8th Workshop of the APS Topical Group on Hadronic Physics

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Book of Abstracts

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Abstract ID : **1**

Hexaquarks under the microscope

Content

Several new findings in the four, five and six quark systems have catalyzed new interest in the field of multiquark states (beyond the trivial $q\bar{q}$ and qqq systems). Very significant progress has recently been made in the 6q sector, on both the theoretical and experimental fronts. A resonance like structure observed in double-pionic fusion to the deuteron, at M = 2.38 GeV with Γ = 70 MeV and $I(J^P) = 0(3^+)$ has been consistently observed in a wealth of reaction channels, supporting the existence of a resonant hexaquark state - the $d^*(2380)$. Such a light hexaquark would have a very wide impact beyond hadronic physics. It was recently indicated that this new particle may set a limit on achievable neutron star masses, play a key role in the dynamics of neutron star merger events (including resultant gravitational wave emission) and has the potential to be an important intermediate step in the nuclear to quark-gluon plasma transition.

The talk will present the first results on d^* photoproduction, obtained with the Crystal Ball at MAMI along with our future plans to improve understanding of the d* with electromagnetic probes at the JLab and Mainz MAMI. The d^* is the only multiquark state which can be produced copiously at current facilities, offering unique access to information beyond its basic quantum numbers, particularly its physical size and internal structure. Further possible astrophysical implications will also be outlined.

Primary author(s) : Dr. BASHKANOV, Mikhail (University of York)

Presenter(s) : Dr. BASHKANOV, Mikhail (University of York)

Contribution Type : invited talk

Abstract ID : **4**

X-ray spectroscopy of hadronic exotic atoms and application in foundations of quantum physics

Content

In hadron physics arrays of silicon drift detectors (SDDs) were extremely successful used for spectroscopy of kaonic atoms. Presently new experiments on X-ray spectroscopy at DAFNE/LNF-INFN in Italy and J-PARC in Japan for the first strong interaction studies of kaonic deuterium are in preparation. The development of SDD X-ray detectors is also crucial for experiments in foundation of quantum physics. The experiment VIP (1,2) at the underground laboratory Gran Sasso is using these solid-state detectors. The talk will provide an overview of application of SDDs in hadron physics at DAFNE and J-PARC involving kaonic atoms and will discuss the application in the underground experiment VIP.

(1) https://www.lngs.infn.it/en/vip

(2) supported by Austrian Science Fund, project P-30635

Primary author(s) : Dr. MARTON, Johann (Stefan Meyer Institute, Austrian Academy of Sciences)

Presenter(s) : Dr. MARTON, Johann (Stefan Meyer Institute, Austrian Academy of Sciences)

Contribution Type : contributed talk

Comments:

VIP supported by Austrian Science Fund, project P-30635 Talk on behalf of the VIP Collaboration

Abstract ID : **5**

Entanglement entropy at small x

Content

The degrees of freedom observed in hadronic collisions at high energies can be strongly entangled with the rest degrees of freedom in the initial light cone hadronic wavefunction. The coherence of the incoming hadron is destroyed by the interaction with the target; this may lead to the transformation of the entropy associated with the entanglement into the thermodynamics entropy of produced particles. We study the entanglement entropy at small x in the Color Glass Condensate effective field theory. In particular, we compute the entanglement entropy of soft gluon field beyond the dilute approximation in the MV model for the soft gluon fields. We discuss the small x evolution of entanglement entropy described by the JIMWLK renormalization group equation.

Primary author(s) : Mr. DUAN, Haowu (North Carolina State University)

Co-author(s) : Dr. SKOKOV, Vladimir (North Carolina State University)

Presenter(s) : Mr. DUAN, Haowu (North Carolina State University)

Contribution Type : contributed talk

Abstract ID : **6**

Charge radii and decay constants of heavy flavored mesons using perturbative approach

Content

We report the results for charge radii and decay constants of various heavy flavored D and B mesons in an improved QCD potential model. To enhance the effectiveness of short range and long range effect of the potential $V(r) = -4\frac{\alpha_s}{3r} + br$ in the perturbative procedure a cut-off parameter r^P is introduced as an integration limit. The obtained results are found to be comparable with other available data. The limitations of the approach are also discussed.

Primary author(s) : Dr. DAS, Tapashi (Assistant Professor, Deptt. of Physics, Madhab Choudhury College)

Co-author(s) : Prof. CHOUDHURY, Dilip Kumar (Retired Professor, Deptt. of Physics, Gauhati University)

Presenter(s) : Dr. DAS, Tapashi (Assistant Professor, Deptt. of Physics, Madhab Choudhury College)

Contribution Type : contributed talk

Abstract ID : **7**

SU(2) Charges with Spherical Symmetry and Confined Boundary Conditions

Content

We present a field-strength description for a simple system of SU(2) charges with spherical symmetry and confining boundary conditions. The static Yang-Mills Maxwell equations admit three types of solutions for this system. Type-0 solutions have no topological structure. Type-1 and Type-2 solutions involve a topologically charge domain wall consisting of a surface volume with CP-odd field strength density. Type-1 solutions display an exterior volume resembling a magnetic condensate while type-2 solutions have an exterior field-free volume with vacuum quantum numbers. In analogy to the kink-solution in the 1+1 dimensional Abelian Higgs model we argue that type-2 solutions should contain a mass gap.

Primary author(s) : SIVERS, Dennis (Portland Physics Institute and University of Michigan)

Presenter(s) : SIVERS, Dennis (Portland Physics Institute and University of Michigan)

Contribution Type : contributed talk

New Baryon States from Exclusive Meson Photo-/Electroproduction off Proton Data

Content

Studies of the excited nucleon state (N^*) spectrum offer insight into the strong QCD dynamics underlying baryon generation. In particular, they elucidate the symmetries of the strong interaction relevant for the bound systems of three constituent quarks in the regime of large QCD-running coupling. The full spectrum of nucleon resonances shaped the transition from a deconfined mixture of quarks and gluons to a hadron gas in the few millisecond age of the Universe when the hadron mass was generated dynamically and quark-gluon confinement emerged. These fundamental subjects are addressed in the search for the "missing" baryon states. Many of the nucleon resonances expected from LQCD and quark models based on SU(6)×O(3) spin-flavor-space symmetry have escaped experimental detection.

Experiments with the CLAS detector in Hall¯B at JLab offer an excellent opportunity in the search for "missing" baryon states from the data on most exclusive meson photo-/electroproduction channels relevant in the N^*-excitation region. In this talk we will present results on the observation of several new nucleon resonances from the global coupled-channel analysis of most exclusive photoproduction data measured at JLab, ELSA, GRAAL, and MAMI, with a major impact from the CLAS results on $K\Lambda$, $K\Sigma$ photoproduction off protons. In addition, the combined studies of $\pi^+\pi^-p$ photo- and electroproduction off proton data from CLAS have revealed the presence of the new $N'(1720)3/2^+$ baryon state. This new state, together with the conventional $N(1720)3/2^+$ resonance, are required in order to describe the $\pi^+\pi^-p$ photo- and electroproduction off proton data with Q^2-independent nucleon resonance masses, and total and partial hadronic decay widths to the $\pi\Delta$ and ρp final states.

Combined studies of the meson photo- and electroproduction off proton data will allow us to complete the exploration of the excited nucleon state spectrum. The future studies of the N^* spectrum with the new CLAS12 detector will be focused on the search for new states of baryon matter, the so-called hybrid baryons, with the glue as an active structural component.\footnote{The Southeastern Universities Research Association (SURA) operates the Thomas Jefferson National Accelerator Facility for the United States Department of Energy under Contract No. DE-AC05-84ER40150. This material is based upon work supported by the US Department of Energy, Office of Science, Office of Nuclear Physics under Contract No DE-AC05-06OR23177 }

Primary author(s) : Dr. MOKEEV, Victor (Thomas Jefferson National Accelerator Facility)

Co-author(s) : Dr. BURKERT, Volker (Jefferson Lab)

Presenter(s) : Dr. MOKEEV, Victor (Thomas Jefferson National Accelerator Facility)

Contribution Type : contributed talk

Abstract ID : **10**

Multiple particles interaction in finite volume

Content

I will discuss briefly on the multiple particles interaction in finite volume. The focus will be given primarily on the variational approach to finite volume multiple particles problems. The general formalism for N non-relativistic spinless particles interacting with periodic pairwise potentials yields N-body secular equations. The solutions depend on the infinite-volume N-body wave functions. Given that the infinite-volume N-body dynamics may be solved by the standard Faddeev approach, the variational N-body formalism can provide a convenient numerical framework for finding discrete energy spectra in periodic lattice structures. In addition, I will also talk about current status and future directions, etc.

Primary author(s) : Dr. GUO, Peng (California State University - Bakersfield); MORRIS, Tyler (California State University - Bakersfield)

Presenter(s) : Dr. GUO, Peng (California State University - Bakersfield); MORRIS, Tyler (California State University - Bakersfield)

Contribution Type : contributed talk

Abstract ID : **11**

Production of $X(3872)$ accompanied by a soft pion in B meson decay

Content

If the $X(3872)$ is a weakly bound charm-meson molecule with flavor structure $(D^{*0}\bar{D}^0 + D^0\bar{D}^{*0})/\sqrt{2}$, it can be produced by the creation of $D^{*0}\bar{D}^0$ or $D^0\bar{D}^{*0}$ at short distances followed by the formation of the bound state from the charm-meson pairs. It can also be produced by the creation of $D^*\bar{D}^*$ at short distances followed by their rescattering into $X\pi$. An effective field theory for charm mesons and pions called XEFT predicts that the rate for producing X accompanied by a soft pion should be roughly comparable to that for an isolated X. We use the results of a previous isospin analysis of B meson decays into $KD^{(*)}\bar{D}^{(*)}$ by Poireau and Zito to estimate the short-distance amplitudes for creating $D^*\bar{D}^*$. We use XEFT to calculate the amplitudes for rescattering into $X\pi$. The resulting predictions for the branching fractions of B mesons into KX plus a soft pion are consistent with measurements of the branching fractions into $KX\pi^\pm$ by the Belle collaboration. If $KX\pi^\pm$ events in which $K\pi^\pm$ come from the K^* resonance are removed, the remaining events are predicted to come primarily from the region of the Dalitz plot with small $X\pi^\pm$ invariant mass.

Primary author(s) : BRAATEN, Eric (Ohio State University); Ms. HE, Liping (Ohio State University); Mr. INGLES, Kevin (Ohio State University)

Presenter(s) : Ms. HE, Liping (Ohio State University)

Contribution Type : contributed talk

Abstract ID : **12**

Progress in hard probes of small collision systems

Content

In this talk, I review the latest developments in high transverse momentum (pT) or mass probes of small heavy ion collision systems. These include measurements which utilize high-pT hadrons, fully reconstructed jets, photons and heavy electroweak bosons, and heavy flavor particles, as probes. I will discuss what these measurements can reveal about partonic structure and parton dynamics in heavy nuclei, and how they relate to evidence for a possible formations of quark-gluon plasma, at RHIC and the LHC. I will also give some thoughts on future prospects with lighter collision species such as Ar+Ar or O+O at the LHC and opportunities with the sPHENIX detector at RHIC.

Primary author(s) : Prof. PEREPELITSA, Dennis (University of Colorado Boulder)

Presenter(s) : Prof. PEREPELITSA, Dennis (University of Colorado Boulder)

Contribution Type : invited talk

Abstract ID : **13**

Pion Form Factor with Overlap Fermion

Content

We present a calculation of the pion form factor using overlap fermions on 2+1-flavor domain-wall configurations on a $24^3 \times 64$ lattice with $a = 0.11\,\mathrm{fm}$ and on a $32^3 \times 64$ lattice with $a = 0.143\,\mathrm{fm}$ generated by the RBC/UKQCD collaboration. Using the multi-mass algorithm, a simulation has been done with various valence quark masses with a range of space-like Q^2 from 0.0 to 0.6 GeV^2.

Primary author(s) : WANG, Gen (University of Kentucky)

Co-author(s) : Dr. LIANG, Jian (University of Kentucky); Prof. DRAPER, Terrence (University of Kentucky); Prof. LIU, Keh-fei (University of Kentucky); Prof. YANG, Yi-bo (Chinese Academy of Sciences)

Presenter(s) : WANG, Gen (University of Kentucky)

Contribution Type : invited talk

Abstract ID : **14**

Extraction of the pion form factor from pion electroproduction

Content

In 2008 the Jefferson Laboratory F_pi-2 Collaboration released results for the pion electromagnetic form factor, which they had extracted from pion electro-production data. The measured values for the pion form factor were extracted using the Vanderhagen, Guidal and Laget Regge Model. While agreement between this model and data is impressive, the theoretical implementation of gauge invariance is less satisfying. We aim to establish how well the extracted form factor corresponds to the true form factor. To do this, we use a simple toy model, which imposes gauge invariance in a more theoretically satisfying way. The model form factor is extracted from our model cross section using the method employed by the F_pi-2 Collaboration to extract the experimental pion form factor. We conclude that while the reconstructed model form factor is a reasonable representation of the true model form factor for the kinematics chosen, the extracted form factor is somewhat smaller than the true form factor. This suggests that current extracted values of pion form factor may be overestimated.

Primary author(s) : Prof. THOMAS, Anthony (CSSM and CoEPP, University of Adelaide)

Co-author(s) : Mr. PERRY, Robert (CSSM and CoEPP, University of Adelaide); Dr. KIZILERSU, Ayse (CSSM, University of Adelaide)

Presenter(s) : Prof. THOMAS, Anthony (CSSM and CoEPP, University of Adelaide)

Contribution Type : invited talk

Abstract ID : **15**

JPAC Overview

Content

I will discuss the history of JPAC, its mission and contributionx to amplitude analysis and hadron spectroscopy.

Primary author(s) : Prof. SZCZEPANIAK, Adam (Indiana Univeristy/JLab)

Presenter(s) : Prof. SZCZEPANIAK, Adam (Indiana Univeristy/JLab)

Contribution Type : invited talk

Abstract ID : **16**

The Science of the Electron-Ion Collider

Content

I will give an overview of the important physics questions to be addressed at the future, US-based Electron-Ion Collider (EIC). This includes the mass and spin structure of the nucleon, multi-dimensional tomography and the gluon saturation at small-x.

Primary author(s) : Dr. HATTA, Yoshitaka (BNL)

Presenter(s) : Dr. HATTA, Yoshitaka (BNL)

Contribution Type : plenary talk

Abstract ID : **17**

Light-front approach to a chiral nucleon-pion Lagrangian

Content

We adopt a chiral nucleon-pion Lagrangian and formulate a Basis Light-Front Quantization approach to solve the resulting light-front Hamiltonian of a nucleon as an eigenvalue problem. We obtain the nucleon mass spectrum and the corresponding light-front wave functions. Based on the light-front wave functions, we calculate the parton distribution functions as well as the elastic electromagnetic form factors of the nucleon. In this talk, we will present the current progress of our research and discuss the prospects for further applications.

Primary author(s) : Mr. DU, Weijie (Iowa State University)

Co-author(s) : Prof. ZHAO, Xingbo (Institute of Modern Physics, Chinese Academy of Sciences); Prof. VARY, James P. (Iowa State University)

Presenter(s) : Mr. DU, Weijie (Iowa State University)

Contribution Type : contributed talk

Comments:
This work was supported by the U.S. Department of Energy (DOE) under grant No. DE-FG02-87ER40371.

Abstract ID : **18**

"Supersymmetric Features of Hadron Physics and other Novel Properties of Quantum Chromodynamics from Light-Front Holography and Superconformal Algebra"

Content

A fundamental question in hadron and nuclear physics is how the mass scale for protons and other hadrons emerges from QCD, even in the limit of zero quark mass. I will discuss a new approach to the origin of the QCD mass scale and color confinement based on "light-front holography", a formalism which relates the bound-state amplitudes in the fifth dimension of AdS space to the boost-invariant light-front wavefunctions describing the structure of hadrons in physical space-time. The result is a set of Poincarè-invariant bound-state wave equations which incorporate quark confinement and predict many observed spectroscopic and dynamical features of hadron physics, such as linear Regge trajectories with identical slope in both the radial quantum number and the internal orbital angular momentum. Generalizing this procedure using superconformal algebra leads to a unified Regge spectroscopy of meson, baryon, and tetraquarks, including remarkable supersymmetric relations between the masses of mesons and baryons. The pion bound-state, although composite, is massless for zero quark mass. One also can predict nonperturbative hadronic observables such as structure functions, transverse momentum distributions, and the distribution amplitudes defined from the hadronic light-front wavefunctions. The analytic behavior of the QCD coupling controlling quark and gluon interactions at large and small distances is also determined. The result is an effective coupling defined at all momenta with a transition mass scale which sets the interface between perturbative and nonperturbative hadron dynamics. One also obtains a relation between the perturbative QCD mass scale and hadron masses.

Primary author(s) : Prof. BRODSKY, Stanley (SLAC National Accelerator Laboratory, Stanford Univsersity)

Presenter(s) : Prof. BRODSKY, Stanley (SLAC National Accelerator Laboratory, Stanford Univsersity)

Contribution Type : invited talk

Abstract ID : **19**

Quarkonium production and polarization

Content

One of the best ways to understand hadronization in QCD is to study the production of quarkonium. However, the production mechanism of quarkonium is still uncertain. Spin-related measurements like the polarization are strong tests of production models. In this talk I will summarize recent results of quarkonium production and polarization in elementary collisions, including the results from NRQCD and a newly-developed improved color evaporation model.

Primary author(s) : Mr. CHEUNG, Vincent (University of California, Davis)

Presenter(s) : Mr. CHEUNG, Vincent (University of California, Davis)

Contribution Type : invited talk

Abstract ID : **20**

Topics in QCD from Dyson-Schwinger equations

Content

The Dyson-Schwinger/Bethe-Salpeter approach provides insight into many connected problems in QCD, proving to be especially powerful in describing processes that are dominated by chiral symmetry and its dynamical breaking. Being formulated in the continuum it avoids some of the difficulties encountered on the Lattice (e.g. chiral quarks etc) at the cost of having to introduce truncations.

I will discuss some of these truncations and how their extension leads to an improved understanding of the (spectrum of) hadrons, not only as concerns mesons and baryons but also exotic states such as tetraquarks.

Furthermore, I will report on recent progress in the generalization of these studies to finite temperature.

Primary author(s) : Dr. WILLIAMS, Richard (University of Giessen)

Presenter(s) : Dr. WILLIAMS, Richard (University of Giessen)

Contribution Type : plenary talk

Abstract ID : **21**

Jefferson Lab's Contribution to the Characterization of the Proton Form Factors

Content

Elastic scattering of electrons (or positrons) on the proton (or neutron) provide information on the charge and magnetization distributions inside the nucleon. Traditionally, following the pioneering work of Hofstadter in the mid-fifties, the electric and magnetic form factors GEp and GMp of the proton have been obtained from elastic cross section data from many experiments. In the late 1990's the new electron accelerator at Jefferson Lab (alias CEBAF) provided an alternate possibility to obtain GEp and GMp using polarized electrons and measuring the polarization of the recoiling proton. The very first of a series of experiments at JLab revealed that the GEp's obtained by the two methods have a drastically different momentum transfer squared (Q2) behavior up to 8 GeV. After presentation of all data available today, I will discuss a few candidate possibilities to explain this difference in behavior of GEp results. I will also briefly discuss approved future experiments planned for the near future with the recently increased beam energies now available at JLab (12 GeV).

Primary author(s) : Prof. PERDRISAT, Charles (The College of William and Mary)

Presenter(s) : Prof. PERDRISAT, Charles (The College of William and Mary)

Contribution Type : plenary talk

Abstract ID : **22**

Experimental results on quark-gluon correlations

Content

We will review recent experimental results on quark-gluon correlations accessible in twist3 observables at RHIC and JLab.

Primary author(s) : Dr. VOSSEN, Anselm (Duke University)

Presenter(s) : Dr. VOSSEN, Anselm (Duke University)

Contribution Type : invited talk

Abstract ID : **23**

Multi-parton correlations: theory overview

Content

There is sufficiently strong motivation to study multi-parton correlations in hadrons. Not only do they contain genuine new physics that is not accessible through ordinary parton densities, but they also show up in the QCD description of many hard scattering processes. We give a brief overview of the theoretical aspects of this field. Some open questions will be discussed as well.

Primary author(s) : Prof. METZ, Andreas (Physics Department, Temple University, Philadelphia)

Presenter(s) : Prof. METZ, Andreas (Physics Department, Temple University, Philadelphia)

Contribution Type : invited talk

Abstract ID : **24**

Non-Strange and Strange Baryon Spectroscopy at GW

Content

Modern experimental facilities and detectors provide tremendous volumes of detailed data. We discuss the analysis of data from piN elastic scattering and single pion photo- and electroproduction. The main focus is a study of low-lying non-strange baryon resonances and physics perspectives for future K-Long facility at JLab.

Primary author(s) : Prof. STRAKOVSKY, Igor (The George Washington University)

Presenter(s) : Prof. STRAKOVSKY, Igor (The George Washington University)

Contribution Type : invited talk

Abstract ID : **25**

The Dalitz decay and frame dependence of transition form factors in light-front dynamics

Content

The radiative transitions between quarkonia states via the emission of a photon $\psi_A \to \psi_B \gamma$ have been studied extensively in the literature. In light-front dynamics, transition form factors are usually computed in the Drell-Yan frame, which limits the transfered momentum to the spacelike region. In this work, we explore the radiative transitions between vector and pseudoscalar quarkonia in more general frames, where we are able to access the form factors over the full kinematic region. We evaluate the frame dependence of the transition form factor for heavy quarkonia with light-front wave functions calculated from the valence Fock sector, and use it to help us understand the violation of Lorentz symmetry that arises from the Fock-space truncation. We also study the electromagnetic Dalitz decay $\psi_A \to \psi_B l^+ l^-$, and predict the effective mass spectrum of the leptonic pair ($l = e, \mu$).

Primary author(s) : LI, Meijian (Iowa State University)

Co-author(s) : Prof. VARY, James (Iowa State University); Prof. MARIS, Pieter (Iowa State University); Dr. LI, Yang (Iowa State University)

Presenter(s) : LI, Meijian (Iowa State University)

Contribution Type : contributed talk

Abstract ID : **26**

Determining the unknown Λ-n interaction by investigating the Λnn resonance

Content

We carried out the experiment E12-17-003 at Jefferson Lab in November 2018 by using the 3H(e,e'K+)Λnn reaction with the high quality CEBAF electron beam and the Hall A high resolution spectrometers. The goal of the experiment is to search for the possible Λnn three-body resonance. If such a resonance exists, it may provide, for the first time, experimental information that can be used to determine the unknown Λn interaction relative to the Λp interaction fitted from limited Λp scattering data. This can help to address the long existing puzzle of Charge-symmetry-breaking (CSB) in ΛN interactions.

Primary author(s) : PANDEY, Bishnu (Hampton University)

Presenter(s) : PANDEY, Bishnu (Hampton University)

Contribution Type : contributed talk

Abstract ID : **27**

Hadron Structure in Lattice QCD: Status and Perspectives

Content

In this talk, I will review recent progress in lattice-QCD calculations of hadron structure with an emphasis on nucleon structure. A wide range of nucleon observables are being studied in modern lattice calculations, and important progress has been made at physical pion mass, including the spin decomposition of the nucleon and the Bjorken-x dependence of hadron structure. Challenges and perspectives for future lattice hadron-structure calculations will be discussed.

Primary author(s) : Prof. LIN, Huey-wen (Michigan State University)

Presenter(s) : Prof. LIN, Huey-wen (Michigan State University)

Contribution Type : plenary talk

Abstract ID : **28**

Experimental Searches for Light Exotica: Precision and Progress

Content

The advent of high intensity hadronic physics experiments has lead to many advances in our understanding of hadronic states, and has raised many questions and new possibilities along the way. One particularly exciting question is how gluonic degrees of freedom contribute to the structure of hadrons. In the meson sector, "hybrid" states with gluonic contributions may have quantum numbers which cannot be formed with a quark-antiquark pair. Identifying such states would be clear evidence of such gluonic contributions, and have been of keen interest for many decades. Recent advances in theoretical predictions of such states, the size and quality of the experimental data available, and the improved theoretical models required to understand these reactions and identify new resonances has reinvigorated the search for hybrid mesons. In this talk, I will describe some of the recent developments in these searches, discuss some of the challenges of analyzing these new data, and illustrate some of the future prospects of studying light quark exotica with hadron and photon beams.

Primary author(s) : DOBBS, Sean (Florida State University)

Presenter(s) : DOBBS, Sean (Florida State University)

Contribution Type : plenary talk

Abstract ID : **29**

Towards a combined analysis of inclusive/exclusive electroproduction

Content

The CLAS experiments have achieved major advances in the study of the N^* region of the electroproduction spectrum. Data on electrocouplings of the many baryon resonances in the mass range up to 1.8 GeV showed consistency between the $N\pi$, $N\eta$ and $N\pi^+\pi^-$ channels. We present our theoretical studies of structure functions in view of the CLAS12 experiments planned in the near future, which are to study electron scattering observables at a wide Q^2 range from 0.05 GeV^2 to 12 GeV^2, with high precision in x. We model the resonant contributions to inclusive electron scattering, using the electrocoupling data as input. Our results are thus not fitted to the inclusive data: instead, we use the reliable extraction of the separate resonance contributions from exclusive reactions.

We combine our resonance model with a non-resonant background based on Regge models, thus for the first time enabling a combined description of the low and high-x regions of the proton structure functions. This is useful for future endeavours on understanding the transition between low and high x regions, strongly related to tests on quark-hadron duality.

Primary author(s) : Dr. HILLER BLIN, Astrid (Johannes Gutenberg Universität Mainz)

Co-author(s) : Dr. MOKEEV, Victor I Mokeev (Thomas Jefferson National Accelerator Facility); Prof. SZCZEPANIAK, Adam (Indiana Univeristy/JLab)

Presenter(s) : Dr. HILLER BLIN, Astrid (Johannes Gutenberg Universität Mainz)

Contribution Type : invited talk

DVCS and exclusive neutral pion at Jefferson Lab: Accomplishments and future developments

Content

Generalized Parton Distributions (GPDs) have become a major topic in the field of hadronic physics and nucleon structure. They parameterize the momentum of the quarks and gluons momentum in correlation with their spatial distribution inside the nucleon, which provides a three-dimensional picture of the nucleon. This feature makes GPDs a powerful tool to study the orbital momentum of partons inside the nucleon, which is the missing piece of the nucleon spin puzzle.

GPDs are studied with the measurements of exclusive leptoproduction channels such as Deeply Virtual Compton Scattering (DVCS) $\ell N \to \ell N \gamma$, and exclusive meson production $\ell N \to \ell N h$ ($h = \pi, \rho, \omega, ...$), in the deep inelastic scattering regime. DVCS is usually the most favored ("golden") channel to study GPDs, and is always associated with exclusive π^0 production measurements (as both require identical experimental setups), which is also highly relevant for flavor separation.

Jefferson Laboratory, with its high intensity polarized electron beam accelerator has been dedicating a significant share of its research resources to a variety of DVCS/π^0 measurements in its different experimental halls. The interest for the GPD related measurements at Jefferson Lab has been further enhanced with the recent Jefferson Lab beam energy upgrade from 6 to 12 GeV.

After a brief introduction on the GPDs phenomenology, I will develop on the DVCS/π^0 production measurements achieved at Jefferson Lab 6 GeV, highlighting how these data has improved our understanding on the nucleon structure. I will also point out the many questions those data have raised, and how we are planning to address these through the different measurements programmed at Jefferson Lab for the 12 GeV era.

Primary author(s) : Dr. FUCHEY, Eric (University of Connecticut)

Presenter(s) : Dr. FUCHEY, Eric (University of Connecticut)

Contribution Type : invited talk

Abstract ID : **31**

Engineering Small QGP Droplets

Content

Exciting new measurements have produced strong evidence for small quark-gluon plasma droplets produced in collisions of protons and small nuclei on large nuclei as well as in proton on proton collisions at RHIC and the LHC. We detail a subset of the most exciting results and discuss the different theoretical interpretations. We highlight the broader physics implications of these observations.

Primary author(s) : Prof. NAGLE, James (University of Colorado Boulder)

Presenter(s) : Prof. NAGLE, James (University of Colorado Boulder)

Contribution Type : plenary talk

Abstract ID : **32**

Theory progress related to the RHIC Beam Energy Scan program

Content

Much needed theoretical progress is being made to support the beam energy scan (BES) program at the Relativistic Heavy Ion Collider (RHIC) and to successfully explore nuclear matter at both low and high baryon density, determine if and where there is a QCD critical point, and whether chiral symmetry is restored and the QCD chiral anomaly can be observed in the accessible region of the phase diagram. I will review recent progress on theoretical topics related to the physics probed in the RHIC BES program, including hot and dense lattice QCD with focus on the equation of state at finite baryon density, modeling of the collision dynamics including advances in the initial state description, hydrodynamics and conversion to particles, effects of a critical point in the equation of state, critical fluctuations and their dynamics, as well as aspects of the chiral magnetic effect.

Primary author(s) : Dr. SCHENKE, Bjoern (Brookhaven National Lab)

Presenter(s) : Dr. SCHENKE, Bjoern (Brookhaven National Lab)

Contribution Type : plenary talk

Abstract ID : **33**

Gravitational structure of the proton – a new direction in experimental hadron physics.

Content

The internal structure of the proton is the result of the strong force, which is by governed Quantum-Chromo-Dynamics (QCD). Experimentally, the internal structure of the proton has been studied extensively through electromagnetic interaction using electron an muon beams. As a result we have precise information about the proton's charge radius, its electromagnetic elastic and transition form factors, and its quark helicity distribution as represented by the PDFs. While these measurements give us indirect information about effects of the strong interaction in the proton, there is not a one-to-one correspondence between electromagnetic form factors and the strong force acting upon the quarks in the proton. For experiments to be sensitive to the distribution of mass, forces, pressure and angular momentum in the proton, i.e. its mechanical properties, we should employ the gravitational interaction [1], which is far too weak on our planet to allow any realistic experiments at the subatomic level to be conducted. The discovery and the further development of the framework of generalized parton distribution (GPDs) has opened up this field to the exploration of the strong force in particular exclusive processes, e.g. deeply virtual Compton scattering (DVCS), that mimic the graviton interaction with the proton but at much higher strength making it experimentally accessible. In this talk I will introduce the underlying background, discuss the experimental methods and the first results of a mechanical property of the proton based on experimental data.

[1] H. Pagels, Phys. Rev. 144 (1966) 1250-1260 [2] V. Burkert, L. Elouadrhiri, and F.X. Girod; Nature 557 (2018) no.7705, 396-399

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Primary author(s) : Dr. BURKERT, Volker (Jefferson Lab)

Co-author(s) : Dr. ELOUADRHIRI, Latifa (Jefferson Lab); Dr. GIROD, Francois-xavier (Jefferson Lab)

Presenter(s) : Dr. BURKERT, Volker (Jefferson Lab)

Contribution Type : plenary talk

Abstract ID : **34**

The Proton Charge Radius (PRad) Experiment at JLab

Content

Motivated by the desire to resolve the proton charge radius puzzle which started in 2010, the PRad experiment (E12-11-106) was performed in 2016 in Hall B at Jefferson Lab, with 1.1 GeV and 2.2 GeV unpolarized electron beams to measure the *ep* elastic scattering cross sections at very low values of four-momentum transfer squared, Q^2, ranging from 2×10^{-4} to 6×10^{-2} $(\mathrm{GeV/c})^2$ with a sub-percent precision. The proton electric form factor is then extracted from the measured cross section in order to extract the proton charge radius. The experiment utilized a calorimetric method with a high resolution calorimeter (HyCal) that is magnet free, and two large area, high spatial resolution Gas Electron Multiplier (GEM) detectors. The experiment also used a windowless H_2 gas flow target to remove typical backgrounds from target cell windows. The systematic uncertainties of the absolute *ep* elastic scattering cross sections are also controlled by the well-known Moller scattering process, which was measured simultaneously in this experiment within similar kinematics and acceptances. In this talk, details about the experiment, the data analysis as well as the results will be presented.

1.On Behalf of the PRad Collaboration. 2.This work is supported in part by the NSF MRI award PHY-1229153, the U.S. Department of Energy under Contract No. DE-FG02-03ER41231, the Thomas Jefferson National Accelerator Facility and Duke University. 3. Spokespersons: D. Dutta, H. Gao, A. Gasparian (contact), M. Khandaker.

Primary author(s) : GAO, Haiyan (Duke University)

Presenter(s) : GAO, Haiyan (Duke University)

Contribution Type : invited talk

Abstract ID : **36**

The Tritium Experiments

Content

The Tritium program in Hall A at Jefferson Lab utilized the mirror nuclei, Tritium and Helium-3, to study, in a model independent way, the d/u ratio at high-x, the EMC effect in the A=3 nuclei, probe nucleon-nucleon short-range correlations and their isospin dependence, and to investigate the three-body hyper-nuclear bound-system. By the end of November 2018, four highly rated Tritium experiments have successfully been completed. In this talk, I will introduce the physics motivation of the program, share the experimental details of these experiments, discuss the status of the data analysis and future prospects.

Primary author(s) : Dr. YE, Zhihong (Argonne National Lab)

Presenter(s) : Dr. YE, Zhihong (Argonne National Lab)

Contribution Type : invited talk

Abstract ID : **37**

Charming discoveries in antimatter-matter annihilations

Content

Despite the successes of the Standard Model of particle physics, it remains a challenge to understand the dynamics of the strong interaction among quarks and gluons. At small distance scales or at high energies, the underlying theory, the Quantum Chromodynamics (QCD), is well tested and understood. Our understanding of the strong interaction deteriorates dramatically at larger distances scales such as the size of the nucleon. This "strong QCD regime" exhibits spectacular effects such as the generation of hadron masses and color confinement. Moreover, the nature of QCD implies the existence of gluon-rich hadrons, such as glueballs and hybrids, multi-quark states, and molecules. The annihilation of matter with antimatter in the mass regime of charmonium has proven to be an ideal environment to discover new forms of hadronic matter. Experiments using electron-positron annihilations at energies in the charmonium-mass regime conducted with the BESIII spectrometer (Beijing, China) revealed a complete new class of hidden-charm matter. A complementary research program is in development with the aim to collide an intense beam of cooled anti-protons with protons or nuclei. This experiment, called PANDA at FAIR, has the ambition to carry out comprehensive spectroscopy studies of hadrons in the strange, charm, and gluon-rich regimes. In this talk, I will highlight the recent discoveries made by BESIII and give perspectives of PANDA in this exciting field of research.

Primary author(s) : Dr. MESSCHENDORP, Johan (University of Groningen)

Presenter(s) : Dr. MESSCHENDORP, Johan (University of Groningen)

Contribution Type : plenary talk

Abstract ID : **38**

Photoproduction of the d*(2380) Dibaryon

Content

The field of multiquark states (beyond the known meson qq and baryon qqq states) has had renewed interest in recent years with findings of potential four, five and six quark states. Recent experiments by the WASA- at-COSY and HADES collaborations have observed a dibaryon (6q) resonant state, the d*(2380). Numerous measurements of this state across a range of different hadronic production channels indicate properties of M = 2380 MeV, Γ = 70 MeV and I(J p) = 0(3 +). So far no photoproduction channels have been examined.
A new measurement by the A2 collaboration at MAMI aims to observe the d*(2380) from a photoproduction reaction for the first time. A new large acceptance recoil polarimeter measures the final state spin polarisation of nucleons from the D(γ , n p) deuteron photodisintegration reaction. A range of polarisation observables are measurable with this configuration. Establishing that the d*(2380) has an electromagnetic coupling opens up opportunities to constrain its size and internal structure. First results from the analysis of the data will be presented, including the recently published results for Σ in the energy range 420-620 MeV. Preliminary results for the recoil polarisation observable, C x 0 , across the energy range relevant to the d*(2380) will also be presented.
This research was supported: The UK Science and Technologies Funding Council (STFC), Studentship 1526286, Grants ST/L00478X/1 and ST/L005824/1 and the Natural Sciences and Engineering Research Council of Canada (NSERC), FRN: SAPIN-2016-00031

Primary author(s) : Dr. KAY, Stephen (University of Regina)

Co-author(s) : Dr. BASHKANOV, Mikhail (University of York)

Presenter(s) : Dr. KAY, Stephen (University of Regina)

Contribution Type : contributed talk

Abstract ID : **39**

Progress in analysis of single and double meson photoproduction

Content

I'll review the recent developments in single and double meson photoproduction, including photoproduction of 1 and 2 pseudoscalar(s), and one vector meson.

Primary author(s) : Dr. MATHIEU, Vincent (JLab)

Presenter(s) : Dr. MATHIEU, Vincent (JLab)

Contribution Type : invited talk

Abstract ID : **40**

Searching for the onset of color transparency in $A(e, e'p)$ in Hall C at Jefferson Lab

Content

Color transparency (CT) is a fundamental phenomenon of QCD postulating that at high momentum transfer, one can preferentially measure hadrons that fluctuate to a small color neutral transverse size in the nucleus, and final state interactions within the nuclear medium are suppressed. CT is observed experimentally as a rise in the measured nuclear transparency as a function of the momentum transferred. While CT has been observed for mesons, it remains unconfirmed in baryons. Observation of CT in baryons would provide a new means to study the nuclear strong force and would be the first clear observation of hadrons fluctuating to a small size in the nucleus. An enhancement in the nuclear transparency was observed in $A(p, 2p)$ reactions at Brookhaven. This experiment, E1206107, seeks to confirm the measurement of proton transparency as well as to measure the onset. During the spring of 2018, this experiment was the first to run in Hall C at Jefferson Lab using the recently upgraded 12 GeV electron beam and obtained four kinematic points at momentum transfer Q^2 from 8-14.3 GeV^2, overlapping the same region where Brookhaven previously observed an enhancement. This experiment used the High Momentum Spectrometer (HMS) and Super High Momentum Spectrometer (SHMS) in coincidence to measure $A(e, e'p)$ on a carbon target. This talk will summarize the status of the experiment since the completion of data taking as well as some preliminary results.

Primary author(s) : SZUMILA-VANCE, Holly (Jefferson Lab)

Presenter(s) : SZUMILA-VANCE, Holly (Jefferson Lab)

Contribution Type : contributed talk

Comments:

DOE Grant Number: DE-FG02-07ER41528

Abstract ID : **41**

Renormalization of n-particle irreducible effective actions

Content

The n-particle irreducible effective action is a powerful approach to study non-perturbative systems. The method provides a systematic expansion for which the truncation occurs at the level of the action. At the 2PI level one can renormalize using a complicated procedure which involves introducing multiple sets of counterterms, but the method cannot be extended to higher orders. We have developed a method based on a renormalization group approach which allows us to construct a renormalized theory at any order in the nPI approximation. We present results from a calculation using a scalar theory with quartic coupling in 4 dimensions, at the 4 loop level. Both the 2PI and 4PI theories can be renormalized using one bare coupling constant and one bare mass, which are introduced at the level of the Lagrangian.

Primary author(s) : Prof. CARRINGTON, Margaret (Brandon University)

Presenter(s) : Prof. CARRINGTON, Margaret (Brandon University)

Contribution Type : contributed talk

Abstract ID : **42**

π^0 Azimuthal Anisotropy in Central d+Au Collisions at 200 GeV with PHENIX

Content

The study of anisotropic flow provides strong constraints to the evolution of the medium produced in heavy ion collisions and its event-by-event geometry fluctuations. The strength and predominance of these observables have long been related to collective behavior in the formed medium. Recent results in small systems both at RHIC and LHC provide strong arguments for the formation of such medium at those scales. However, for a complete characterization of the phenomena, additional differential measurements are desirable.

PHENIX recorded data from d+Au collisions at 200GeV, 62GeV and 39GeV in 2016 using a special trigger which enriches the data size for collisions that are very central. In this talk, I will show our recent anisotropic flow measurements for fully reconstructed π^0 at $-0.35 < \eta < +0.35$ for d+Au.

Primary author(s) : Dr. CANOA ROMAN, Veronica (Stony Brook University)

Presenter(s) : Dr. CANOA ROMAN, Veronica (Stony Brook University)

Contribution Type : contributed talk

Abstract ID : **43**

A theoretical analysis of $\eta' \to \eta\pi\pi$, and of the doubly radiative $\eta^{(\prime)} \to \pi^0\gamma\gamma$ and $\eta' \to \eta\gamma\gamma$ decays

Content

In the first part of this talk, we present an analysis of the $\eta' \to \eta\pi\pi$ decays within the framework of $U(3)_L \times U(3)_R$ ChPT including resonance states and the complete one-loop corrections. The amplitude is projected in partial waves and unitarized by means of the N/D method resumming both the important S-and D-wave $\pi\pi$ and the subleading S-wave $\pi\eta$ final-state interactions. Using the new data from the A2 collaboration we perform a very precise analysis of this channel and make predictions for the neutral channel that are in good agreement with the BESIII measurement. In the second part of the talk, the rare, doubly radiative decays $\eta^{(\prime)} \to \pi^0\gamma\gamma$ and $\eta' \to \eta\gamma\gamma$ are analysed in terms of scalar and vector meson exchange contributions using the frameworks of the Linear Sigma Model and Vector Meson Dominance, respectively.

Primary author(s) : Dr. GONZÀLEZ-SOLÍS, Sergi (Indiana University)

Co-author(s) : Prof. PASSEMAR, Emilie (Indiana University and JLab); Prof. ESCRIBANO, Rafel (IFAE (UAB), Barcelona); Dr. JORA, Renata (National Institute of Physics and Nuclear Engineering, Bucharest, Romania); Mr. ROYO, Emilio (Universitat Autònoma de Barcelona)

Presenter(s) : Dr. GONZÀLEZ-SOLÍS, Sergi (Indiana University)

Contribution Type : contributed talk

Abstract ID : **44**

A peek into quark confinement: transverse polarized scattering and quark-gluon correlations in nucleons.

Content

Why quarks cannot be separated far enough to be observed in isolation remains a major unresolved question in hadronic structure: What are the types and strengths of the interactions that keep the colorful, asymptotically free, partons of short distance, high energy perturbative QCD confined inside colorless entities like mesons and baryons? One step towards the answer is the study of quark-gluon (qg) correlations, a process described as having twist-3, by using inclusive scattering of polarized lepton beams on nucleons with spins aligned transversely to the lepton helicity. Transverse double polarized scattering provides direct access to twist-3, which represents qg correlations, the simplest form of partonic interaction beyond scale corrections. In this talk I will review the experimental study of nucleon spin structure with transverse polarization at SLAC and JLab over a 25 years period, with conclusive results of non-zero twist-3 processes, providing a quantitative glimpse into one type of mechanism that can help in understanding why quarks cannot escape hadrons.

Primary author(s) : Dr. RONDON ARAMAYO, Oscar (Institute for Nuclear and Particle Physics - U. of Virginia (Emeritus))

Presenter(s) : Dr. RONDON ARAMAYO, Oscar (Institute for Nuclear and Particle Physics - U. of Virginia (Emeritus))

Contribution Type : plenary talk

Abstract ID : **45**

Strange Hadron Spectroscopy: Current Status and Future Prospects

Content

In this talk I review the current status of hadron spectroscopy in the hyperon and strange meson sectors. The possibility to improve existing database by orders of magnitude with a secondary beam of K_L at JLab with the GlueX setup in Hall D will be discussed. The proposed measurements will have a broad impact on a different aspects of nuclear and particle physics including: establishment of the low lying scalar meson nonet, discovery of dozens of missing excited states of Λ, Σ, Ξ and Ω hyperons predicted by recent lattice QCD calculations, precise measurement of $K-\pi$ scattering amplitude as well as on our understanding of thermodynamic properties of the Early Universe at freeze-out, microseconds after the Big Bang.

Primary author(s) : Prof. AMARYAN, Moskov (Old Dominion University)

Presenter(s) : Prof. AMARYAN, Moskov (Old Dominion University)

Contribution Type : plenary talk

Abstract ID : **46**

A Monte Carlo analysis of nuclear PDFs with neural networks

Content

While tremendous effort has been made to determine the parton distribution functions (PDFs) of a free proton, less is known about their modification in nuclei. Such information is vital for our understanding of parton dynamics, since it can provide valuable insight into nuclear effects that are not well understood. In this talk, I present nNNPDF1.0, the first analysis of nuclear PDFs from the NNPDF collaboration. Using Monte Carlo techniques together with powerful machine learning algorithms, we obtain a reliable estimation of nPDF central values and their uncertainties.

Primary author(s) : ETHIER, Jacob (Vrije Universiteit / Nikhef); ROJO, Juan (Vrije Universiteit / Nikhef); ABDUL KHALEK, Rabah (Vrije Universiteit / Nikhef)

Presenter(s) : ETHIER, Jacob (Vrije Universiteit / Nikhef)

Contribution Type : invited talk

Abstract ID : **47**

Recent developements at the A2 real photon facility at MAMI

Content

The A2 Collaboration at the Mainz Microtron MAMI measures photon absorption cross sections using circularly and linearly polarized 'Bremsstrahlung' photons up to an energy of ˜1.5GeV. We use a 4 π detection system with the 'Crystal Ball' as central part.
We have developed a Frozen Spin Target in close collaboration with the polarized target group of the Joint Institute for Nuclear Research (JINR, DLNP) in Dubna, Russia. The 3/4Helium dilution refrigerator provides temperatures down to 25 mKelvin. Both longitudinally and transversely polarized protons and deuterons are possible with the help of superconducting holding coils.
In this talk recent developements at A2, especially the first use of a newly developed active polarized solid target in the year 2016 will be described and new possibilities for the application of this technology in high energy physics experiments will be adressed.
In addition, results from recent measurements related to meson photoproduction will be presented.

Primary author(s) : Dr. THOMAS, Andreas (Institut für Kernphysik University Mainz)

Presenter(s) : Dr. THOMAS, Andreas (Institut für Kernphysik University Mainz)

Contribution Type : contributed talk

Comments:
for the A2-collaboration

Abstract ID : **48**

Open Challenges in Neutrino Nucleon/Nucleus Scattering Across the Neutrino Energy Spectrum

Content

This talk will concentrate on recent developments and the resulting current open challenges in neutrino nucleon/nucleus scattering physics across the neutrino energy spectrum. Emphasis will be placed on those aspects where hadronic physics studies can aid in meeting these challenges.

Primary author(s) : MORFIN, Jorge G (Fermilab)

Presenter(s) : MORFIN, Jorge G (Fermilab)

Contribution Type : plenary talk

Abstract ID : **49**

Fracture Functions from Λ^0 Leptoproduction for Target Remnant Description

Content

Fracture functions describe the production of hadrons in the target remnant region. Similar to both fragmentation and structure functions, these non-perturbative objects are measurable, universal functions that can be extracted from experiment in one kinematic regime and used to compute reactions at different scales, factorizing and evolving in a predictable way. The Jefferson Lab CLAS EG2 data-set, which measured high statistics 5-GeV electron-scattering data binned in variables such as Q^2, x_B and ν, offers a rich opportunity to extract fracture functions using electron triggered processes. This talk will describe the ongoing work to extract fracture functions from the Λ^0 yields identified in binned EG2 data.
This work is supported in part by the US DOE contracts # DE-AC02-06CH11357 and DE-FG02-03ER41528
On behalf of the CLAS Collaboration

Primary author(s) : JOHNSTON, Sereres (ANL)

Co-author(s) : Dr. EL FASSI, Lamiaa (MSU)

Presenter(s) : JOHNSTON, Sereres (ANL)

Contribution Type : contributed talk

Abstract ID : **50**

Minkowski space 4D dynamics for hadrons

Content

We present recent collaborative efforts for solving the bound state Bethe-Salpeter equation in the Minkowski space with the use of the Nakanishi integral representation and also by explicit rotation of the Euclidean energy axis towards the Minkowski axis. We are envisaging future applications to hadrons and in particular to model the pion. In order to do so, we also have to use similar techniques to obtain the quark self-energy in Minkowski space. As a first step in this direction we present results for the fermion self-energy in Minkowski space in a QED-like model in the rainbow truncation.

Primary author(s) : Prof. FREDERICO, Tobias (Instituto Tecnologico de Aeronautica)

Presenter(s) : Prof. FREDERICO, Tobias (Instituto Tecnologico de Aeronautica)

Contribution Type : contributed talk

Abstract ID : **51**

Exploring the origin of mass through the properties of pseudoscalar mesons

Content

Among the basic questions posed by Nature, the following three are basic to hadron physics: How does the ≈ 1 GeV mass-scale that characterizes atomic nuclei appear; Why does it have the observed value; and, enigmatically, why are the composite Nambu-Goldstone bosons in QCD abnormally light in comparison? This presentation will describe analyses of the mass budget of the pion and proton in QCD; discuss the special role of the kaon, which lies near the boundary between dominance of Higgs- and strong-mass generation mechanisms; and explain the need for a coherent effort in QCD experiment, phenomenology and theory to make progress in understanding the origins of hadron masses and the distribution of that mass within them.

Primary author(s) : Dr. ROBERTS, Craig (Argonne)

Presenter(s) : Dr. ROBERTS, Craig (Argonne)

Contribution Type : invited talk

Abstract ID : **52**

Energy-momentum tensor of hadrons in the NJL model

Content

The energy-momentum tensor (EMT) encodes information about how energy, momentum, forces, and angular momentum are distributed within a particle. Recent work has been done to explore the rich and unique structure contained in the EMT of spin-1 hadrons. This includes the derivation of a new collection of sum rules relating gravitational form factors to conservation laws, multipole moments, and generalized parton distributions. The Nambu-Jona-Lasinio (NJL) model is used here to illustrate these aspects of the spin-1 EMT through an exploration of the partonic structure of the rho meson.

Primary author(s) : Dr. FREESE, Adam (Argonne National Laboratory)

Presenter(s) : Dr. FREESE, Adam (Argonne National Laboratory)

Contribution Type : contributed talk

Abstract ID : **53**

Heavy quarkonium in QCD: from JLab to EIC

Content

Production of heavy quarkonium provides a unique probe to the gluonic structure of the nucleon. A new generation of experiments at Jefferson Lab in the 12 GeV era will use near-threshold J/ψ production to study topics related to the dynamic origin of nucleon mass, the nature of the color Van der Waals force, and the existence of the LHCb charmed pentaquark. These topics can also be studied at a future electron-ion collider (EIC) through near-threshold Y production. Furthermore, an EIC will enable access to the full three-dimensional tomographic image of the gluonic structure of the nucleon through J/ψ and Y production at high energies. I will discuss in particular my experiment in Hall C, the future SoLID J/ψ experiment, and the possibilities at an EIC.

Primary author(s) : Dr. JOOSTEN, Sylvester (Argonne National Laboratory)

Presenter(s) : Dr. JOOSTEN, Sylvester (Argonne National Laboratory)

Contribution Type : invited talk

Abstract ID : **54**

Exclusive Backward-Angle Meson Electroproduction – Unique access to u-channel physics

Content

Exclusive meson electroproduction at different squared four-momenta of the exchanged virtual photon, Q^2, and at different four-momentum transfers, t and u, can be used to probe QCD's transition from hadronic degrees of freedom at long distance scale to quark-gluon degrees of freedom at short distance scale. Backward-angle meson electroproduction was previously ignored, but is anticipated to offer complimentary information to conventional forward-angle meson electroproduction studies on nucleon structure. The results of our pioneering study of backward-angle omega cross sections through the exclusive p(e,e'p)ω reaction will be presented. The experiment was performed as part of E01-004 in Jefferson Lab Hall C, with central Q^2 values of 1.60 and 2.45 GeV^2, and W=2.21 GeV. The extracted cross sections were separated into transverse (T), longitudinal (L), and LT, TT interference terms. The data set has a unique coverage of u$\sim$0, opening up a new means to study the transition of the nucleon wave function through backward-angle experimental observables. Plans to extend these studies to the π^0 channel will also be presented.

Primary author(s) : Prof. HUBER, Garth (University of Regina)

Co-author(s) : Dr. LI, Wenliang (bill) (College of William and Mary)

Presenter(s) : Prof. HUBER, Garth (University of Regina)

Contribution Type : contributed talk

Abstract ID : **55**

Extraction of Observables from Deeply Virtual Electron Proton Scattering Experiments

Content

Imaging the 3D partonic structure of the nucleon is a fundamental goal of every major nuclear experimental program, including the EIC. Ji first proposed Deeply Virtual Compton Scattering (DVCS) as a probe for understanding the spatial distribution of the partons by fourier transform of the exchanged momentum transfer between the initial and final proton. The extraction of observables from Deeply Virtual Exclusive Reactions in a clear and concise formalism, such that the various twist components and angular dependencies can be untangled, is key. We present a completely covariant description of the DVCS process that can be extended to any kinematics, either fixed target or collider. In our helicity formalism, we extract our observables such that the dependence on Q2 is clear. We can separate kinematic twist, characterized by subleading dependence on 1/Q2, from the dynamic twist, given by the Q2 suppression and azimuthal angle Φ. Since the higher twist terms are characterized by their dependence on Φ, it is important to understand the angular contribution arising from the kinematic variables and separate it from the characteristic angular dependence of the higher twist terms. The extension to other Deeply Virtual Exclusive Reactions, such as TCS, is in progress. From our formalism, one can extract observables important in understanding the physical properties of the proton such as the angular momentum of the quarks and gluons inside of the proton.

Primary author(s) : KRIESTEN, Brandon (University of Virginia)

Co-author(s) : Prof. LIUTI, Simonetta (university of virginia)

Presenter(s) : KRIESTEN, Brandon (University of Virginia)

Contribution Type : contributed talk

Abstract ID : **56**

Searching for stable tetraquark states in QCD

Content

A compact tetraquark is composed of a pair of diquark-antidiquark. Such a configuration has been used to interpret some unexpected hadron states. Recently, there are some efforts of searching for stable tetraquarks. In this talk, I will present our recent studies for the stable tetraquark states, including the doubly-bottom ud\bar b\bar d, the triply bottom bb\bar b\bar q and the fully-bottom bb\bar b\bar b tetraquarks. We calculated the mass spectra for these tetraquark states in a systematical way. Our results show that some of these states lie below the corresponding two-body hadronic decay thresholds. Once produced, they can only decay via electromagnetic and weak interactions. Very probably these tetraquark states are stable.

Primary author(s) : Prof. CHEN, Wei (Sun Yet-Sen University)

Presenter(s) : Prof. CHEN, Wei (Sun Yet-Sen University)

Contribution Type : contributed talk

Abstract ID : **57**

Recent lattice QCD results on bottomonia at high temperatures

Content

We explore the S- and P-states for bottomonia at high temperaures, above the critical temperature T_c, using non-relativistic QCD (NRQCD). We extract the spectrum as a function of temperature by looking at point to point correlators and smoothed correlators. We push to the limit of NRQCD for $N_\tau = 12$ which allows us to find the bottomonium spectrum up to a temperature of 334MeV.

Primary author(s) : Mr. LARSEN, Rasmus (Brookhaven National Laboratory); MUKHERJEE, Swagato (Brookhaven National Laboratory); PETRECZKY, Peter (BNL)

Presenter(s) : Mr. LARSEN, Rasmus (Brookhaven National Laboratory)

Contribution Type : invited talk

Abstract ID : **58**

Study of Λ Hyperon Fragmentation in Current and Target Regions using CLAS

Content

The color propagation and hadron production from hard interactions in nuclei have been extensively studied over the last few decades. These studies are related to one of the basic phenomenon of quantum chromodynamics (QCD) referred to as hadronization or fragmentation. In this process, an energetic struck quark transforms to color-neutral hadrons making it an effective probe of the confinement dynamics as well as the characteristic time-scales involved. This talk will highlight ongoing efforts to study, for the first time, the semi-inclusive deep inelastic production of Λ hyperon in the current and target fragmentation regions using the Jefferson Lab CLAS EG2 data. The results of this baryon channel combined with other meson production in the same data sets will improve our understanding of the space-time evolution of hadrons at intermediate beam energy of 5 GeV. Additionally, the results will provide a strong baseline for the extension of this hadronization program using the upgraded Jefferson Lab electron beam of 11 GeV and the CLAS12 spectrometer.
This work is supported in part by the US DOE contracts \# DE-FG02-03ER41528 and DE-AC02-06CH11357.
(On behalf of the CLAS Collaboration)

Primary author(s) : Dr. CHETRY, Taya (Mississippi State University); Dr. EL FASSI, Lamiaa (MSU); JOHNSTON, Sereres (ANL); KABIR, Latif (Mississippi State University)

Presenter(s) : Dr. CHETRY, Taya (Mississippi State University)

Contribution Type : contributed talk

Abstract ID : **59**

Collective excitations and electromagnetic probes of momentum-anisotropic quark-gluon plasma

Content

In a rapidly evolving quark-gluon plasma, local rest frame momentum distributions can largely deviate from isotropic equilibrium statistics. In recent years, progress in the realization of an anisotropic hydrodynamic description beyond the linear viscous corrections has set the stage for further investigating the collective properties and the role of plasma instabilities at earlier stages of the system evolution. In this talk, recent developments in the study of collective excitations, unstable modes and the relevant phenomenology of electromagnetic probes of momentum-anisotropic quark-gluon plasma will be presented.

Primary author(s) : Mr. SALEHI KASMAEI, Babak (Kent State University)

Co-author(s) : Dr. STRICKLAND, Michael (Kent State University)

Presenter(s) : Mr. SALEHI KASMAEI, Babak (Kent State University)

Contribution Type : contributed talk

Abstract ID : **60**

Status of understanding the proton charge radius

Content

We will discuss the up-to-date theory and review recent experimental results related to understanding the proton radius puzzle, which is the conflict between measurements of the proton radius using muons as compared to measurements using electrons. There are signs that recent electron results are coming closer to the muonic ones, but there is not yet universal agreement, and disagreement leaves open possibility of a beyond the standard model solution.

Primary author(s) : Prof. CARLSON, Carl (William & Mary)

Presenter(s) : Prof. CARLSON, Carl (William & Mary)

Contribution Type : plenary talk

Abstract ID : **61**

Towards an Analytical Description of Three Particle Scattering

Content

Advances in Lattice QCD computations of the excited hadron spectrum require analytic representation of infinite volume three particle scattering amplitudes. We present a representation of the elastic three particle scattering amplitude consistent with the unitarity of the S-matrix. We investigate aspects of its analytic properties, specifically one-particle exchange effects and triangle singularities.

Primary author(s) : Mr. JACKURA, Andrew (Indiana University)

Presenter(s) : Mr. JACKURA, Andrew (Indiana University)

Contribution Type : invited talk

Abstract ID : **62**

The QCD critical point hunt:new theoretical development and the first result from simulation

Content

Experimentally locating the QCD critical point is one of the important scientific goals for the relativistic heavy-ion collision program, with potential connections to a plethora of deep questions on the phase diagram of nuclear matter. I will first argue based on simple parametric reasonings that there shall emerge a set of new dynamical degrees of freedom for the system evolving near the critical point. As a result, the conventional hydrodynamic modeling in heavy-ion collisions would not be sufficient for the purpose of the quantitative study of the critical point. Instead, I will present a novel theoretical framework, namely "hydro+", which couples those emergent degrees of freedom to hydrodynamical variables. "Hydro+" would provide a quantitative description of both the critical fluctuations and the bulk evolution near the QCD critical point. I will show the first results on the numerical simulations of "hydro+", and, if time is permitted, discuss the interesting connection of "hydro+" to other approaches of fluctuating hydrodynamics.

Primary author(s) : Dr. YIN, Yi (MIT)

Presenter(s) : Dr. YIN, Yi (MIT)

Contribution Type : invited talk

Abstract ID : **63**

Partial Wave Analysis for Electron-Positron and Antiproton-Proton Annihilations

Content

Despite the success of the simple quark model, the spectrum of light mesons is not well understood yet. For the mandatory understanding of the light-meson properties it is necessary to investigate different production processes and decay channels. Two complementary processes, the electron-positron and antiproton-proton annihilation, provide an excellent laboratory for such studies. The presence of many broad and often overlapping states in this energy region requires a full partial wave analysis for the extraction of the properties of the contributing resonances.

In this talk recent results from analyses of data from electron-positron and from antiproton-proton annihilations are presented. The analyses were performed with the easy-to-use partial wave analysis software PAWIAN, which is being developed at Ruhr-University Bochum.

We will report on the analysis of BESIII data as well as a coupled channel analysis of light meson final states based on CB/LEAR data together with $\pi\pi$ scattering data from earlier CERN and BNL experiments.

Primary author(s) : ALBRECHT, Malte (Ruhr-University Bochum)

Presenter(s) : ALBRECHT, Malte (Ruhr-University Bochum)

Contribution Type : invited talk

Abstract ID : **64**

Dynamical modeling of relativistic heavy-ion collisions at Beam Energy Scan energies

Content

We present a fully three-dimensional model providing initial conditions for energy and conserved charge density distributions in heavy ion collisions at RHIC Beam Energy Scan (BES) collision energies [1,2]. The model includes the dynamical deceleration of participating nucleons or valence quarks. It provides a realistic estimation of the initial baryon stopping during the early stage of collisions. We study various observables obtained directly from the initial state model, including net-baryon rapidity distributions, 2-particle rapidity correlations, and the rapidity decorrelation of the transverse geometry. Their dependence on the model implementation and parameter values is investigated. We also present the implementation of the model with 3+1 dimensional hydrodynamics, which involves the addition of source terms that deposit energy and net-baryon densities produced by the initial state model at proper times greater than the initial time for the hydrodynamic simulation. The importance of this pre-equilibrium stage on hadronic flow observables at the RHIC BES will be quantified.

1] C. Shen and B. Schenke, "Dynamical initial state model for relativistic heavy-ion collisions", arXiv:1710.00881 [nucl-th].

[2] C. Shen and B. Schenke, "Initial state and hydrodynamic modeling of heavy-ion collisions at RHIC BES energies", arXiv:1711.10544 [nucl-th]

Primary author(s) : Mr. SHEN, Chun (Wayne State University)

Co-author(s) : Dr. SCHENKE, Bjoern (Brookhaven National Lab)

Presenter(s) : Mr. SHEN, Chun (Wayne State University)

Contribution Type : invited talk

Abstract ID : **65**

Parton distribution functions from the light front parton gas model

Content

We present a statistical description of the hadron structures in terms of the parton gas on the light front. Specifically, the microcanonical molecular dynamics ensemble is generalized to preserve the light front 3-momentum in order to model the phase space distribution of partons confined inside a hardon. With only the light front kinetic energy, the joint longitudinal momentum fraction distribution of these partons can be deduced analytically. The parton distribution functions are then obtained as the marginal distribution of the joint distribution.

Primary author(s) : Dr. JIA, Shaoyang (Department of Physics and Astronomy, Iowa State University)

Co-author(s) : Prof. VARY, James (Iowa State University)

Presenter(s) : Dr. JIA, Shaoyang (Department of Physics and Astronomy, Iowa State University)

Contribution Type : contributed talk

Abstract ID : **66**

Measurement of long-range correlations in Z-boson tagged pp collisions

Content

Measurements of two-particle correlations in relative azimuthal angle and pesudorapidity have shown striking similarities between results obtained in pp, and in p+A and A+A collision systems. In pp collisions, unlike in the p+A and A+A systems, the strength of the correlations quantified by the anisotropy parameter v_2 does not show any dependence on the charged-particle multiplicity. Recent theoretical models suggest that this can be due to lack of correlation between the charged-particle multiplicity and the impact parameter of the pp collision. An independent handle on the impact parameter can be obtained by requiring the presence of a hard-scattering process in the collision. This talk presents the first measurement of two-particle correlations in pp collisions with a Z boson identified via its dimuon decay channel. The analysis uses ATLAS data recorded under nominal pp luminosities, and a procedure to correct for contribution of the tracks coming from pileup vertices is used. The anisotropy parameter v_2 measured in Z-tagged events is compared to the v_2 measured in minimum-bias collisions.

Primary author(s) : Dr. MOHAPATRA, Soumya Mohapatra (Columbia University, Department of Physics)

Presenter(s) : Dr. MOHAPATRA, Soumya Mohapatra (Columbia University, Department of Physics)

Contribution Type : invited talk

Abstract ID : **67**

Novel Features of Nuclear Parton Distributions

Content

One of the most interesting aspects of neutrino-nucleus DIS measurements is the apparent absence of antishadowing of the nuclear parton distributions, in direct contradiction to electron-nucleus and muon-nucleus measurements. This has several implications: (1) antishadowing may be flavor specific. This can be tested in semi-inclusive deep inelastic lepton scattering. (2) antishadowing cannot compensate for shadowing in the momentum sum rule (3) the momentum sum rule may in fact be inapplicable for the nuclear pdf, and (4) the standard operator product analysis can fail for nuclei because of shadowing and antishadowing. I will discuss the implications of these issues for nuclear pdfs in QCD based on Glauber-Gribov theory and its important connections to leading-twist diffractive DIS.

Primary author(s) : Prof. BRODSKY, Stanley (SLAC National Accelerator Laboratory, Stanford Univsersity)

Presenter(s) : Prof. BRODSKY, Stanley (SLAC National Accelerator Laboratory, Stanford Univsersity)

Contribution Type : invited talk

Abstract ID : **68**

Twist-3 PDFs

Content

In this talk the collinear twist-3 formalism is reviewed, in particular its application to pQCD analyses of transverse spin observables in single-inclusive high-energy processes. The main ingredients in this formalism are three-parton correlation functions that may provide new information on the inner dynamics of quarks and gluons in the nucleon as well as in fragmentation processes. Elements of next-to-leading order calculations in that formalism are also discussed.

Primary author(s) : Prof. SCHLEGEL, Marc (New Mexico State University)

Presenter(s) : Prof. SCHLEGEL, Marc (New Mexico State University)

Contribution Type : invited talk

Abstract ID : **69**

Hadronic physics with the inelasticity of high-energy neutrino interactions in IceCube

Content

In addition to its role in high-energy astrophysics, the IceCube Neutrino Observatory is a laboratory to study neutrino-nucleon deep inelastic scattering at multi-TeV energies far beyond the reach of accelerators. A recent analysis of contained neutrino interactions in IceCube will be presented where the inelasticity of charged-current ν_μ interactions (the fraction of neutrino energy transferred to hadrons) is reconstructed as a new observable. The inelasticity distribution is found to be consistent with next-to-leading order pQCD calculations based on HERA PDFs in a neutrino energy range from 1 TeV to 100 TeV. The inelasticity distribution is also sensitive to neutrino charm production in an energy range up to 340 TeV—high enough that interactions of charm hadrons with nuclei in ice occur with high probability. Although the small event sample size limits the precision of results compared to theoretical uncertainties, a next-generation detector should improve these results and enable other studies of bottom and top physics as well as searches for physics beyond the Standard Model.

Primary author(s) : Dr. BINDER, Gary (LBNL)

Presenter(s) : Dr. BINDER, Gary (LBNL)

Contribution Type : invited talk

Abstract ID : **70**

TMD measurements and requirements at the EIC

Content

Transverse momentum dependent (TMD) distributions are a novel QCD tool that allow the mapping of the motion of quarks and gluons in nuclear matter. The Electron-Ion Collider (EIC) will allow for a high-precision study of TMDs at the scale of sea quarks and gluons. In my presentation, I will discuss the requirements on theory as well as on accelerator, detector, and computer technology for the TMD program at the EIC with a focus on recent progress on Monte Carlo Event Generators for TMDs.

Primary author(s) : Dr. DIEFENTHALER, Markus (Jefferson Lab)

Presenter(s) : Dr. DIEFENTHALER, Markus (Jefferson Lab)

Contribution Type : contributed talk

Abstract ID : **71**

Studying the hadronic and semi-leptonic Decay Modes of the $\eta^{(\prime)}$-Meson with GlueX-I

Content

The isospin violating decay $\eta \to \pi^+\pi^-\pi^0$ is the dominant charged decay mode of the η-meson. This decay is driven by the strong force and allows probing of the light quark masses, because the corresponding decay amplitude is proportional to the quark mass ratio Q. The decay amplitude is accessible either via a Dalitz-Plot or partial wave analysis. The latter one allows for a direct calculation of Q whereas the parameters from the Dalitz Plot analysis give insights into the decay dynamics and can be compared to theoretical calculations.
The semi-leptonic decay $\eta^{(\prime)} \to \pi^+\pi^-\gamma^*[\gamma^* \to e^+e^-]$ allows study of quantum anomalies, because its decay amplitude is driven by the box anomaly. Moreover, CP-symmetry can be tested by measuring the angle of the decay plane between the dilepton and pion pair.
These $\eta^{(\prime)}$-decays have been produced and measured in the reaction $\gamma p \to p\eta^{(\prime)}$ with the GlueX experiment, located at the Thomas Jefferson National Laboratory. GlueX finished the first phase of measurements in the winter last year. The second phase will start this spring with an upgraded setup including a DIRC-detector.
This talk will discuss the status and prospects of the analysis of the two decay modes within the GlueX-I data set.

Primary author(s) : Mr. LERSCH, Daniel (Florida State University)

Presenter(s) : Mr. LERSCH, Daniel (Florida State University)

Contribution Type : invited talk

Abstract ID : **72**

Parton distribution inside the pion from lattice QCD

Content

We will present our lattice computation of the valence Parton Distribution Function of 300 MeV pion. For this work, we use perturbative matching of the Euclidean RI-MOM renormalized quasi Parton Distribution Function that we compute on HISQ ensembles with 0.06 and 0.04 fm lattice spacings. In addition, we will discuss the validity of leading order perturbative matching and other systematic effects that potentially enter such lattice computations of PDF.

Primary author(s) : Dr. KARTHIK, Nikhil (BNL)

Co-author(s) : Dr. IZUBUCHI, Taku (RIKEN-BNL); PETRECZKY, Peter (BNL); MUKHERJEE, Swagato (Brookhaven National Laboratory); Dr. SYRITSYN, Sergey (Stony Brook University); Mr. SHUGERT, Charles (Stony Brook University); Dr. JIN, Luchang (BNL); Dr. KALLIDONIS, Christos (Stony Brook University)

Presenter(s) : Dr. KARTHIK, Nikhil (BNL)

Contribution Type : contributed talk

Abstract ID : **73**

The nCTEQ PDF determinations and LHC nuclear scattering data

Content

Recent nuclear scattering data from the LHC contain a wealth of information providing important constraints on our knowledge of both nuclear and proton parton distribution functions (PDFs). In this talk, I present the nCTEQ nPDFs (which are now based upon a substantially upgraded code, nCTEQ++) to illustrate this point with a special focus on the ability of $W^{\pm}/Z$ boson production to help disentangle the PDFs' flavor dependence; this can be seen, for example, in the complementarity of the $W^{\pm}/Z$ information to fixed-target neutrino DIS data in affording leverage over the strangeness distribution. Given the fact that determinations of nucleon PDFs are often dependent upon nuclear corrections, I also demonstrate how improvements in nPDFs provided by LHC $p\,Pb$ and $Pb\,Pb$ data can mutually benefit proton PDF fits. Lastly, I will highlight some future directions for our nCTEQ analyses.

Primary author(s) : Dr. HOBBS, Timothy (Southern Methodist University)

Presenter(s) : Dr. HOBBS, Timothy (Southern Methodist University)

Contribution Type : invited talk

Comments:
Given on behalf of the nCTEQ Collaboration. This work was supported by the U.S. Department of Energy under Grant No. de-sc0010129 and the EIC Center@JLab Fellowship Program.

Abstract ID : **74**

The Future synergy between Lattice QCD and Global Analyses of HEP data

Content

Owing to the growing availability of computational resources as well as steady theoretical advances in lattice gauge theory and perturbative QCD analyses, the dual technologies of Lattice QCD and QCD Global Analyses have proceeded apace in recent years. In this context, it is increasingly suggested that the output of Lattice QCD calculations could serve as important input to Global Analyses of PDFs (and related quantities). In this talk I will discuss this exciting possibility, specifically demonstrating the important role Global Analyses will play in benchmarking improving Lattice QCD output. I will stress that, going forward, the relationship between the QCD Lattice and Global Analyses of high energy data will provide a powerful synergistic basis to improve our knowledge of the hadron tomography in the EIC era.

Primary author(s) : Dr. HOBBS, Timothy (Southern Methodist University)

Presenter(s) : Dr. HOBBS, Timothy (Southern Methodist University)

Contribution Type : contributed talk

Comments:

This work was supported by the U.S. Department of Energy under Grant No. desc0010129 and the EIC Center@JLab Fellowship Program.

Abstract ID : **75**

Ultra-peripheral Collisions in STAR

Content

In ultra-peripheral relativistic nuclear collisions, the impact parameter is greater than the sum of the radii of the colliding nuclei. Hadronic interactions are suppressed in these collisions, but the intense flux of photons allows the study of photonuclear and two-photon interactions, providing information about the initial state of the nuclei. The STAR experiment has studied Au+Au collisions at $\sqrt{s_{\rm NN}} = 200$ GeV at central rapidity. High-statistics samples of coherently produced ρ mesons and $\pi^+\pi^-$ pairs allowed the observation of a diffractive pattern in $d\sigma/dt$. The diffractive dips have been studied as a function of $\pi^+\pi^-$ pair mass and compared with model expectations. Preliminary results of the coherent photoproduction of J/Ψ mesons and e^+e^- pairs will also be presented. The experimental cross section for coherent J/Ψ photoproduction is of interest as a probe of gluon saturation and nuclear gluon shadowing. The J/Ψ mesons are heavy enough to be described by perturbative QCD, where at the first order the coherent cross section is proportional to the square of the nuclear gluon distribution. The coherent production of e^+e^- pairs is a background process for the J/Ψ measurement, but also interesting in its own right. STAR has observed an enhancement, relative to known hadronic interactions, in e^+e^- production at low transverse momentum in peripheral Au+Au and U+U collisions. This enhancement can be explained by photoproduction, and a precision measurement of e^+e^- production in ultra-peripheral collisions provides a baseline for comparison with these results.

Primary author(s) : Prof. SEGER, Janet (Creighton University Department of Physics)

Presenter(s) : Prof. SEGER, Janet (Creighton University Department of Physics)

Contribution Type : invited talk

Comments:
for the STAR Collaboration

Abstract ID : **76**

3-body quantization condition in a minimal unitary relativistic approach

Content

The interacting three-particle states are populated via an interacting two-particle subsystem (resonant or non-resonant), and a spectator. Using this formulation, we derive the relativistic isobar-spectator amplitude such that the three-body Unitarity is ensured exactly (*arXiv:1706.06118*).

Unitarity constrains the imaginary parts of such an amplitude in infinite volume. In the finite volume this determines the leading power-law finite-volume effects allowing for a derivation of a highly desired 3-body quantization condition. Short derivation of the latter in the present formalism (*arXiv:1709.08222*) as well as a subsequent application to the physical system for which Lattice results exist (*arXiv:1807.04746*) will be presented in this talk.

Primary author(s) : Dr. MAI, Maxim (The George Washington University)

Co-author(s) : Dr. DOERING, Michael (The George Washington University)

Presenter(s) : Dr. MAI, Maxim (The George Washington University)

Contribution Type : invited talk

Abstract ID : **77**

Benchmarking Air Light-Guide Cherenkov Detectors at SLAC ESTB

Content

The MOLLER experiment proposed at the Thomas Jefferson National Accelerator Facility plans a precision low energy determination of the weak mixing angle via the measurement of the parity-violating asymmetry in longitudinally polarized beam electron scattering on the unpolarized electrons in a liquid hydrogen target (Møller scattering). The scattered electrons are measured by a circular array of thin fused silica tiles which generate Cherenkov photons and transport them to photomultiplier tubes (PMTs) through air light-guides. The detector design must balance constraints of machining, structural support, maximizing the PMTs' optical photon yield and resolution, and minimizing the backgrounds from neighboring separated fluxes. Prior tests at the MAMI facility at Johannes Gutenberg University, Mainz, Germany characterized the effects of Cherenkov and scintillation light generated by flux passing through the air of the detectors' light guides. We report on tests performed at the SLAC End Station A Test Beam (ESTB), Geant4 optical physics simulations, and ongoing studies of optimized detector geometry prototypes for the MOLLER experiment.

Primary author(s) : CLARKE, Cameron (Stony Brook University)

Presenter(s) : CLARKE, Cameron (Stony Brook University)

Contribution Type : contributed talk

Abstract ID : **78**

Meson production in ultra-peripheral heavy ion collisions

Content

Meson production cross sections in ultraperipheral relativistic heavy ion collisions at the CERN Large Hadron Collider are revisited. The relevance of meson models and of exotic QCD states is discussed. This study includes states that have not been considered before in the literature.

Primary author(s) : Prof. CARLOS BERTULANI, Carlos (Texas A&M University-Commerce)

Presenter(s) : Prof. CARLOS BERTULANI, Carlos (Texas A&M University-Commerce)

Contribution Type : invited talk

Abstract ID : **79**

Pion Valence Quark Distribution from Lattice Calculable Current-Current Correlations

Content

An understanding of the partonic structure of hadrons is an essential ingredient in making precise predictions and measurements of hadronic cross-sections and various Standard, and Beyond Standard, Model parameters. Direct first-principles calculations of parton distribution functions (PDFs) via lattice QCD were historically limited to the lowest few moments, principally due to the time-dependence of PDFs and the breaking of rotational symmetry. Several encouraging proposals have since been developed that relate lattice calculable quantities with PDFs via frameworks akin to QCD factorization. We present the first lattice QCD calculations of one such proposal, wherein the pion valence quark distribution is obtained from a renormalizable and factorizable matrix element of an antisymmetric combination of vector and axial-vector current-current correlations of fixed spatial separation. The valence distribution is extracted by considering the NLO perturbative kernel for this current combination, thereby giving better control over corrections in the spatial separation. Results are presented for several lattice ensembles, with an eye towards proper chiral, continuum, and infinite volume limits.

Primary author(s) : SUFIAN, Raza (Jefferson Lab); KARPIE, Joseph (College of William and Mary); Mr. EGERER, Colin (William and Mary)

Co-author(s) : Prof. ORGINOS, Kostas (William and Mary / JLab); Dr. QIU, Jianwei (Jefferson Lab); Dr. RICHARDS, David (Jefferson Lab)

Presenter(s) : Mr. EGERER, Colin (William and Mary)

Contribution Type : invited talk

Abstract ID : **80**

Probing Hadronic Entanglement with Quantum Tomography

Content

{\it Quantum tomography} is a model-independent approach to characterizing quantum mechanical systems. Recent research in nuclear and particle physics has led to confronting issues of coherence and entanglement, that were sometimes suppressed, or sometimes implemented with models. The classic example is the parton model replacing quantum mechanical formalism by classical probabilistic proxies. Quantum tomography bypasses models and structure functions by extracting a density matrix describing the unknown system by using a known density matrix as a probe. While the notion of using a "probe" to explore an unknown system appears everywhere, the only true realization in quantum mechanics is quantum tomography. We illustrate a practical realization of quantum tomography that goes directly from momentum 4-vectors to quantum mechanical matrix elements. Applications to experiment have found unexpected new phenomena in every case explored so far.

Primary author(s) : Prof. RALSTON, John (University of Kansas)

Co-author(s) : Dr. TAPIA TAKAKI, Daniel (University of Kansas)

Presenter(s) : Prof. RALSTON, John (University of Kansas)

Contribution Type : contributed talk

Abstract ID : **81**

The impact of eta photoproduction on the resonance spectrum

Content

With new and precise eta photoproduction data, electromagnetic properties of baryonic resonances can be determined with unprecedented accuracy. Recent progress in multi-reaction analyses carried out by the Jülich-Bonn, MAID, Bonn-Gatchina, and other groups are reviewed, with a focus on the resonance spectrum and particular structures at around W=1.68 GeV. Model selection for the determination of the spectrum and ways to select new observables with large expected impact on resonance properties are discussed.

Primary author(s) : DORING, Michael (The George Washington University)

Presenter(s) : DORING, Michael (The George Washington University)

Contribution Type : invited talk

Abstract ID : **82**

Constraining the Equation of State of Neutron Stars with High Energy Deeply Virtual Exclusive Experiments

Content

The recent detection of gravitational waves from merging neutron star events has opened a new window on the many unknown aspects of their internal dynamics. A key role in this context is played by the transition from baryon to quark matter described in the neutron star equation of state (EoS). In particular, the binary pulsar observation of heavy neutron stars requires appropriately stiff dense matter in order to counter gravitational collapse, at variance with the predictions of many phenomenological quark models. On the other side, the LIGO observations favor a softer EoS therefore providing a lower bound to the equation stiffness. We introduce a quantum chromodynamics (QCD) description of the neutron star's high baryon density regime where the pressure and energy density distributions are directly obtained from the matrix elements of the QCD energy momentum tensor. Recent ab initio calculations allow us to evaluate the energy-momentum tensor in a model independent way including both quark and gluon degrees of freedom. Our approach is a first effort to replace quark models and effective gluon interactions with a first principles, fully QCD-based description. Most importantly, the QCD energy momentum tensor matrix elements are connected to the Mellin moments of the generalized parton distributions which can be measured in deeply virtual exclusive scattering experiments. As a consequence, we establish a connection between observables from high energy experiments and from the analysis of gravitational wave events. Both can be used to mutually constrain the respective sets of data. In particular, the emerging QCD-based picture is consistent with the GW170817 neutron star merger event once we allow a first-order phase transition from a low-density nuclear matter EoS to the newly-constructed high-density quark-gluon one.

Primary author(s) : Prof. LIUTI, Simonetta (university of virginia)

Co-author(s) : RAJAN, Abha (University of Virginia); Prof. YAGI, Kent (University of Virginia)

Presenter(s) : Prof. LIUTI, Simonetta (university of virginia)

Contribution Type : invited talk

Abstract ID : **83**

The LPM effect in QCD revisited

Content

The QCD analog of the Laudau-Pomeranchuk-Migdal (LPM) effect is at the core jet quenching physics. In QCD, the medium-induced gluon radiation spectrum is suppressed in the ultraviolet due to the fact that during the quantum mechanical radiation time, that increases with the gluon frequency, multiple scattering centers act coherently as a single scattering center thus reducing the radiation intensity. I will present a novel analytic approach to the problem that encompasses the two known limits: multiple-soft scattering and single-hard scattering approximations. Implications to heavy ion phenomenology will be discussed.

Primary author(s) : Dr. MEHTAR-TANI, Yacine (Brookhaven National Laboratory)

Presenter(s) : Dr. MEHTAR-TANI, Yacine (Brookhaven National Laboratory)

Contribution Type : invited talk

Abstract ID : **84**

Search for the chiral and vortical effects at the RHIC

Content

In this talk, I will give an overview of the recent experimental results from RHIC towards the search for the chiral and vortical effects in p/d+Au, Au+Au and U+U collisions. I will mostly focus on the results from the STAR experiment, RHIC BES program and briefly discuss the plans for the recent Isobar run at RHIC.

Primary author(s) : TRIBEDY, Prithwish (Brookhaven National Lab.)

Presenter(s) : TRIBEDY, Prithwish (Brookhaven National Lab.)

Contribution Type : invited talk

Abstract ID : **85**

Investigating the EMC effect in highly-virtual nucleons at Jefferson Lab

Content

Deep Inelastic Scattering (DIS) experiments on deuterium where the recoiling nucleon is detected as well ("tagged"), allows to measure how the quark-structure of the bound nucleon (as measured by its “structure function”) varies with its initial momentum (as measured by the spectator nucleon momentum). Therefore, we can determine how and why the structure of bound protons differs from free ones. This will resolve the 35-year-old enigma of the EMC effect.

Two measurements for tagged DIS measurements on deuterium are planned at Jefferson Lab. They will use two new detectors, BAND (Backward Angle Neutron Detector) and LAD (Large Angle Spectrometer), to detect the recoiling neutrons and protons, respectively. BAND is installed just upstream of the existing CLAS12 spectrometer in Hall B to detect high momentum neutrons at scattering angles between 160 and 170 degrees. LAD will be installed at Hall C to detect high momentum protons at 90 to 170 degrees. In my talk, I will present the planned measurements and preliminary results from the fall 2018 calibration and winter 2019 production runs for the BAND detector.

Primary author(s) : HAUENSTEIN, Florian (Old Dominion University)

Presenter(s) : HAUENSTEIN, Florian (Old Dominion University)

Contribution Type : invited talk

Abstract ID : **86**

Thermodynamic properties along the QCD crossover from Lattice QCD

Content

We will present lattice QCD results on the chiral crossover temperature of QCD for moderately large baryon chemical potential. Firstly, we will present a precise measurement of the QCD pseudo-critical temperature at zero baryon chemical potential, obtained from several chiral susceptibilities. Then we will present results on the QCD pseudo-critical temperature at non-zero baryon chemical potential, computed using Taylor-expansions of chiral condensate and chiral susceptibilities up to 6th-order in the chemical potential. Finally, we will present all independent thermodynamic observables along the QCD crossover such as: specific heat, compressibility, speed of sound and thermal expansion coefficient, and compare these to HRG results to look for signs of a possible QCD chiral critical point.

Primary author(s) : PETRECZKY, Peter (BNL)

Presenter(s) : PETRECZKY, Peter (BNL)

Contribution Type : invited talk

Abstract ID : **87**

Quark and gluon contributions to the proton mass and spin

Content

The Mellin moments of Generalized Parton Distributions connect to quantities that describe the QCD energy momentum tensor. They allow us to single out the separate contributions from quarks and gluons. Partonic orbital angular momentum (OAM) plays a key role in our understanding of the long standing proton spin puzzle. Our recent work demonstrates the connection between quark gluon interactions and intrinsic kT relevant for describing OAM. The QCD trace anomaly is crucial for understanding the origin of hadron mass. Although the total energy momentum tensor is a conserved quantity, the separate contributions from quarks and gluons are not and hence are renormalization scale dependent. By studying the correct connection of the trace anomaly to the quark and gluon gravitational form factors, we can estimate the size of these contributions and even connect to experimental observables.

Primary author(s) : RAJAN, Abha (University of Virginia)

Presenter(s) : RAJAN, Abha (University of Virginia)

Contribution Type : contributed talk

Abstract ID : **88**

Search for dark photon, dark scalar, axion-like, or dark matter particle in Compton-like processes

Content

We propose a novel way to search for the dark photon (A'), the axion-like pseudo-scalar (a), the dark scalar (ϕ), and the light dark matter (χ) in the Compton process, $\gamma + e^- \to A'/a/\phi + e^-$ with $A'/a/\phi$ decaying into leptons, photons, or χ's (when permitted) for the mass ranges of $1 \leq m_{A'/a/\phi} \leq 100$ MeV/c^2 and $0.5 \leq m_\chi \leq 50$ MeV/c^2, respectively. We will review how current photon beam experiments (FOREST, GlueX, LEPS, and LEPS2) can use this new production mechanism of dark particles. We will discuss the expected sensitivities of these experiments on the kinetic mixing (ϵ), the axion-like pseudo-scalar coupling to electron (g_{ae}), and the dark scalar coupling to electron (y_e).

Primary author(s) : JAEGLE, Igal (University of Florida in Gainesville)

Presenter(s) : JAEGLE, Igal (University of Florida in Gainesville)

Contribution Type : plenary talk

Abstract ID : **89**

Recent measurements of jets in QCD matter

Content

Heavy ion collisions at high energies are used to study QCD at high temperatures. These high temperatures allow for the formation of a new state of matter called quark-gluon plasma (QGP) where the quarks and gluons inside of the nuclei are no longer confined. Jets are a useful probe of this medium since partons inside the jet are expected to lose energy in interactions with the strongly interacting matter, a phenomena called jet quenching. Many measurements of jet quenching have been performed at the Relativistic Heavy Ion Collider (RHIC) and the Large Hadron Collider (LHC). In these measurements energy loss is quantified through many observables that each probe different mechanisms of energy loss. This talk will discuss recent measurements of jet quenching at RHIC and the LHC, where higher energies and luminosities have allowed for more precise measurements that better constrain models of energy loss and provide insight into the properties of the medium.

Primary author(s) : HAVENER, Laura (Yale University)

Presenter(s) : HAVENER, Laura (Yale University)

Contribution Type : invited talk

Abstract ID : **90**

Jet and dijet production in heavy-ion collisions

Content

I will discuss recent developments in the theory of jets in ultra-relativistic nuclear collision, with an emphasis on heavy flavor production. Starting with inclusive jets, I will show how the technique of semi-inclusive jet functions, first developed in the framework of soft collinear effective theory, can be applied to c-jets and b-jets in heavy ion collisions. For the case of dijets, I will present the first calculation of the dijet mass modification in nucleus-nucleus reactions. The advantage of this new observable is that the energy loss effects on the individual jets combine to give enhanced sensitivity to the transport properties of the quark-gluon plasma.

Primary author(s) : Dr. VITEV, Ivan (LANL)

Presenter(s) : Dr. VITEV, Ivan (LANL)

Contribution Type : invited talk

Abstract ID : **91**

eRHIC Machine Design Overview

Content

The future electron-ion collider will open exciting new frontiers for research in nuclear physics and QCD. The US nuclear physics community, with world-wide support, has compiled a comprehensive white paper that provides a detailed description of the potential of such a machine and the associated design requirements. Brookhaven National Laboratory is proposing eRHIC, an electron-ion collider based on the highly successful RHIC facility. An electron storage ring is planned to be installed in the existing RHIC tunnel to provide electron-ion collisions at a center-of-mass energy of 29 to 140 GeV with luminosities up to 10^{34} cm^{-2} sec^{-1}. An overview of the eRHIC machine design will be presented.

Primary author(s) : MONTAG, Christoph (BNL)

Presenter(s) : MONTAG, Christoph (BNL)

Contribution Type : invited talk

Abstract ID : **92**

Overview of quarkonium results at RHIC and the LHC

Content

The study of bound heavy quark states has proven to be a crucial tool for investigating the matter formed in collisions of large nuclei. At both RHIC and the LHC, there has been considerable work in understanding the creation of these states in pp collisions, the effects of the nucleus in p+A collisions, and the spectral modifications that arise in A+A collisions. However, despite decades of experimental and theoretical work, precise quantification of the various effects that contribute to quarkonia suppression and enhancement remains elusive. This talk will give an overview of heavy quarkonium measurements from the RHIC and LHC detectors, with a focus on some recent measurements and their interpretations.

Primary author(s) : DURHAM, J. Matthew (Los Alamos National Laboratory)

Presenter(s) : DURHAM, J. Matthew (Los Alamos National Laboratory)

Contribution Type : invited talk

Abstract ID : **93**

Dispersive KT Equations for Three-Body Decays of Mesons with Higher Mass or Spin

Content

The Khuri-Treiman (KT) formalism has been used to great effect to describe the low-energy dynamics involved in relativistic three body decays. This dispersive framework relies on truncating the infinite sum of partial waves via the isobar decomposition and imposing unitarity on the three resulting subchannels. Because of this truncation, however, the dispersion equations resulting from unitarity are unconstrained at higher energies, limiting their usefulness to decays with small phase spaces. We propose an extension to the conventional KT formalism incorporating a Veneziano amplitude-like background to constrain the high-energy behavior. The resulting model reduces to conventional isobar/KT in the low-energy resonance region but has the proper high-energy Regge behavior, constraining the dispersion relations at intermediate energies. This allows for dispersive analysis techniques to be use for decays of mesons with higher mass or spin. We apply this technique to the decay $J/\psi \to 3\pi$.

Collaboration: Joint Physics Analysis Center

Primary author(s) : Mr. WINNEY, Daniel (Indiana Unversity Bloomington)

Co-author(s) : Prof. SZCZEPANIAK, Adam (Indiana Univeristy/JLab)

Presenter(s) : Mr. WINNEY, Daniel (Indiana Unversity Bloomington)

Contribution Type : invited talk

Abstract ID : **94**

Light and heavy quark spectroscopy at EIC

Content

The Electron Ion Collider (EIC), which will be built in the US during next decade, is proposed as a facility to probe the fundamental structure of matter trough lepton scattering off nucleon and nuclei with unprecedented luminosity. The broad EIC physics program spans from the nucleon tomography to the hadronization in dense nuclear matter. In this talk I'll discuss the opportunity for a light and heavy quark spectroscopy program at the EIC and its implication on the design of the EIC detectors.

Primary author(s) : Dr. BATTAGLIERI, Marco (INFN-GE)

Presenter(s) : Dr. BATTAGLIERI, Marco (INFN-GE)

Contribution Type : invited talk

Abstract ID : **95**

Photon collisions in ultraperipheral collisions at RHIC and the LHC

Content

Heavy ion collisions at RHIC and the LHC are perhaps best known for events in which the nuclei collide head-on, creating a volume of hot and dense matter which then decays into very high multiplicity final states. However, large (high Z) nuclei are also intense sources of high energy photons, which can interact with the other nucleus either directly or diffractively, or with each other in a gamma-gamma collision. These events are generally referred to as ultraperipheral collisions (UPC). This talk reviews results where pairs of oppositely charged leptons are produced either diffractively or electromagnetically, each of which probe different stages of the temporal evolution of the nuclear collision. Exclusive non-resonant dilepton events arise from gamma-gamma collisions and are sensitive to the very initial photon luminosity, an important input into theoretical calculations. Exclusive production of vector mesons results from photon-pomeron interactions and can thus probe the partonic structure of the nucleus. Finally, there are also classes of events which appear to be the simultaneous occurrence of a head-on heavy ion collision as well as a dilepton pair from electromagnetic processes. The systematic modification of the lepton pair kinematics suggests that they are potentially sensitive to strong magnetic fields, or even the microscopic properties of the hot, dense QGP.

Primary author(s) : STEINBERG, Peter (Brookhaven National Lab)

Presenter(s) : STEINBERG, Peter (Brookhaven National Lab)

Contribution Type : plenary talk

Abstract ID : **96**

Using ultra-peripheral collisions to probe nuclear parton distributions

Content

Ultra-peripheral nucleus-nucleus collisions provide an opportunity to study nuclear parton distributions in a kinematic range not covered by previously existing measurements through measurements of jet photo-production. The ATLAS experiment at the LHC has carried out a set of measurements in 5.02 TeV ultra-peripheral Pb+Pb collisions including a measurement of light-by-light scattering, a preliminary measurement of di-muon photo production, and a preliminary measurement of di- and multi-jet photo-production. The dimuon measurements provide a valuable calibration of the photon fluxes associated with the ultra-relativistic nuclei and comparisons of the measured cross-sections with theoretical calculations will be shown. The jet photoproduction measurement will be the primary focus of the talk. The methods for selecting photo production events, comparisons with Monte Carlo simulations, and the resulting preliminary cross-sections will be shown and discussed.

Primary author(s) : COLE, Brian (Columbia University)

Presenter(s) : COLE, Brian (Columbia University)

Contribution Type : invited talk

Abstract ID : **97**

On the smallest droplets of QCD fluids

Content

Hydrodynamics is the accepted framework to describe the evolution of systems created in relativistic heavy-ion collisions. In smaller collision systems, such as proton-lead and proton-proton collisions, other, non-hydrodynamic explanations for the experimentally observed flow signals have been suggested. So which explanation is right or are they both? In this talk I review the applicability of hydrodynamics to small systems, and the conclusions one can draw for the origin of experimental flow signals in small collision systems.

Primary author(s) : ROMATSCHKE, Paul (CU Boulder)

Presenter(s) : ROMATSCHKE, Paul (CU Boulder)

Contribution Type : invited talk

Abstract ID : **98**

Results from the GMp Experiment at Jefferson Lab

Content

The GMp Experiment which ran in Experimental Hall A at Jefferson Lab as one of the 12 GeV commissioning experiments measured the elastic cross section from electron-proton scattering with 2-3% accuracy in the Q^2 range from 7 to 16 $(GeV/c)^2$. Such measurements test our understanding of nucleon structure in terms of Quantum Chromodynamics (QCD), with high-Q^2, high-precision data providing strong constraints to models of nucleon structure, with lower Q^2 data on other form factors providing additional constraints on the separation of the u versus d quark contributions to the elastic scattering, and charge versus magnetization distributions. Additionally, the GMp data combined with other existing elastic cross section measurements and polarization observables is expected to provide best constraints on 2-photon contributions. The status of the analysis and final results will be presented.

Primary author(s) : CHRISTY, Eric (Hampton University / Jefferson Lab)

Presenter(s) : CHRISTY, Eric (Hampton University / Jefferson Lab)

Contribution Type : invited talk

Abstract ID : **99**

The g_2 structure function and recent results from the SANE experiment

Content

The Spin Asymmetries of the Nucleon Experiment (SANE) measured two double spin asymmetries using a polarized proton target and polarized electron beam at two beam energies, 4.7 GeV and 5.9 GeV. A large-acceptance open-configuration detector package identified scattered electrons at 40° and covered a wide range in Bjorken x ($0.3 < x < 0.8$). Proportional to an average color Lorentz force, the twist-3 matrix element, $\tilde{d}_2^p$, was extracted from the measured asymmetries at Q^2 values ranging from 2.0 to 6.0 GeV^2. This talk will cover the status of the g_2 structure function and present the results for $\tilde{d}_2^p$ with a discussion of the puzzling scale dependence observed and future measurements.

Primary author(s) : ARMSTRONG, Whitney (Argonne National Laboratory)

Presenter(s) : ARMSTRONG, Whitney (Argonne National Laboratory)

Contribution Type : invited talk

Abstract ID : **100**

On the lepton azimuthal angular distributions in the Drell-Yan process

Content

The lepton angular distributions of the Drell-Yan process in fixed-target experiments and the Z-boson production at colliders are investigated by NLO and NNLO perturbative QCD and an intuitive geometric approach. The main features of the kinematic dependencies of the angular distributions coefficients can be well understood in the geometrical approach. Implications of this approach on the rotational invariance of the angular coefficients, the behavior of the coefficients for Z plus jets events, and the extraction of the Boer-Mulders functions from the Drell-Yan process will be presented.

Primary author(s) : PENG, Jen-chieh (University of Illinois at Urbana-Chamapign)

Presenter(s) : PENG, Jen-chieh (University of Illinois at Urbana-Chamapign)

Contribution Type : invited talk

Abstract ID : **101**

Some Recent Theoretical Developments in Small Systems

Content

While proton-proton collisions and heavy-ion collisions can be well-described by their own theoretical frameworks – factorization and hydrodynamics, respectively – the collisions of intermediate "small systems" pose unique challenges and opportunities. The "dilute-dilute" limit associated with proton-proton collisions is characterized by the dominance of a single partonic hard scattering event and can be described theoretically in terms of collinear or transverse-momentum-dependent factorization theorems. In contrast, the "dense-dense" limit associated with heavy-ion collisions is characterized by abundant multi-parton interactions and multiple rescattering and can be described theoretically as a resummation of these effects, leading to the geometry-driven collective flow of soft particles and the quenching or modification of hard particle production. But the intermediate regime, which might be characterized as "semi-dilute", lies in a regime in which neither description is sufficient. Multi-parton interactions are enhanced and can play an important role in particle production, while the small system size poses a challenge for any in-equilibrium description in hydrodynamics. As such, the collisions of small nuclei with each other and in asymmetric collisions with dilute or dense probes provides a fertile ground for exploring these mechanisms. In this talk, I will present a few new results applicable for particle production in small systems. One growing niche is the extension of the saturation framework, typically applied to small-x kinematics and heavy nuclei, to describe particle production and correlations in asymmetric "heavy-light ion collisions." Recent calculations in this framework can describe correlations among several produced quarks and gluons, highlighting the interesting role of Bose versus Fermi statistics. Another developing area is the study of collisions of nuclei which are smaller or deformed. This thrust has the potential to use high-energy hadronic collisions to obtain new constraints on the shape parameters associated with these nuclei and to study the properties of the quark-gluon plasma which could be produced in such collisions, which would be smaller and hotter than the corresponding plasmas achieved in large systems. Finally, I will present a new application which combines these two areas: the calculation of spatial correlations among quarks and antiquarks in the initial stages of heavy-light ion collisions, which can be used to initialize and study the evolution of conserved charges through the hydrodynamic phase.

Primary author(s) : Dr. SIEVERT, Matthew (Rutgers University)

Presenter(s) : Dr. SIEVERT, Matthew (Rutgers University)

Contribution Type : invited talk

Abstract ID : **102**

Jet quenching: the end game

Content

With the advent of advanced event generators, and a variety of theoretical advances, jet quenching has now transitioned from a discovery stage to one of systematic exploration. While calculations (or rather simulations) have become considerably extensive, there are practically no jet observables left that cannot be described by what is now referred to as the multi-stage approach. I will describe the origin and current theoretical justification for this approach, and in particular the ability to reduce almost all observables to a handful of transport coefficients. This will be followed by a discussion of the variety of observables that can be described by a state-of-the-art event generator based only on these transport coefficients. In conclusion, we will focus on the new kinds of observables which combine the quenching of jets with the response generated in the medium and their ability to reveal new properties of the quark gluon plasma.

Primary author(s) : MAJUMDER, Abhijit (Wayne State University)

Presenter(s) : MAJUMDER, Abhijit (Wayne State University)

Contribution Type : plenary talk

Abstract ID : **103**

New determination of the lightest hybrid meson candidate

Content

In this talk I will review the recent analyses and other activities carried out by the JPAC collaboration. In particular, the phenomenological analysis of the $\eta^{(\prime)}\pi$ partial waves measured at COMPASS. We fit the data using a coupled-channel amplitude based on first principles, determining in a robust way the existence of only one hybrid meson candidate π_1, corresponding to the $\pi_1(1600)$. We also extract the parameters of the ordinary mesons $a_2(1320)$ and $a_2'(1700)$.

Primary author(s) : Mr. RODAS, Arkaitz (Universidad Complutense de Madrid)

Presenter(s) : Mr. RODAS, Arkaitz (Universidad Complutense de Madrid)

Contribution Type : invited talk

Abstract ID : **104**

Analysis of three body decays

Content

In this talk we will present the formalism of Khuri-Treiman equations and how this is useful for the analysis of three body decays. We will show how it works in different reactions, and discuss some of the necessary generalizations, such as the inclusion of coupled channels. We will also discuss future applications.

Primary author(s) : Dr. ALBALADEJO, Miguel (JLab)

Presenter(s) : Dr. ALBALADEJO, Miguel (JLab)

Contribution Type : invited talk

Abstract ID : **105**

Overview of heavy flavor results at RHIC and the LHC

Content

Heavy flavor quarks offer unique insights to the properties of the strongly coupled Quark-Gluon Plasma (QGP) created in heavy-ion collisions. Recently, precision heavy flavor measurements are made available thanks to the advanced detector technology and high luminosity collisions provided by RHIC and the LHC colliders. In this talk, I will review these recent experimental achievements and discuss physics we learn in terms of QCD in finite temperature regions. I will also highlight some issues and challenges, and present future experimental prospects with heavy flavor measurements at RHIC and the LHC.

Primary author(s) : DONG, Xin (Lawrence Berkeley National Laboratory)

Presenter(s) : DONG, Xin (Lawrence Berkeley National Laboratory)

Contribution Type : invited talk

Abstract ID : **106**

Ultra-peripheral heavy-ion collisions in CMS

Content

In this talk, we will review the results by the CMS Collaboration in ultra-peripheral heavy-ion collisions (UPC). In particular, we will present and discuss the results on exclusive Rho0 and Upsilon photo production off the proton, and coherent J/psi photo production off the Pb target. Results on light-by-light scattering and in dijet photoproduction in ultra-peripheral PbPb collisions will also be presented. Finally, the prospects for future UPC measurements will also be presented.

Primary author(s) : Dr. TAPIA TAKAKI, Daniel (University of Kansas)

Presenter(s) : Dr. TAPIA TAKAKI, Daniel (University of Kansas)

Contribution Type : invited talk

Abstract ID : **107**

Extracting the Neutron Structure Function from Global DIS Data using CJ15

Content

The CJ (CTEQ-Jefferson Lab) Collaboration provides a global fit of parton distribution functions (PDFs) with a special emphasis on the large xbj region. The latest fit (CJ15) implemented deuteron nuclear corrections at the parton level, and included data that were sensitive specifically to the neutron. These nuclear corrections allow for a calculation of the F2 structure functions of the proton, deuteron, and neutron from PDFs. In this work we re-estimated the uncertainties in the DIS F2 data utilized in CJ15, and collected an extended set of existing high-precision, small Q2, large xbj DIS data from JLab 6 GeV experiments. We employed the CJ15 calculation to remove nuclear effects from deuteron data where the proton was available from the same experiment, and thereby constructed a global data set for the F2 neutron structure function. In this talk we will present the extracted F2 neutron data sets, and also a new neutron excess (isoscalar) correction as an application.

Primary author(s) : LI, Shujie (University of New Hampshire)

Presenter(s) : LI, Shujie (University of New Hampshire)

Contribution Type : contributed talk

Abstract ID : **108**

Jets in QCD matter

Content

The propagation of quarks and gluons through a QCD medium, such as nuclei or the quark-gluon plasma, remains poorly understood. Elucidating this phenomena is a central aspect of the research program of a diverse variety of experiments at JLab12, RHIC, LHC and the future Electron-Ion Collider. At collider energies, this process can be studied with measurements of jet cross-sections and their substructure. These measurements hold promise to extract medium properties and elucidate the hadronization process in nuclei. I will review recent measurements by the ALICE experiment at the LHC and discuss future prospects.

Primary author(s) : ARRATIA, Miguel (UC Berkeley)

Presenter(s) : ARRATIA, Miguel (UC Berkeley)

Contribution Type : invited talk

Abstract ID : **109**

Recent results in hadron spectroscopy at Belle and prospects for Belle II

Content

The Belle II experiment, currently under construction at the KEK laboratory in Tsukuba, Japan, is the next generation of the highly successful B-factories. A substantial upgrade of both the Belle detector and the KEKB accelerator represent an essentially new experiment. Full physics running will start in early 2019 with a goal of collecting 50 times more data than the first generation B-factories. Belle II is uniquely positioned to make detailed studies of exotic hadron states, the so-called XYZ states, that represent the emergence of a new category within quantum chromodynamics. This talk will review some recent results in hadron spectroscopy from Belle and present the capability of Belle II to explore both conventional and exotic quarkonium physics.

Contribution Type : contributed talk

Abstract ID : **110**

Gluon TMDs from Quarkonium production in proton collisions

Content

In this talk it is discussed how gluon TMDs - in particular the distribution of linearly polarized gluons - can be accessed in proton collisions at the LHC. A particularly promising reaction is the production of quarkonium pairs. Using existing LHCb data for this final state allows to obtain a first idea of how the TMD distribution of unpolarized gluons in the nucleon might look like. In addition, estimates of azimuthal modulations that are sensitive to a possible linear polarization of gluons in the nucleon are presented.

Primary author(s) : Prof. SCHLEGEL, Marc (New Mexico State University)

Presenter(s) : Prof. SCHLEGEL, Marc (New Mexico State University)

Contribution Type : invited talk

Abstract ID : **111**

Experimental Signals of Low-x Saturation

Content

The power-law growth of gluon and sea quark PDFs that has been experimentally observed in the small-x regime is fundamentally inconsistent with basic tenets of quantum field theory. This phenomenon is driven by the explosive rate of soft gluon bremsstrahlung which is a fundamental feature of QCD (or any non-Abelian field theory). In order to be consistent with essential features such as unitarity, this power-law growth of color-charge density at small x must eventually be softened by the onset of a high-density phase of QCD. This behavior, termed "gluon saturation," is a non-negotiable consequence of QCD at high energies or small x. Observing the onset of gluon saturation and characterizing its properties would elucidate not only the nature of the exotic high-density regime of QCD, but also the fundamental mechanisms by which any quantum field theory can achieve UV completeness.

At present, there has been no unambiguous detection of gluon saturation. There are, however, a range of tantalizing signals consistent with saturation physics seen in electron-proton, proton-nucleus, and nucleus-nucleus collisions. The high-density phase of QCD can be described by the "color-glass condensate" effective field theory, which makes simultaneous consistent predictions for diverse phenomena from diffractive cross sections to jet quenching to multiparticle correlations. In this talk, I will discuss the common theoretical framework that underpins these predictions and compare it to the hints seen in experiment. I will also discuss the prospects for peering into the saturation regime with a future high-energy Electron-Ion Collider.

Primary author(s) : SIEVERT, Matthew (Rutgers University)

Presenter(s) : SIEVERT, Matthew (Rutgers University)

Contribution Type : invited talk

Abstract ID : **112**

Collinear Distributions from a Universal QCD Analysis

Content

Collinear distributions such as PDFs and fragmentation functions (FFs) have long been constrained by independent global QCD analyses. However, it is well known that these functions are intimately related across various scattering processes used in global fits, particularly in the polarized sector. Recently, the JAM collaboration performed the first simultaneous analysis of spin-dependent PDFs and FFs to constrain the sea quark helicities and resolve the strange polarization puzzle with semi-inclusive DIS data. In this talk, I review this effort and highlight new results from a universal QCD analysis in which spin-averaged and spin-dependent PDFs, together with FFs, are constrained simultaneously from unpolarized and polarized observables. I also discuss current and future fitting strategies that are needed to reliably determine the distributions and their uncertainties.

Primary author(s) : ETHIER, Jacob ((Vrije Universiteit / Nikhef))

Presenter(s) : ETHIER, Jacob ((Vrije Universiteit / Nikhef))

Contribution Type : plenary talk

Abstract ID : **113**

JLEIC Electron-Ion Collider Advances and Opportunities

Content

A U.S.-based Electron-Ion Collider (EIC) has recently been endorsed by the U.S. National Academies of Sciences, Engineering, and Medicine (NAS). This brings the realization of such a collider another step closer, after its earlier recommendation in the 2015 Long-Range Plan for U.S. nuclear science of the Nuclear Science Advisory Committee "as the highest priority for new facility construction following the completion of FRIB". An EIC will be an unprecedented collider that will need to maintain high luminosity ($10^{33} - 10^{34}$ cm^{-2} s^{-1}) over a very wide range of Center-of- Mass energies ($\sim$20 GeV to $\sim$100 GeV, upgradable to $\sim$140 GeV), while accommodating highly polarized beams and many different ion species. A multi-laboratory collaboration is presently working on two site-specific EIC designs – eRHIC led by Brookhaven National Laboratory and JLEIC led by Jefferson Lab. The JLEIC design maximally leverages the existing CEBAF capability for production of polarized electron beams, and leverages the innovative figure-8 rings to achieve high luminosity and high values of beam polarization for protons, deuterons and other ions. The present talk will summarise the status of JLEIC Electron Ion Collider design and R&D.

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Primary author(s) : SERYI, Andrei (JLAB)

Presenter(s) : SERYI, Andrei (JLAB)

Contribution Type : invited talk

Abstract ID : **115**

Interaction Region Design Considerations and the Machine Detector Interface for Electron Ion Colliders

Content

Melding the physics goals of an EIC with the practicalities of accelerator and magnet design leads to many IR design challenges. Simply bringing beams with quite different properties cleanly into collision with high luminosity and without placing intrusive machine elements inside the detector volume is a first major challenge. In addition, EIC physics requires polarized beams, high field and/or large bore IR magnets for good forward charged/neutral acceptance and rear electron tagging and the integration of systems for precision luminosity and polarization determination. We draw upon HERA-II, eRHIC, JLEIC and LHeC IR design experience to show how to address such challenges in this talk.

Primary author(s) : Dr. PARKER, Brett (BNL)

Presenter(s) : Dr. PARKER, Brett (BNL)

Contribution Type : invited talk

Abstract ID : **116**

Meson structure at CERN M2 beamline

Content

The M2 beam line at CERN can be used to shed new light to the light-meson structure using the Drell-Yan process. We propose a new Drell-Yan experiment to make a major step forward in the determination of the nearly unknown pion and kaon parton distribution functions (PDFs). The planned measurements will provide key benchmarks for testing the most recent predictions of fun- damental, non-perturbative QCD calculations, such as lattice QCD and Dyson-Schwinger Equations formalism. At medium and large values of Bjorken-x, a quantitative comparison between the pion and the kaon valence distributions is of utmost importance. At smaller values of Bjorken-x, improved knowl- edge of the onset of the sea and gluon distributions in the meson will help in explaining the differences between the gluon contents of pions, kaons and nucleons, and hopefully provide clues to understand the mechanism that generates the hadron masses. The M2 secondary hadron beam line at the CERN SPS provides an exclusive opportunity for such measurements.

Primary author(s) : ANDRIEUX, Vincent (UIUC/CERN)

Presenter(s) : ANDRIEUX, Vincent (UIUC/CERN)

Contribution Type : invited talk

Abstract ID : **117**

GPD studies at the EIC

Content

The 2015 U.S. Nuclear Physics Long-Range Plan recommended the realization of an electron-ion collider (EIC) as the next large construction project in the United States. A U.S.-based EIC has also recently been endorsed by the U.S. National Academy of Sciences. With the design of an EIC, advancements in theory and further development of phenomenological tools, we are now preparing for the next step in subnuclear tomographic imaging. The collider's large range of center-of-mass energies in combination with very high luminosity and polarization of both the lepton and the hadron beams, will open a unique opportunity for very high precision measurements of both cross sections and spin-asymmetries. This will allow us for a detailed investigation of the partonic substructure of hadrons in multi-dimensions, as well as addressing the role of orbital angular momentum with respect to the nucleon spin. Generalized parton distributions (GPDs) describe the multi-dimensional partonic structure of a nucleon in coordinate space, providing new information about the internal dynamics of quarks and gluons. Measurements of GPDs with hard exclusive processes, with all related probes, are an essential element of the EIC science program. This talk will highlight key measurements, experimental challenges, and finally discuss the EIC's expected impact over the current knowledge of the partonic multidimensional structure of hadrons in space coordinates.

Primary author(s) : Dr. FAZIO, Salvatore (Brookhaven National Laboratory)

Presenter(s) : Dr. FAZIO, Salvatore (Brookhaven National Laboratory)

Contribution Type : invited talk

Abstract ID : **118**

Exploring the Properties of Cold, Dense Matter

Content

Hot, dense QCD matter has been shown to have some very remarkable properties. Its vanishingly small shear viscosity to entropy density ratio means that it flows essentially without internal friction. It is also very opaque to transiting strongly interacting particles, dispersing the deposited energy rather efficiently. It remains a mystery, though, how this plasma can emerge from the cold, dense gluonic matter deep inside nuclei so quickly. Proton-nucleus and high multiplicity proton-proton collisions show some of the same behavior as hot, dense matter in heavy ion collisions. However, properties of the cold QCD matter deep inside nuclei are not well known. Jets of hadrons offer a promising probe of both hot and cold dense QCD matter. I will discuss some of the jet measurements needed at a future Electron-Ion Collider, and what it will take to make those measurements.

Primary author(s) : JACAK, Barbara (UC Berkeley and Lawrence Berkeley National Laboratory)

Presenter(s) : JACAK, Barbara (UC Berkeley and Lawrence Berkeley National Laboratory)

Contribution Type : plenary talk

Abstract ID : **130**

Transverse Force Tomography

Content

While twist-2 GPDs allow determining the distribution of partons on the transverse plane, twist-3 GPDs contain quark-gluon correlations that provide information about the average transverse force acting on quarks in a DIS experiment. We demonstrate how twist-3 GPDs can be used to provide transverse position information about that force.

Primary author(s) : Prof. BURKARDT, Matthias (NMSU)

Presenter(s) : Prof. BURKARDT, Matthias (NMSU)

Contribution Type : invited talk

Abstract ID : **131**

Challenges in Nuclear Femtography

Content

Major progress in theoretical formalism of the interior structure of the Nucleon over the last 30 years has led to breakthroughs in our understanding of the theory of the fundamental substructure of the protons and neutrons. At the same time, the technical advances in particle accelerator and state of the art experimental detection technologies along with dramatic developments in computing power and algorithms, have brought us to the threshold of a new science. Large amounts of data (∼PB per week) will need to be analyzed to provide the experimental input to the 3D proton/neutron imaging. The characterization and visualization of these distributions is an additional challenge. We will present the status and the plans for the current and future experiments and discuss the required interdisciplinary effort between physics theory and experiment, computing in data science, imaging/visualization and mathematics to start addressing some of the fundamental questions at the sub-femtometer scale critical to the understanding of our universe.

Primary author(s) : ELOUADRHIRI, Latifa (Jefferson Lab)

Presenter(s) : ELOUADRHIRI, Latifa (Jefferson Lab)

Contribution Type : invited talk