HOOMAN DAVOUDIASL[1]

[1] *Brookhaven National Laboratory*

Corresponding Author: hooman@bnl.gov

The Electron Ion Collider (EIC) is designed to further our understanding of hadronic physics. However, it could also provide opportunities to look for new phenomena beyond the Standard Model. In this talk, we will provide examples of such physics, with a focus on new light particles that may be associated with a dark sector. We will illustrate how the EIC can probe new model parameter space and complement searches in other experimental venues, over the coming decades.

46

Proton leading scalar and spin polarisabilities from proton Compton scattering data

Authors: Franziska Hagelstein[1]; Timon Esser[None]; Vadim Lensky[2]

[1] *Institut für Kernphysik, Universität Mainz, Germany*

[2] *Institut für Kernphysik, Johannes Gutenberg-Universität Mainz*

Corresponding Authors: hagelste@uni-mainz.de, tesser@students.uni-mainz.de, vlenskiy@uni-mainz.de

We present the results of a partial wave analysis of the global real Compton scattering (RCS) database, extracting the leading scalar and spin polarisabilities of the proton. Exploring the nucleon using electromagnetic probes reveals a fine and intricate interplay between its various structural properties. As an example, the nucleon polarisabilities encode the two-photon response, such as measured in RCS [1, 2]. On the other hand, their precise knowledge is very important for the analysis of atomic

spectra, especially in muonic atoms [3], which serves to constrain the details of the nucleon charge distribution such as the charge radius. The polarisabilities are introduced as the coefficients in the low-energy expansion (LEX) of the RCS amplitudes, and can, in principle, be extracted using the LEX to analyse the RCS data [1, 4]. However, the energies where quality experimental data are available are too high to use the LEX for an analysis, forcing one to use a more sophisticated framework such as effective field theories [5, 6], dispersion relations [7], or partial wave analysis [8]. We use the latter framework here, include the most recent RCS data from MAMI [9] and HIGS [10], and introduce a few further modifications in the formalism. The results of our refined analysis are presented in this contribution.

---

[1] D. Babusci et al. In: Phys. Rev. C 58 (1998).
[2] B. R. Holstein et al. In: Phys. Rev. C 61 (2000).
[3] K. Pachucki et al. In: Rev. Mod. Phys. 96.1 (2024).
[4] N. Krupina et al. In: Phys. Rev. Lett. 110.26 (2013).
[5] H. W. Griesshammer et al. In: Prog. Part. Nucl. Phys. 67 (2012).
[6] V. Lensky et al. In: Phys. Rev. C 89.3 (2014).
[7] E. Mornacchi et al. In: Phys. Rev. Lett. 129.10 (2022).
[8] N. Krupina et al. In: Phys. Lett. B 782 (2018).
[9] E. Mornacchi et al. In: Phys. Rev. Lett. 128.13 (2022).
[10] X. Li et al. In: Phys. Rev. Lett. 128 (2022).

47

Coherence: a Resource for Quantum Algorithms in Quantum Computing

Authors: Karl Jansen[1]; Kostas Blekos[2]; Nikos Kollas[3]; Stefan Kühn[1]; Syed Muhammad Ali Hassan[2]

[1] *DESY Zeuthen*

[2] *The Cyprus Institute*

[3] *University of Patras*

Corresponding Authors: s.m.hassan@cyi.ac.cy, stefan.kuehn@desy.de, kollas@upatras.gr, karl.jansen@desy.de, k.blekos@cyi.ac.cy

Quantum computing uses principles from quantum mechanics that might solve certain problems that classical computers find very hard or slow to handle. It can be especially helpful in areas like optimization, cryptography and simulating quantum systems. A key aspect of this is quantum coherence, we discuss the role of resource theory in understanding the potential power of quantum computing. This shows the need for resource theory framework to understand and measure coherence. This work explores how coherence can be detected and measured in different quantum algorithms. We also study how to manage and analyze coherence in quantum systems using free states, free operations and quantum noise channel. The aim is to strengthen quantum computing by preserving and utilizing coherence more efficiently.

48

The Mellin Moments of the Pion and the Kaon

Authors: Carsten Urbach[1]; Constantia Alexandrou[2]; Fernanda Steffens[3]; Gregoris Spanoudes[4]; Luis Alberto Rodriguez Chacon[5]; Simone Bacchio[None]; Urs Wenger[6]

[1] *HISKP, Uni Bonn*

[2] *University of Cyprus & Cyprus Institute*

[3] *DESY - Zeuthen*

[4] *University of Cyprus*

[5] *The Cyprus Institute*

[6] *Institute for Theoretical Physics, University of Bern*

Corresponding Authors: alexand@ucy.ac.cy, wenger@itp.unibe.ch, fsteffens@uol.com.br, gspano01@ucy.ac.cy, l.a.chacon@cyi.ac.cy, s.bacchio@gmail.com, urbach@hiskp.uni-bonn.de

We present a calculation of the second, third and fourth Mellin moments of the pion and the kaon in lattice QCD. We use one ensemble of gauge configurations with two degenerate light, the strange and charm quarks with masses tuned to their physical ones. The renormalization is carried out non-perturbatively using RI-MOM and the values at given at a scale of 2 GeV in the $\bar{M}S$ scheme. We explore SU(3) flavor symmetry breaking by calculating ratios between the different moments of pion and kaon. We used the computed Mellin moments to reconstruct the pion and kaon PDFs and compare with other lattice QCD and phenomenological determinations.

49

Lattice Study of $cc\bar{u}\bar{s}$ tetraquark channel in $D^{(*)}D_s^{(*)}$ scattering

Author: Tanishk Shrimal[1]

Co-authors: Padmanath Madanagopalan [1]; Priyajit Jana [2]

[1] *IMSc, Chennai*

[2] *University of Cyprus*

Corresponding Author: jana.priyajit@ucy.ac.cy

We present a lattice QCD study of DD_s scattering in the $J^P = 0^+$ channel employing a newly proposed finite-volume Hamiltonian method using the Lippmann-Schwinger equation formulated in the plane-wave basis. This novel approach provides a direct way to analyze two-hadron interacting systems without relying on the traditional Lüscher formalism formulated in the partial-wave basis. From the extracted finite-volume spectra, we studied the scattering amplitude to look for any hadron pole in the near-threshold region. We observe small, non-zero shifts in the simulated finite-volume interacting energy levels compared to the non-interacting levels, which indicates a nontrivial interaction between D and D_s mesons in the channel of our interest. However, the extracted S-wave amplitude confirms no hadron pole in the near-threshold region. These findings provide new insight into heavy-meson dynamics. Also, they highlight the use of the plane-wave-based formalism as a complementary approach to study multi-hadron spectra in lattice QCD.

50

Multiphoton-assisted α-tunneling in deformed SHN driven by X-ray field

Authors: Shubham Bharmoria[None]; Harjeet Kaur[1]

[1] *Guru Nanak Dev University, Amritsar*

Corresponding Authors: harjeet.phy@gndu.ac.in, bharmoriashubham@gmail.com

We develop the Floquet-Volkov formalism for the multiphoton ionization process grounded in a microscopic phenomenological approach that incorporates the Skyrme force model within the Wentzel-Kramers-Brillouin (WKB) approximation to calculate the α-particle's penetration probabilities in the deformed SHN subjected to an intense X-ray laser field. Our findings reveal that such high-intensity

electromagnetic (EM) fields significantly alter the tunneling phenomenon followed by the emitted α-particle. The sensitivity of relative enhancement in penetration probabilities (ΔPrel-values) is found to correlate strongly with the effective nuclear charge (Zeff) and the decay energy(Qα). Many empirical formulae relating log10ΔPrel-values with Zeff-values are suggested, offering a predictive handle on laser-induced α-particle's penetration probabilities. In addition, the changes in tunneling probability are shown to inversely influence the α-decay half-lives (ΔTrel). By extending the scope of multiphoton interactions into the nuclear regime, this work provides new perspectives for probing nuclear structure under extreme fields and for exploring controlled modifications of decay lifetimes at the intersection of nuclear and electromagnetic physics.

51

TMD factorization at next-to-leading power

Authors: Ignazio Scimemi[1]; Max Jaarsma[2]; Oscar del Rio Garcia[3]; Wouter Waalewijn[2]

[1] *Universidad Complutense Madrid*

[2] *NIKHEF*

[3] *Complutense University of Madrid*

Corresponding Authors: oscgar03@ucm.es, wouterw@nikhef.nl, ignazios@fis.ucm.es, m.jaarsma@uva.nl

Theoretical control of soft interactions is fundamental to establish TMD factorization. It is possible to sistematically include soft interactions through soft modes in bacckground field method to reach a consistente factorization of SIDIS or Drell-Yan cross sections at next-to-leading power, where all nonperturbative terms are expressed as martix elements of field operators. As a practical example one can consider the case of jet production in SIDIS

52

Heavy-Ion Collisions as a Precision Laboratory for Hot and Cold QCD

Author: Bjoern Schenke[1]

[1] *Brookhaven National Laboratory*

Corresponding Author: bschenke@bnl.gov

I review recent developments in the field of heavy ion collisions and quark gluon plasma physics with focus on the role of nucleon and nuclear structure, electromagnetic probes, as well as connections to the future Electron Ion Collider.

53

Studying Two-Photon Exchange at high Q^2 with the HERA Collider Data

Author: Henry Klest[1]

[1] *Argonne National Laboratory*

Corresponding Author: hklest@anl.gov

Two-photon exchange (TPE) is one of the leading explanations for discrepancies in measurements of the proton electromagnetic form factors. It has been proposed that TPE could impact not only elastic scattering but also the cross sections for both inclusive deep inelastic scattering (DIS) and semi-inclusive DIS, thereby affecting the interpretation of DIS structure functions in terms of parton distributions. It is expected that higher-order QED effects such as TPE should manifest as a deviation from unity in the ratio of \epp and \emp DIS cross sections.

In this talk, I will present an analysis of two-photon exchange effects at Q^2 up to 300 GeV^2 using the existing inclusive $e^{\pm}p$ DIS data from HERA and SLAC.

54

Continuum limit of the unpolarized gluon PDF using twisted-mass fermions

Authors: Constantia Alexandrou[1]; Joseph Delmar[2]; Krzysztof Cichy[3]; Luis Alberto Rodriguez Chacon[4]; Martha Constantinou[2]; Simone Bacchio[None]

[1] *University of Cyprus & Cyprus Institute*

[2] *Temple University*

[3] *Adam Mickiewicz University*

[4] *The Cyprus Institute*

Corresponding Authors: krzysztof.cichy@gmail.com, s.bacchio@gmail.com, marthac@temple.edu, alexand@ucy.ac.cy, l.a.chacon@cyi.ac.cy, jdelmar@temple.edu

Gluons play a central role in the proton's structure, carrying a substantial fraction of its momentum and driving its dynamics at small Bjorken-x. A precise determination of the unpolarized gluon parton distribution function (PDF) from first principles is essential for understanding QCD and for reducing uncertainties in high-energy collider predictions. In this talk, we extend our work on the unpolarized gluon PDF to a continuum limit extraction. We use four $N_f = 2 + 1 + 1$ ensembles of maximally-twisted clover fermions and Iwasaki improved gluons at higher than physical pion mass with lattice spacings $a = 0.094,\ 0.079,\ 0.069$, and $0.057\,\mathrm{fm}$. We provide an analysis of excited-state effects and compare our PDF to global fitting results.

55

Role of AI and ML in Medical Physics

Author: Cameron Clarke[1]

[1] *Thomas Jefferson National Accelerator Facility*

Corresponding Author: cameronc@jlab.org

Medical Physics has grown out of nuclear physics from the very beginning and today the nuclear physics detectors, data acquisition systems, simulations, and particle accelerator systems that make up the backbone of medical imaging and cancer treatment systems in the clinic have integrated artificial intelligence and machine learning (AI/ML) deeply into their research and development cycles and clinical workflows. From early detection of cancer in screening images trained on labeled global datasets to anatomical feature identification and automated contouring, AI/ML has stepped into the clinic and vastly streamlined the workload of clinicians. Next generation medical physics applications, such as photon counting computed tomography (PCCT) and in-beam positron emission tomography (PET) radiotherapy activation washout modeling, are enabled by the deployment of AI/ML based detector and functional nuclear imaging physiological physics models. I will give an

overview of the recent advances in medical physics that take advantage of AI/ML tools. I will highlight the synergies and areas of mutual benefit where nuclear physics and medical physics can learn from each other, tracing the arc of AI/ML advances in medical physics from cancer treatment workflow improvements through next-generation imaging modalities. I will finish by describing several AI/ML detector and imaging projects currently in progress in the Radiation Detector and Imaging Group as part of the Biomedical Research and Innovation Center (BRIC) at the Thomas Jefferson National Accelerator Facility (JLab).

56

Overview of Experimental Efforts on GPDs

Author: Charlotte Van Hulse[None]

Corresponding Author: cvanhuls@mail.cern.ch

An overview of the experimental activities for the study of generalised parton distributions will be presented. These include existing measurements of exclusive processes in lepton-hadron and hadron-hadron interactions as well as planned activities for the future.

57

Studies of nucleon 3D structure using the CLAS12 at JLab

Author: Harutyun Avagyan[None]

Corresponding Author: avakian@jlab.org

Recent studies of spin and azimuthal asymmetries at JLab suggest that separation of different dynamical contributions may be critical for interpretation of observables in both exclusive and semi-inclusive production of hadrons in electroproduction. Measurements of multiparticle final states in multidimensional space will be needed to sort out all disagreements with theory predictions and improve the phenomenology of 3D partonic distribution and fragmentation function.
In this contribution, we will present ongoing studies and some future measurements with hadrons in electroproduction of semi-inclusive and exclusive final states at Jefferson Lab.

58

Chiral symmetry and nuclear interactions

Author: Evgeny Epelbaum[None]

Corresponding Author: evgeny.epelbaum@rub.de

Chiral effective field theory has become a standard tool to analyze low-energy reactions involving pions, nucleons and external electroweak sources. I will briefly describe conceptual foundations of this method, review our recent efforts towards developing it into a precision tool for low-energy nuclear physics and discuss some of the remaining challenges.

59

Theoretical Perspectives on Electromagnetic Hadronic Physics

Author: Marco Radici[1]

[1] *Istituto Nazionale di Fisica Nucleare*

Corresponding Author: marco.radici@pv.infn.it

I'll give my personal perspective on a general overview of the most recent and relevant theoretical developments about how we picture the internal structure of hadrons.

60

Directions in hadron physics: theory

Author: Ian Cloet[None]

Corresponding Author: icloet@anl.gov

Plan for Nuclear Science and the NuPECC 2024 Long Range Plan for European Nuclear Physics. Both reports emphasize the central role of QCD-focused nuclear theory in supporting and guiding the hadron physics program. This talk will outline the major directions for hadron physics theory in the coming decade, highlight the big science questions that must be addressed, discuss the evolving research and funding landscape, and describe the new tools and approaches that theory should embrace.

61

Lattice QCD calculations for Nuclear Physics

Author: Assumpta Parreño[1]

[1] *University of Barcelona*

Corresponding Author: aparrenog@ub.edu

Lattice QCD has matured into a powerful nonperturbative tool for directly probing the low-energy regime of the strong interaction from the QCD Lagrangian. Specifically, lattice QCD now offers quantitative insights into two- and three-nucleon interactions, nuclear binding energies, hypernuclear forces, and electroweak matrix elements relevant to neutrino-nucleus scattering and double beta decay. Despite the challenges of signal-to-noise degradation and computational scaling for multi-baryon systems, recent algorithmic developments and analysis techniques have enabled ab initio calculations of hadronic and nuclear observables with increasing precision. Moreover, lattice QCD plays a pivotal role in constraining effective field theories and informing phenomenological models, bridging the gap between fundamental theory and experimental observables.

In this talk, I will present key results obtained by the NPLQCD collaboration. I will focus on baryon-baryon interactions and discuss how these findings compare with results from other lattice collaborations.

62

The Proton Size Revealed through the Energy Momentum Tensor Form Factors

Author: Zein-Eddine Meziani[1]

[1] *Argonne National Laboratory*

Corresponding Author: zmeziani@anl.gov

The size of the proton has traditionally been defined by its charge radius, neglecting the role of gluons despite their dominance in its structure. Here we report the first global experimental extraction of the proton's total scalar energy density, reconstructed from near-threshold J/ψ production data to provide the gluonic contribution and the quark contribution from DVCS. We show that the total scalar field defines the proton's largest spatial extent, exceeding both mass and charge radii, and thus sets the effective size of the proton. This result fundamentally reframes our understanding of nucleon structure and highlights the central role of gluons in shaping visible matter.

63

Hyperon Time-like Form Factors at BESIII

Author: Simone Pacetti[1]

Co-author: Francesco Rosini [2]

[1] *Istituto Nazionale di Fisica Nucleare*

[2] *INFN and Perugia University*

Corresponding Authors: simone.pacetti@pg.infn.it, francesco.rosini@pg.infn.it

The never ending story of baryon time-like form factors continues and renew itself, fed by the powerful process of synergic and mutually reinforcing actions of experiments and theory.
Hyperons, with their self analyzing weak decays give the unique possibility to investigate the complex nature of form factors and mainly to test concepts based on first principles, which can be exploited to study dynamical mechanisms considered unknowable until recently.
BESIII analysis, with their accuracy, offer the opportunity of enhancing knowledge and understanding of the mechanisms underlying the electromagnetic interaction of hyperons.
I will review recent discoveries, highlighting new developments and improvements to existing knowledge—improvements that, in some cases, have actually rethought previously well-established concepts.

64

Saturation vs Sudakov effects in SIDIS at small x

Author: Jamal Jalilian-Marian[1]

[1] *Baruch College*

Corresponding Author: jamal.jalilian-marian@baruch.cuny.edu

We calculate the Next to Leading Order (NLO) corrections to single inclusive hadron production in DIS (SIDIS) in the forward rapidity region using the Color Glass Condensate (CGC) formalism. We then consider the kinematic region where the transverse momentum of the produced hadron is much less than the virtuality of the photon and show that there are large (Sudakov) logs originating from this kinematics. We then proceed to derive the Collins-Soper-Sterman (CSS) evolution equation using the background field methods employed in the CGC formalism.

65

Compton amplitude and the nucleon structure functions from Lattice QCD

Author: Utku Can[1]

[1] *University of Adelaide*

Corresponding Author: kadirutku.can@adelaide.edu.au

The structure of hadrons relevant for deep-inelastic scattering are completely characterised by the Compton amplitude. It is possible to directly calculate the Compton amplitude by taking advantage of the familiar Feynman-Hellmann approach applied in the context of lattice QCD. In principle, the x-dependent structure functions can be recovered from the amplitude or the amplitude itself can be incorporated to global QCD analyses. In this contribution, I will be highlighting QCDSF Collaboration's developments on computing the Compton amplitude and extracting the (moments of) structure functions.

66

Recent Results from GlueX

Author: Farah Afzal[1]

[1] *Ruhr University Bochum*

Corresponding Author: farahnoreen.afzal@ruhr-uni-bochum.de

The detailed understanding of how quantum chromodynamics (QCD) gives rise to the spectrum of hadrons is currently one of the biggest open questions in hadron physics. Most of the observed states are classified as quark-antiquark mesons or three-quark baryons. However, QCD allows for a much richer spectrum with more complex configurations. Experimental evidence exists for such non-conventional hadrons like hybrid mesons, in which an excited gluonic field is coupled to a quark-antiquark pair and contributes directly to the meson properties.
Worldwide, different experimental facilities have dedicated and complementary hadron spectroscopy programs. The GlueX experiment, which is located in Hall D at Jefferson Lab, USA, uses a linearly polarized photon beam with energies of up to 12 GeV incident on a liquid hydrogen target and consists of a high-acceptance spectrometer with excellent charged as well as neutral particle detection capabilities. This allows us to study the production mechanisms and decays of a wide range of hadronic resonances.

This talk gives an overview of the recent results from the GlueX experiment.

67

Directions in hadronic physics: experiment

Author: Richard Milner[1]

[1] *MIT*

Corresponding Author: milner@mit.edu

The status and plans for experimental programs in hadronic physics in Asia, Europe and N. America will be summarized.

68

A Practical Approach to the Overlap Operator on the Lattice. The Kenney-Laub Rational Approximation

Author: Stylianos Gregoriou[1]

[1] *The Cyprus Institute*

Corresponding Author: s.gregoriou@cyi.ac.cy

We present a practical approach for implementing the overlap Dirac operator in lattice QCD that combines the Kenney-Laub (KL) rational iterates for approximating the matrix sign function, their partial fraction decomposition enabling Multi-Shift Conjugate Gradient solvers, and the parameter-free Brillouin operator as kernel. This method requires no spectral information, avoiding the costly eigenvalue estimates common in other methods, while systematically improving chiral symmetry preservation with approximation order.

Preliminary benchmarking against the widely-used Chebyshev approach indicates that the KL method exhibits more predictable, monotonic convergence with improved efficiency. Physical observables, including PCAC mass and critical bare mass, show the KL-Brillouin combination to be especially effective. The Brillouin kernel outperforms the Wilson kernel, and equivalent precision can be reached with roughly 20% fewer computational resources. With minimal parameter tuning, no spectral input, and systematically improvable convergence, the method offers a straightforward and efficient alternative for overlap operator implementations where chiral symmetry is essential.

69

The proton electromagnetic generalized polarizabilities

Author: Nikos Sparveris[None]

Corresponding Author: sparveri@temple.edu

The electromagnetic polarizabilities of the proton are fundamental structure constants, that describe the proton's response to an external electromagnetic (EM) field and quantify the deformation of the charge and magnetization distributions inside the proton caused by the electric or magnetic field, respectively. When studied through the virtual Compton scattering process, the virtuality of the photon provides access to the generalized polarizabilities, that open a powerful path to study the internal structure of the proton e.g. they map out the spatial distribution of the polarization densities in the proton, they provide access to key dynamical mechanisms that contribute to the electric and the magnetic polarizability effects, and allow to determine fundamental characteristics of the system, such as the electric and the magnetic polarizability radii. This talk will briefly review the recent progress on the topic, followed by a discussion of the VCS-II experiment that will have the first phase of data-taking in the spring of 2026 at Hall C/JLab, as well as of the future experimental program for the VCS measurements with a polarized electron beam at JLab (VCS-IIIp) that was recently approved by the JLab PAC.

70

The nucleon's generalized form factors and Mellin moments up to fourth order

Author: Christian Kummer[1]

[1] *University of Cyprus*

Corresponding Author: kummer.christian@ucy.ac.cy

The Mellin moments can be used to construct parton distribution functions that are essential for phenomenology. Since they are non-perturbative quantities, they are challenging to compute. Lattice QCD provides the frame to compute generalized form factors (GFFs) providing these moments and unveil the polynomiality structure of generalized parton distributions. In this work, we present the first lattice calculation of the nucleon GFFs up to fourth order using simulations at physical pion mass. While earlier studies were limited to second order for the nucleon or to higher orders for mesons, our calculation extends the landscape of proton structure observables to third- and fourth-order GFFs. The computation is performed using one ensemble at the physical point and employs boosted frames with nonzero sink momentum to access the higher-order contributions. From the resulting GFFs we extract the forward-limit Mellin moments $\langle x^n \rangle$, providing new input for global analyses and phenomenology. These results establish benchmarks for future lattice studies and expand the understanding of the partonic structure of the proton.

71

Bridging Lattice QCD and Experiment: Universal Parameters of the $\Lambda(1380)$, $\Lambda(1405)$, and Isospin Partners

Authors: Bryan McKinnon[1]; David Ireland[1]; Ferenc Pittler[2]; Maxim Mai[3]; Peter Hurck[1]; Ryan Ferguson[1]; Ulf-G. Meißner[4]

[1] *University of Glasgow*

[2] *The Cyprus Institute*

[3] *The George Washington University*

[4] *Univ. Bonn and FZ Jülich*

Corresponding Authors: maximmai@gwu.edu, david.ireland@glasgow.ac.uk, f.pittler@cyi.ac.cy, bryan.mckinnon@glasgow.ac.uk, meissner@hiskp.uni-bonn.de, peter.hurck@glasgow.ac.uk, r.ferguson.3@research.gla.ac.uk

We perform a global analysis of negative-strangeness meson–baryon scattering using lattice QCD and experimental data within the Chiral Unitary Approach. The lattice data are analyzed via the Lüscher formalism, including coupled channels. Systematic uncertainties from data limitations, ambiguities, and framework dependence are quantified using statistical tools. We present pole positions for isoscalar resonances with full uncertainty estimates and provide predictions for isovector states, which remain less constrained.

72

Effective Field Theories for Few-Nucleon Systems

Author: Ubirajara Van Kolck[None]

Corresponding Author: vankolck@ipno.in2p3.fr

The low-energy limit of QCD is represented by a tower of effective field theories (EFTs): Chiral, Pionless, Halo/Cluster, and Roto-Vibrational, with perhaps others still to be developed. EFTs have transformed the landscape of nuclear theory by providing a systematic framework to account for multi-body forces and currents following the same tenets used in other areas of physics. However, issues of consistency remain with the most popular, Chiral EFT. I will describe recent developments in the simpler, Pionless EFT to illustrate how it provides a basis for nuclear structure and reactions that is consistent with QCD.

73

Nucleon electromagnetic form factors at large momentum from Lattice QCD

Author: Sergey Syritsyn[1]

[1] *Stony Brook University*

Corresponding Author: syritsyn@alum.mit.edu

Proton and neutron electric and magnetic form factors are the primary characteristics of their spatial structure and have been studied extensively over the past half-century. At large values of the momentum transfer Q^2 they should reveal transition from nonperturbative to perturbative QCD dynamics and effects of quark orbital angular momenta and diquark correlations. Currently, these form factors are being measured at JLab at momentum transfer up to $Q^2 = 18$ GeV^2 for the proton and up to 14 GeV^2 for the neutron. We will report an updated calculation of these form factors using nonperturbative QCD on the lattice, including G_E and G_M nucleon form factors with momenta up to $Q^2 = 12$ GeV^2, pion masses down to the almost-physical m_π=170 MeV, several lattice spacings down to $a = 0.073$ fm, and high $O(10^5)$ statistics. Specifically, we study the G_E/G_M ratios, asymptotic behavior of the F_2/F_1 ratios, and flavor dependence of contributions to the form factors. We observe some qualitative agreement of our ab initio theory calculations with experiment. Comparison of our calculations and upcoming JLab experimental results will be an important test of nonperturbative QCD methods in the almost-perturbative regime.

74

Quark and Gluon Momentum Fractions in the Nucleon

Authors: Constantia Alexandrou[1]; Simone Bacchio[None]; Giannis Koutsou[2]; Christian Kummer[3]; Yan Li[4]; Luis Alberto Rodriguez Chacon[2]; Gregoris Spanoudes[3]

[1] *University of Cyprus & Cyprus Institute*

[2] *The Cyprus Institute*

[3] *University of Cyprus*

[4] *The Cyprus institute*

Corresponding Authors: gspano01@ucy.ac.cy, g.koutsou@cyi.ac.cy, kummer.christian@ucy.ac.cy, alexand@ucy.ac.cy, s.bacchio@gmail.com, l.a.chacon@cyi.ac.cy, yan.li@cyi.ac.cy

We present the full decomposition of the momentum fraction carried by quarks and gluons in the nucleon. We employ three gauge ensembles generated with Nf=2+1+1 Wilson twisted-mass clover-improved fermions at the physical quark masses. It allows us to determine for the first time the momentum decomposition at the continuum limit with the extrapolation directly performed at the physical pion mass.

75

Kaon semileptonic form factors at the physical quark masses on large volumes in lattice QCD

Author: Takeshi Yamazaki[1]

Co-authors: Ken-ichi Ishikawa ; Naruhito Ishizuka ; Yoshinobu Kuramashi ; Yusuke Namekawa ; Yusuke Taniguchi ; Naoya Ukita

[1] *University of Tsukuba*

Corresponding Author: yamazaki@het.ph.tsukuba.ac.jp

We present our results for the kaon semileptonic form factors calculated by using the $N_f = 2 + 1$ and $2 + 1 + 1$ PACS10 configuration, whose physical volumes are more than $(10 \text{ fm})^4$ at the physical quark masses in the lattice spacings from 0.04 to 0.08 fm. The configurations were generated using the Iwasaki gauge action and stout-smeared clover quark action. The form factors near zero momentum transfer can be calculated thanks to the large volume. Using our data, a stable interpolation of the form factors to zero momentum transfer is carried out. The value of $|V_{us}|$ is determined using the interpolated result of the form factors at zero momentum transfer. Our value of $|V_{us}|$ is compared with a prediction of the standard model estimated from the CKM matrix unitarity and with those determined using the previous lattice results.

76

Towards continuum limit of Meson Charge Radii using large volume configuration at physical point in Nf=2+1 lattice QCD

Author: Kohei Sato[1]

Co-authors: Hiromasa Watanabe [2]; Takeshi Yamazaki [3]

[1] *Seikei University*

[2] *Keio University*

[3] *University of Tsukuba*

Corresponding Authors: ksatoh@het.ph.tsukuba.ac.jp, yamazaki@het.ph.tsukuba.ac.jp

We present our preliminary determination of the charge radii of light mesons using the PACS10 configurations, which were generated at the physical point on large volumes of more than $(10\,\text{fm})^3$ by the PACS Collaboration. In general, charge radius calculations suffer from systematic effects due to chiral extrapolation, finite lattice spacing effect, finite volume effect, and the choice of fit ansatz. By employing the PACS10 configurations, we can control the first three systematics in a unified manner. Furthermore, we apply a model-independent extraction method to avoid the systematic uncertainty associated with the fit ansatz. Our preliminary results of the charge radii for π^+, K^+, and K^0 are consistent with experimental and previous lattice determinations, while exhibiting reduced uncertainties.

77

Gluonic Origin of Visible Mass: Lattice QCD Baryon Mass Decomposition

Authors: Bolun Hu[1]; Haiyang Du[None]; Keh-Fei Liu[None]; Peng Sun[None]; Xiangyu Jiang[None]; Yi-bo Yang[None]

[1] *The Cyprus Institute*

Corresponding Author: hubolun1@gmail.com

The masses of visible matter arise from both the Higgs mechanism and strong interactions, yet how six Higgs-generated quark masses and flavor-neutral gluons jointly determine the hadron spectrum remains unclear. Using state-of-the-art lattice QCD with controlled continuum and infinite-volume extrapolations, we predict ground-state spin-1/2 and spin-3/2 baryon masses containing

light, strange, and charm quarks in agreement with experiment at the ≈1% level, and perform a first-principles mass decomposition. We find flavor-dependent enhancements of the Higgs (sigma-term) contributions—about 4–8 (light), 2–3 (strange), and 1.2–1.3 (charm)—while the gluonic trace-anomaly contribution is largely flavor-insensitive and clusters around ~0.8–1.2 GeV across baryons, indicating a universal gluonic origin of visible mass. These results, together with systematic-uncertainty controls, provide quantitative evidence for the strong-interaction mechanism of mass generation and supply key inputs to areas such as dark-matter–nucleon couplings.

78

Proton and neutron electromagnetic form factors from lattice QCD in the continuum limit.

Authors: Constantia Alexandrou[1]; Simone Bacchio[None]; Jacob Finkenrath[2]; Christos Iona[3]; Giannis Koutsou[4]; Ferenc Pittler[4]; Bhavna Prasad[None]; Gregoris Spanoudes[5]

[1] *University of Cyprus & Cyprus Institute*

[2] *CERN*

[3] *University of Cyprus and The Cyprus Institute*

[4] *The Cyprus Institute*

[5] *University of Cyprus*

Corresponding Authors: b.prasad@cyi.ac.cy, ciona001@ucy.ac.cy, s.bacchio@gmail.com, j.finkenrath@cern.ch, g.koutsou@cyi.ac.cy, gspano01@ucy.ac.cy, f.pittler@cyi.ac.cy, alexand@ucy.ac.cy

We present the results for the electromagnetic form factors of the proton and neutron using lattice QCD. We employ three ensembles of twisted mass fermions with two degenerate light, a strange, and a charm quark with masses tuned to their physical values. Studying the momentum transfer dependence of the form factors resulting from a multi-state fitting procedure, we obtain the electric and magnetic radii and the magnetic moments, as well as the Zemach and Friar radii in the continuum limit. Our final results include systematics arising from excited states, cut-off effects, the functional form of the momentum transfer dependence and the momenta cuts.

79

ML-Enhanced Neutron Detection in CLAS12 for Short-Ranged Correlation Studies

Author: Natalie Wright[1]

[1] *MIT*

Corresponding Author: wrightne@mit.edu

Short-ranged correlations (SRCs) provide insight into the fundamental forces that drive nuclear dynamics. Current experimental goals in this area include increasing precision in two-nucleon (2N) observables and the discovery and characterization of 3N SRCs. Exclusive measurements for these efforts require immense statistics and, given the tensor force's preference for neutron-proton pairing, precise detection of both protons and neutrons.

CLAS12 is well-suited for such measurements due to its high luminosity and large angular coverage. In particular, the CLAS12 central detector offers complete azimuthal and broad polar-angle acceptance, as well as two dedicated scintillator arrays for neutral particle reconstruction. However, imperfect efficiency in tracking introduces a major source of background as untracked protons are generally reconstructed as neutrons.

To address this challenge, we design and implement a machine-learning algorithm that uses signals from the central detector to predict whether a CLAS-reconstructed neutron is correctly identified or instead an untracked charged particle. Our model is purely data-driven, with training and test samples taken from multiple exclusive reaction channels. As a baseline, we correctly reclassify over 90% of misidentified protons, with performance stable across kinematic ranges and reaction channels.

I will present initial results using this model to extract the $e'pn/e'p$ cross-section ratio in ^{4}He, providing both a validation of its performance and a significant improvement in the precision of this measurement of the short-range two-nucleon interaction.

80

Understanding nucleon excitations in electromagnetic interactions

Author: Volker Burkert[1]

[1] *Jefferson Lab*

Corresponding Author: burkert@jlab.org

The search for "missing resonances,"first highlighted by Koniuk and Isgur in 1980, has shaped the field of baryon spectroscopy for more than four decades. It inspired worldwide experimental programs and new theoretical approaches to uncover the spectrum and structure of excited nucleon states.
This talk will review recent progress from meson photo- and electroproduction studies that have identified new resonances and advanced our understanding of the nature of well-known states. I will also discuss the essential role of baryon excitations in the hadronic phase transition of the early universe, and how electroexcitation experiments shed light on one of the central questions of QCD —the emergence of mass.
Finally, I will highlight novel approaches that probe baryon properties in exclusive deep-inelastic processes. These developments, enabled by large-acceptance spectrometers operating at high luminosities, open new windows into the effective degrees of freedom inside nucleons across distance scales.

81

Advances in AI/ML for theoretical nuclear physics

Author: Felix Ringer[1]

[1] *Stony Brook University*

Corresponding Author: felix.ringer@stonybrook.edu

The rapid progress in AI/ML has led to numerous applications in theoretical nuclear physics, often transforming how we carry out calculations and analyze data. I will review recent developments, including generative modeling of collider events, simulation-based inference at the event level, and novel search strategies for physics beyond the Standard Model. These techniques are relevant to current experiments at CEBAF, RHIC, and the LHC, as well as the future Electron-Ion Collider.

82

Joint neutron-polarizability extraction and dark-sector search using deuteron photodisintegration

Author: Cornelis Mommers[1]

Co-author: Marc Vanderhaeghen [2]

[1] *Johannes Gutenberg University Mainz*

[2] *Johannes Gutenberg University of Mainz*

Corresponding Authors: cmommers@uni-mainz.de, vandma00@uni-mainz.de

We assess the potential of using deuteron photodisintegration around the neutron quasi-free peak as a dual-purpose experiment to simultaneously constrain neutron polarizabilities and probe physics beyond the Standard Model. Such a combined approach would uniquely tackle two distinct research programs simultaneously: nucleon electromagnetic structure and searches for light new physics.

The neutron electric and magnetic polarizabilities are essential inputs for precision calculations but often dominate theoretical uncertainties. One established method to infer neutron polarizabilities uses deuteron photodisintegration near the neutron quasi-free peak. Here, we explore this reaction, $\gamma d \rightarrow e^+e^-pn$, with quasi-free neutron kinematics in the context of a low-energy, high-intensity experiment at MAGIX@MESA. With a projected e^+e^- invariant mass resolution of 0.1 MeV, MAGIX@MESA is expected to offer significantly improved sensitivity over prior efforts (such as MAMI-A2).

In addition, we identify an overlap between kinematic regions relevant for polarizability extraction and for searches of new light bosons in the 10–100 MeV mass range. Given the growing interest in light mediator models—which may give rise to such bosons—we extend our previous work, in which we built a framework to obtain bounds on the coupling of the neutron to a new light boson using deuteron photodisintegration.

83

First priciples lattice QCD calculation of inclusive semileptonic decays of the Ds meson

Author: Antonio Evangelista[1]

[1] *University of Cyprus*

Corresponding Author: antonio.evangelista@roma2.infn.it

Inclusive processes pose a long-standing challenge for lattice QCD due to their inherently multi-hadron nature and the need to access fully summed final states. Here, we demonstrate how first-principles methods can now overcome these obstacles through spectral reconstruction techniques. We present a first-principles lattice QCD study of the inclusive semileptonic decays of the D_s meson, providing precise determinations of the decay rate and the first two lepton-energy moments with full control over systematic uncertainties. Our predictions show excellent agreement with experiment and demonstrate that, while inclusive D_s decays are not yet as competitive as exclusive modes for extracting $|V_{cs}|$, they hold strong potential to become a precision tool in the near future. Using the same lattice methods, we also investigate the inclusive process $\tau \rightarrow X_{us}\nu_\tau$, achieving subpercent accuracy and motivating future first-principles calculations of long-distance isospin-breaking effects. These studies establish inclusive decays as a new precision frontier in lattice QCD, enabling increasingly accurate determinations of CKM parameters and providing stringent tests of the Standard Model.

84

Overview of Charmonium-like Spectroscopy

Author: Nils Hüsken[1]

[1] *JGU Mainz*

Corresponding Author: nhuesken@uni-mainz.de

In recent years, a number of charmonium-like XYZ states have been observed above the open-charm threshold in experiments like BABAR, BESIII, Belle(II) and LHCb. Their properties often go against our expectations for regular charmonium states, rendering their interpretation difficult. In this talk, I will give an overview of recent activities aiming to shed light on the nature of the XYZ states.

85

AI-Enhanced BEGe Detectors for Low-Energy X-ray Collapse Model Tests

Author: Simone Manti[1]

Co-author: Catalina Oana Curceanu [1]

[1] *Istituto Nazionale di Fisica Nucleare*

Corresponding Authors: simone.manti@lnf.infn.it, catalina.curceanu@lnf.infn.it

Testing the foundations of quantum mechanics requires experiments with extremely high sensitivity to the detection of events, which, if they occur, would have an extremely low rate. The VIP collaboration at the Gran Sasso National Laboratory (LNGS) is performing tests on the spontaneous collapse of the wave function, where recent results indicate that different collapse models predict distinct photon emission features at low energies (<10 keV). Here, I introduce tests carried out at LNGS by VIP with a Broad-Energy Germanium Detector (BEGe) for probing spontaneous emission in collapse theories. In this talk, I will present recent results and describe the new methodologies and approaches being implemented to reach progressively lower energy ranges. Special emphasis will be placed on the development of a BEGe-based experimental setup, in which machine learning techniques are employed to classify event waveforms and enhance performance at low energies, where interference from microphonic noise makes classification challenging with conventional pulse-shape analysis techniques. These strategies represent a promising direction for extending sensitivity to rare events and improving the ability to test foundational models of quantum mechanics.

86

Status of ePIC Collaboration and the Science Program

Author: Maria Żurek[1]

[1] *Lawrence Berkeley National Labolatory*

Corresponding Author: mariakzurek@lbl.gov

The Electron-Ion Collider will explore the internal structure of nucleons and nuclei with unprecedented precision. By colliding polarized electrons with polarized protons and a range of nuclei

across a broad kinematic regime, the EIC will enable multi-dimensional probes of nucleon structure, including TMDs, GPDs, and other partonic correlations. These measurements are essential for understanding the origin of nucleon spin, mass, and other emergent QCD phenomena.

In this talk, I will present the status of the ePIC Collaboration and its science program, briefly reviewing the detector design and capabilities as well as the collaboration organization. I will outline the physics priorities, highlight key goals enabled by the EIC, and note how ePIC's program complements and extends ongoing efforts across the global hadron physics community.

87

The MAGIX Trigger Veto System

Author: Hannah Kessler[1]

[1] *JGU, Institute for Nuclear Physics*

Corresponding Author: hakessle@students.uni-mainz.de

The MAinz Gas Injection Target EXperiment (MAGIX) experiment at the
Mainz Energy-Recovering Superconducting Accelerator (MESA) requires precise event selection and background supression. This poster presents the dedicated Trigger Veto System developed for that purpose.

The MAGIX setup consists of a windowless gas jet target, followed by two high-resolution magnetic spectrometers that focus the scattered electrons onto their focal planes. There, the detector system is located, starting with the TPC (Time Projection Chamber), which is described on a companion poster. Directly underneath is the MAGIX Trigger Veto System.

The system features a segmented plastic scintillator trigger layer with dual photomultiplier readout, providing precise timing and position information. The veto layers with SiPM readout and passive lead absorbers suppress background from cosmic muons, neutrons, and other background particles. The system is built in a modular "drawer"design, allowing flexible configuration and easy maintenance.

This combination of fast triggering, background suppression, and modularity ensures reliable event selection, leading to a significant improvement in the overall data quality of MAGIX measurements. By providing this setup, the MAGIX Trigger Veto System is a key element in enabling the MAGIX physics program, which ranges from precise astrophysical S-factor determinations to detailed studies of nucleon form factors.

88

A Low-Material Time Projection Chamber for MAGIX

Author: Lucie Bister[1]

[1] *JGU, Institute for Nuclear Physics*

Corresponding Author: lbister@students.uni-mainz.de

The MAinz Gas Injection Target EXperiment (MAGIX) will be operated at the Mainz Energy-Recovering Superconducting Accelerator (MESA), performing high-precision electron scattering experiments on a variety of targets, ranging from hydrogen to argon.

The setup includes a windowless gas jet target, followed by two high-resolution magnetic spectrometers that focus the scattered electrons onto their focal plane. Due to the significant impact of background effects, such as multiple scattering at low energies, a low-material Time Projection Chamber

(TPC) has been developed to achieve a momentum resolution of $\Delta p/p < 10^{-4}$. Underneath sits a Trigger Veto System, which will be presented by an additional poster.

To eliminate material in the particle path, an innovative open field cage design has been developed, ensuring that the only material in the particles' trajectory is a 75 µm thin Kapton foil. This design minimizes the material budget and preserves track quality.

These features make the TPC an essential component for realizing the physics program of MAGIX, which spans from studies of nucleon form factors to astrophysical S-factor measurements. This contribution focuses on the design considerations and the performance of the low-material TPC, highlighting its role within the MAGIX setup.

89

Modeling lepton-nucleus scattering cross sections using transfer learning technique

Authors: Beata Kowal[1]; Krzysztof Graczyk[1]

Co-authors: Artur Ankowski [2]; Hemant Prasad [1]; Jan Sobczyk [1]; José Luis Bonilla Ramirez [1]; Rwik Dharmapal Banerjee [1]

[1] *University of Wrocław*

[2] *University of Wroclaw*

Corresponding Authors: beata.kowal@uwr.edu.pl, artur.ankowski@uwr.edu.pl, jan.sobczyk@uwr.edu.pl, krzysztof.graczyk@uwr.edu.pl

The neural network framework allows us to obtain empirical fits to electron scattering cross sections on carbon over a wide kinematic region. Transfer learning makes it possible to adapt a deep neural network trained on one type of data to new problems. We apply transfer learning to derive a new model from a previously obtained set of neural networks trained on electron-carbon cross-section data. Using the bootstrap method, we retrain this set of networks on cross-section data for electron interactions with other nuclear targets. This procedure yields fits and their uncertainties for helium, lithium, oxygen, aluminum, calcium, and iron.

In our analysis, the loss function is defined by the χ2, which incorporates both point-to-point and normalization uncertainties for each independent dataset. Since electron–nucleus and neutrino–nucleus interactions share many similarities, our technique has the potential to significantly improve the understanding of neutrino interactions with nuclei, which is crucial for neutrino oscillation experiments such as DUNE and Hyper-Kamiokande.

The presentation is based on the papers Phys.Rev.C 110 (2024) 2, 025501; Phys. Rev. Lett. 135, 052502; arXiv:2508.00996

90

Studying hadrons and nuclei with electromagnetic processes: Experimental overview

Author: Christine Aidala[None]

Corresponding Author: caidala@umich.edu

Electromagnetic processes are essential and versatile tools in studying myriad aspects of hadronic and nuclear physics. This talk will offer a tour of the various ways in which electromagnetic processes and probes are used to inform our understanding of hadron structure, hadronization mechanisms, what partonic bound states exist, and properties of extreme nuclear matter. We'll also consider how electromagnetic interactions in comparison to hadron-hadron interactions can shed light

on questions of universality and unique features of QCD due specifically to its non-Abelian nature.

91

Overview of Recent Developments of TMDs from Lattice QCD

Author: Jianhui Zhang[1]

[1] *The Chinese University of Hong Kong, Shenzhen*

Corresponding Author: zhangjianhui@gmail.com

In recent years, significant progress has been made in extracting transverse-momentum-dependent (TMD) hadron structure from lattice QCD. In this talk, I will give a brief overview of recent developments in lattice calculations of TMD physics, including the determination of the soft function, the Collins–Soper kernel, and the computation of TMD parton distribution functions and TMD wave functions.

92

Progress in three-particle scattering from lattice QCD

Author: Maxwell Hansen[1]

[1] *University of Edinburgh*

Corresponding Author: maxwell.hansen@ed.ac.uk

I will review recent advances in studying three-particle interactions directly from lattice QCD. By employing mathematical relations that connect discrete finite-volume energies and matrix elements to physical scattering and decay amplitudes, it is now possible to calculate observables that go beyond the single-hadron or elastic two-hadron regime. In addition to outlining the formalism, I will highlight recent applications and discuss future prospects and open challenges.

93

Imaging Quarks and Gluons: From Global Analyses to AI-Driven Insights

Author: Nobuo Sato[1]

[1] *Jefferson Lab*

Corresponding Author: nsato@jlab.org

Reconstructing the internal quark and gluon structure of nucleons and nuclei is a central goal of the JLab 12 GeV program and the future Electron–Ion Collider. Achieving this goal is a formidable challenge that demands the integration of theory, experiment, and data science. In this talk, I will present recent progress by the JAM Collaboration toward this mission and highlight emerging opportunities enabled by advances in AI and machine learning.

94

Phenomenology of GPDs and synergy with lattice QCD

Author: Paweł Sznajder[1]

[1] *National Centre for Nuclear Research, Poland*

Corresponding Author: pawel.sznajder@ncbj.gov.pl

Generalized parton distributions (GPDs) offer a powerful framework to access the multidimensional structure of hadrons, allowing in particular for so-called nucleon tomography and providing access to elements of the hadron energy–momentum tensor. The extraction of GPDs from experimental data is, however, challenging and often cannot be performed in a complete way due to difficulties arising from the deconvolution of amplitudes. In parallel, lattice QCD has achieved notable progress in computing quantities relevant to GPDs from first principles. The growing synergy between lattice results and phenomenological models provides new opportunities for cross-validation, improved parametrizations, and enhanced predictive power.

In my talk, I will highlight recent developments in GPD phenomenology, discuss ongoing efforts to integrate lattice inputs, and outline prospects for a unified description of hadron structure through combined theoretical and experimental approaches.

95

What's next for the theory of muon g-2?

Author: Vladimir Pascalutsa[1]

[1] *University of Mainz*

Corresponding Author: pascalu@uni-mainz.de

The anomalous magnetic moments of the muon and the electron, a_μ and a_e, are precision benchmarks of the Standard Model and promising New-Physics probes. The hadronic vacuum polarization (HVP) contribution remains the dominant source of uncertainty, a problem compounded by the current tension between data-driven (dispersive) and lattice QCD evaluations. I will discuss the status of the HVP contribution, contrasting the two approaches and highlighting recent progress in understanding isospin-breaking effects. The subleading hadronic light-by-light (HLbL) contribution still leaves considerable room for improvement. Looking further ahead, the electron $g-2$, once the fine-structure constant α_{em} is known with greater precision, may provide an additional stringent constraint on hadronic contributions. These developments chart the path toward reducing theoretical uncertainties to the level of the completed Fermilab measurement of the muon $g-2$.

96

Exploring strange hadronic matter through femtoscopy at the LHC

Author: Raffaele Del Grande[1]

[1] *Czech Technical University in Prague (CZ)*

Corresponding Author: raffaele.del.grande@fjfi.cvut.cz

Understanding the interactions among strange hadrons is crucial for developing a realistic equation of state of nuclear matter in dense environments as in the interior of neutron stars. In recent years,

significant theoretical progress has been achieved through Effective Field Theories, which provide interaction models anchored to experimental data, and through Lattice QCD calculations that enable first-principles studies of baryon-baryon and meson-baryon interactions. On the experimental side, major efforts at facilities such as DAΦNE, J-PARC, RHIC, FAIR, and the LHC have yielded increasingly precise measurements aimed at constraining and validating theoretical predictions. In this contribution, I will highlight the main achievements in this field, with a focus on the femtoscopy technique at the LHC. This method has provided the most precise information to date on the low-energy dynamics of several particle pairs in the strangeness sector, including systems with double and triple strangeness. Recent extensions to the three-body systems further demonstrate the capability of femtoscopy to investigate few-body dynamics for strange hadrons with unprecedented precision. Finally, I will discuss the implications of these measurements for our understanding of the equation of state of neutron stars.

Welcome / 97

test