HK 18: Hadron Structure and Spectroscopy II

Time: Tuesday 17:00–19:00 Location: SCH/A316

Group Report HK 18.1 Tue 17:00 SCH/A316

Measurement of the proton charge radius at AMBER — •Martin Hoffmann for the AMBER-Collaboration — Universität Bonn, Helmholtz-Institut für Strahlen- und Kernphysik, Bonn, Germany

The proton charge radius can be measured either by hydrogen spectroscopy or in lepton-proton elastic scattering. Previous measurements resulted in discrepant radii, which became known as the proton radius puzzle. The AMBER collaboration at CERN plans to perform a new precision measurement of the proton form factor at low momentum transfer using high-energy muon-proton elastic scattering. This measurement has different systematic uncertainties compared to those of low-energy elastic scattering. The recoil proton will be detected with a high-pressurized hydrogen-filled Time Projection Chamber (TPC), measuring the transferred energy and thus the squared four-momentum Q^2. The muon kinematics will be measured with high-precision vertex detectors around the TPC and a downstream spectrometer, which allows to select for elastic scattering events.

The core setup consisting of silicon tracking detectors and a prototype TPC was studied under realistic beam conditions during a pilot run in 2021. In 2022, the newly developed unified tracking system consisting of scintillating fibers for accurate timing and monolithic pixel-silicon detectors for high spatial precision was tested. This talk will present results of the on-going analyses and an overview of further developments towards the final setup.

Supported by EU.

HK 18.2 Tue 17:30 SCH/A316

Testing Predictions of the Chiral Anomaly in Primakoff Reactions at COMPASS* — •Dominik Ecker and Andrii Maltsev for the COMPASS-Collaboration — Physik-Department, Technische Universität München

Chiral Perturbation Theory (ChPT) makes effective predictions for low-energy phenomena of QCD, i.e. dynamics and decays of light mesons, and their couplings to photons and nucleons. Processes, which are governed by the chiral anomaly, are described in the effective Lagrangian by the Wess-Zumino-Witten (WZW) term. The WZW term describes for example the coupling of one pion to two photons. Hence, it describes the π^0 lifetime, which has been well confirmed by multiple measurements.

There are however many more couplings governed by the chiral anomaly, which lack precise experimental verification: for example, the direct coupling of one photon to three pions. The corresponding coupling constant $F_{3\pi}$ is described by the WZW term and can experimentally be accessed in $\pi^- + \gamma \to \pi^- + \pi^0$ scattering reactions.

At the COMPASS experiment at CERN, we study pion-photon scattering reactions via the Primakoff effect. These data allow us to verify the ChPT prediction for $F_{3\pi}$. We will present preliminary result of this measurement and ongoing efforts to improve its accuracy.

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HK 18.3 Tue 17:45 SCH/A316

Small Angle Initial State Radiation Analysis of the Pion Form Factor at BESIII — •Yasemin Schelhaas, Riccardo Aliberti, and Achim Denig for the BESIII-Collaboration — Institut für Kernphysik, Johannes Gutenberg-Universität Mainz, Deutschland

The anomalous magnetic moment of the muon is one of the most precisely measured quantities in modern physics. However, there is a discrepancy of 4.2 standard deviations between the Standard Model (SM) prediction and the average of the latest direct measurements at BNL and FNAL. This discrepancy is known as the Muon $(g-2)$-puzzle. For the SM prediction the main uncertainty arises from hadronic contributions and can be improved systematically using measurements of hadronic cross sections at e^+e^- colliders. One of the most important processes is $e^+e^- \to \pi^+\pi^-$. Using a data set of $1.9\,\mathrm{fb}^{-1}$ (in the near future $20\,\mathrm{fb}^{-1}$) at a center of mass energy of 3.77 GeV, the $\pi^+\pi^-$ cross section is measured at the BESIII experiment located at the BEPCII collider in Beijing, exploiting the initial state radiation technique at small angles. The analysis aims to determine the pion form factor at masses above 0.8 GeV, which is also interesting for hadron spectroscopy. In this talk the current status of the analysis is presented.

Supported by DFG.

HK 18.4 Tue 18:00 SCH/A316

SIDIS Kaon Beam Spin Asymmetry Measurements with CLAS12 — •Áron Kripkó[1], Stefan Diehl[1,2], and Kai-Thomas Brinkmann[1] for the CLAS-Collaboration — [1]Justus Liebig Universität Gießen, 35390 Gießen, Germany — [2]University of Connecticut, Storrs, CT 06269, USA

A multidimensional study of the structure function ratio $F_{LU}^{\sin(\phi)}/F_{UU}$ has been performed for $K^{\pm}$, based on the measurement of beam-spin asymmetries. It uses the high statistics data recorded with the CLAS12 spectrometer at Jefferson Laboratory. The 10.6 GeV longitudinally polarized electron beam interacted with an unpolarized liquid hydrogen target during the experiment. $F_{LU}^{\sin(\phi)}$ is a twist-3 quantity that provides information about the quark gluon correlations in the proton.
The talk will present a simultaneous analysis of two kaon channels (K^+ and K^-) over a large kinematic range with virtualities Q^2 ranging from 1 GeV^2 to 8 GeV^2. The precise multidimensional measurement was performed in a large range of z, x_B, p_T and Q^2 for the first time. This multidimensional binning will allow a comparison with different reaction models.
This work is supported by HFHF and funded by DFG (project number: 508107918).

HK 18.5 Tue 18:15 SCH/A316

Exposing the structure of pion — •Minghui Ding — Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany

As the theory of quantum chromodynamics has unfolded, the pion has come to be understood as Nature*s most fundamental Nambu-Goldstone boson. It is attached to chiral symmetry, which is dynamically broken, quite probably as a corollary of emergence of hadron mass. Continuum Schwinger function methods are well suited to tackling the pion. This presentation describes the theoretical developments on pion structure in which the methods preserve the fundamental underlying symmetries, thereby providing challenges and opportunities for modern and anticipated high-luminosity, high-energy facilities - JLab at 12GeV, the AMBER project at CERN, and electron ion colliders in the USA and China - and surveys the developments in global phenomenological fits and lattice regularised QCD, enabling the picture of the pion to be drawn.

HK 18.6 Tue 18:30 SCH/A316

Numerische Analyse der nichtlinearen GLR-MQ-Gleichungen für nukleare Partondichtefunktionen — •Janik Rausch[1], Vadim Guzey[2] und Michael Klasen[3] — [1]Humboldt-Universität Berlin, Deutschland — [2]Universität Jyväskylä, Finnland — [3]Westfälische Wilhelms-Universität Münster, Deutschland

Wir untersuchen erstmalig die nichtlinearen GLR-MQ-Gleichungen für die Entwicklung nuklearer Partondichtefunktionen (nPDFs) numerisch bis zur next-to-leading order für verschiedene Kerne und quantifizieren den Einfluss von Gluonen-Rekombination bei kleinem Bjorken-x. Mit den nCTEQ15 nPDFs als Input bestätigen wir die Relevanz der nichtlinearen Korrekturen, deren Größe mit fallendem x und steigender Massenzahl A wächst, für $x \lesssim 10^{-3}$. Wir zeigen, dass die Quark-Singlet- und Gluon-Distributionen $\Omega(x,Q^2)$ und $G(x,Q^2)$ bei $x = 10^{-5}$ für schwere Kerne nach der nichtlinearen Evolution von $Q_0 = 2\,\mathrm{GeV}$ bis $Q = 10\,\mathrm{GeV}$ verglichen mit der linearen Evolution um $9-15\%$ verringert sind. Wenn abwärts von $Q_0 = 10\,\mathrm{GeV}$ bis $Q = 2\,\mathrm{GeV}$ entwickelt wird, ist der relative Effekt deutlich größer, $\Omega(x,Q^2)$ ist um 40% reduziert und $G(x,Q^2)$ um 140% erhöht. Diese Trends finden sich in den Strukturfunktionen $F_2^A(x,Q^2)$ und $F_L^A(x,Q^2)$ wieder, die nach der Abwärtsentwicklung um 45% reduziert bzw. um 80% erhöht sind. Unsere Ergebnisse zeigen, dass die nichtlinearen Effekte in $F_L^A(x,Q^2)$ am deutlichsten auftreten und für schwere Kerne bereits bei $x \sim 10^{-3}$ erheblich sind.

HK 18.7 Tue 18:45 SCH/A316

Measuring Generalized Distribution Amplitudes in Proton-Antiproton Annihilation with PANDA at FAIR — •Faiza Khalid, Stefan Diehl, and Kai-Thomas Brinkmann — II. Physikalisches Institut, Justus Liebig Universität Gießen

The future PANDA experiment at FAIR with the HESR antiproton beam provides unique possibilities to study the 3D nucleon structure with exclusive channels in $\overline{p}p$ annihilation. One of the channels of interest for the measurement of Generalized Distribution Amplitudes (GDAs) is $\overline{p}p \to \pi^0\gamma$. Simulations at several center-of-mass energies were done for this signal channel ($\overline{p}p \to \pi^0\gamma$) and for the main background channel($\overline{p}p \to \pi^0\pi^0$) to check the feasibility of the measurement. The talk will present the feasibility study for the measurement of the cos(θ) dependence of the differential cross-section for $\overline{p}p \to \pi^0\gamma$ at different integrated luminosities. The cross sections have been estimated based on data from the E760 experiment at Fermilab, which is available in a limited kinematic range. Various optimal set of cuts were investigated to reduce the high background in this channel. Results of count rate estimates and estimates of the expected statistical uncertainty are presented. Different event selection cuts have been investigated to optimize the signal to background ratio while keeping a reasonable reconstruction efficiency. Also presented is the feasibility study of the channel $\overline{p}p \to \pi^0\pi^0$ whose cross-section needs to be measured to subtract the high background in the channel $\overline{p}p \to \pi^0\gamma$.

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