MESON2021

Monday, 17 May 2021 - Thursday, 20 May 2021

online via ZOOM

Book of Abstracts

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Quarkonium at Belle II

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The Belle II experiment at the SuperKEKB energy-asymmetric e^+e^- collider is an upgrade of the B factory facility at KEK in Tsukuba, Japan. The experiment began operation in 2019 and aims to record a factor of 50 times more data than its predecessor. Belle II is uniquely capable of studying the so-called "XYZ" particles: heavy exotic hadrons consisting of more than three quarks. First discovered by Belle, these now number in the dozens, and represent the emergence of a new category within quantum chromodynamics. We present recent results in new Belle II data, and the future prospects to explore both exotic and conventional quarkonium physics.

Collaboration:

Belle II

Plenary Session / **87**

LHCb results on exotic spectroscopy

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Exotic hadrons, which are composed of more than three valence quarks, can provide new insights into the internal structure and dynamics of hadrons, thus improving our knowledge of the non-perturbative regime of QCD. The data collected by the LHCb experiment provides unique opportunities for precise measurement of properties of established exotic hadrons and search for new ones. This talk discusses the new results of exotic hadron studies at LHCb.

Collaboration:

Plenary Session / **74**

Recent Achievements of BESIII

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The BESIII experiment at the electron-positron collider BEPCII in Beijing, China is studying e+e- annihilations at center-of-mass energies up to 4.6 GeV. This offers excellent opportunities for a broad physics program. In this talk recent achievements of the collaboration will be discussed, highlighting in particular the precise investigation of the spectrum and decay properties of hadrons in the charm and light quark domain.

Collaboration:

BESIII

Plenary Session / **42**

Experimental results on charmonium-like states

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A variety of unexpected states have been discovered in the charmonium sector since the beginning of the millennium. Some of them are charged and thus manifestly exotic states. Even though meanwhile confirmed in various different experiments, especially the e+e- experiments have largely contributed to this exciting field of charmonium-like (exotic) XYZ states. An overview of selected results obtained using e+e- annihilation is given.

Collaboration:

Plenary Session / **9**

Unconventional heavy meson states

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Since the turn of the century a large number of states was established experimentally in the quarkonium mass range, most of which do not fit into the scheme provided by the until then for the doubly heavy sector very successful quark model. I will discuss current proposals for the structure of these so called XYZ states with special emphasis on possible experimental signatures that would allow one to pin down the internal structure
of certain states.I will also briefly discuss the recent LHCb observation of a signal related to two charm and two anti-charm quarks.

Collaboration:

Plenary Session / **6**

Overview on ordinary and exotic mesons from Dyson-Schwinger equations

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In this talk I will give an overview on recent results on the spectrum and properties of conventional and exotic mesons (glueballs, tetraquarks) as obtained in the framework of Dyson-Schwinger and Bethe-Salpeter equations. I will discuss the spectrum of (quenched) glueballs with focus on the comparison with results from lattice gauge theory. For four-quark systems I will summarize results for light quarks and discuss recent progress on discriminating between tetraquark, molecule or hadro-quarkonium configurations in heavy-light systems.

Collaboration:

Plenary Session / **5**

Meson Spectroscopy at CLAS and CLAS12

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Hadron spectroscopy is a valuable tool to experimentally investigate the low-energy, non-perturbative QCD regime, corresponding to the dominant manifestation of the strong force in Nature, in terms of hadrons that constitute the bulk of the visible mass of the Universe. In particular, the measurement of the mesons spectrum, searching for exotic states not compatible with the Quark Model, would provide access to the gluonic degrees of freedom that bind particles together.

A broad program to study meson spectroscopy in the light quark sector started at Jefferson Laboratory during the previous 6-GeV period. The CLAS experiment in Hall B used a Bremmstrahlung tagged photon beam impinging on a proton target to provide the first measurement of many photoproduction reactions. Currently, in the 12-GeV era, the MesonEx experiment continues this physics effort, exploiting the larger beam energy and intensity. MesonEx employs low-Q^2 electron scattering as a technique to produce an intense and highly energetic quasi-real photon beam. In the experiment, the low-angle scattered electron is measured in a dedicated detector, the Forward Tagger, in coincidence with final state hadrons measured in the CLAS12 spectrometer.

In this talk, after discussing some selected results from the CLAS program, I'll present the ongoing MesonEx experiment, showing some preliminary results.

Collaboration:

CLAS

Plenary Session / **3**

Hadron reactions and spectroscopy studies at JPAC

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Recently there have been dramatic advancements in accelerator technologies, detection techniques and on the theoretical side, algorithms for first-principle QCD analyses. These have led to several candidates for possible "exotic" hadrons, i.e., multiquark states or quark-gluon hybrids. It thus appears that interpretating the entire hadron spectrum in terms of the most naive constituent quark model is no longer possible. If confirmed, such exotic hadrons could drastically alter our understanding of strong QCD and shed new light on the confinement of quarks. Given the wide interest in hadron spectroscopy, the Joint Physics Analysis Center (JPAC) has been dedicated to the development of theoretical and phenomenological analysis methods for hadron reactions.

Collaboration:

Plenary Session / **12**

Meson Transition Form Factors

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The electromagnetic transition form factors (TFFs) of the light mesons provide a unique laboratory to test fundamental aspects of hadron physics. The TFF describes the coupling between the meson and photons and hence provides a probe of the intrinsic electromagnetic structure of the meson. High statistics measurements of pseudoscalar meson TFFs also play a role for the precision frontier of the Standard Model as they are needed to describe the hadronic Light-by-Light scattering contribution to the Standard Model calculation of the anomalous magnetic moment of the muon.

The TFFs depend on the momentum transfer of the two photons, q_i^2 ($i = 1, 2$), and therefore it is important to measure in both space-like ($q_i^2 < 0$) and time-like ($q_i^2 > 0$) regions. This has been achieved through a variety of measurements at meson factories and in heavy ion collisions. This presentation will review the current experimental status and summarise the available measurements of the light meson TFFs.

Collaboration:

Plenary Session / **59**

Transition Form Factors from HADES

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A major goal of the High Acceptance Di-Electron experiment (HADES) [1] at GSI is to study the electromagnetic properties of hadronic matter in the 1-3.5 GeV/nucleon incident energy range. Its excellent particle identification capabilities allowed for a systematic investigation of dielectron, strange particles and pion production in pion, proton, deuteron or heavy-ion induced reactions on proton or nucleus. The obtained dilepton spectra measured at various beam energies show important contributions from baryon resonance decays (R⟶Ne+e−) and a strong influence of the intermediate vector mesons (ρ/ω/φ).

A prominent enhancement in the respective electromagnetic Transition Form-Factors (eTFF) at q2 near the vector meson (rho/omega) poles has been predicted by various calculations reflecting strong baryon-vector meson couplings [2]. The first measurements of the Dalitz decay of Delta(1232) and of higher mass resonances in p+p collisions have been recently concluded [3, 4], indicating the important role played by rho meson. In order to directly access such transitions, combined measurements of hadronic and dielectron final states have been performed in π−N reactions in the second resonance region, using polyethylene and carbon targets [5]. The two-pion data have been analysed using the Bonn-Gatchina PWA together with results of other experiments allowing for the separation of resonance contributions and their decay channels. In particular the off-shell rho meson contribution has been extracted providing an important constraint for the interpretation of dielectron invariant mass spectra measured in the same reaction [6]. Angular distributions of emitted electrons have been also analysed allowing for the estimation of hadronic spin density matrix elements as a function of virtual photon emission angle, as suggested in [7, 8]. They provide independent information about spin and parity of the involved resonances and about virtual photon polarization. This presentation will summarize most important results obtained in proton and pion induced reactions measured with HADES and discuss the future plans with the elementary beams at higher energies.

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[3] J. Adamczewski-Musch et al. (HADES), Eur. Phys. J. A53 (2017) 188
[4] J. Adamczewski-Musch et al. (HADES), Phys. Rev. C95 (2017) 06520
[5] J. Adamczewski-Musch et al. (HADES), Eur. Phys. J. A53 (2017) 188
[6] J. Adamczewski-Musch et al. (HADES), Phys. Rev. C 102 (2020) 024001
[7] E. Speranza, M. Zetenyi, B. Friman, Phys. Lett. B764 (2017) 282
[8] M. Zetenyi et al., arXiv:2012.07546v2

Collaboration:

HADES Collaboration

Parallel Session B1 / 8

Inclusive production of prompt charged particles in pp collisions at LHCb

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An analysis of the double-differential cross-section in pseudorapidity and transverse momentum of charged particles in unbiased proton-proton collisions at 13 TeV measured with the LHCb experiment, is presented. This analysis complements previous LHCb measurements at 7 TeV. Noteworthy aspects of our result are the forward pseudorapidity coverage from 2 to 4.8 and the unbiased trigger conditions under which the events were collected. The result has applications for the tuning of hadron interaction generators and in particular provides important input for astroparticle physics. A long-standing issue in the field of cosmic-ray research is the discrepancy in the number of muons produced in high-energy air showers between observations and simulations, referred to as the Muon

Puzzle. Precision measurements of the hadron production in unbiased collisions in the forward region are ideal to validate and improve the hadron interaction generators used in air-shower simulations and to solve the Muon Puzzle.

Collaboration:

Parallel Session C1 / **37**

Modification of heavy mesons in a hot medium within effective hadronic theories

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Understanding the modification of heavy mesons when embedded in a high-temperature medium of light mesons is essential in order to properly extract information from the hot matter created in heavy-ion collisions in LHC and RHIC. With this aim, we employ an effective field theory based on chiral and heavy-quark spin-flavor symmetries to describe the scattering of the open heavy-flavor mesons with the pseudoscalar light mesons, and incorporate the non-zero temperature effects within the imaginary-time formalism [1,2]. In this approach the in-medium unitarized scattering amplitudes and the ground-state self-energies are calculated self-consistently. For the $D^{(*)}$ and $D_s^{(*)}$ mesons we find that the resulting masses decrease with increasing temperatures together with a substantial broadening of their widths. This has a direct impact to the thermal modification of the excited mesonic states generated dynamically in our heavy-light molecular model, particularly the $D_0^*(2300)$, $D_1^*(2430)$, $D_{s0}^*(2317)$ and $D_{s1}^*(2460)$ resonances. Moreover, these results can be tested against lattice QCD simulations through the calculation of open-charm Euclidean correlators from the thermal ground-state spectral functions.We find that in the open-charm sector our results compare reasonably well with those of lattice QCD well below T_c [3].

[1] G. Montaña, A. Ramos, L. Tolos and J. M. Torres-Rincon, Phys. Lett. B 806 (2020), 135464 doi:10.1016/j.physletb.2020.
[2] G. Montaña, A. Ramos, L. Tolos and J. M. Torres-Rincon, Phys.Rev.D 102 (2020) 9, 096020 doi:10.1103/PhysRevD.102.
[3] G. Montaña, O. Kaczmarek, L. Tolos and A. Ramos, Eur.Phys.J.A 56 (2020) 11, 294 doi:10.1140/epja/s10050-020-00300-y

Collaboration:

Parallel Session A1 / **13**

Implications of the D+s→π+π0η decay in the nature of a0(980) and molecular interpretation of the new X0(2900)

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In a recent paper \cite{Ablikim:2019pit}, the BESIII collaboration reported the so-called first observation of pure W-annihilation decays D+s⟶a+0(980)π0 and D+s⟶a00(980)π+. The measured absolute branching fractions are, however, puzzlingly larger than those of other measured pure W-annihilation decays by at least one order of magnitude. In addition, the relative phase between the two decay modes is found to be about 180 degrees. In this letter, we show that all these can be easily understood if the a0(980) is a dynamically generated state from K¯K and πη interactions in coupled channels. In such a scenario, the D+s decay proceeds via internal W emission instead of W-annihilation, which has a larger decay rate than W-annihilation. The proposed decay mechanism and the molecular nature of the a0(980) also provide a natural explanation to the measured negative interference between the two decay modes. In addition, the molecular interpretation of the new flavor exotic meson, the X0(2900), is revisited, including a discussion on its possible decay modes.

Collaboration:

Parallel Session A1 / **40**

Charmonium production in hadron-nucleus reactions

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We calculate the dilepton spectrum at the mass range of the low-lying charmonium states in $\bar{p}$, p and π Au collisions taking into account their in-medium propagation. The time evolution of the spectral functions of the charmonium state is studied with a BUU type transport model. We calculated the charmonium contribution to the dilepton spectrum and show that for Ψ(3686) production there is a good chance to observe its in-medium modification with good resolution detectors. We,furthermore, show that by studying the excitation function of the charmonium state J/Ψ in $\bar{p}$A collisions we may study the high momentum tail of the protons inside the nuclei.

Collaboration:

Parallel Session B1 / **29**

Exclusive production of f1(1285) meson at low and high energies

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We present a new study of the exclusive production of $f_1(1285)$ meson at near threshold energies relevant for the HADES and PANDA experiments at GSI-FAIR [1]. At energies close to the threshold the $VV \to f_1(1285)$ fusion processes ($V = \rho, \omega$) are the dominant production mechanisms. The vertex for the $VV \to f_1$ coupling is derived from an effective coupling Lagrangian. In order to determine the parameters of the model the $\gamma p \to f_1 p$ reaction is discussed and results are compared with the CLAS experimental data [2]. The possibility of a measurement by HADES@GSI is discussed.

In a second part we discuss the central exclusive diffractive production of f_1 mesons in high-energy proton-proton collisions, where the pomeron-pomeron fusion process is expected to be dominant. The vertex for the pomeron-pomeron-f_1 coupling is derived within the tensor-pomeron approach [3]. We adjust the parameters of our model to the WA102 experimental data [4] and compare with predictions of the Sakai-Sugimoto model, where the couplings are determined by the mixed axial-gravitational anomaly of QCD [5]. The total cross section and several differential distributions are presented. Our results may be used to investigate the $pp \to pp\pi^+\pi^-\pi^+\pi^-$ reaction at LHC energies [6]. The four-pion final state is also interesting in searches for glueball. We predict a much larger cross section for production of $f_1(1285)$ than for production of $f_2(1270)$ in the $\pi^+\pi^-\pi^+\pi^-$ channel for the LHC energies. This opens a possibility to study the $f_1(1285)$ meson in experiments at the LHC. Some effort to measure central exclusive four-pion production was initiated already by the ATLAS Collaboration [7].

[1] P. Lebiedowicz, O. Nachtmann, P. Salabura, A. Szczurek, in preparation
[2] R. Dickson et al. (CLAS Collaboration), Phys. Rev. C93 (2016) 065202
[3] P. Lebiedowicz, J. Leutgeb, O. Nachtmann, A. Rebhan, A. Szczurek, Phys. Rev. D102 (2020) 114003; C. Ewerz, M. Maniatis, O. Nachtmann, Annals Phys. 342 (2014) 31
[4] D. Barberis et al. (WA102 Collaboration), Phys. Lett. B440 (1998) 225; A. Kirk, Phys. Lett. B489 (2000) 29
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[6] P. Lebiedowicz, O. Nachtmann, A. Szczurek, Phys. Rev. D94 (2016) 034017
[7] R. Sikora, PhD Thesis, http://www.ftj.agh.edu.pl/koidc/materials/doktoraty/RafalSikora2020.pdf

Collaboration:

Parallel Session C1 / 41

Study the nature of $f_0(980)$ and $a_0(980)$

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In our work, we use the coupled channel approach to revisite the interaction of $K\bar{K}$ and its coupled channel, where the states $f_0(980)$ and $a_0(980)$ were dynamically reproduced in the interaction of isospin I=0 and I=1 sectors, respectively. In our results, the states of σ and $f_0(980)$ can be dynamically reproduced stably with varying cutoffs both in the coupled channel and the single channel cases. We find that the πη components is much important in the coupled channel interactions to dynamically reproduce the $a_0(980)$ state, which means that $a_0(980)$ state can not be a pure $K\bar{K}$ molecular state. Furthermore, we also calculated their radii, the compositeness, the wave functions and their productions in the final state interactions, aiming at looking inside their molecular nature.

Collaboration:

Parallel Session B1 / 39

Exotic mesons and final state interactions in electron-positron collisions

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Co-authors: Igor Danilkin [1]; Marc Vanderhaeghen [1]

[1] *Johannes Gutenberg University Mainz*

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In my talk I will present the dispersive formalism we developed to analyse the BESIII data for the processes $e^+e^- \to \psi(2S)\,\pi\,\pi$ and $e^+e^- \to J/\psi\,\pi\,\pi$. We use the powerful dispersion theory, which combines fundamental physical principles such as causality, conservation of probability and crossing symmetry. Furthermore, we test the hypothesis whether exotic states can be parametrized as physical resonances and analyze effects of triangle and anomalous singularities as well as study the final state interactions of pions and kaons.

Collaboration:

Parallel Session A1 / 20

Rare b→d decays in covariant confined quark model

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We study the rare decays corresponding to b → d transition in the framework of covariant confined quark model. The transition form factors for the channels B→ (π,ρ,ω) and Bs → K(∗) are computed in the entire dynamical range of momentum transfer squared. Using
the form factors, we compute the branching fractions of the rare decays and our results are found to be matching well with the experimental data. We also compute the ratios of the branching fractions of the b → s to b → d rare decays using the inputs from previous papers on this model.

Collaboration:

Parallel Session C1 / 57

In medium properties and effects of vector mesons from effective field theories: recent advances

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Co-authors: György Wolf [1]; Győző Kovács [1]; János Takátsy [1]

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We investigate (axial)vector meson mass modifications and their effects on the chiral phase transition and various thermodynamical quantities within the framework of an (axial)vector meson extended Polyakov quark meson model. The model is parameterized at zero temperature and density by comparing calculated masses and decay widths with their experimental values taken from the PDG. Meson curvature masses are calculated with the inclusion of one-loop constituent quark loops into the meson self-energies. We calculate the chiral phase boundary and the critical endpoint (CEP). We also investigate the baryon number fluctuations and related quantities such as kurtosis and other susceptibility ratios and compare with existing lattice results. Moreover, vector condensates and

their effects on compact star properties are also considered. If time permits I would like to show some large N_c results as well.

Collaboration:

Plenary Session / **82**

Precision tests of fundamental physics with eta and eta' mesons

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In this talk, we review recent advances in η and η' physics allowing to test the Standard Model and extract fundamental parameters such as quark mass ratios. We will focus on processes where final state interactions play a crucial role such as $\eta \to 3\pi$ or $\eta' \to \eta\pi\pi$.

Collaboration:

Plenary Session / **4**

Measurement of hadronic cross sections of e+e- annihilation at the VEPP-2000 collider in Novosibirsk

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At VEPP-2000 electron-positron collider in Novosibirsk
the experiments with CMD-3 and SND detectors are performed.
Recent results of hadronic cross section measurements are presented.

Collaboration:

Plenary Session / **68**

Recent results on hadron physics at KLOE/KLOE-2

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KLOE-2 experiment is a successor of KLOE, continuing and extending the broad physics program. In hadron physics, this includes search for a signal from dark mediators, $\gamma\gamma$-processes, and measurement of meson properties. Recent results on progress in $\gamma\gamma$ studies, decays of η meson in $\pi^+\pi^-$ and

$\pi^0\gamma\gamma$ channels and searches for leptophobic dark boson will be presented.
The recently collected more then 5 fb^{-1} at ϕ peak will allow to improve precision of measurements by a factor of two and with inclusion of KLOE data $2.4 \cdot 10^{10}$ ϕ's serves so far as the biggest data sample in e^+e^- collider at this energy.

Collaboration:

KLOE-2

Plenary Session / **14**

Data-driven dispersive analysis of the $\pi\pi$ and πK scattering for physical and unphysical pion masses

Authors: Oleksandra Deineka[1]; Igor Danilkin[1]; Marc Vanderhaeghen[1]

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We present a data-driven analysis of the resonant S-wave $\pi\pi \to \pi\pi$ and $\pi K \to \pi K$ reactions using the partial-wave dispersion relation. The contributions from the left-hand cuts are accounted for in a model-independent way using the Taylor expansion in a suitably constructed conformal variable. The fits are performed to experimental and lattice data as well as Roy analyses. For the $\pi\pi$ scattering we present both a single- and coupled-channel analysis by including additionally the $K\bar{K}$ channel. For the latter the central result is the Omn\'es matrix, which is consistent with the most recent Roy and Roy-Steiner results on $\pi\pi \to \pi\pi$ and $\pi\pi \to K\bar{K}$, respectively. By the analytic continuation to the complex plane, we found poles associated with the lightest scalar resonances $\sigma/f_0(500)$, $f_0(980)$, and $\kappa/K_0^*(700)$ for the physical pion mass value and in the case of $\sigma/f_0(500)$, $\kappa/K_0^*(700)$ also for unphysical pion mass values. The obtained Omn\'es functions are used for the description of the double-virtual photon-photon scattering to two pions up to 1.5 GeV.

Collaboration:

Plenary Session / **15**

High Energy Behaviour of the Light Meson Photoproduction and the Quark Counting Rules

Authors: Igor Strakovsky[1]; Moskov Amaryan[2]; Briscoe William[1]; Michail Ryskin[3]

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We evaluated recent CLAS Collaboration measurements for the 90 deg meson photoproduction off the nucleon using a tagged photon beam spanning the energy interval s = 3 - 11 GeV^2. The results are compared with the Quark Counting Rules (QCR). predictions. Since Sudakov form factor is absent in the case of photoproduction these processes allows a better check/study of the QCR.

Collaboration:

Plenary Session / **85**

Meson as messengers for hot and dense QCD matter

Author: Viktor Riabov[1]

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We present results on the measurement of transverse momentum spectra, integrated yields, and angular distributions for light flavor hadrons with a focus on meson production in pp, p-Pb, Xe-Xe, and Pb-Pb collisions. Resonance particles with very short lifetimes probe the rescattering and regeneration processes in the hadronic phase of the system produced in high-energy collisions. The resonance yields and the transverse momentum spectra are analyzed as a function of the system size and collision energy and are compared with the model calculations with and without the hadronic cascades. Further, polarization measurements for vector mesons are crucial for the understanding of particle production mechanisms in high-energy collisions. In non-central heavy-ion collisions, the presence of the large initial angular momentum can polarize the vector mesons due to spin-orbital-angular-momentum interaction or due to hadronization from polarized quarks. We present recent measurements of spin alignment for $K^*(892)$ and $\phi(1020)$ mesons at midrapidity in pp and Pb-Pb collisions. Neutral meson invariant differential yields and nuclear modification factors provide important information on the modification of nucleon structure functions in nuclei and serve as a baseline for the observed strong suppression of hadron yields at high transverse momenta in heavy-ion collisions. The measurements for π^0 and η mesons are presented in pp and p-Pb collisions in a wide transverse momentum range up to tens of GeV/c and are compared to model calculations.

Collaboration:

ALICE

Plenary Session / **81**

Results on hadron properties in pion, p, A+A collisions from HADES

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The HADES experiment at the GSI Helmholtz Center for Heavy Ion Research in Darmstadt, Germany
is measuring systematicly hadron properties in π+A, p+A and A+A collisions at energies of a few GeV.
The versatility of HADES allows to address the medium-modifications of hadrons with a huge variety of different observables: ranging from direct line-shape modifications via the dilepton decay, over more indirect ones like kinematic distributions and yields of hadrons carrying strangeness, to macroscopic ones like chemical and kinetic freeze-out parameters or collective flow and its anisotropies.
In this contribution we elaborate, which common picture from the wealth of data and observables is emerging.

Collaboration:

HADES

Plenary Session / **77**

In-medium spectral functions of vector and axial-vector mesons from analytically continued FRG flow equations

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The Functional Renormalization Group (FRG) can be used to calculate spectral functions from analytically continued FRG flow equations for two-point correlation functions. Here we report on the current status of applying this aFRG framework to the calculation of vector and axial-vector meson spectral functions in effective hadronic theories at finite temperature and density. Their medium modifications have a direct impact on the electromagnetic spectral function and thus on thermal dilepton rates in the range of invariant-mass values of up to about 1 GeV. Because chiral symmetry restoration at finite temperature and/or density is reflected in these spectral functions, this can be exploited to search for experimental signatures, from heavy-ion collisions at HADES energies and later with CBM at FAIR, of a chiral first-order phase transition and the associated critical endpoint (CEP) in the phase diagram of QCD.

Collaboration:

Theory

Plenary Session / **16**

Scattering Theory Approach to the Thermodynamics of Hadrons

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In this talk I shall review how the S-matrix formalism can be applied to study the thermal properties of interacting hadrons.

The central idea of this approach is to compute an effective density of state from the scattering phase shifts.
As the phase shifts encode a wealth of information on the hadronic interactions, e.g. the resonance widths and masses,
the method can robustly handle the case of a broad resonance or a purely repulsive channel.

As an application I will present an analysis on the proton yield from the heavy ion collision experiments at the LHC.
I will discuss how the inconsistency between theory and experiment, the so-called proton puzzle, may be resolved by considering some essential features of the empirical baryon spectrum.
These features are also crucial for understanding the Lattice results on thermal QCD, such as the baryon electric charge correlation.

Lastly, I will report on some recent progress in analyzing the coupled-channel system of hyperons and the inclusion of $N > 2$-body scatterings.

Collaboration:

Plenary Session / 10

Meson properties and production in nuclear medium

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This talk will give a short overview of recent experimental progress in using meson as probes to study nuclear matter effects, such as the probes of initial cold nuclear matter effects and the intermediate hot and dense nuclear medium in proton-ion and ion-ion collisions at LHC. If no dedicated talks on ultra-peripheral collisions (UPC) in the conference, recent meson production results in UPC to probe the gluon distribution functions will also be covered.

Collaboration:

LHCb

Parallel Session A2 / 22

Charmless B decays at Belle II

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Charmless B decays provide a unique portion of the Belle II program. The expected large signal yields with moderate backgrounds associated with efficient reconstruction of neutral particles enable world-leading determination of the CKM phase α/ϕ_2, a conclusive understanding of the so-called K-π CP puzzle, and further insight into the nature of localized CP violation in three-body decays. We report preliminary measurements based on the sample collected during 2019-2020 operations and corresponding to 65 fb^{-1} of integrated luminosity. Results include a test of the $K\pi$ isospin sum-rule, an angular analysis of $B \to \rho^+\rho^0$ decays, and the reconstruction of a $B^0 \to \pi^0\pi^0$ signal.

Collaboration:

Belle II

Parallel Session B2 / 45

New Baryon State N'(1720)3/2+ from the CLAS pi^+pi^−p Photo- and Electroproduction Data

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Combined studies of exclusive meson photo- and electroproduction have extended the capabilities in the search for new excited states of the nucleon, the so called “missing” resonances. New excited state of the nucleon, N’(1720)3/2+ has been observed in the combined studies of the pi^+pi^-p photo- and electroproduction off protons data measured with the CLAS detector at Jlab. The results on the new baryon state observation will be presented and discussed in the talk. A successful description of the pi^+pi^-p photo- and electroproduction data achieved with independent from photon virtualities (Q^2) mass, total and partial hadronic decay widths of N’(1720)3/2^+ state offers a strong evidence for the existence of this new resonance. Currently, N’(1720)3/2^+ resonance is the only observed new baryon state for which the results on Q^2-evolution of the electroexcitation amplitudes have become available. They offer an insight into the “missing” resonance structure for the first time. Future analyses of the N’(1720)3/2^+ electroexcitation amplitudes will shed light on the particular structural features of “missing” resonances which made their observation so challenging for decades.

Collaboration:

CLAS Collaboration

Parallel Session C2 / 2

Neutral meson production in AgAg@1.58 A GeV

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Relativistic nucleus–nucleus collisions offer a unique possibility for studying nuclear matter under the influence of high temperature and pressure. During the collision a system of interacting nucleons, resonances, and mesons, called hadronic fireball, is created.\par
The Dielectron Spectrometer HADES operated at the SIS18 synchrotron of FAIR/GSI Darmstadt recently provided new intriguing results on production of electron pairs and strangeness from nucleus-nucleus collisions, as well as from reference elementary reactions, in energy region of $1 - 2$ A GeV. At 2019 it was complemented by a new electromagnetic calorimeter based on lead-glass modules, which allows to measure production of the π^0 and η mesons via their two-photon decay. In this energy range, π^0 and η mesons are the most abundantly produced mesons carrying information from the hadronic fireball. In addition, the knowledge of the neutral meson production is a mandatory prerequisite for the interpretation of dielectron data and at the same time almost no respective data are presently available for this energy range.\par
Recent result on π^0 and η production in Ag + Ag collisions at 1.58 A GeV with 14×10^9 collected events will be presented . The yields, transverse mass and rapidity distributions will be shown and compared with existing data from other experiments as well as with transport model calculations.

Collaboration:

HADES

Parallel Session A2 / 31

Intrinsic charm in the nucleon, forward production of charm meson and high-energy neutrino flux

Authors: Rafał Maciuła[1]; Antoni Szczurek[1]

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We discuss the role of intrinsic charm (IC) in the nucleon for forward production of open charm meson in proton-proton collisions at low and high energies. The calculations are performed in collinear-factorization approach with on-shell partons, $_T$-factorization approach with off-shell partons as well as in a hybrid approach using collinear charm distributions and unintegrated (transverse momentum dependent) gluon distributions. The distributions in rapidity and transverse momentum of charm quark/antiquark as weel as of open charm meson are shown for a few different models of IC. Forward charm meson production is dominated by -fusion processes. The IC contribution dominates over the standard pQCD (extrinsic) -fusion mechanism of $c\bar{c}$-pair production at large rapidities or Feynman-. At high energies and large rapidities of charm meson one tests gluon distributions at extremely small . We show that the IC contribution can be, to some extent, tested at the LHC by the FASER and at the SPS by the SHIP experiments by studies production of the ν_τ neutrinos coming from the decay of open charm meson.

In addition, we will show that the IC contribution to forward production of open charm meson has important consequences for understanding high-energy neutrino flux measured by the IceCube Neutrino Observatory. We will present our new constrain on the size of the intrinsic charm content in the nucleon coming from the IceCube data. The results of relevant numerical studies with off-shell small-⊠ partons will be shown. Both scenarios with and without saturation effects will be discussed.

Based on:
[1] R. Maciuła, and A.Szczurek, "Intrinsic charm in the nucleon and charm production at large rapidities in collinear, hybrid and ⊠⊠-factorization approaches", J. High Energy Phys. 10 (2020) 135.

[2] V.P. Goncalves, R. Maciuła, and A.Szczurek, a paper in prepration.

Collaboration:

Parallel Session B2 / 58

Is the glueballonium possible?

Authors: Francesco Giacosa[1]; Alessandro Pilloni[2]; Enrico Trotti[1]; Phillip Lakaschus[3]

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We present the results of the phase-shifts and scattering lenght/volumes of the scattering of two scalar glueballs in the framework of an effective approach of Yang-Mills theory with N=3 (QCD without quarks). We show that the interaction is attractive, hence we investigate if a bound state can form. Quite interestingly, it seems possible.

Collaboration:

Parallel Session C2 / 38

Spectator induced electromagnetic effects on charged meson production in nucleus-nucleus collisions from NA61/SHINE at CERN SPS

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The SPS Heavy Ion and Neutrino Experiment (NA61/SHINE) studies the properties of hadron production in collisions of beam hadrons and nuclei with fixed hadronic and nuclear targets.
In this talk I will discuss the space-time evolution of the system of strongly interacting matter created in the collision, studied from the modification of charged pion spectra and π^+/π^- ratios by the electromagnetic (EM) field induced by the spectator system as a function of collision centrality. First results on Ar+Sc collisions at 40A GeV/c ($\sqrt{s_{NN}}$ = 8.8 GeV) will be shown, including the first-ever measurement of spectator induced EM effects in a small peripheral nucleus-nucleus system in the SPS energy range.
These will be compared to intermediate Ar+Sc collisions at 150A GeV/c ($\sqrt{s_{NN}}$ = 16.8 GeV) from NA61/SHINEs and Pb+Pb peripheral collision data at 158A GeV/c ($\sqrt{s_{NN}}$ = 17.3 GeV) obtained by the NA49 experiment at the CERN SPS. The present implications of the new data from NA61/SHINE for the space-time evolution of the system will be discussed.

Collaboration:

NA61/SHINE

Parallel Session A2 / 43

Nature of the LHCb pentaquarks from an analysis of the J/Psi p spectrum

Authors: Vadim Baru[1]; Meng-Lin Du[None]; Feng-Kun Guo[None]; Christoph Hanhart[2]; Ulf-G. Meißner[None]; Jose A. Oller[None]; Qian Wang[None]

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In this talk, we will present the results of a coupled-channel analysis of the $J/\Psi p$ invariant mass distribution, in which the P_c states are treated as $\Sigma_c^{(*)}\bar{D}^{(*)}$ molecules, [Phys. Rev. Lett., 124, 072001 (2020)] and its recent update [arXiv:2102.07159 [hep-ph]]. The effective $\bar{D}^{(*)}\Sigma_c^{(*)}$ meson-baryon scattering potential involves the long-range one-pion exchange interactions and short-range operators constrained by heavy quark spin symmetry (HQSS) and renormalization group invariance. In addition to the $J/\Psi p$, the $\Lambda_c\bar{D}^{(*)}$ and $\eta_c p$ are included as explicit inelastic channels, as required by unitarity and HQSS. The approach yields a very good description of the data. Apart from the three established states, a new state, associated with the $J^P = 3/2^-$ $\Sigma_c^*\bar{D}$ molecule and predicted from HQSS, has a clear manifestation in the data. The line shapes in the elastic and inelastic channels are predicted and will be important for revealing the decay properties of the P_c states and their quantum numbers, once new data become available.

Collaboration:

Parallel Session B2 / 61

Measurement of Exclusive pi+pi- and rho0 Meson Photoproduction at HERA

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Exclusive photoproduction of $\rho^0(770)$ mesons is studied using the H1 detector at the ep collider HERA. A sample of about 900000 events is used to measure single- and double-differential cross sections for the reaction $\gamma p \to \pi^+\pi^- Y$. Reactions where the proton stays intact ($m_Y = m_p$) are statistically separated from those where the proton dissociates to a low-mass hadronic system ($m_p < m_Y < 10$ GeV). The double-differential cross sections are measured as a function of the invariant mass $m_{\pi\pi}$ of the decay pions and the squared 4-momentum transfer t at the proton vertex. The measurements are presented in various bins of the photon-proton collision energy $W_{\gamma p}$. The phase space restrictions are $0.5 < m_{\pi\pi} < 2.2$ GeV, $|t| < 1.5$ GeV^2, and $20 < W_{\gamma p} < 80$ GeV. Cross section measurements are presented for both elastic and proton-dissociative scattering. The observed cross section dependencies are described by analytic functions. Parametrising the $m_{\pi\pi}$ dependence with resonant and non-resonant contributions added at the amplitude level leads to a measurement of the $\rho^0(770)$ meson mass and width at $m_\rho = 770.8^{+2.6}_{-2.7}$ (tot) MeV and $\Gamma_\rho = 151.3^{+2.7}_{-3.6}$v (tot) MeV, respectively. The model is used to extract the $\rho^0(770)$ contribution to the $\pi^+\pi^-$ cross sections and measure it as a function of t and $W_{\gamma p}$. In a Regge asymptotic limit in which one Regge trajectory $\alpha(t)$ dominates, the intercept $\alpha(t{=}0) = 1.0654^{+0.0098}_{-0.0067}$ (tot) and the slope $\alpha'(t{=}0) = 0.233^{+0.067}_{-0.074}$ (tot) GeV^{-2} of the t dependence are extracted for the case $m_Y{=}m_p$.

Eur.Phys.J.C80 (2020), 1189

Collaboration:

H1 collaboration

Parallel Session C2 / 28

Beauty production in pp and Pb–Pb collisions with ALICE

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Nuclear collisions provide an excellent opportunity to understand the properties of a strongly coupled deconfined medium $i.e.$ the quark-gluon plasma (QGP), along with the production mechanism of heavy quarks (beauty or charm quarks). Beauty quarks are produced by hard parton scatterings in hadronic collisions and their production can be measured by the decay products of the B meson. In pp collisions, beauty production is an effective tool to test perturbative QCD (pQCD) calculations. In addition, pp collisions offer a baseline to study the Pb-Pb collisions which are important to investigate the energy loss dependence on the quark mass in a hot QCD medium as well as studying the sensitivity of bulk properties on quark diffusion constants.

In this talk, the beauty production will be discussed via the measurements of electrons and D mesons from beauty-hadron decays. In particular, their production cross sections and the extrapolated $\mathrm{b\bar{b}}$ cross section per unit of rapidity at midrapidity, in pp collisions at $\sqrt{s}$ = 5.02 TeV, will be presented and compared with pQCD calculations. In addition, the non-prompt D^0 nuclear modification factor (R_{AA}) and elliptic flow of electrons from beauty-hadron decays in Pb-Pb collisions at $\sqrt{s_{\mathrm{NN}}}$ = 5.02

will be discussed and compared with different theoretical models. Furthermore, future prospects will be presented for the J/ψ measurement from beauty hadron decays in contrast with the measurements from LHC Run 1 datasets.

Collaboration:

ALICE

Parallel Session A2 / 56

J-PET: a new experimental facility for studies of discrete symmetries in charged leptons sector

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First studies of discrete symmetries in purely leptonic systems started several decades ago and led to the discovery of weak interactions. Nowadays a positronium is considered as a fine probe into this subject, due to the fact that it is the lightest matter-antimatter system and at the same time an eigenstate of the C and P operators.
The Jagiellonian Positron Emission Tomography (J-PET) collaboration works on developing its new experimental program focusing on using large-acceptance detector of gamma quanta originating from positronium decays [1,2]. The experimental apparatus consists of 192 plastic scintillators read out from both ends with vacuum tube photomultipliers. Signals produced by photomultipliers are probed at four levels [3] in the amplitude domain and digitized on 8 FPGA based readout boards in triggerless mode [4]. In order to The energy deposition inside detection modules is determined based on the TOT (Time Over Threshold) response. Using the TOT technique, as a measure of energy loss instead of charge integration methods, significantly reduces system deadtime. This is especially crucial in case of J-PET, built out of plastic scintillators producing very fast light pulses. The drawback in adopting this technique lies in the non-linear correlation between input energy loss and TOT of the signal, which has been already characterised [5]. Additionally whole system calibration can be performed on the same data which is used to study discrete symmetries [6] which increases time which can be delegated to proper data taking.
It was observed experimentally that C-symmetry is violated in weak interactions and the best limit of the C symmetry violation in the electromagnetic interaction was set with the $\pi 0 \longrightarrow 3\gamma$ decays which amounts to branching ratio of $(3\gamma/2\gamma)$ equal to $3.1 \times 10{-}8$ at 90% C.L [7]. Experimental test of C-symmetry in positronium decays was performed by Mills and Berko (1967) [8] and the best limit was set for $1\hat{}S\_0 \longrightarrow 3\gamma$ which amounted to $2.6 \times 10{-}6$ at 68% C.L.
In the scope of this presentation a description of measurements performed in order to test C-symmetry [9] will be discussed and initial results from the studies performed with J-PET detector with small detection chamber will be shown.

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Collaboration:

J-PET group

Parallel Session C2 / **44**

Decay processes of ϕ (2170) to kaonic resonances

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We have recently studied the strong decays of φ(2170) to final states involving the kaonic resonances K(1460), K1(1270) and K1(1400), on which experimental data have been extracted by the BESIII Collaboration. The formalism developed is based on interpreting φ(2170) and K(1460) as states arising from three-hadron dynamics. For K1(1270) and K1(1400) we investigate different descriptions, such as a mixture of states belonging to the nonet of axial resonances, or the former one as a state originating from the vector- pseudoscalar dynamics. The ratios among the partial widths of K+(1460)K−, K1+(1400)K− and K1+(1270)K− obtained are compatible with the experimental results, reinforcing the three-body nature of φ(2170). Within our formalism, we can also explain the suppressed decay of φ(2170) to K∗(892)$\bar{K}$∗(892), as found by the BESIII Collaboration. Furthermore, our results can be useful in clarifying the properties of K(1460), K1(1270) and K1(1400) when higher statistics data would be available.

Collaboration:

Plenary Session / **7**

Exploring the 3D nucleon structure with CLAS and CLAS12 at JLAB

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Exploring the 3 dimensional structure of the nucleon can help to understand several fundamental questions of nature, such as the origin of the nucleon spin and the charge and density distributions inside the nucleon. In QCD, the 3-dimensional structure of the nucleon is described by Wigner functions. However, experimentally momentum and coordinate space have to be assessed independently. The momentum distribution can be accessed by transverse momentum dependent distribution functions (TMDs) measured in semi-inclusive deep inelastic scattering (SIDIS) or Drell-Yan processes while the distribution in transverse coordinate and longitudinal momentum space is described by generalized parton distributions (GPDs) which can be accessed for example by deeply virtual Compton scattering (DVCS) and hard exclusive meson production (DVMP). Based on the high quality data of CLAS and the recently upgraded CLAS12 detector at Jefferson Laboratory (JLAB), a detailed study of these distribution functions is being performed. With the new CLAS12 data, multidimensional, high precision studies in an extended kinematic range become possible for the first time. The talk will present the results of recent SIDIS, DVCS and DVMP studies with CLAS and CLAS12 and their impact on the understanding of the 3D nucleon structure.

Collaboration:

Plenary Session / **69**

Search for the neutron Electric Dipole Moment at the Paul Scherrer Institute

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The quest for the neutron electric dipole moment (neutron EDM) started more than sixty years ago and is still one of the most important tasks faced by experimental physicists. The reason is that a non-zero value of this observable would break both parity and time reversal symmetries. Such a symmetry violation can help us to explain why the Universe is essentially made of matter and not of antimatter. A non-zero value of neutron EDM is predicted by the Standard Model (SM) as well as by the various Standard Model extensions; however the value predicted by the SM is several orders of magnitude smaller. Therefore, measurements of the neutron EDM value test the SM extensions. The newest result of an experiment to measure the neutron EDM will be presented. The experiment was performed at the Paul Scherrer Institute using Ramsey's method of separated oscillating magnetic fields with ultracold neutrons. The statistical analysis was performed on blinded datasets by two separate groups while the estimation of systematic effects profited from an unprecedented knowledge of the magnetic field. As a result, the highest sensitivity among all neutron EDM measurements made to date has been achieved. The further development of the experiment will also be briefly outlined.

Collaboration:

nEDM collaboration

Plenary Session / **49**

The search for electric dipole moment of charged particles using storage rings

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One of the main problems of modern particle physics is the inability of the Standard Model (SM) of Particle Physics to explain the matter-antimatter asymmetry in the Universe. The pursuit of physics beyond the SM is required and one way to achieve it is to strive for the highest precision in the search for electric dipole moments. Permanent electric dipole moments (EDMs) of particles violate both time reversal and parity invariance and, through the CPT-theorem they also violate the combined CP symmetry. Therefore, EDM measurements of fundamental particles are capable to probe new sources of CP-violation, and finding an EDM would be a convincing indicator for physics beyond the Standard Model.

Up to now, EDM searches focused on neutral systems (neutrons, atoms, molecules). Storage rings, however, make it possible to measure EDMs of charged particles by observing the effect of the EDM on the spin motion in the ring [1], [2], [3]. The direct search for proton and deuteron EDMs bears the potential to reach sensitivity beyond 10^{-29} e cm. The Cooler Synchrotron COSY at the Forschungszentrum Jülich provides polarized protons and deuterons with momenta up to 3.7 GeV/s, which is an ideal testing ground and starting point for such an experimental program. The JEDI collaboration is currently aiming at the first direct (precursor) measurement of the deuteron EDM

in COSY. Beyond that, the technical design of the prototype EDM storage ring is the next milestone of the JEDI research program.

The talk will present the JEDI program for the measurement of proton and deuteron EDMs, and discuss the various technical developments, and show recent results.

References
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Collaboration:

JEDI (Jülich Electric Dipole moment Investigations)

Plenary Session / **75**

The size of the Proton: Recent Results from the PRad Experiment

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Two new extremely high precision measurements of the proton rms charge radius performed in 2010-2013 with muonic hydrogen atom demonstrated up to six standard deviations smaller values than the accepted average from all previous experiments performed with different methods (scattering and atomic spectroscopy) on ordinary hydrogen. This discrepancy triggered the well-known "proton radius puzzle" in hadronic physics. To address this puzzle, the PRad collaboration in spring of 2016 performed a novel magnetic-spectrometer-free ep-scattering experiment in Hall B at Jefferson Lab accumulating high statistics and a rich experimental data set. The specifics of the PRad experiment and the final physics results, including the extracted proton radius, as well as, the current status of the puzzle will be presented and discussed in this talk.

Collaboration:

PRad collaboration at JLab

Plenary Session / **70**

Unveiling the antikaon/nucleon-nuclei strong interaction dynamics in the low-energy regime with SIDDHARTA-2 and AMADEUS

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The investigation of the low-energy strong interaction between antikaons and nucleons is crucial for a better understanding of the QCD in non-perturbative regime, with implications going from the domain of particle and nuclear physics to astrophysics. Precise experimental information on the K^-N

scattering at the energy threshold can be extracted exploiting kaonic atoms. SIDDHARTA-2, which is presently installed at the DAΦNE collider (in its reduced version SIDDHARTINO), will measure the X-rays emitted in the atomic transitions of the kaonic deuterium, with the aim to extract the energy shift and broadening of the 1s level induced by the strong interaction. The combined measurements for the kaonic deuterium and the kaonic hydrogen will allow to extract for the first time the isospin I=0 and I=1 K^-N scattering lengths, which will place strong constraints to the low-energy antikaon-nucleon dynamics. Further experimental information are provided by the AMADEUS collaboration from the study of the K^- absorptions at-rest and in-flight (p_K ~ 100 MeV/c) on light nuclei (H, ^{4}He, ^{9}Be and ^{12}C). The hyperon-pion and hyperon-nucleon/nuclei emitted in the final state of the K^- captures on the materials of the KLOE detector, used as an active target, are reconstructed and analysed. Such studies delivered in the last few years the first comprehensive measurement of the yields of the K^- two-, three- and four-nucleon absorption processes, fundamental ingredients for the determination of the K^- nuclear optical potential, as well as the first measurement of the $K^-n \to \Lambda\pi^-$ s-wave amplitude in the energy region below the threshold. The contribution will give an overview of the new SIDDHARTA-2 setup, recently installed at the DAΦNE collider, showing the preliminary results and future plans. Finally, the main AMADEUS results will be presented.

Collaboration:

Plenary Session / **71**

Low-energy QCD – kaonic atom experiments at DAFNE and J-PARC

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The antikaon-nucleon interaction close to threshold provides crucial information on the interplay between spontaneous and explicit chiral symmetry breaking in low-energy QCD. The unique feature of DAFNE, namely the production of low-energy kaons, as well as J-PARC with its high intensity kaon beam, has led to a series of successfully conducted experiments with light kaonic atoms, which have provided important contributions to low-energy QCD.
An overview of the status of the proposed kaonic deuterium measurement at J-PARC and DAFNE will be given, which will allow for the first time, together with the already existing kaonic hydrogen data, the determination of the isospin dependent antikaon-nucleon scattering lengths a0 and a1.
Finally, an outlook of possible future experiments at DAFNE, using this unique source of kaons, will be discussed:
Measurements of light kaonic atoms transitions are fundamental to address important open problems like kaon-nuclei potential and chiral models below threshold.
While new precise measurements of transitions to low n levels of heavy kaonic atoms allows to study multi-nucleon interactions of the kaon.
New precise measurements of medium and heavy kaonic atoms transitions will allow measuring the charged kaon mass with higher precision in order to solve the existing kaon mass puzzle.
The study of elastic K-p scattering, but also of inelastic channels near threshold with high precision, provides tight constrains on models using Coupled-Channels Chiral SU(3) Dynamics. It has to be mentioned that there are almost no scattering data available at low energy or if, only with large error bars.

Collaboration:

SIDDHARTA-2 and E57

Plenary Session / **35**

Precise tests of the hadron-hadron strong interaction via femtoscopy with ALICE

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In this talk, we will show how the study of two-particle correlations at small relative momentum can be used to give a direct insight into short-range hadron-hadron strong interactions.

Our experimental knowledge on hadron-hadron interactions is based mostly on scattering data and, in the case of systems with strangeness, the study of exotic atoms and the characterization of hypernuclei. We now demonstrate that the femtoscopic technique can be applied to study the effects of the strong interaction between hadrons with unprecedented precision. Two-particle correlations at small relative momentum originate from final-state interactions and are also sensitive to the size of the particle-emitting source. In the pp and p-Pb collisions studied by ALICE, hadrons originate from very small spacetime volumes, of the order of 1 fm. Since the proton-proton interaction is well known, the proton-proton correlation function is used to constrain the size and shape of the hadron-emitting source. Newly developed analysis tools are used to compare the experimentally measured correlation functions to theory predictions using either potentials or wave functions as input.

We will present results from baryon-hyperon (p-Λ, p-Σ^0, p-Ξ^- and p-Ω^-), hyperon-hyperon (Λ-Λ) and baryon-meson (p-K^-) correlations using ALICE data in pp and p-Pb collisions. The high precision of the ALICE data allow testing with high sensitivity the predictions from the most recent models of such interactions, including chiral, meson exchange models, and recent Lattice QCD calculations. The consequences for the equation of state for neutron-rich matter including hyperons and for the possible existence of exotic di-baryons are discussed.

Collaboration:

ALICE

Plenary Session / 65

Hyperon physics with BESIII

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Many of the most intriguing questions in contemporary physics manifest themselves in the nucleon puzzles: despite being known for more than a century, basic properties like its mass, spin, structure, radius and abundance are to this day subjected to intense discussions and research. One approach to shed light on a system one wants to learn more about is to replace one of its building blocks and see how the system reacts. This leads to the central question in hyperon physics: what happens if we replace one of the light quarks in a proton, with a heavier one? Thanks to the weak, self-analysing decay of the ground-state hyperons, their spin properties are straight-forward to access experimentally. This provides a unique opportunity to study the role of spin in non-perturbative strong interactions. Experiments performed with various probes and in different energy regimes show that hyperons often are produced polarised, even when the initial state is unpolarised. Furthermore, it offers a diagnostic tool to study fundamental symmetries, e.g. CP conservation, since spin behave differently with respect to momentum under parity inversion. The violation of CP symmetry is one of the necessary conditions for the dynamic generation of the abundance of matter with respect to antimatter, i.e. Baryogenesis.

The BESIII experiment in Beijing, China, offers unique opportunities to study hyperons in clean, exclusive two-body processes. These conditions enable the application of new, multidimensional techniques providing optimal precision. In this talk, I will present recent hyperon physics results from BESIII with emphasis on electromagnetic structure studies and CP symmetry tests.

Collaboration:

BESIII

Plenary Session / **11**

Hyperon-nucleon interaction in few- and many-body systems

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Over the last few years the Julich-Bonn-Munich Group has performed extensive studies of the baryon-baryon interaction involving strange baryons (Λ, Σ, Ξ) within chiral effective field theory. An overview of the achieved results will be presented, with emphasis on baryon-baryon scattering in the strangeness S=-1 sector. Predictions for few- and many-body systems involving hyperons will be reported and the role of possible three-body forces will be discussed.

Collaboration:

Plenary Session / **78**

Theoretical approach to correlation functions of strange hadrons at accelerator experiments and search for exotic bound states

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Hadron-hadron interactions are the basic inputs to discuss hadronic molecules and hadronic nuclei. Flavored hadron interactions, however, are generally difficult to access in standard scattering experiments. Recent research activities on hadron-hadron correlation functions open a systematic way to access flavored hadron interactions such as ΩN, ΞN, $\bar{K}N$ and even DN ($\bar{D}N$). SInce the correlation function is given as the average of the wave function squared with the normalized source function weight, it contains the information of the hadron-hadron interaction. In this talk, I first give a brief review of femtoscopic studies of hadron-hadron interactions based on the correlation functions obtained mainly by the RHIC-STAR and LHC-ALICE collaborations. I also discuss how to diagnose the existence of the bound state by using correlation functions. Specifically, I argue that the STAR and ALICE data of the $p\Omega$ correlation function suggest the existence of a $N\Omega$ bound state. Also, the pK^- correlation function from pp, pA and heavy-ion collisions may further elucidate the $\bar{K}N$ bound state nature of the $\Lambda(1405)$.

Collaboration:

Parallel Session B3 / **19**

Study of $e^+e^- \to e^+e^-\eta'$ in the double-tag mode at BABAR

Author: Evgeny Kozyrev[1]

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We present a study of the process $e^+e^- \to e^+e^-\eta'$ in the double-tag mode and a measurement for the first time of the $\gamma^\star\gamma^\star \to \eta'$ transition form factor $F_{\eta'}(Q_1^2, Q_2^2)$ in the momentum-transfer range $2 < Q_1^2, Q_2^2 < 60$ GeV^2. The results for the form factor are compared with the predictions based on pQCD and VMD.
We also present our most recent results on measurement of exclusive hadronic cross sections which are the experimental input to the calculation of the muon $g-2$. In particular, we report the results on e^+e^- annihilation into six- and seven-pion final states, with the study of the very rich dynamics of these processes.
The analysis is based on data with an integrated luminosity 469 fb^{-1} collected at the PEP-II e^+e^- collider with the BABAR detector at center-of-mass energies near 10.6 GeV.

Collaboration:

BABAR

Parallel Session C3 / **27**

Electroproduction of hypernuclei

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Electroproduction of hypernuclei is an object of interest. The experiments carried out at the Thomas Jefferson National Accelerator Facility (USA) provide an accurate measurement of the cross section in electroproduction of hypernuclei. I will provide basic ideas of theory that describes the process in impulse approximation. Issues will be discussed, such as kinematics, calculating kaon momentum either from many-body energy conservation or two-body energy conservation, and optimum factorization, with non-zero proton momentum, which was calculated up to now by using "frozen proton approximation". Another topic will be description of the technique of the calculation of the elementary amplitude in general reference frame that allows comparison between "frozen proton" and moving proton approximations. The results of the cross section will be shown to demonstrate the differences between these two approaches.

Collaboration:

Parallel Session A3 / **30**

On the mechanism of the $T_{4c}(6900)$ tetraquark production

Authors: Antoni Szczurek[1]; Rafał Maciuła[1]; Wolfgang Schaefer[1]

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We discuss the production mechanism of a new state,
a fully charm tetraquark, discovered last year by the LHCb at
M = 6.9 GeV in the $J/\psi J/\psi$ channel.
Both single parton scattering (SPS) and double parton scattering (DPS)
mechanisms are considered. We calculate the distribution in the invariant
mass of the four-quark system M_{4c} for SPS and DPS production of
$cc\bar{c}\bar{c}$ in the k_t-factorization approach with modern
unintegrated gluon distribution functions (UGDFs).
The so-calculated contribution of DPS is almost two orders of
magnitude larger than the SPS one, but the tetraquark formation
mechanism is unknown at present.
We construct a simple coalescence model of the tetraquark out of
$c\bar{c}\bar{c}$ continuum.
Imposing a mass window around the resonance position we calculate the
corresponding distribution in $p_{t,4c}$ – the potential tetraquark
transverse momentum. The cross section for the $J/\psi J/\psi$ continuum
is calculated in addition, again including SPS (box diagrams) and
DPS contributions which are of similar size.
The formation probability is estimated trying to reproduce
the LHCb signal-to-background ratio. The calculation of the SPS
$gg \to T_{4c}(6900)$ fusion mechanism is performed in the
k_T-factorization approach assuming different spin scenarios (0^+,
0^- and 2^+). The 2^+ and 0^+ assignment is preferred over
the 0^- one by the comparison of the transverse momentum distribution of signal
and background with the LHCb preliminary data assuming the SPS mechanism
dominance. There is no microscopic approach for the DPS formation mechanism
of tetraquarks at present as this is a complicated multi-body problem.

We do similar analysis for FCC energy $\sqrt{s}$ = 100 TeV.
We predict cross section order of magnitude larger than its counterpart
for the LHC.
We discuss also a possibility to observe the T_{4c} state in the
$\gamma\gamma$ channel. The signal-to-background ratio is estimated.

First part of the presentation will be based on our recent paper:

R. Maciu{\l}a, W. Sch\"afer and A. Szczurek,
"On the mechanism of $T_{4c}(6900)$ tetraquark production",
Phys. Lett. {\bf B812} (2021) 136010.

Collaboration:

Parallel Session C3 / 25

On Electromagnetic Production of Strange and Charm Mesons

Author: Dalibor Skoupil[1]

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New models for photo- and electroproduction of kaons on the proton were constructed [1,2,3] utilizing new experimental data from LEPS, GRAAL, and particularly CLAS collaborations. The higher spin nucleon (spin-3/2 and spin-5/2) and hyperon (spin-3/2) resonances were included using a consistent formalism and they were found to play an important role in the data description. In these analyses, we paid close attention to model predictions of the cross section at small kaon angles which are vital for accurate calculations of the hypernucleus-production cross section.

In order to account for the unitarity corrections at the tree level, we have introduced energy-dependent widths of nucleon resonances, which affect the choice of hadron form factors and the values of their cutoff parameters extracted in the fitting procedure.

We have implemented a new shape of electromagnetic form factors so that we are now able to describe also the process of electroproduction [4]. Moreover, for a reliable description of $K^+\Lambda$ electroproduction at small Q^2 within our models it is necessary to take into account also a longitudinal coupling of virtual photons to nucleon resonances.

For the investigation of kaon photoproduction off the proton target, we have exploited also the hybrid Regge-plus-resonance (RPR) model [3] which provides an acceptable description of data in and above the resonance region. A novel feature of our version of the RPR model consists in applying a different scheme for the gauge-invariance restoration [5], which results in a need for a contact current. We reveal that the choice of the gauge-invariance restoration method may play a significant role for cross-section predictions at forward angles where data are scarce.

The sets of chosen nucleon resonances in our recent models are mutually quite well consistent and they also greatly overlap with the set selected in the Ghent analysis [6]. The results of our new isobar and RPR models will be compared with photo- and electroproduction experimental data and the properties of the models will be discussed.

The RPR approach was utilized to study also the $\bar{D}^0$ meson photoproduction off the proton target [7]. Besides the contributions of kaon trajectories and three hidden-charm pentaquarks, we revealed that the contact term plays a non-negligible role. For the time being, there are no experimental data on this process available. Thus, being limited by the broken SU(4) symmetry we adjusted the parameters of the model manually in order to provide at least qualitative predictions of the differential cross sections.

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[6] L. De Cruz et al., Phys. Rev. Lett. 108, 192002 (2012).

[7] D. Skoupil, Y. Yamaguchi, Phys. Rev. D 102, 074009 (2020).

Collaboration:

Parallel Session A3 / **46**

Lattice QCD rules out some predictions for deeply-bound light-heavy tetraquarks

Authors: Brian Colquhoun[1]; Renwick James Hudspith[2]; Anthony Francis[3]; Randy Lewis[1]; Kim Maltman[1]

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Some phenomenological models, already fully constrained by fits to the ordinary meson and baryon spectrum, predict deeply-bound tetraquark states containing one or more heavy quarks. We describe lattice QCD studies of a number of channels where such predictions exist. While not precluding shallow binding, our lattice investigations find no evidence of deep binding in either doubly charmed or bottom-charm channels, allowing us to rule out models that predict deep binding in those channels. On the other hand, a consistent picture has emerged from lattice studies by a number of lattice groups of the existence of deeply-bound, strong-interaction-stable $I = 0$, $J^P = 1^+$ $ud\bar{b}\bar{b}$ and $I = 1/2$, $J^P = 1^+$ $\ell s\bar{b}\bar{b}$ tetraquarks, where $\ell = u$ or d. In this talk we provide the current status of these calculations, describing recent improvements that provide more robust results and shore up phenomenological expectations.

Collaboration:

Parallel Session B3 / 33

Combined theoretical study of the D+ -> pi+ eta eta and D+ -> pi+ pi0 eta reactions

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We study the D+ -> pi+ eta eta and D+ -> pi+ pi0 eta reactions, which are single Cabibbo suppressed and can proceed both through internal and external emission. The primary mechanisms at quark level are considered, followed by hadronization to produce three mesons in the D+ decay, and after that the final state interaction of these mesons leads to the production of the a0(980) resonance, seen in the pi+ eta , pi0 eta mass distributions. The theory has three unknown parameters to determine the
shape of the distributions and the ratio between the D+ -> pi+ eta eta and D+ -> pi+ pi0 eta rates. This ratio restricts much the sets of parameters but there is still much freedom leading to different shapes in the mass distributions. We call for a measurement of these mass distributions that will settle the reaction mechanism, while at the same time provide relevant information on the way that the a0(980) resonance is produced in the reactions.

Collaboration:

Parallel Session B3 / 60

Bound states in the three-body scattering formalisms

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Co-authors: Adam Szczepaniak ; Raúl Briceño ; Connor McCarty ; Md Habib E Islam ; Andrew Jackura

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Strong interactions produce a rich spectrum of resonances which decay into three or more hadrons. Understanding their phenomenology requires a theoretical framework to extract parameters from

experimental data and lattice QCD simulations of hadron scattering. Two classes of relativistic three-body approaches are currently being pursued: the EFT-based and unitarity-based one. We consider a model of relativistic three-body scattering with an S-wave bound state in the two-body sub-channel using both formalisms. We present and discuss numerical solutions for the multi-hadron scattering amplitudes in different kinematical regions, obtained from integral equations of the EFT-based approach. We also show how to generalize the unitarity-based framework to include all relevant open channels, discuss the nonphysical singularities near the physical region, and propose how to eliminate them.

Collaboration:

Parallel Session C3 / **32**

New systematics of strange hadron production from HADES

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Recently the HADES Collaboration published the data on strangeness production in the medium-abundant Au+Au system at the deeply subthreshold beam energy of 1.23A GeV [1]. The conditions in this system provide a sensitive testing ground for the description of the strangeness dynamics. Therefore, several transport approaches were compared to the data, including IQMD, (P)HSD and UrQMD [1,2], and their results will be presented.

First results of the strangeness production in the high-statistics run of Ag+Ag collisions at 1.58A GeV will be also shown.

HADES also provided data on strangeness production from more elementary p+Nb collisions at 3.5 GeV [3], and π^- + C and π^- + W collisions at 1.7 GeV/c [4]. These systems permit for testing various scenarios of in-medium potentials. Some of these tests will be presented in the talk.

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[2] T. Song, L. Tolos, J. Wirth, J. Aichelin, E. Bratkovskaya, arXiv:2012.05589
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Collaboration:

HADES

Parallel Session A3 / **63**

Heavy quark masses and their impact on the muon g-2

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A determination of the heavy quark masses from combinations of QCD sum rules of the moments of the vector current correlator calculated in perturbative QCD are presented. Only experimental data for the resonance below the continuum threshold are needed in our approach, while the continuum contribution is determined by requiring self-consistency between various sum rules and the zeroth moment. As soon as the charm-quark and bottom-quark masses are determined, their individual impact on the Hadronic Vacuum Polarization contribution to the muon g-2 is also provided.

Collaboration:

Plenary Session / **52**

Microscopic model of K^-NN absorption and its application in kaonic atoms calculations

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This contribution reports on our recently developed microscopic model for an antikaon absorption on two nucleons in nuclear matter [1]. The absorption is described within a meson-exchange picture and the primary K^-N interaction strength is derived from the state-of-the-art chiral coupled channel meson-baryon interaction models. The medium modification of the K^-N scattering amplitudes were taken into account and the crucial role of in-medium effects was confirmed. The K^- single- and two-nucleon absorption fractions and branching ratios for various mesonic and non-mesonic absorption channels were calculated. The results are in very good agreement with experimental data from old bubble chamber experiments as well as with the latest results from the AMADEUS collaboration.
The model was applied in calculations of kaonic atoms. The energy shifts and widths were calculated for 23 nuclear targets and corresponding $K^-N + K^-NN$ potentials were confronted with kaonic atom data. The description of the data significantly improves when the two-nucleon absorption is considered. Finally, a phenomenological term describing three- and four-nucleon processes was added to the microscopic $K^-N + K^-NN$ potentials and its parameters were fitted to the data.

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Collaboration:

Plenary Session / **86**

Rare kaon decays from NA62

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Historically important to build the Standard Model (SM) of particle physics, rare kaon decays are still a privileged tool to look beyond it. Current research focuses mostly on $K \to \pi\nu\bar{\nu}$ decays which

are predicted with good accuracy within the SM and beyond. NA62 is the CERN experiment at the SPS built to study precisely $K^+ \to \pi^+\nu\bar{\nu}$ and other rare decays. The branching ratio measurement BR ($K^+ \to \pi^+\nu\bar{\nu}$) based on the full 2016-2018 data set will be presented. The latest results from other searches will also be reported.

Collaboration:

NA62

Plenary Session / **17**

KL-Facility

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A lot of progress has recently been made in a field of hadron spectroscopy. Intense photon beams complemented by high-resolution hermetic 4pi detectors, supplied with linearly or circularly polarised photons, polarised nuclear targets and ability to detect recoil nucleon polarisation improved our knowledge on excited nucleon states considerably. Most of the progress has been achieved in N*and Δ* areas. A poorly established field of particles with strangeness (hyperons and strange mesons) had little to no benefit from this progress.
We propose to make a significant breakthrough in this field by building novel, high-intensity neutral Kaon beamline at Thomas Jefferson National Laboratory (JLab) to expand accessible strange particle spectrometry programme of Hall-D, rearranging Hall-D with its superior GlueX spectrometer into K_L-Facility, KLF.
In our proposal a powerful electron beam, provided by CEBAF accelerator, will be converted into high-intensity Kaon flux, on the order of 10^4 K_L/s, which exceeds the flux of that previously attained at SLAC by three orders of magnitude! This achievement will allow a broad range of measurements with single-, double- and triple-strange hyperons to be performed with unprecedented statistical and systematical accuracy. The use of a deuteron target, which will complement experiments on hydrogen target, will provide the first measurement ever with neutral kaons on neutrons. Substantial progress is expected in the field of strange mesons. Besides other things, we expect to solidify famous κ-particle (a strange partner of meanwhile well established σ-meson) and complete lowest lying multiplet of scalar mesons.
In a talk, I will review a current status of the project, major development in the main hardware systems, e.g. Compact Photon Source, Be-Target, Flux Monitor…as well as theoretical development related to the project.

Collaboration:

KLF

Plenary Session / **67**

Strangeness in compact stars

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I will review the relevance and the implications of strangeness production in compact stars. In particular, I will discuss kaon condensation, hyperons' production, strange quark matter production and Witten's hypothesis on the absolute stability of strange quark matter. I will also outline which are the most promising ways to tests these possibilities in the next 20 years.

Collaboration:

Plenary Session / **76**

Study of discrete symmetries in positronium decay with the J-PET detector

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The first PET tomograph based on plastic scintillators was designed and built at the Institute of Physics of the Jagiellonian University. Jagiellonian PET (J-PET) is optimized for the detection of photons originating from positron-electron annihilation. It is a unique research device that allows studying decays of positronium in a whole available phase-space. Moreover, it enables to determine not only momentum vectors of photons but it is also capable of determining photon's polarization and imaging of the annihilation places. Access to the photons' polarization allows exploring a new class of discrete symmetry odd operators that were not investigated before. It enables also studying the quantum entanglement of high-energy photons originating from the decay of positronium.
The presentation will include the description of the methods, results, and research plans for discrete symmetries tests in the decays of positronium – the purely leptonic system built from charged leptons. Emphasis will be put on the tests with new operators involving polarization of annihilation photons and on the exploratory research of quantum entanglement of annihilation photons.
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Collaboration:

J-PET

Plenary Session / **72**

Measurement of the muon anomalous magnetic moment at Fermilab

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Magnetic moments of light charged leptons (ℓ), the electron and the muon, have figured prominently in the early development and evolution of the Standard Model (SM) of elementary particles and interactions. The magnetic anomaly, $a_\ell \equiv (g_\ell - 2)/2$, continues to provide unique sensitivity to

contributions from virtual heavy particle loops. This coupling typically scales as the lepton mass squared, giving the muon an advantage of a factor of $(m_\mu/m_e)^2 \simeq 43,000$ over the electron, thus more than compensating for the greater precision achieved in measurements of a_e. Consequently, a_μ provides one of the most sensitive experimental probes into the realm of particles that may exist in nature, but are not included, nor described in the SM.

For almost 20 years a tantalizing discrepancy of $\sim 3-4\sigma$ has persisted between the measurements of a_μ, dominated in precision by BNL experiment E821 [1], and the SM calculations, most recently updated by the Muon g$-$2 Theory Initiative in [2]. This discrepancy has been just large enough to leave room for new, non-SM phenomena. In response, the Fermilab Muon g$-$2 collaboration has set out to improve the precision of a_μ by a factor of four, down to 0.14 ppm. The Fermilab experiment uses the same basic approach as the BNL E821, using the same superconducting muon storage ring, but with significant improvements. This talk will discuss the experimental technique, and present the first results from Muon g$-$2 Run-1 at Fermilab, comprising about 6% of the planned full data set for the experiment [3].

1. G.W. Bennett, et al. (BNL Muon g-2 Collaboration), *Final report of the muon E821 anomalous magnetic moment measurement at BNL*, Phys. Rev. D **73** (2006) 072003.
2. T. Aoyama, et al., *The anomalous magnetic moment of the muon in the standard model*, Phys. Rep. **887** (2020) 1.
3. B. Abi et al. (Muon g-2 Collaboration), *Measurement of the positive muon anomalous magnetic moment to 0.46 ppm*, Phys. Rev. Lett. **126** (2021) 141801.

Collaboration:

Muon g-2 Collaboration

Plenary Session / **73**

Hadronic contributions to $g-2$ of the muon – theory

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The first new experimental results on the anomalous magnetic moment of the muon from Fermilab, published in April 2021, confirm the tension with the Standard Model prediction, now at 4.2σ. The uncertainty in the theory prediction is by far dominated by hadronic effects. I discuss how different important contributions can be made more precise by using rigorous theoretical constraints, especially due to analyticity: this includes hadronic vacuum polarisation due to 3π and $\pi^0\gamma$ intermediate states, and hadronic light-by-light scattering via the largest individual contribution therein, the π^0-pole term. The latter is determined in terms of the π^0 transition form factor, for which a representation that incorporates all low-lying singularities and matches correctly onto the asymptotic behaviour expected from perturbative QCD has been derived. Further, ongoing, extensions of this work will briefly be mentioned.

Collaboration:

Plenary Session / **66**

Dark photon research and the X17 hypothetical particle

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Dark Matter is currently one of the greatest unsolved mysteries in physics. Our current knowledge is encompassed in the Standard Model (SM) of particle physics. While the SM is phenomenally successful in describing the physics of familiar matter to high precision, it is also known to be incomplete. In particular, new physics must be responsible for the dark matter. This discovery triggered an enormous theoretical and experimental interest in the particle and hadron physics community.
The theoretically predicted hypothetical Dark Photon particles does not serve as the Dark Matter particle itself, but acts as a messenger particle of a hypothetical Dark Sector with residual interaction to the Standard Model. Dark Photons are of an extra U(1) gauge group. Such extra U(1) gauge groups are predicted by almost any extension of the Standard Model. Indeed, the related extra U(1) gauge bosons are searched for from the lowest energies up to the highest ones. Recently, the mass range for a vector particle in the MeV to GeV scale has been in the focus, since such a mass scale might explain a surprisingly large number of astrophysical and other anomalies.
Recently, we observed a peak-like enhancement relative to the internal pair creation at 140° in the angular correlation of the e+e- pairs created in the 18.15 MeV ground state transition of 8Be [1]. It turned out that this could be a first hint for a new mxc2=17 MeV boson, called X17 in the literature. The data are explained by Feng et al. [2] with a 16.7 MeV, Jπ= 1- vector gauge boson, which may mediate the fifth force with some coupling to SM particles. Ellwanger and Moretti made another possible explanation of the experimental results through a light pseudo scalar, Jπ= 0- particle [3], while Kozaczuk et al., [4] explained it as an axial vector, Jπ= 1+ boson. There are also many more possible explanations in the literature.
Using a significantly modified and improved detector setup, we reinvestigated the anomaly observed in the e+e- angular correlation by using a new Tandetron accelerator of our institute and the previous data were reproduced within the error bars.
We also studied the 3H(p,γ)4He reaction (Q=20.6 MeV) at three different proton energies (Ep=510, 610 and 900 keV) and observed e+e- pairs with a smooth angular correlation, but on top of that a peak at Θ≈115° is clearly visible at each proton energies with larger than 7σ confidence, which can be described by assuming the creation and decay of the same X17 boson [5] as observed previously in 8Be..

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Collaboration:

ATOMKI

Plenary Session / **80**

Outlook talk: Status of g-2 problem

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Collaboration:

Parallel Session A4 / 54

Indirect searches for new physics with heavy flavour decays at CMS

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Indirect probes to new physics searches beyond the standard model have been performed in rare decays and angular analyses in the heavy flavour sector in proton collisions with the CMS detector at the LHC. The flavour changing neutral current decays are interesting probes to new physics searches. The measurement of Bs and B0 mesons decaying into dimuons can only proceed through higher-order flavour changing neutral current processes, and are highly suppressed in the standard model (SM). The measured observable includes the decay branching fraction. The angular distributions of b->sl+l- transition processes in heavy flavour decays have been studied. Angular analyses have been performed to determine the angular parameters as functions of the dimuon invariant mass squared to investigate any deviations from SM predictions that would signal new physics.

Collaboration:

The CMS Collaboration

Parallel Session B4 / 26

Phenomenology of spin-3 tensor mesons

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I will present our recent study of the strong and radiative decays of spin-3 mesons {ρ3(1690), K3(1780), φ3(1850), ω3(1670)} in the framework of an effective quantum field theory approach, based on the SU(3)v-flavor-symmetry. After introducing possible tree level interaction terms, I will compare the fitted effective model results with the experimental data of Particle Data Group. Finally, I will show numerous predictions for experimentally unknown branching ratios for the tensor mesons and the tensor glueball with the same quantum number.

Collaboration:

Parallel Session C4 / 34

$\Lambda(1520)$ production in proton-proton and proton-nucleus collisions with HADES

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The internal structure of hyperons is controversially discussed based on various models, e.g. quark, bag and molecular models [1,2]. Recent publications presents a new approach wherein exited hyperon states are dynamically generated by interactions between the baryonic decuplet and the masonic octet. That approach predicts also a substantial in-medium modifications for some hyperons, like $\Lambda(1520)$, $\Sigma^*(1380)$ [3].

The HADES collaboration has collected the data in a vast of diverse experiments: proton-proton and proton-nucleus collisions, heavy ion experiments and pion induced reactions. This versatility gives a possibility to compare similar processes occurring in a different environment. In the talk, I would like to present a comparison between an inclusive $\Lambda(1520)$ production in pp@3.5 GeV and pNb@3.5 GeV reactions measured by the HADES. The respective cross-sections for hyperon production via [$\Lambda(1116)\pi^+\pi^-$] X decay channel will be shown together with differential distribution in a function of transverse momentum and rapidity. Significant differences and enhancement of the $\Lambda(1520)$ production w.r.t to $A^{2/3}$ scaling in p-Nb data are visible. Furthermore, in the latter case also the hyperon line shape differs w.r.t the one measured in pp collisions.

[1] E. Kaxiras et al., Phys. Rev. D 32, August 1985
[2] Lang Yu et al., Phys. Rev. D 73, 114001, June 2006
[3] M. Kaskulov, E. Oset, Phys. Rev. C 73, 045213, April 2006

Collaboration:

HADES

Parallel Session B4 / 51

Overview of recent HERMES results on transverse-momentum dependent spin asymmetries

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The HERMES experiment has collected a wealth of data using the 27.6 GeV polarized HERA lepton beam and various polarized and unpolarized gaseous targets. This allows for a series of unique measurements of observables sensitive to the multidimensional (spin) structure of the nucleon, in particular semi-inclusive deep-inelastic scattering (SIDIS) measurements, for which the HERMES dual-radiator ring-imaging Cherenkov counter provided final-hadron identification between 2 GeV to 15 GeV for pions, kaons, and (anti)protons.
In this contribution, longitudinal and transverse single- and double-spin asymmetries in SIDIS will be presented. The azimuthally uniform longitudinal double-spin asymmetries using longitudinally polarized nucleons constrain the flavor dependence of the quark-spin contribution to the nucleon spin. For a first time, such asymmetries are explored differential in three dimensions in Bjorken-x and the in the hadron kinematics z and ⊠$h\perp$ (which respectively represent the energy fraction and transverse momentum of the final-state hadron) simultaneously. This approach increases the quark-flavor sensitivity and allows one to probe the transverse-momentum dependence of the helicity distribution. The measurement of hadron charge-difference asymmetries allows, under certain simplifying assumptions, for the direct extraction of valence-quark polarizations. The azimuthal modulation of this double-spin as well as of the single-(beam)spin asymmetry probe novel quark-gluon-quark correlations through twist-3 distribution and fragmentation functions. Also here asymmetries are explored in several dimensions. Furthermore, in case of the beam-spin asymmetry, results for electroproduced protons and antiprotons have become available. The beam-spin asymmetries for pions are compared to similar measurements for pions at CLAS and unidentified hadrons at COMPASS. Last but not least, a glimpse on similar measurements using a transversely polarized target will be given, providing information on the novel Sivers and Collins effects, among others.

Collaboration:

HERMES

Parallel Session A4 / 55

Test of the CPT symmetry in positronium annihilations at sub-permil precision using the J-PET tomography device

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The symmetry under combined charge, parity, and time-reversal transformation (CPT) remains scarcely tested in leptonic systems. We demonstrate that a Positron Emission Tomography device can be put to use in a search for CPT-violating angular correlations in the annihilations of the lightest leptonic bound system, the positronium atom. Using the Jagiellonian PET (J-PET) prototype conceived as a medical imaging device constructed entirely with plastic scintillators, we have collected an unprecedented range of kinematical configurations of exclusively-recorded annihilations of the positronium triplet state (ortho-positronium) into three photons. Employing a novel technique for estimation of positronuium spin axis on the basis of a single event, we determined the complete distribution of an angular correlation between spin and annihilation plane of ortho-positronium, non-zero expectation value of which would be a sign of CPT noninvariance. With the first measurement demonstrating this experimental technique, we are able to reach the precision of the CPT test beyond the level of one permill. As the present sensitivity is mostly limited by statistical uncertainty, we discuss the prospects for reaching the precision level of 10^{-5} with the CPT tests in J-PET.

Collaboration:

J-PET

Parallel Session C4 / 62

A conventional explanation of the ”dibaryon d*(2380)” peak

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We study the two step sequential one pion production mechanism, $np(I=0)\to^{-}pp$, followed by the fusion reaction $pp\to^{+}d$, in order to describe the $np\to^{+-}d$ reaction with $^{+-}$ in $I=0$, where a narrow peak, so far identified with a "$d(2380)$" dibaryon, has been observed. We find that the second step $pp\to^{+}d$ is driven by a triangle singularity that determines the position of the peak of the reaction and the large strength of the cross section. The combined cross section of these two mechanisms produce a narrow peak with the position, width and strength compatible with the experimental observation within the approximations done. This novel interpretation of the peak without invoking a dibaryon explains why the peak is not observed in other reactions where it has been searched for.

Collaboration:

Parallel Session A4 / 48

The interplay of axial mesons and short-distance constraints in g-2

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The anomalous magnetic moment of the muon, g-2, is among the most precise measured quantities in physics. Its nonzero value emerges purely out of quantum effects and its theoretical estimate involves all the known sectors of the Standard Model — QED, QCD, and EW sectors— to meet the current level of experimental precision. Interesting enough, there is at present 3.7σ tension among experiment and theory, that suggests the possibility of new physics effects hiding around the corner. In order to confirm or discard such possibility, the new ongoing experiments need to be accompanied by precise theoretical estimates.

In this work, I will discuss the role of axial-vector meson contributions as well as short-distance constraints to the hadronic light-by-light contribution to the muon g-2. In particular, we point out to interesting connections among both of them that have been ignored in the past. Such connections allow to overcome theoretical difficulties when dealing with axial-vector mesons and help comparing the different available estimates. Furthermore, such relations shed light on current approaches to fulfill short-distance constraints, pointing to inconsistencies and possible solutions.

Collaboration:

Parallel Session C4 / 47

Latest results of dp breakup and dp elastic reaction investigation at Nuclotron

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The goal of the Deuteron Spin Structure experimental program is to obtain the information about two and three nucleon forces, including their spin dependent parts, from dp elastic scattering at the energies between 400 – 2000 MeV and dp breakup reactions with registration of two protons at deuteron energies of 300 – 500 MeV. Experimental and simulated results obtained from fragmentation of deuterons on polyethylene and carbon targets are compared to each other at 300 and 400 MeV of deuteron incoming energy. Latest results of cross section and vector and tensor analyzing powers of elastic dp scattering in mentioned energy range are discussed from the point of nucleon-nucleon correlations including short range ones.

Collaboration:

DSS collaboration

Parallel Session C4 / 83

Covariant calculations of Dalitz decays of nucleon resonances and hyperons

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We present calculations for Dalitz decays of nucleon resonances and hyperons, based on a covariant quark model, where the contribution of the quark core is complemented with contributions from the meson cloud.
The model was originally developed for the calculation of transition form factors in the electroproduction of nucleon resonances and transitions between hyperon states, in the spacelike region.
More recently, the model was extended to the timelike region and used to calculate the $\Delta(1232)$, $N(1520)$ and $N(1535)$ Dalitz decay rates, and compared with the available data.
We discuss also estimates of some hyperon Dalitz decays, including the $\Sigma^{*0}(1385) \to e^+e^-\Lambda(1116)$, $\Sigma^{*+}(1385) \to e^+e^-\Sigma^+(1193)$, $\Sigma^{*0}(1385) \to e^+e^-\Sigma^0(1193)$
and $\Xi^{*0}(1585) \to e^+e^-\Xi^0(1318)$ decays.

Collaboration: