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Book of Abstracts

Contents

Plenary session THURSDAY

Studies of Mesons in Quark Model and Beyond: from Belle to BelleII

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We give a review of selected results on meson studies at Belle. Mechanisms of meson production are presented for conventional light and heavy mesons as well as for so called XYZ states. Examples of new states discovered at Belle are given. Also discussed are expectations for future experiments at BelleII.

Pentaquarks+exotic baryonic states

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In 2015 LHCb reported the discovery of two pentaquark resonances in the decay of lambda b baryons. Various interpretations into the nature of these pentaquarks predict that they are in fact part of a larger multiplet of exotic states. Searches for these states, as well as further exotic hadrons that do not conform to the established quark-anti-quark meson and three-quark baryon model are a main focus for heavy flavour experiments. LHCb is in a unique position to study a wide range of decay modes for multiple b-hadron species. The latest results of these studies from LHCb are presented.

Exotics@BESIII

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With about 12 fb^{-1} collected, useful data set for XYZ new resonances, BESIII continues the exploration of these exotic charmonium-like states. In these talk, recent results of the measurements of the line-shape of $e^+e^- \to$? ? ?(3686), K^+K^- J/?, and ? ? D^0D^{*-}, as well as the J^P determination of $Z_c(3900)$ and $Z_c(3900)$ observation in $e^+e^- \to$?c1/2 at $W = 4.6$ GeV will be presented. Present Belle data on the candidate charmed baryonium $Y(4660)$ are barely in agreement with present BESIII data above the $e^+e^- \to$?c[U+F020]?cbar threshold. These data will be shortly discussed. A BEPCII upgrade has been funded, that will allow to settle this open question.

Physics opportunities with meson beams

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A secondary beam of neutral kaons has been proposed for Hall D at Jefferson Lab; this beam line is to be used with the GlueX experimental setup for strange hadron spectroscopy. A flux on the order of 3×10^4 K_L/s will allow a broad range of measurements to be made by improving the statistics of previous data obtained on hydrogen targets by three orders of magnitude. Use of a deuteron target will provide first measurements on the neutron. This talk will present the opportunities for new physics afforded by this proposed beam line.

FAIR - overview

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TBA

Pauli blocking in the pion gas - a lesson for compact star physics

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We show that the Φ-derivable formulation of the cluster virial expansion for quark–hadron matter contains the quark Pauli blocking effect in the lowest order expansion with respect to the backreaction of hadrons on the quark dynamics.
We discuss two examples for the application of the approach. First the quark Pauli blocking in the pion gas is shown to explain the repulsive $I = 2$ phase shift near threshold and its almost perfect cancellation with the attractive $I = 0$ channel. Second, the quark Pauli blocking in nuclear matter is shown to be in good agreement with repulsive, density-dependent interactions in density functionals of the Skyrme type. The relationship to modern excluded volume approaches to nuclear and neutron star matter at supersaturation densities is demonstrated and consequences for compact star phenomenology are discussed.

The CLAS12 experiment: status and plans

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The CLAS12 experiment in Hall B at Jefferson Lab aims at investigating the hadron structure and spectrum by making use of the 12 GeV electron beam provided by the CEBAF accelerator. The CLAS12 physics program includes the study of the 3D structure of the nucleon, the study of the baryon and meson spectrum and structure, the search for exotic states and the study of quark hadronization and nuclear effects. This broad program is accessible thanks to the excellent acceptance and resolution of the CLAS12 spectrometer, a multi-detector system designed to detect and identify both charged and neutral particles over a large portion of the solid angle. In this talk, the status and plans for the experiment will be reviewed.

Parallel session A1

The onsets of deconfinement and fireball of NA61/SHINE

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The NA61/SHINE experiment at the CERN SPS is pursuing a rich programme on strong interactions, covering the study of the onset of deconfinement and aims to discover the critical point of the strongly interacting matter by performing an energy and system-size scan at the full CERN SPS momentum range. These scans of p+p, p+Pb, Be+Be, Ar+Sc and Pb+Pb have been mostly completed with Xe+La last year (more Pb+Pb to be taken this year).
Results from the different reactions are now emerging. As a surprise, some measurements did not scale smoothly. In particular, for the K^+/π^+ ratio, Be+Be collisions behaved similarly to p+p (as a superposition of nucleon collisions), while Ar+Sc was closer to Pb+Pb collisions. This step can not be explained by the onset of deconfinement and may indicate that there is also an onset of a fireball in relativistic heavy ion collisions. A review of the results, as well as possible interpretation, will be presented. The theoretical models (SMES, PHSD) describe the onset of deconfinement at the heaviest system relatively well. However, no model describes the behavior of data at previously unmeasured collisions of light and intermediate size ions. The onset of the fireball is not described by any model.

Searches for heavy neutral lepton production and lepton flavour violation in kaon decays at the NA62 experiment

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Searches for heavy neutral lepton (HNL) production in charged kaon decays using the data collected by the NA62 experiment at CERN are reported. Upper limits are established on the elements of the extended neutrino mixing matrix for heavy neutral lepton mass in the range 130-450 MeV, improving on the results from previous HNL production searches. The status and prospects of searches for lepton flavor and lepton number violation in kaon decays at the NA62 experiment is also presented.

The $Y(4260)$ and $Y(4360)$ enhancements within coupled channels

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Puzzling structures have been observed in the charmonium energy region, namely the $Y(4260)$ and the $Y(4360)$, which decay channels are poorly understood, in spite of their large widths. The proximity of nearby hadronic thresholds suggests that they play an important role in the formation of the enhancements. We present an unitarized effective Lagrangian model, where mesonic loops and the $\psi(4160)$ interplay to generate line-shapes at the same energy region.

Light Hadron Spectroscopy @ BESIII

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The unambiguous identification and systematic study of bound states beyond the constituent quark degrees of freedom, e.g., multiquark states or states with gluonic degrees of freedom (hybrids, glueballs) would provide validation of and valuable input to the quantitative understanding of QCD. Hadron spectroscopy is one of the most important physics goals of BESIII. Since 2009, BESIII has collected 1.3×10^9 J/ψ and 4.5×10^8 of ψ', which are the world's largest data samples of J/ψ and ψ' from e^+e^- collision. Radiative decays of charmonium provide a gluon-rich environment and are therefore regarded as one of the most promising hunting grounds for gluonic excitations. Significant progress in the light-quark sector have been made with the unprecedented high statistics data sets. Several recent results on light hadron spectroscopy and light hadron decays will be reported, including:

1. Studies of glueballs in J/ψ radiative decays;
2. Observations of $X(1835)$ and $\eta(1475)$ in $J/\psi \to \gamma\gamma\phi$;
3. Search for 1^{-+} exotic in $\chi_{c1} \to \eta\pi\pi$;
4. Search for charged-strangeonium Z_s;
5. Observation of the helicity-selection-rule suppressed decay of the χ_{c2}.

Photon Beam Asymmetry Measurement from the $\gamma n \to K^+\Sigma^-$ Reaction

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Strangeness channels are important in the experimental search for missing baryon resonances. Phenomenological reaction models for the extraction of resonance parameters, such as coupled-channels analyses, require data for many observables, in different channels, and on different targets. The analysis presented in this work is the first measurement of the beam asymmetry over a wide range in the kaon azimuthal center-of-mass angle (which is essential for accessing the s-channel contribution) for the exclusive $\gamma n \to K^+\Sigma^-$ reaction, using the deuteron as a quasi-free neutron target. The data used were from the CLAS g13b run period (experiment E06-103) at Jefferson Lab, which used linearly polarized tagged real photons with energies between 1.1 and 2.3 GeV. Results are shown for photon energies between 1.7 and 2.3 GeV. They agree well (within uncertainties) with the beam asymmetries obtained at LEPS for forward angles.

Parallel session B1

Theoretical analysis of the $\gamma^{(*)}\gamma \to \pi^0\eta$ process

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We present a theoretical study of the $\gamma\gamma \to \pi\eta$ process from the threshold up to 1.4 GeV in the $\pi\eta$ invariant mass. For the s-wave $a_0(980)$ resonance state we adopt a dispersive formalism using a coupled-channel Omn\'es representation, while the d-wave $a_2(1320)$ state is described as a Breit-Wigner resonance. An analytic continuation to the $a_0(980)$ pole position allows us to extract its two-photon decay width as $\Gamma_{a_0\to\gamma\gamma} = 0.27(4)$ keV. [Phys. Rev. D 96, 114018]. As an extension of our work, the preliminary results for the single virtual case will be shown.

Various types of theoretical uncertainties by the examples of the elastic nucleon-deuteron scattering observables

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An estimation of the theoretical uncertainties present in the nuclear physics is an interesting issue. The necessity of reliable estimation of theoretical errors origins in a growing precision of experimental data as well as in the fact that currently, we are often in the position to study details of underlying physics. A study of the nuclear interaction within the elastic nucleon-deuteron (Nd) scattering can be a good example: while the two-nucleon potential is well known, the details of the three-nucleon force are still not clear. The elastic Nd scattering at energies up to 200 MeV can be used to study the three-nucleon interaction but to draw final conclusions based on the comparison of theoretical predictions and data estimation of theoretical uncertainties is necessary.
There are different types of theoretical uncertainties of the elastic Nd scattering observables. We are interested here in (a) the statistical errors arising from a propagation of uncertainties of parameters of two-nucleon interaction to three-nucleon system, (b) the truncation errors present for chiral interactions, (c) the regulator dependence also connected to chiral forces, (d) the numerical uncertainties as well as the uncertainties bound with the computational scheme used, and last but not least, in (e) the uncertainties arising from using the various models of nuclear interaction. It will be shown

that the latter ones are a dominant source of uncertainties of modern predictions for the three-nucleon scattering observables.
To perform above studies we employ the One-Pion-Exchange Gaussian (OPE-Gaussian) nucleon-nucleon potential [1], for which the covariance matrix of its parameters are known. Among other interactions we also use the chiral forces at the fifth order of chiral expansion (N4LO) recently derived by the Moscow(Idaho)-Salamanca [2] and the Bochum-Bonn [3] groups. We use the Faddeev approach [4] to obtain the elastic Nd scattering cross section and various polarization observables. A systematic comparison of the various theoretical uncertainties and their dependence on the reaction energy as well as a comparison of the predictions with data will be discussed.
[1] R.Navarro Perez, J.E.Amaro, and E.Ruiz Arriola, Phys. Rev. C89, 064006 (2014).
[2] E.Epelbaum, H.Krebs, and Ulf-G.Meißner, Phys. Rev. Lett. 115, 122301 (2015).
[3] D.R.Entem, R.Machleidt, and Y.Nosyk, Phys. Rev. C96, 024004 (2017).
[4] W.Glöckle et al., Phys. Rept. 274, 107 (1996).

Resonance behaviours of the reactions $pp \to \{pp\}_s\pi^0$ and $pd \to pd\pi\pi$ in the GeV region

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Recently differential cross section and vector analyzing power A_y of the one pion production reaction $pp \to pp_s\pi^0$, where pp_s denotes the pp-pair in the $^1S_0$ state, were measured by ANKE@COSY [1] at proton beam energies 0.3-0.8 GeV. A resonance behavior of the differential cross section was observed at 0.5-0.8 GeV. This behavior and measured A_y were described using fit by two isovector Breit-Wigner resonances in the $^3P_0$ and $^3P_2$ states. The contribution of the Δ-isobar mechanism in this reaction was studied in [2]. The parameters for the coupling constants and vertex form factors which were used to explain the COSY data on the reaction $dp \to pp_s\pi N$ [3] are applied here. The calculated energy dependence of the differential cross section of the reaction $pp \to pp_s\pi$ at zero angle of the pion is in qualitative agreement in shape with the data at energy 0.35-0.8 MeV. It is shown that main contribution is made by three partial waves of the pp-channel: $^3P_0$, $^3P_2$, $^3F_2$. The model explains the position of the peak observed at 0.6 GeV and zero diproton scattering angle but underestimates its absolute value. Furthermore, the Δ-mechanism fails to describe the analyzing power A_y.
Resonance structure was observed by ANKE@COSY also in the behavior of the differential cross section of the two-pion production reaction $pd \to pdX$ at beam energies 0.8-2.0 GeV with high transferred momentum to the deuteron at small scattering angles of the final proton and deuteron (see a talk by D.Tsirkov at this conference). The $d\pi\pi$ invariant masses of the observed peaks are close to 2.380 GeV that is the mass of isoscalar two-baryon resonance $D_{IJ} = D_{03}$ observed by WASA@COSY in the reaction $pn \to d\pi^0\pi^0$ [4], while the width is by a factor of ~ 1.5 larger than for the D_{03}. One possible mechanism of the reaction $pn \to d\pi^0\pi^0$ suggested in the paper [5] involves two dibaryon resonances, D_{03} and D_{12}. We modify this model by inclusion of the σ-meson exchange between the proton and deuteron and apply it to the process $pd \to pdX$.

[1] V.I.Komarov et al. (ANKE@COSY Collab.) Phys. Rev. C 93, 065206 (2016).
[2] Yu.N. Uzikov, Izv. RAN. Ser. Fiz. v.81, 815 (2017) [Bull. Rus. Ac. Sc. 81, 739 (2017)].

[3] Yu.N. Uzikov, J. Haidenbauer, C. Wilkin, PoS (Baldin ISHEPP XXII) 093 (arXiv:1502.04675 [nucl-th]).
[4] P. Adlarson et al. (WASA@COSY Collab.), Phys. Rev. Lett. 106, 242302 (2011).
[5] M.N. Platonova, V.I. Kukulin, Phys. Rev. C 87, 025202 (2013).

Covariant vector meson-vector meson interaction and dynamically generated resonances

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We do the analysis of the covariant vector meson-vector meson scattering in a unitarized $SU(3)$ chiral theory with the lowest lying vector meson octet. We demonstrate that the left-hand cuts would cross over the right-hand cuts for the coupled-channel unitarization with the on-shell factorization approach of Bethe-Salpeter equation. Therefore, first iterated solution to N/D method is employed to overcome the difficulties of the on-shell factorization of Bethe-Salpeter equation. We investigate the possible dynamically generated resonances and bound states. A comparison with the extreme non-relativistic calculation, free of left-hand cuts, is provided. This comparison is important since in the extreme non-relativistic approach some of the bound states are far away from the threshold. In the full covariant form, we have shown some of those bound states do not appear and some resonances are problematic to work within this scheme.

Near threshold kaon-kaon interactions in the reactions $e^+e^- \to K^+K^-\gamma$ and $e^+e^- \to K^0\bar{K}^0\gamma$

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The strong interactions between pairs of the K^+K^- and $K^0\bar{K}^0$ mesons can be studied in the radiative decays of $\phi(1020)$ mesons. We present a theoretical model of the reactions $e^+e^- \to K^+K^-\gamma$ and $e^+e^- \to K^0\bar{K}^0\gamma$. The K^+K^- and $K^0\bar{K}^0$ effective mass dependence of the differential cross sections is derived. The kaon and photon angular distributions and the branching fractions for the two radiative phi decays are calculated. Numerical results corresponding to different parameterizations of the $K\bar{K}$ interaction amplitudes are given.
The model can be generalized to treat other reactions with two pseudoscalar mesons accompanying photon in the final states formed in the collisions of the e^+e^- beams. A determination of the parameters of the scalar resonances $a_0(980)$ and $f_0(980)$ in the combined experimental analyses of several coupled channel reactions is then possible.

Parallel session A2

Recent results of quarkonium and heavy flavour meson production at ATLAS

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Heavy quark spectroscopy and exotic states are studied with the ATLAS detector, mainly thorough final states containing muon pairs from J/ψ decays from both proton-proton, proton-lead and lead-lead collisions. This talk will summarise recent results from ATLAS, including production of quarkonium and heavy flavour, searches for exotic states and measurements of decay properties in open beauty production.

Study of the possible role of triangle singularities in $B^- \to D^{*0}\pi^-\pi^0\eta$ and $B^- \to D^{*0}\pi^-\pi^+\pi^-$

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Studying the effects of triangle singularities in hadronic processes is of the utmost importance since they can originate peaks that may wrongfully be associated with resonances. In this work, the role of the triangle mechanism in the decays $B^- \to D^{*0}\pi^-\pi^0\eta$ and $B^- \to D^{*0}\pi^-\pi^+\pi^-$ is explored. Here, the singularity appears when B^- decays into $D^*K^{*0}K^-$, then K^{*0} decays into K^+ through pion emission, and K^-K^+ fuse together forming either the $a_0(980)$ or $f_0(980)$ which then decays into $\pi^0\eta$ or $\pi^+\pi^-$, respectively. As a result, the $K^*K^+K^-$ loop generates a peak in the invariant mass of π^-a_0 or π^-f_0 around 1420 MeV. The branching ratios that come from this peak are $Br(B^- \to D^{*0}\pi^-a_0; a_0 \to \pi^0\eta) = (1.66 \pm 0.45) \times 10^{-6}$ and $Br(B^- \to D^{*0}\pi^-f_0; f_0 \to \pi^+\pi^-) = (2.82 \pm 0.75) \times 10^{-6}$, which are well within the measurable range. Thus, this work makes interesting predictions about an effect of a triangle singularity in an experiment that is feasible in the present experimental facilities.
Based on: Eur. Phys. J. C 77 (2017) no.9, 599

New Results on Charmonium like states at Belle

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The Belle experiment, the first generation B factory using e^+e^- asymmetric collider at the KEKB in KEK Japan, has collected a total data sample of 710 fb^{-1} at the center of mass energy of the $\Upsilon(4S)$. Belle has played a leading role in the charmonium spectroscopy by finding many new charmonium(-like) states. In this talk, new measurement results on the angular analysis of $e^+e^- \to D^{*+}D^{*-}$ process near the open charm threshold will be presented. The recent results on the observation of new charmonium like-state produced in $e^+e^- \to J/\psi D\bar{D}$ will also be discussed. In addition, the results on the first observation of the $\Xi_c(2930)^0$ charmed-strange baryon will be presented, where $\Xi_c(2930)^0$ is found in its decay to $K^-\Lambda_c^+$ in $B^- \to K^-\Lambda_c^+\bar{\Lambda}_c^-$ decays. Further, analysis efforts for the precision measurement of the branching ratio of $B^- \to K^-\Lambda_c^+\bar{\Lambda}_c^-$ and to search for the charmonium-like state $Y(4660)$ and its spin partner Y_n in the invariant mass spectrum of $\Lambda_c^+\bar{\Lambda}_c^-$ will also be discussed. The measurement results of the absolute branching fractions of $B^+ \to X_c\bar{c}K^+$ and $B^+ \to \bar{D}^{*0}\pi^+$ decays will also be discussed, where $X_c\bar{c}$ denotes η_c, J/ψ, χ_{c0}, χ_{c1}, $\eta_c(2S)$, $\psi(2S)$, $\psi(3770)$, $X(3872)$ and $X(3915)$.
Further, the analysis results for the search of Z_c pair production in $\Upsilon(1S)$ and $\Upsilon(2S)$ decays and in the e^+e^- annihilation will be presented at the center of mass energies of 10.52, 10.58 and 10.867 GeV with Belle experiment.

Charm physics prospects at the Belle II experiment

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The Belle II experiment is a substantial upgrade of the Belle detector and will operate at the SuperKEKB energy-asymmetric e^+e^- collider. The accelerator has already successfully completed the first phase of commissioning in 2016 and first electron-positron collisions in Belle II are expected for April 2018. The design luminosity of SuperKEKB is 8×10^{35} cm^{-2}s^{-1} and the Belle II experiment aims to record 50 ab^{-1} of data, a factor of 50 more than the Belle experiment. In this presentation, we will discuss the expected sensitivity of Belle II for CPV measurements and New Physics searches in the charm sector. Alternative flavor-tagging techniques have been developed, a novel flavor-tagging method of prompt D^0s will be presented. Finally, we will present the impact of the improved tracking at Belle II, that will allow to significantly increase the precision of time-dependent measurements. This abstract is presented on behalf of the Belle II collaboration; if accepted the Speakers Committee will assign the talk to a speaker.

Parallel session B2

Kaonic deuterium from realistic antikaon-nucleon interaction

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The antikaon plays an interesting role in low-energy QCD, reflecting the spontaneous and explicit breaking of chiral SU(3) symmetry. In this talk, we present the current status of theoretical studies of the kaonic deuterium from the viewpoint of few-body calculations. After the introduction of recent developments of the realistic antikaon-nucleon interactions, we show the results of accurate three-body calculations for the spectrum of kaonic deuterium using a realistic antikaon-nucleon interaction. Examining the sensitivity of the $I = 1$ component of the two-body interaction, we discuss the future perspective in relation with the forthcoming experiments of J-PARC E57 and SIDDHARTA-2.

Spectroscopy of kaonic atoms at DAFNE and J-PARC

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The interaction of antikaons (K-) with nucleons and nuclei in the low-energy regime represents a very active research field in hadron physics. A unique and rather direct experimental access to the antikaon-nucleon scattering lengths is provided by precision X-ray spectroscopy of transitions in low-lying states in the lightest kaonic atoms (i.e. kaonic hydrogen and deuterium). In the SIDDHARTA experiment at the electron-positron collider DAFNE of LNF-INFN we measured the most precise values of the strong interaction observables in conic hydrogen. The strong interaction on the 1s ground state of the electromagnetically bound K-p atom causes an energy shift and broadening of the 1s state. SIDDHARTA will extend the spectroscopy to kaonic deuterium to get access to the antikaon-neutron interaction and thus the isospin dependent scattering lengths. At J-PARC a kaon beam is used in a complementary experiment with a different setup for spectroscopy of kaonic deuterium atoms. The talk will give an overview of the of the upcoming experiments SIDDHARTA and the complementary experiment at J-PARC.Furthermore, the implications of the experiments for the theory of low-energy strong interaction with strangeness will be discussed.

New Insights on Low Energy πN Scattering Amplitudes

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The S- and P- wave phase shifts of low-energy pion-nucleon scatterings are analysed using production representation of partial wave S matrix, in which they are decomposed into various terms contributing either from poles or branch cuts. We estimate the left-hand cut contributions with the help of tree-level perturbative amplitudes derived in relativistic baryon chiral perturbation theory up to $\mathcal{O}(p^2)$. It is found that in S_{11} and P_{11} channels, contributions from known resonances and cuts are far from enough to saturate experimental phase shift data – strongly indicating contributions from low lying poles undiscovered before, and we fully explore possible physics behind. On the other side, no serious disagreements are observed in the other channels.

Dipole Dynamical Polarizabilities from proton Real Compton Scattering data

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I will discuss the results of a recent work on the extraction of the dipole dynamic polarizabilities (DDPs) from proton Real Compton Scattering (RCS) data below pion production threshold. The dynamical polarizabilities are energy dependent functions which parametrize the response of the internal degrees of freedom of the proton to an external, real-photon field of arbitrary energy. As such, they contain enriched information with respect to the static polarizabilities defined in the limit of zero-frequency photon field.

I will introduce the theoretical framework, which combines dispersion relations and the low-energy expansion and multipole decomposition of the scattering amplitude, focusing the attention on the electric and magnetic DDPs.

Furthermore, I will discuss the statistical analysis, based on the parametric bootstrap technique. These statistical tools have been applied for the first time to analyze RCS data, and have been crucial to overcome problems inherent to the analysis of the available data set. I will present the main advantages of this fitting method, including preliminary results about the statistical interpretation of the χ^2 function when also systematical errors are taken into account. Finally, I will show new results for the extraction of the static polarizabilities α_{E1} and β_{M1}, using subtracted dispersion relations and the bootstrap technique.

Plenary session FRIDAY

Tetra and pentaquarks from the molecular perspective

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The interaction between hadrons has sometimes the consequence that bound states and resonances are formed, involving four quarks for mesons and five quarks for baryons, although they cluster in the form of more elementary mesons and baryons. I select two examples: the $D^*\bar{D}^*$, $D_s^*\bar{D}_s^*$ interaction leading to some XYZ states in the region of 4000 MeV and the interaction of $\xi\bar{K}$ and coupled channels to give the Ω_c states, in good agreement with some of the recently found experimental states by the LHCb collaboration. Similarly, I shall show predictions for Ω_b states. Finally, I shall show results for the $B+ \to J/\psi\Phi K^+$ decay, comparing results for the $\Phi J/\psi$ mass distribution with the measurements and analysis of LHCb, showing the role of the $X(4140)$ and $X(4160)$ resonances and reinterpreting the experimental results.

Exotic atoms by the DIRAC experiment

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DIRAC is an experiment which aims to study double-exotic atoms formed by π- and K-mesons to check the QCD predictions. DIRAC is a fixed target experiment which uses the proton beam, extracted from the CERN Proton Synchrotron at 24 GeV/c. Exotic hydrogen-like atoms are generated in relativistic proton-nuclei collisions and later identified through characteristic ("atomic") pairs of mesons with low relative momenta. Atomic pairs originate from the ionization of exotic atoms in collisions with ordinary atoms in thin dense foils. The ionization process is competitive to annihilation of exotic atoms due to strong interaction. Thus the study of exotic atoms reveals parameters of the strong interaction of pions and kaons at low energy. There is an accurate relation between $\pi^+\pi^-$ atom lifetime and a difference of S-wave pion-pion scattering lengths with isospin 0 (a_0) and 2 (a_2). A similar relation connects the lifetime of πK atom to pion-kaon scattering lengths with isospin 1/2 and 3/2. The values of above mentioned scattering lengths are predicted with high precision by low energy QCD theories, i.e. chiral perturbation theory (χPT) and lattice gauge theory (LQCD). Lifetimes of $\pi^+\pi^-$ and πK atoms, predicted by theory, are of the order 10^{-15} s.
In 2017 DIRAC reported the measurement of the πK atom lifetime in the ground state based on statistics of about 350 ionized πK atoms. This lifetime measurement leads to the deduced value of the S-wave isospin-odd πK scattering length $|a_0^-| = \frac{1}{3}|a_{1/2} - a_{3/2}| =$

$(0.072^{+0.031}_{-0.020})M_\pi^{-1}$. Earlier the collaboration measured the $\pi^+\pi^-$ atom (pionium) lifetime with 9% precision.
The DIRAC collaboration collected data towards observation of long-lived (metastable) states of pionium. The observation of long-lived states opens the possibility to measure the energy difference between ns and np states and to determine the value of the combination $(2a_0 + a_2)$ of S-wave $\pi\pi$ scattering lengths. The experiment uses a two-foil method: after production in the beryllium foil, the atoms propagate through a permanent magnetic field to reach the ionization foil, made of platinum. The distance of about 10 cm between foils is large enough for ns-states to vanish due to annihilation. The lifetime of states with $l > 0$ is defined by radiative de-excitation into ns-states, followed by annihilation: typical lifetimes are of the order 10^{-11} s, depending on the atomic state. Only $\pi^+\pi^-$ atoms in states with non-zero angular momentum can get into the ionization foil. We report the observation of long-lived (metastable) states of $\pi^+\pi^-$ atoms and the measurement of their lifetime.

Latest Results from GlueX

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The GlueX experiment is housed in the newest experimental hall at the Thomas Jefferson National Accelerator facility in Newport News, Virginia. It was successfully commissioned in 2015 and is in its third year of data taking. GlueX uses a 12 GeV electron beam incident on a diamond radiator, producing a linearly polarized, coherent Bremsstrahlung photon beam. The ultimate goal of GlueX is to search for exotic hybrid mesons (e.g. qqg), with either exotic or conventional quantum numbers, whose existence, or lack thereof, would allow for the exploration of the gluon-gluon coupling present in QCD through the manifestation of hadrons with gluonic degrees of freedom. Photo-production at these energies is fairly unexplored and the polarization allows GlueX to discriminate between various production mechanisms which may be an effective way to identify such exotic hybrid mesons. In addition to exotic mesons, GlueX will also be poised to map out the conventional meson spectrum and to study the spectrum of excited vector mesons, which are often poorly understood. In this talk, we will present an overview of the GlueX experiment, its goals, current physics results, and future plans.

Recent results of the pion-nucleon scattering and the widths of the delta and Roper resonances in BChPT

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Recent calculations of the pion-nucleon scattering in covariant baryon chiral perturbation theory with explicit Δ resonances will be presented. Two-loop results of the widths of the Δ- and Roper resonances will be discussed in the framework of an effective field theory with nucleons, pions and the Roper and Δ resonances as dynamical degrees of freedom.

η meson physics with WASA-at-COSY

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The study of η mesons has been one of the main objectives of the WASA experiment, ever since its relocation to the accelerator complex COSY at the Research Center Jülich. As the interaction of η mesons with nucleons is attractive in s-wave, with the $S_{11}(1535)$ resonance situated close to the ηN threshold, studying the properties of ηN and ηA interactions has long been an active research topic. With the η meson being uncharged and short-lived, such studies are best performed in nucleon-nucleon and nucleon-nucleus collisions containing an η meson in the final state. With both COSY and an internal pellet target being able to provide protons as well as deuterons, η meson production can be studied in various reactions, most notably the proton-deuteron fusion. Here, experimental evidence for a strong final state interaction in the $\eta\,^3$He system has lead to an ongoing discussion of a potential η-nucleus bound state.
Another major part of the η physics program with WASA-at-COSY is the search for rare or forbidden decays. The η meson, possessing no allowed strong decays, provides ideal surroundings to search for both rare standard model processes and symmetry violating decays potentially involving beyond standard model physics. Two dedicated datasets, containing 30×10^6 η mesons in $pd \to {}^3\mathrm{He}\eta$ and 500×10^6 η mesons in $pp \to pp\eta$, allow precision studies of standard model decays and stringent limits on symmetry violating processes. Recent results on η meson physics with the WASA-at-COSY experiment will be discussed.

Search for $K^+ \to \pi^+\nu\nu$ at NA62

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The decay $K^+ \to \pi^+\nu\nu$, with a very precisely predicted branching ratio of less than 10^{-10}, is one of the best candidates to reveal indirect effects of new physics at the highest mass scales. The NA62 experiment at CERN SPS is designed to measure the branching ratio of the $K^+ \to p + nn$ with a decay-in-flight technique, novel for this channel. NA62 took data in 2016, 2017 and another year run is scheduled in 2018. Statistics collected in 2016 allows NA62 to reach the Standard Model sensitivity for $K^+ \to \pi^+\nu\nu$, entering the domain of 10^{-10} single event sensitivity and showing the proof of principle of the experiment. The $K^+ \to \pi^+\nu\nu$ analysis data is reviewed and the preliminary result from the 2016 dataset presented.

Time-Like Baryon Transitions studies with HADES

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The High Acceptance Di-Electron Spectrometer (HADES) [1] installed at GSI is a versatile detector, which was originally designed to study medium effects in e^+e^- production in heavy-ion reactions in the SIS-18 energy range (1-2 GeV/nucleon). Its excellent particle identification capabilities allowed for a systematic investigation of dielectron, strange particles and pion production in 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 ($R \to Ne^+e^-$) and a strong influence of the intermediate vector mesons ($\rho/\omega/\phi$) in the corresponding time-like electromagnetic form factors.
In order to directly access such transitions, HADES has started a dedicated pion-nucleon program using the pion beam line at GSI [2]. For the first time, combined measurements of hadronic and dielectron final states have been performed in $\pi - N$ reactions in the second resonance region, using polyethylene and carbon targets. While providing new determi- nations of the baryon-meson couplings, the results allow to investigate the validity of the Vector Dominance Model for baryon transitions and the helicity structure of the time like electromagnetic baryon transitions, paving the way for more precise future measurements.
The results of the HADES collaboration obtained with proton and pion beams will be presented, with emphasis on the connection with the HADES hadronic matter program. Prospects for HADES measurements at SIS-18 in the near future within the FAIR-Phase0 programme and later on at SIS-100 (FAIR) will also be discussed.
References:
[1] G. Agakishiev et al. (HADES collaboration), Eur. Phys. J. A41 (2009) 243.
[2] J. Adamczewski-Musch et al. (HADES collaboration), Eur. Phys. J. A53 (2017) 188.

The meson production reactions: the analysis methods and recent results

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The analysis methods for the meson pion-induced and photo-production methods are discussed. The resent results from the Bonn-Gatchina group are presented and compared with the results of other partial wave analysis groups.

Parallel session A3

XYZ states at LHCb

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The latest years have observed a resurrection of interest in searches for exotic states motivated by precision spectroscopy studies of beauty and charm hadrons providing the observation of several exotic states. The latest results on spectroscopy of conventional and exotic hadrons are reviewed, using the pp collisions data collected by the LHCb experiment. These are e.g. the discovery of the first charmonium pentaquark states in the J/Psi p system or the confirmation of the resonant nature of the Z(4430)- mesonic state. LHCb has also made significant contributions to the determination of the quantum numbers of the X(3872) state and excluded the existence of the X(5568) tetraquark candidate. Interest in heavy hadron spectroscopy has increased dramatically with the new LHCb results.

Semileptonic B meson decays: recent results and their implications

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The semileptonic decays of the B meson play a crucial role in the determination of the magnitude of the V_{ub} and V_{cb} Cabibbo-Kobayashi-Maskawa matrix elements. These parameters are measured with high precision using inclusive or exclusive techniques. These two complementary approaches rely on very different theoretical frameworks and experimental techniques, allowing important cross-checks. Despite the huge improvements in the understanding of semileptonic B decays gained in the last ten years, for both V_{ub} and V_{cb} there are discrepancies at 3-sigma level, between inclusive and exclusive determinations, that have not been understood yet. Very recent experimental results and theoretical developments, start to shed light on this important long-standing puzzle. I will review the recent measurements from BaBar and their implications concerning this

puzzle, and in relation with the recently observed anomalies in semi-tauonic B decays resulting from the combination of measurements performed by BaBar, Belle and LHCb.

Measurement of azimuthal correlations of D mesons with charged particles in pp collisions at $\sqrt{s} = 13$ TeV with ALICE at the LHC

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The ALICE (A Large Ion Collider Experiment) detector at the LHC is dedicated to the study of the properties of the hot and dense QCD matter (Quark Gluons Plasma) produced in the nucleus-nucleus collisions at high energy. The heavy quarks (charm and beauty), having a large masses, are produced in the hard-parton scattering in the early stages of the collision. Therefore, they experience the whole evolution of the hot and dense medium, representing an important tool for its characterization.
The study of angular correlations between D mesons and charged particles in Pb-Pb collisions gives insight about the energy loss of charm quark and the medium-induced modification of its fragmentation into jets. Moreover, in pp collisions helps understanding the production mechanisms, fragmentation and hadronization of charm quarks and acts as a reference for p-Pb and Pb-Pb measurements.
In this talk, the measurement of azimuthal correlations between D^0 meson and charged particles in pp collisions at $\sqrt{s} = 13$ TeV is presented. The comparison of results with $\sqrt{s} = 7$ TeV results gives the collisional energy dependence of correlations. The data are also be compared with simulations results performed with different event generators.

Baryon-baryon femtoscopy in pp and p-A collisions (ALICE collaboration)

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Femtoscopy is a method relating particle correlations to their emission source and interaction potential. Applying this technique to a small collision system, such as pp, has the advantage of probing the inner part of the interaction potential. In order to allow for an accurate determination of the correlation function for small sources, we have developed a new C++ analysis tool called "Correlation Analysis Tool using the Schrödinger equation" (CATS), which will be presented in this talk.
We present ALICE results on baryon-baryon correlations obtained from the RUN 2 operation of the LHC in pp collisions at 13 TeV and p-Pb collisions at 5.02 TeV. The statistics of RUN 2 data provide a higher precision in the analysis of the p-p, p-Λ and Λ-Λ correlations, and additionally make it possible to probe the interaction of more

exotic pairs like p-Ξ. Thanks to ongoing collaborations with theory groups working on chiral and lattice calculations we are in the position to compare the predicted correlation functions with the experimental data.

Polarimetry for an Electric-Dipole-Moment measurement at COSY and beyond

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Understanding the origin of the matter-antimatter imbalance in the universe is one of the grand challenges of modern physics. One of the necessary conditions is the violation of CP symmetry. Predictions given by the Standard Model fail to explain the observed preponderance of matter by orders of magnitude. Therefore, new sources of CP violation, coming from outside the Standard Model, are needed. They can manifest themselves in Electric Dipole Moments (EDM) of elementary particles.
The efforts of the Jülich Electric Dipole Moment Investigations (JEDI) Collaboration concentrate on a direct measurement of EDMs of charged hadrons (protons and deuterons). Currently, the focus of the project is on the development of the required technologies for a dedicated storage-ring experiment and the preparation of a first precursor measurement at the Cooler Synchrotron (COSY).
The principle of the EDM measurement is based on the observation of the time development of the miniscule vertical-polarization buildup of the horizontally-polarized beam, due to the interaction of a finite EDM with a radial electric field. The key challenge is a sensitive and efficient determination of the tiny change of the polarization.
The polarization measurement exploits elastic scattering of the beam particles on a carbon target. The design of the dedicated polarimeter requires a solid database. The corresponding measurements have been started at COSY, and preliminary results from the experiment on deuteron-carbon scattering will be shown.

Parallel session B3

Conventional and exotic meson states in the DSE/BSE framework

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We summarize recent results on the spectrum and form factors of conventional and exotic meson states in the DSE/BSE framework. We contrast states with conventional and exotic quantum numbers and outline the ability of the framework to accommodate for hybrid, tetraquark and glueball states. We furthermore report on recent technical progress allowing the consistent treatment of strong and electromagnetic meson decays and discuss possible applications.

The role of isospin filtering reactions in the $S = -1$ sector.

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The plausible explanation of the $\Lambda(1405)$ resonance as a molecular state arising from coupled channel meson-baryon re-scattering in the strangeness $S = -1$ sector employing the lowest order chiral Lagrangian is one of the most important successes of Unitaritzed Chiral Perturbation Theory (UChPT). Despite this theoretical breakthrough, the aim for more precise calculations led the community to extend this approach with the inclusion of higher order terms and to explore higher energies. Unfortunately, the parameters of these higher-order terms are not fixed by the symmetries of the underlying theory, thus making the experimental fitting procedures to play a key role. In our previous studies [1,2], the relevance of the next-to-leading order (NLO) terms as well as the Born terms of the Chiral $SU(3)$ Lagrangian for the $K\Xi$ channels was proved establishing the experimental $K^-p \to K\Xi$ cross-section data as a very important ingredient to obtain more reliable values of the NLO parameters. The analysis of the isospin components of the $K^-p \to K\Xi$ cross-section for different parametrizations in [2] revealed the need to explore reactions acting as isospin selectors. Motivated by the previous findings, we present results of a new fit which includes additional experimental data from the reactions $K^-p \to \eta\Lambda(I = 0), \eta\Sigma^0(I = 1)$ [3] and analyse their effect on the NLO parameters. In addition, we give predictions for other isospin filtering processes whose measurement would provide valuable constraints on the chiral models, namely, the $K_L^0 p \to K^+\Xi^0$ reaction, which is an $I = 1$ filtering process and is planned to be measured at JLab, and the weak Λ_b decay into a J/Ψ and the $I = 0$ component of a $S = -1$ meson-baryon [4]. The stability and the accuracy of all the parameters involved in the model have been

examined by means of the explicit inclusion of $\Lambda(1890), \Sigma(2030)$ and $\Sigma(2250)$ resonances into the channels estimated to be sensitive to the NLO terms.

[1] A. Feijoo, V. K. Magas and A. Ramos, Phys. Rev.C 92, 015206 (2015).
[2] A. Ramos, A. Feijoo and V. K. Magas, Nucl. Phys. A 954, 58 (2016).
[3] A. Starostin et al. (Crystal Ball Collaboration), Phys. Rev. C 64, 055205 (2001); D. F. Baxter et al., Nucl. Phys. B 67, 125 (1973); A. Berthon et al., Nuovo Cim. A 21, 146 (1974).
[4] A. Feijoo, V. K. Magas, A. Ramos and E. Oset, Phys. Rev. D 92, no.7, 076015 (2015); Erratum: Phys. Rev. D 95, no.3, 039905 (2017).

Ab-initio calculations of eta-nuclear quasi-bound states

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We report on ongoing studies of in-medium η N interactions and η-nuclear quasi-bound states in few-nucleon systems, accounting self-consistently for the ηN and η-nucleus subthreshold dynamics and extending the few-body calculations of η quasi-bound states in ^{3}He and ^{4}He [1,2,3]. Our new ab-initio self-consistent calculations of the lightest η-nuclear systems, including for the first time ${}^{6}_{\eta}$ Li and ${}^{7}_{\eta}$Li, were performed within the Stochastic Variational Method. Input ηN scattering amplitudes for these calculations were constructed within coupled-channel meson-baryon interaction models that incorporate the $N^*(1535)$ resonance. It was found that the ηd system is not bound in any of the models considered, and ${}^{3}_{\eta}$He and ${}^{4}_{\eta}$He are likely to be nearly or just bound [1,2,3], while ${}^{6}_{\eta}$Li and ${}^{7}_{\eta}$Li are bound. The connection between our few-body calculations and optical-model calculations in heavier systems [4,5] will be discussed as well.

[1] N. Barnea, E. Friedman, A. Gal, PLB 747 (2015) 345.
[2] N. Barnea, B. Bazak, E. Friedman, A. Gal, PLB 771 (2017) 297, PLB 775 (2017) 364 (E).
[3] N. Barnea, E. Friedman, A. Gal, NPA 968 (2017) 35.
[4] E. Friedman, A. Gal, J. Mares, PLB 725 (2013) 334.
[5] A. Cieply, E. Friedman, A. Gal, J. Mares, NPA 925 (2014) 126.

The most correct $\rho^0(770)$ meson mass and width values

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It is clearly demonstrated that Gounaris-Sakurai pion EM FF model at the elastic region is not enough accurate for a determination of the $\rho^0(770)$ parameters. Then in no case it can be exploited even for a determination of the excited $\rho(770)$ parameters from whatever precise data on the $e^+e^- \to \pi^+\pi^-$ and $\tau^- \to \pi^-\pi^0\nu_\tau$ processes.

There is only one set of the correct values of f^F, f^D and f^S coupling constants in SU(3) invariant Lagrangian of the vector-meson-baryon interactions

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One can prove, ther is generally eight various $\omega - \phi$ mixings forms in elementary particle physics, which on one side give different forms of the vector-meson-nucleon coupling constants through f^F, f^D and f^S in SU(3) invariant Lagrangian of the vector-meson-baryon interactions, and on the other side different signs of the universal vector-meson coupling constants f_ρ, f_ω and f_ϕ. Identical set of numerical values of f^F, f^D and f^S is evaluated only in that case, if the same $\omega - \phi$ mixing is applied to a derivation of the vector-meson-nucleon coupling constant forms and also to the signs of the universal vector-meson coupling constants f_ρ, f_ω and f_ϕ.

Parallel session C3

Excitation of $d^*(2380)$ dibaryon in the coherent $pd \to pd\pi\pi$ channel at ANKE

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The reaction $p + d \to p + d + X$ was studied at 0.8–2.0 GeV proton beam energies with the ANKE magnetic spectrometer at the COSY synchrotron storage ring. The proton-deuteron pairs emerging with high momenta, 0.6–1.8 GeV/c, were detected at small angles with respect to the proton beam. Distribution above the reaction missing mass M_x reveals a local enhancement near the threshold of the pion pair production specific to the so-called ABC effect. The enhancement has a structure of a narrow bump placed above a smooth continuum. The invariant mass of the $d\pi\pi$ system in this enhancement region exhibits a resonance-like peak at $M_{d\pi\pi} \approx 2.36$ GeV/c^2 with the width $\Gamma \approx 0.10$ GeV/c^2, corresponding to the excitation of the $d^*(2380)$ dibaryon resonance. A possible interpretation of these features is discussed.

$d^*(2380)$ in a chiral constituent quark model

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In this talk, I briefly summarize our progress made in the study of the structure and decay properties of the $d^*(2380)$, a dibaryon state recently reported by the WASA@COSY Collaboration. We studied the $d^*(2380)$ in a chiral quark model by performing a RGM dynamical investigation of the coupled-channel $\Delta\Delta + CC$ interaction. The mass of $d^*(2380)$ is properly reproduced and the results show that the $d^*(2380)$ is a compact six-quark cluster dominated by about 2/3 CC component. The obtained wave function is applied to study the single-pion and double-pion decays, and the calculated partial decay widths are in agreement with the experimental data. The charge distribution of $d^*(2380)$ is also calculated and discussed, which is expected to be able to distinguish various pictures of the structure of $d^*(2380)$.

Structure and Width of the d*(2380) Dibaryon

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We discuss the structure and width of the recently established $d^*(2380)$ dibaryon, confronting the consequences of the Gal-Garcilazo Pion Assisted Dibaryons hadronic model with those of quark motivated calculations. In particular, its relatively small width of about 70 MeV favors hadronic structure for the $d^*(2380)$ dibaryon rather than a six-quark compact structure [1].
[1] A. Gal, Phys. Lett. B 769 (2017) 436.

Are the chiral based $\bar{K}N$ potentials really energy-dependent?

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It is shown, that the energy dependence of the chiral based $\bar{K}N$ potentials, responsible for the occurrence of two poles in the $I = 0$ sector, is the consequence of applying the on-shell factorization introduced in [1]. When the dynamical equation is solved without this approximation, the second, unphysical, pole disappears. Accordingly, an energy-independent $\bar{K}N$ potential was derived, which supports only one pole in the region of the $\Lambda(1405)$ resonance. The potential, being energy-independent, is suitable for standard quantum mechanical calculations in $n > 2$ systems, including coordinate space variational approaches, where the energy-dependence leads to serious difficulties.
[1] E. Oset and A. Ramos Nucl.Phys. A 635, 99 (1998).

On the width of Δ in $N\Delta$ and $\Delta\Delta$ systems

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In two-nucleon reactions it is rather common usage to take into account the effect of the $\Delta(1232)$ excitation by simply including an additional channel with the $\Delta - N$ mass difference and free Δ width. In the momentum space propagator this leads to a factor $(E - \Delta M + i\Gamma/2)^{-1}$ and by its absolute square trivially to a resonant total cross section. In the coordinate representation $\Delta M - i\Gamma/2$ would be a repulsive and absorptive constant potential in the $N\Delta$ channel part of the Schrödinger equation. Also in this case the $N\Delta$ amplitude tends to maximize at the threshold energy.

This work studied in a simple phenomenological way the effect of the relative kinetic energy between the two intermediate baryons to see how or if it decreases the effective decay width of the $N\Delta$ and $\Delta\Delta$ two-baryon systems. Obviously this kinetic portion is not available for the (internal) pionic decay of the Δ's. Because, the wave function is necessarily also spatially constrained (must die asymptotically) the kinetic energy is not arbitrary, but its average is finite and, therefore, some suppression is expected and found. Another aspect of kinetic energy, the effect of angular momentum barrier in the $N\Delta$ channel is also manifest in coordinate space calculations. Necessarily in higher angular

momentum states the wave functions are strongly suppressed and this also can be seen in the widths. The dependence on $L_{N\Delta}$ is drastic {\it e.g.} in $pp \to d\pi^+$ amplitudes ${}^1D_2(NN) \to {}^5S_2(N\Delta)$, ${}^5D_2(N\Delta)$ and ${}^5G_2(N\Delta)$. In fact, due to the asymptotically bounded wave functions, the energy related to the angular momentum barrier is quantized and leads to rotational series in $L_{N\Delta}$, which closely describe the isovector dibaryons. Similar suppression can be seen also in $\Delta\Delta$ states. This may have bearance in the context of the $d'(2380)$ resonance discovered at COSY.

Parallel session A4

Recent Hall C results and future plans with the 12 GeV upgrade

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Hall C at Jefferson Lab has added a new "super" high momentum spectrometer to complement the recent upgrade of the JLab accelerator to 12 GeV. We will present results from the pre-upgrade era, including a measurement of the weak charge of the proton, hypernuclear physics and electro-meson production. After the upgrade, data taking has resumed with a variety of physics programs using high-intensity electron beams including a new program of exclusive and semi-inclusive meson (charged pions, neutral pions and kaons) production. We will report on the prospects for these programs as well as the continuation of the hypernuclear program in JLab's Hall A.

Production asymmetry of open charm mesons within unfavoured fragmentaton scenario

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We consider unfavoured light quark/antiquark to D meson fragmentation. We discuss nonperturbative effects for small transverse momenta. The asymmetry for D^+ and D^- production measured by the LHCb collaboration provides natural constraints on the parton (quark/antiquark) fragmentation functions. We find that already a fraction of $q/\bar{q} \to D$ fragmentation probability is sufficient to account for the measured asymmetry. We make predictions for similar asymmetry for neutral D mesons. Large D-meson production asymmetries are found for large x_F which is related to dominance of light quark/antiquark $q/\bar{q} \to D$ fragmentation over the standard $c \to D$ fragmentation. As a consequence, prompt atmospheric neutrino flux at high neutrino energies can be much larger than for the conventional $c \to D$ fragmentation. The latter can constitute a sizeable background for the cosmic neutrinos claimed to be observed recently by the IceCube Observatory. Large rapidity-dependent D^+/D^- and $D^0/\bar{D}^0$ asymmetries are predicted for low ($\sqrt{s}$ = 20 - 100 GeV) energies. The $q/\bar{q} \to D$ fragmentation leads to enhanced production of D mesons at low energies. At $\sqrt{s} = 20$ GeV the enhancement factor with respect to the conventional contribution is larger than a factor of five. In the considered picture the large-x_F D mesons are produced dominantly via fragmentation of light quarks/antiquarks. Predictions for fixed target $p + {}^4$He collisions relevant for a fixed target LHCb experiment are presented.

Constituent Quark Models for Hadronic Systems

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In this work we introduce two different potential models for the hadronic systems such that the QCD concepts of the quark-quark interactions be satisfied. We present the simple methods to solve two- and three-body equation of the meson and baryon systems respectively. The introduced models are studied in the relativistic and non-relativistic limits.

Transverse momentum spectra of hadrons in p+p collisions at CERN SPS energies from the UrQMD transport model

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The UrQMD transport model, version 3.4, is used to study the new experimental data on total yields, rapidity distributions and transverse momentum spectra of $\pi\pm$, K±, p and p^- produced in inelastic p+p interactions at SPS energies, recently published by the NA61/SHINE Collaboration.

The comparison of model predictions to these new measurements is presented as a function of collision energy for central and forward particle rapidity intervals. In addition, the inverse slope parameters characterising the transverse momentum distributions are extracted from the predicted spectra and compared to corresponding values obtained from experimental distributions, as a function of particle rapidity and collision energy.

A complex pattern of deviations between the experimental data and the UrQMD model emerges. For charged π mesons, the fair agreement visible at top SPS energies deteriorates with decreasing energy. For charged K mesons, UrQMD significantly underpredicts positive kaon production at lower beam momenta. It also underpredicts the central rapidity proton yield at top collision energy and overpredicts antiproton production at all considered energies.

We conclude that new experimental data at SPS energies still constitute a challenge for specific transport models, at least as far as the present version of the UrQMD code is concerned. In view of the importance of the RHIC BES and SPS energy regime which is claimed to host the onset of deconfinement from hadronic matter to quark-gluon plasma in heavy ion collisions, a further discrimination and tuning of model assumptions seems highly indicated as a new step towards a better understanding of the strong interaction at high energy.

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Parallel session B4

Meson transition form factor measurements from A2

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A meson transition form factor (TFF) describes the dynamics of the transition between photons and mesons and hence provides an important probe of the intrinsic structure of mesons. High statistics measurements of TFFs also play a role for the precision frontier of the Standard Model (SM). In the SM calculation of the anomalous magnetic moment of the muon, the largest uncertainty is given by the hadronic part in which the hadronic Light-by-Light (hLbL) scattering plays a significant role. The largest individual contribution to the hLbL is an exchange of light pseudoscalar mesons coupling to two virtual photons. This coupling is in turn described by the corresponding TFF.
The A2 experiment at MAMI provides a high yield of light mesons produced by photo-induced reactions on protons, which makes the experiment ideal for precision measurements of meson TFFs. The A2 collaboration has recently published results of TFFs obtained by studies of Dalitz decays of the π^0 and η mesons as well as the $\omega \to \pi^0 e^+ e^-$ decay. For the study of the η' Dalitz decay, data has been collected and is being analyzed. And as a future endeavor, A2 will perform a dedicated measurement of the π^0 TFF with statistics increased by several factors compared to the previous A2 result.

A revision of radiative corrections to double-Dalitz decays

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The transition form factors (TFFs) of pseudoscalar mesons were—and continue to be—an active field of research, especially in their connection with the hadronic light-by-light contribution to the muon g-2. A particular aspect which is still a matter of debate concerns their double-virtual behavior, for which experimental data would be extremely welcomed in any theoretical approach. A long-time proposed possibility is to study the double-Dalitz decays of pseudoscalar mesons. Still, given the mild effect that TFFs play in these decays, a thorough investigation of NLO radiative corrections is extremely important. In our study, we revise the existing calculation and complete the—so far missing—full NLO calculation, finding some discrepancies which could be of relevance for existing and projected pseudocalar meson factories. The calculations can also be used for the crossing-related process, $e^+e^- \to e^+e^-P$, where future measurements are foreseen.

Work based on arXiv:1801.06067 and selected for PRD Editors' Suggestion in March 2018 issue.

Radiative corrections in Dalitz decays of π^0, η and η' mesons

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We briefly summarize current experimental and theoretical results on the two important processes of the low energy hadron physics involving neutral pions: the Dalitz decay of π^0 and the rare decay $\pi^0 \to e^+e^-$. As novel results we present the complete set of radiative corrections to the Dalitz decays $\eta^{(\prime)} \to \ell^+\ell^-\gamma$ beyond the soft-photon approximation, i.e. over the whole range of the Dalitz plot and with no restrictions on the energy of a radiative photon. The corrections inevitably depend on the $\eta^{(\prime)} \to \gamma^*\gamma^{(*)}$ transition form factors. For the singly virtual transition form factor appearing e.g. in the bremsstrahlung correction, recent dispersive calculations are used. For the one-photon-irreducible contribution at the one-loop level (for the doubly virtual form factor), we use a vector-meson-dominance-inspired model while taking into account the η-η' mixing.

Strange Meson Production in Pion-Nucleus Reactions at 1.7 GeV/c

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The production of strange mesons in pion-nucleus reactions allows for a quantitative investigation of in-medium effects such as re-scattering or absorption processes at well-defined nuclear density. Overall, 10×10^7 and 13×10^7 events have been collected with the HADES detector at the GSI pion beam facility in $\pi^- + C$ and $\pi^- + W$ collisions at $p_{\pi^-} = 1.7$ GeV/c. We present our results on the open and hidden strange meson ($K^\pm$ and ϕ) production in cold nuclear matter. Special emphasis will be put on the study of K^- absorption driven by strangeness exchange processes on one ($K^-N \to Y\pi$) or more nucleons ($K^-NN \to YN$). The data supports K^- absorption in the heavier system (W) by comparing the K^-/K^+ ratios measured in collisions with heavy targets (W) and lighter ones (C). In addition, the ϕ absorption in nuclear medium will be addressed by comparing the production in both nuclear environments as well as the ϕ feed-down to the K^- production.
Work supported by the DFG cluster of excellence "Origin and Structure of the Universe" and SFB 1258.

Parallel session C4

Triangle singularity enhancing isospin violation in $\bar{B}_s^0 \to J/\psi\pi^0 f_0(980)$ and $D_s^+ \to \pi^+\pi^0 f_0(980)$

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We investigate isospin violation and $a_0 - f_0$ mixing in the $\bar{B}_s^0 \to J/\psi\pi^0 a_0(980)(f_0(980))$ and $D_s^+ \to \pi^+\pi^0 a_0(980)(f_0(980))$ reactions, where $\bar{B}_s^0 \to J/\psi\pi^0 f_0(980)$ and $D_s^+ \to \pi^+\pi^0 f_0(980)$ are isospin-suppressed while $\bar{B}_s^0 \to J/\psi\pi^0 a_0(980)$ and $D_s^+ \to \pi^+\pi^0 a_0(980)$ are isospin-allowed. The reaction proceeds via a triangle mechanism, with $\bar{B}_s^0 \to J/\psi K^*\bar{K} + c.c.$ or $D_s^+ \to \pi^+ K^*\bar{K}$, followed by the decay $K^* \to K\pi$ and a further fusion of $K\bar{K}$ into the $f_0(980)$ or $a_0(980)$. We show that the mechanism develops a singularity around the $\pi^0 f_0(980)$ or $\pi^0 a_0(980)$ invariant mass of 1420 MeV where the $\pi^0 f_0$ and $\pi^0 a_0$ decay modes are magnified and also the ratio of $\pi^0 f_0$ to $\pi^0 a_0$ production, stressing the role of the triangle singularities as a factor to enhance the mixing of the $f_0(980)$ and $a_0(980)$ resonances. We calculate absolute rates for the reactions and show that they are within present measurable range. The measurement of these reactions would bring further information into the role of triangle singularities in isospin violation and the $a_0 - f_0$ mixing in particular and shed further light into the nature of the low lying scalar mesons.

a0(980)−f0(980) mixing in χc1→π0f0(980)→π0π+π− and χc1→π0a0(980)→π0π0η

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We study the isospin breaking in the reactions χc1→π0π+π− and χc1→π0π0η and its relation to the a0(980)−f0(980) mixing, which was measured by the BESIII Collaboration. We show that the same theoretical model previously developed to study the χc1→ηπ+π− reaction (also measured by BESIII), and further explored in the predictions to the ηc→ηπ+π−, can be successfully employed in the present study. We assume that the χc1 behaves as an SU(3) singlet to find the weight in which trios of pseudoscalars are created,

followed by the final state interaction of pairs of mesons to describe how the a0(980) and f0(980) are dynamically generated, using the chiral unitary approach in coupled channels. The isospin violation is introduced through the use of different masses for the charged and neutral kaons, either in the propagators of the pairs of mesons created in the $\chi c1$ decay, or in the propagators inside the T matrix, constructed through the unitarization of the scattering and transition amplitudes of pairs of pseudoscalar mesons. We find that violating isospin inside the T matrix makes the $\pi 0\eta \to \pi + \pi -$ amplitude nonzero, which gives an important contribution and also enhances the effect of the KK^- term. Also, we find that in the total amplitude the most important effect is the isospin breaking inside the T matrix, due to the constructive sum of $\pi 0\eta \to \pi + \pi -$ and $KK^- \to \pi + \pi -$, which is essential to get a good agreement with the experimental measurement of the mixing.

Polarization analysis of antiprotons produced in pA collisions

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A polarized antiproton beam would allow for the extraction of more detailed information in various fields like the structure of hadrons and their interaction but till now, although possible methods have been discussed since the first antiproton beams were produced [1], no simple procedure for the preparation of a well defined polarized antiproton beam is available. The actual favored solution is the spin filter method where a stored unpolarized antiproton beam is polarized by passing through a polarized target. Due to the spin dependent interaction one polarization component is depleted and after a certain storage time a beam polarization is build up. The technique in principle works as shown with protons but it is rather effortful [2]. A quite simple procedure for the generation of a polarized antiproton beam could be worked out if antiprotons are produced with some polarization.

In order to investigate this possibility measurements of the polarization of produced antiprotons have been started at a CERN/PS testbeam. Secondary particles produced with the PS beam were transferred through a beam line adjusted to 3.5 GeV/c momentum to a detection system which includes a liquid hydrogen analyzer target, tracking detectors, scintillators, a Cherenkov detector to veto the dominant pion background and a DIRC for the particle identification. The polarization will be determined from the asymmetry of the elastic antiproton scattering at the liquid hydrogen target in the CNI region for which the analyzing power is well known. The tracks of beam and scattered particle are reconstructed from drift chamber signals and the particle identification is done by the Cherenkov cone in the DIRC.

The data are still under analysis and in order to improve the statistics an additional measurement is planned for summer 2018. Details on the experiment and the ongoing data analysis [3,4] will be given.

References:

[1] A. D. Krisch, AIP Conf. Proc. 145 (1986).

[2] W. Augustyniak et al., Phys. Lett. B 718 64-69 (2012).

[3] D. Alfs et al., Acta Phys. Pol. B 48 1983 (2017).

[4] D. Grzonka et al., Acta Phys. Pol. B 46, 191 (2015).

High spin resonances produced in $\pi^+\pi^-\pi^-$ and $\pi^-\pi^0\pi^0$ systems at VES setup

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A study of high spin resonances produced in $\pi^+\pi^-\pi^-$ and $\pi^-\pi^0\pi^0$ systems with 29 GeV/c π^- beam on Be target is presented. Above 90 million events for the first one and 32 million events for the second one are collected with VES setup in a wide range of transfer momentum squared $0 < |t'| < 1\ GeV/c^2$. This is the largest statistics in the word. The $a_3(1875)$ and $a_4(2050)$ meson parameters are given and their production mechanism is discussed.

Plenary session SATURDAY

Thermal Dileptons and Hadrons in Medium

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Dilepton radiation from the exploding fireballs formed in energetic collisions of heavy nuclei provides a unique opportunity to investigate medium modifications of the light vector mesons. We discuss theoretical calculations of in-medium spectral functions and how they can help to interpret the experimentally measured dilepton spectra in heavy-ion collisions over a large range of energies, providing a large coverage of baryon density and temperature across the QCD phase diagram. In particular, we elaborate on implications for the restoration of the spontaneously broken chiral symmetry and the transition from hadronic to partonic the degrees of freedom in hot and dense matter.

The Role of Mesons in Muon $g-2$

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The muon anomaly $a_\mu = (g_\mu - 2)/2$ showing a persisting 3 to 4 σ deviation between the SM prediction and the experiment is one of the most promising signals for physics beyond the SM. As is well known, the hadronic uncertainties are limiting the accuracy of the Standard Model prediction. Therefore a big effort is going on to improve the evaluations of hadronic effects in order to keep up with the 4-fold improved precision expected from the new Fermilab measurement in the near future. A novel complementary type experiment planned at J-PARC in Japan, operating with ultracold muons, is expected to be able to achieve the same accuracy but with completely different systematics. So exciting times in searching for New Physics are underway. I discuss the role of meson physics in calculations of the hadronic part of the muon g-2. The improvement is expected to substantiate the present deviation $\Delta a_\mu^{\text{New Physics}} = \Delta a_\mu^{\text{Experiment}} - \Delta a_\mu^{\text{Standard Model}}$ to a 6 to 10 standard deviation effect, provided hadronic uncertainties can be reduced by a factor two. This concerns the hadronic vacuum polarization as well as the hadronic light-by-light scattering contributions, both to a large extent determined by the low lying meson spectrum. Better meson production data and progress in modeling meson form factors could greatly help to improve the precision and reliability of the SM prediction of a_μ and thereby provide more information on what is missing in the SM.

Energy and system dependence of light- and heavy-flavor hadron production in pp, p-Pb, Xe-Xe and Pb-Pb collisions at the LHC

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We report the measurement of light- and heavy-flavor hadron production in central ($|\eta| < 0.9$) and forward ($-4.0 < \eta < -2.5$) rapidities in pp ($\sqrt{s}$ = 2.76 TeV, 5.02 TeV and 7 TeV), p-Pb ($\sqrt{s_{\rm NN}}$ = 5.02 TeV), Xe-Xe ($\sqrt{s_{NN}}$ = 5.44 TeV) and Pb-Pb ($\sqrt{s_{\rm NN}}$ = 2.76 TeV and 5.02 TeV) collisions with ALICE at the LHC. We present the transverse momentum ($p_{\rm T}$) spectra and $p_{\rm T}$-integrated yields for different hadron species. The hadron production for different collision systems is compared as a function of collision energy, collision centrality or charged particle multiplicity. It allows us to explore the effect of multiple-parton interactions on hadron production in small systems as well as to characterize the thermodynamic and transport properties of hot and dense QCD matter produced in heavy-ion collisions. The measurement of a comprehensive set of resonances with lifetimes in a wide range of 1-46 fm/c is suitable for a systematic study of the role of re-scattering and regeneration in the hadronic phase. The $p_{\rm T}$-integrated hadron yields are compared to predictions from thermal-statistical models. Hydrodynamic and recombination models are tested against the measured spectra and particle ratios (baryon/meson, resonance/non-resonance) at low and intermediate $p_{\rm T}$. Finally, the $p_{\rm T}$ spectra measured in p-Pb, Xe-Xe and Pb-Pb collisions are compared to those in pp collisions in terms of nuclear modification factors and are confronted with the parton energy loss models.

Highlights from the STAR experiment

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The exploration of QCD phase diagram and study of the dynamics and mechanism of particle production in heavy-ion collisions is one of the current research interest in the field of high energy physics. In addition, the search for the QCD critical point in the phase diagram has been the main motivation to carry out the Beam Energy Scan program at the Relativistic Heavy Ion Collider (RHIC) facility at BNL. Under this program Au+Au collisions were recorded at $\sqrt{s_{NN}}$ = 7.7, 11.5, 14.5, 19.6, 27 and 39 GeV by the STAR detector at RHIC. We will present results of the identified particle production from BES energies. Our study focuses on the extraction of the chemical and kinetic freeze-out properties of the system and understanding the evolution and dynamics of particle production.

News from the Lattice

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In the talk, I will overview the recent progress in Lattice QCD techniques related to different aspects of meson physics. In particular, I will present calculations of the mass spectrum, decay constants, pion form factors, moments of meson distribution amplitudes as well as results from a direct evaluation of meson distribution amplitudes and eventually results for η/η' masses and decay constants.

Heavy mesons in the quark model

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Since the discovery of the J/Ψ the quark model was very successful describing the spectrum and properties of heavy mesons including only $q\bar{q}$ components. However since 2003, with the discovery of the $X(3872)$, many states that can not be accommodated on the naive quark model have been discovered, and they made unavoidable to include higher Fock components on the heavy meson states. We will give an overview of the success of the quark model for heavy mesons and point some of the states that are likely to be more complicated structures such as meson-meson molecules.

Poster session

Study of $\phi(2170)$ @ BESIII

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The $\phi(2170)$ maybe a strange partner of $Y(4260)$, and there are a lot of theoretical interpretations to explain the nature of $\phi(2170)$, including a traditional $s\bar{s}$ state, a $s\bar{s}g$ hybrid, tetraquark state, $\Lambda\bar{\Lambda}$ bound state, and ϕKK resonance state. Their predictions for different exclusive decays may have big discrepancy. However, there are inconsistencies on mass and width of $\phi(2170)$. There are no experimental results on exclusive decay modes predicted by theory. With 500 pb^{-1} data collected by the BESIII detector between 2.0 GeV and 3.08 GeV, we report recent results on line-shape of $e^+e^- \to K^+K^-/2(K^+K^-)/\phi\eta/\phi\eta\prime/\omega\pi^{0/-}$ and also extract resonance parameters by fitting Born cross sections of exclusive decay modes.

A Coupled-Channel Perspective for the Charmoniumlike state $X(4360)$

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Very recently, we studied charmoniumlike state $X(4260)$ in the coupled-channel quark model [1], where we considered nonperturbative creation of the quark-antiquark pair is triggered form the QCD vacuum, the so-called $^3P_0$ mechanism [2]. We computed the probabilities of various charmed meson molecules for the $X(4260)$. Our study indicates that, even though heavy quark spin symmetry forbids $S-$wave coupling of $D_1\bar{D}$ to the $^3S_1$ charmonia, viz. $\psi(nS)$, the D wave coupling is allowed and not negligible. We argued that the $X(4260)$ cannot be a pure molecule but a mixture of a charmonium and various charmed meson components. We found that the $D_1\bar{D}$ couples strongly to the $\psi(nD)$ which indicates that in the $D_1\bar{D}$ molecular picture, the charmonium core of $X(4260)$ is $\psi(nD)$ instead of $\psi(nS)$. The experimental fact that the R ratio has a dip around 4.26 GeV can be well-understood in light of this finding.

In this contribution, we plan to present the extended version of our mentioned study, where we predict the spin partners of $X(4260)$, which is identified to be the $X(4360)$ [3]. We compute the probabilities of various charmed meson molecules for the $X(4360)$

by including the contributions from intermediate excited charmed mesons [4]. We find that the channel $D_1\bar{D}^*$ couples more strongly around the $X(4360)$ mass regime, this enlighten that the most favourable molecular scenario for $X(4360)$ is the $D_1\bar{D}^*$. Hence, in coupled-channel quark model, the $X(4360)$ can be interpreted as the spin partner of the $X(4260)$. However, our analysis for the $X(4360)$ does not spotlight on its charmonium core, since the coupling of $D_1\bar{D}^*$ with $\psi(nS)$ and $\psi(nD)$ is roughly the same around $X(4360)$ mass.

References:
[1] Y. Lu, M. N. Anwar, and B.-S. Zou, Phys. Rev. D96 no. 11, (2017) 114022.
[2] Y. Lu, M. N. Anwar, and B.-S. Zou, Phys. Rev. D94 no. 3, (2016) 034021.
[3] M. N. Anwar, Y. Lu, and B.-S. Zou, in preparation .
[4] Y. Lu, M. N. Anwar, and B.-S. Zou, Phys. Rev. D95 no. 3, (2017) 034018.

Meson dissociation in hot, dense matter within the Beth-Uhlenbeck approach

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We investigate the meson dissociation in dense matter at finite temperature within the Polyakov-loop improved NJL model. To this end we first consider quark-antiquark correlations in the pion channel within a Beth-Uhlenbeck approach that treats bound states and scattering continuum on the same footing and encodes the Mott dissociation in the behaviour of the in-medium phase shifts [1]. The Mott transition is triggered by the melting of the chiral condensate which entails a drop reduction of the dynamical quark masses and thus a downwards shift of the scattering continuum which eventually "eats up" the bound state, transforming it to a resonance in the continuum. In [2] it has been demonstrated how the backreaction of the pion gas on the chiral condensate can be taken into account within the Beth-Uhlenbeck approach by adopting a simplified model of the medium-dependent phase shifts where the scattering continuum was replaced by an antibound state at the continuum threshold. In the present work [3], we relax this assumption and improve the ansatz for the continuum phase shift. We also include further low-lying meson states (kaons, ρ-mesons) and study their influence on the pseudocritical temperature of the chiral transition.

[1] D. Blaschke et al. Ann. Phys. 348 (2014) 228.
[2] D. Blaschke, A. Dubinin, D. Ebert and A. Friesen, Phys. Part. Nucl.Lett. 15 (2018) 230.
[3] I. Soudi, D. Blaschke, in preparation (2018).

Investigation of K^+ emission from Ru+Ru collisions at 1.65A GeV with FOPI.

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Investigation of kaon production in heavy ion collisions at beam energies around threshold in the elementary NN collision has often aroused interest due to its sensitivity to the in-medium modifications of basic hadron properties, like mass and decay constant [1-4]. The FOPI Collaboration has investigated the collisions of Ru+Ru at the beam kinetic energy of 1.65A GeV. An installation of the RPC-based ToF detector with the good timing capabilities and granularity enhanced the acceptance of charged kaon measurements [5]. In this contribution, we present the K^+ phase space distribution analysis. Our work is a part of the analysis of hadron emission from the abovementioned collisions, with the aim to compare the yields to the predictions of the Statistical Model [6].

[1] C. Hartnack et al., Phys. Rep. 510, 119 (2012).
[2] C. Fuchs, Prog. Part. Nucl. Phys. 56, 1 (2006).
[3] P. Gasik et al., Eur. Phys. J. A 52, 177 (2016).
[4] K. Wiśniewski et al., Eur. Phys. J. A 9, 515 (2000).
[5] M. Kiš et al., Nucl. Instr. Meth. A 646, 27 (2011).
[6] A. Andronic, P. Braun-Munzinger, J. Stachel, Nucl. Phys. A 772, 167 (2006).

Open charm measurements at CERN SPS energies with the new Vertex Detector of the NA61/SHINE experiment

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The study of open charm meson production provides an efficient tool for detailed investigations of the properties of hot and dense matter formed in nucleus-nucleus collisions. The interpretation of the existing data from the CERN SPS suffers from a lack of knowledge on the total charm production rate. To overcome this limitation the heavy-ion programme of the NA61/SHINE experiment at CERN SPS has been expanded to allow for precise measurements of particles with a short lifetime. A new Vertex Detector, based on the MIMOSA pixel chip family, was designed and constructed to meet the challenges of open charm measurements in nucleus-nucleus collisions.
A small-acceptance version of the Vertex Detector, SAVD (Small Acceptance Vertex Detector), was installed in December 2016 for data taking with Pb+Pb collisions at 150A GeV/c. An exploratory set of collected data allowed to validate the general concept of the D0 mesons detection via its $D_0 \to \pi + K$ decay channel and delivered the first indication of open charm observation at SPS energies. In October and November of 2017 a large statistic data set has been taken for Xe+La at the beam momenta of 150A, 75A, and 40A GeV/c, these data are currently under intense analysis.
The physics motivation behind the open charm measurements at the SPS energies will be discussed. Moreover, the concept of the SAVD hardware and status of the analysis will be shown, discussing challenges related to the tracking in the inhomogeneous magnetic field, as well as the matching of SAVD tracks to TPCs tracks needed for the extraction of physics results. Also, the future plans of open charm measurements in NA61/SHINE experiment related to the upgraded version of the Vertex Detector will be presented.

Production of χ_c meson pairs with additional emission

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We discuss production of different pairs of χ_c mesons with large rapidity separation. Compared to earlier calculations we include also some extra gluon emissions. The calculation is done in the collinear approximation. Both partonic and hadronic phase will be discussed. Both real and virtual corrections are taken into account. Special attention will be given to large rapidity separations. Several differential distributions will be shown. Correlations between the two χ_c mesons will be discussed. The result is important in the context of enhanced double J/ψ production.

Study of the resonance $\psi(4040)$ and its companion poles

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We study the vector state $\psi(4040)$ and its decays into the channels DD, DD^* and D^*D^* by making use a QFT approach. We study the spectral function in the vector kaonic sector up to 4.2 GeV and we are looking for the pole(s) in the complex plane. In particular, we perform a fit to the experimental data of the cross-sections of the reactions e^+e^- into DD^* and D^*D^* and investigate if, besides the standard seed pole corresponding to $\psi(4040)$, other poles exist. A possibility is to describe the meson $Y(4008)$ as a dynamically generated companion pole of $\psi(4040)$.

New results on the vector Ay and tensor Ayy and Axx analyzing powers in deuteron-proton elastic scattering at 400-1800 MeV.

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New results on the vector A_y and tensor A_{yy} and A_{xx} analyzing powers in deuteron-proton elastic scattering obtained at Nuclotron in the energy range 400-1800 MeV are presented. These data have been obtained at DSS setup at internal target station at Nuclotron-JINR using polarized deuteron beam from the new ion source. The preliminary data on the deuteron analyzing powers in the wide energy range demonstrate the sensitivity to the short-range spin structure of the nucleon-nucleon correlations.

Systematic study of the nucleon induced deuteron breakup at E=13 MeV with the JISP16 potential

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In the recent paper [1] we have revealed the shortcomings of the JISP16 nucleon-nucleon interaction [2] leading to a poor description of the nucleon-deuteron elastic scattering observables at low energies. It can be traced back to the off-the-energy-shell parts of the P-wave components of this interaction, which responsible for observed discrepancies between data and theoretical predictions. This in turn shows that the observables used during the fixing of free parameters of the JISP16 force (i.e. the energies of ground and selected excited states of some nuclei with A$\leq$16) are not sensitive enough to details of the nuclear interaction in specific partial waves.
In order to improve the JISP16 model it is necessary to refit the JISP16 force parameters. It seems reasonable to use for this purpose the nucleon-deuteron elastic scattering and/or the nucleon induced deuteron breakup data, inasmuch the exact theoretical predictions for these processes are available.
In this contribution we explore a possibility of using the nucleon induced deuteron breakup differential cross section to constrain values of the JISP16 parameters. To that end we calculate, by solving the Faddeev equation [3], the differential cross section for complete kinematical configurations defined uniquely by five independent variables describing the final state kinematics. We perform such calculations, at initial nucleon laboratory energy E=13 MeV, twice: using the JISP16 force or using the standard semi-phenomenological AV18 nucleon-nucleon potential [4]. It has been already shown that the latter force delivers a good description of deuteron breakup data [3,5]. We search over the whole phase space for the kinematical configurations for which the differences between the JISP16 predictions and the AV18 ones are big, and thus could be used for improving the JISP16 force. In a proposed poster presentation we will report the obtained results, compare them with the existing data, and discuss a usefulness of the deuteron breakup process for fixing free parameters of the JISP16 potential.
[1] R. Skibinski et al., Phys. Rev. C97, 014002 (2018).
[2] A.M.Shirokov, J.P.Vary, A.I.Mazur, and T.A.Weber, Phys. Lett. B644, 33 (2007).
[3] W.Gloeckle, H.Witala, D.Huber, H.Kamada, and J.Golak, Phys. Rept. 274, 107 (1996).
[4] R.B.Wiringa, V.G.J.Stoks, and R.Schiavilla, Phys. Rev. C51, 38 (1995).
[5] J.Kuros-Zolnierczuk et al., Phys. Rev. C66, 024004 (2002).

GPDs of ρ meson from a light-front constituent quark model

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The work is about the ρ meson unpolarized generalized parton distributions based on a light-front constituent quark model. The form factors and some other low-energy observables of the ρ meson are calculated. The contributions to the form factors and generalized parton distributions from the valence and nonvalence regimes are discussed and analyzed in detail. Moreover, by employing a Gaussian form wave packet, the ρ meson impact parameter dependent parton distributions and the impact parameter dependent form factors are introduced and discussed.

Measurement of the proton scalar polarizabilities at MAMI

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The electric (α_{E1}) and magnetic (β_{M1}) scalar polarizabilities describe the response of the nucleon to an applied electric or magnetic field. They are not only fundamental properties related to the internal structure and dynamics of the nucleon, but they are important also in other areas of physics, such as atomic structure. The values of α_{E1} and β_{M1} quoted by the Particle Data Group were determined using data on the unpolarized differential cross-section of the Compton scattering $\gamma p \to \gamma p$. The measurement of the beam asymmetry Σ_3 provides an alternative approach to the extraction of the scalar polarizabilities, with different sensitivity and systematics compared to the unpolarized cross-section. This asymmetry was measured recently for the first time below the pion photoproduction threshold by the A2 Collaboration with the Crystal Ball/TAPS experiment at MAMI (Mainz, Germany). A linearly polarized photon beam impinged on a liquid hydrogen target and the scattered photons were detected with the Crystal Ball/TAPS setup, providing almost 4π coverage.
A new high precision measurement of both a unpolarized cross-section and beam asymmetry Σ_3 is ongoing at MAMI and the polarizabilities α_{E1} and β_{M1} will be extracted with unprecedented precision. The impact of the recently obtained and expected results on the extraction of the scalar polarizabilities will be discussed in this talk.
*On behalf of the A2 Collaboration at MAMI.

Study of time reversal symmetry in the decay of Ortho-Positronium atoms using J-PET

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The Jagiellonian Positron Emission Tomograph (J-PET) is one of its kind based on organic scintillators being developed at Jagiellonian University in Krakow, Poland [1,2]. J-PET is an axially symmetric and high acceptance scanner that can be used as a multi-purpose detector system. It is well suited to pursue tests of discrete symmetries

in decays of positronium in addition to medical imaging [3,4,5]. J-PET enables the measurement of the momentum vector $\vec{k_i}$ and the polarization vector $\vec{\epsilon_j}$ of annihilation photons [4]. Measurement of polarization of high energy photons (511 keV) is a unique feature of the J-PET detector which allows the study of time reversal symmetry violation by determining the expectation values of the time reversal symmetry odd operator [4], $(\vec{\epsilon_j}.\vec{k_i}), (\text{for} j \neq i)$. So far, Time reversal symmetry violation has not been observed in purely leptonic systems [6]. The best experimental upper limits for CP and CPT (C-Charge Conjugation, P-Parity, and T-Time) symmetry violation in positronium decay is set to 0.3×10^{-3} [7,8]. According to the standard model predictions, photon-photon interaction or weak interaction can mimic the symmetry violation at the level of 10^{-9} (photon-photon interaction) and 10^{-13} (weak interactions) respectively [9-11]. There are about 6 orders of magnitude difference between the present experimental upper limit and the standard model predictions [6]. J-PET group aims to improve the sensitivity for the tests of the time reversal symmetry with respect to the previous experiments in the leptonic sector. At the turn of 2017 and 2018, a three month experimental run with the positronium produced in the porous polymer was conducted. The first results of the analysis will be presented in the poster.

[1] P. Moskal et al., Phys. Med. Biol. 61 (2016)
[2] P. Moskal et al., Nucl. Instr. and Meth. A 764 (2014) 317-321
[3] D. Kamińska et al. Eur. Phys. J. C 76, 445 (2016)
[4] P. Moskal et al., Acta Phys. Polon. B 47, 509 (2016)
[5] A. Gajos et al., Nucl. Instrum. Methods A 819, 54 (2016)
[6] V.A. Kostelecky and N. Russell, January 2018 update to *Reviews of Modern Physics* 83, 11(2011)
[7] T. Yamazaki, T. Namba, S. Asai, T. Kobayashi, Phys. Rev. Lett. 104, 083401 (2010)
[8] P.A. Vetter, S.J. Freedman, Phys. Rev. Lett. 91, 263401 (2003)
[9] M. S. Sozzi, Discrete Symmetries and CP Violation. From Experiment to Theory, Oxford University Press (2008)
[10] W. Bernreyther et. al., Z. Phys. C 41, 143 (1988)
[11] B. K. Arbic et. al., Phys. Rev. A 37, 3189 (1988)

Three-nucleon bound state calculations using the "three-dimensional" formalism

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An overview of the, so called, “three dimensional” formalism will be presented with an emphasis on three nucleon bound state calculations. In this approach calculations are performed without the partial wave decomposition (PWD) of operators - instead the three dimensional degrees of freedom of the nucleons are used. The ability to avoid PWD has possible applications in situations where a large amount of partial waves needs to be used in order to achieve convergence. These situations include scattering calculations at higher energies and bound state calculations with the Coulomb interaction. Details on

the improved implementation of three-nucleon forces in the calculations will be given. Additionally results that use the 3/2 isospin component will be presented.

Contribution of QCD Condensates to the OPE of Green Functions of Chiral Currents

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In this talk, basic properties of QCD condensates will be presented, together with theirs relation to the operator product expansion (OPE) and the two-point and three-point Green functions constructed of chiral currents. Next, we will discuss our newest results for contribution of the QCD condensates with dimension D<6 to the Green functions calculated within the framework of ChPT/RChT, i.e. chiral perturbation theory or resonance chiral theory. This matching of the OPE and such effective theories can lead to some coupling constants constraints and, therefore, thus allows us to obtain some unknown parameters of the chiral/resonance Lagrangian.

The Tests of CP and CPT Asymmetry using J-PET Detector

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Abstract
Symmetries under the parity transformation (P), charge-conjugation (C) and time reversal (T) are of fundamental importance in nuclear and elementary particle physics. Studies of the observables violating the combined CP symmetry constitute precise tests of the Standard Model. However, CP violation was observed to date only for systems involving quarks, raising the importance of searches its manifestations e.g. in purely leptonic systems.
The 3γ decay of spin-aligned ortho-positronium atoms (o-Ps) can be used to test CP invariance in such a purely leptonic system. The Jagiellonian Positron Emission Tomograph (J-PET) detection system [1] enables experimental tests of CP and CPT through measurement of the expectation values of angular correlation operators odd under these transformations and constructed from (i) spin vector of the ortho-positronium atom, (ii) co-planar momentum vectors of photons originating from the decay of positronium, and (iii) linear polarization direction of annihilation photons [2,3].
Precise experimental symmetry tests with J-PET are possible thanks to a dedicated reconstruction technique of 3γ ortho-positronium decays [4] and a positronium production chamber including a highly porous aerogel target, whose setup allows for determining the ortho-positronium spin polarization without the use of external magnetic field [5].
References: [1] E. Czerwiński et al., Acta Phys. Polon. B10, 1961 (2017).
[2] P. Moskal et al., Acta Phys. Polon. B47, 509 (2016).

[3] D. Kamińska et al., Eur. Phys. J. C76, 445 (2016).
[4] A. Gajos et al., Nucl. Instrum. and Meth. A819, 54 (2016).
[5] M. Mohammed et al., Acta Phys. Polon. A130, 1486 (2017).

S-matrix approach to the hadron gas

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In this talk, I shall discuss the S-matrix formulation of statistical mechanics, which connects the scattering matrix elements to the thermodynamic observables. The approach allows a consistent treatment of broad resonances and purely repulsive channels, while correctly implementing the constraints from the chiral perturbation theory. This provides a useful framework for identifying the limitations of the Hadron Resonance Gas model and for incorporating additional effects from hadron physics to reliably describing the thermal medium.
We shall apply the method to study (1) the ρ-meson and (2) the pion-nucleon system. In the first case, the importance of the non-resonant contribution will be demonstrated in the correct description of the soft part of the decay pion momentum spectra. For the latter, we will describe how the natural implementation of the repulsive forces can help to better understand the lattice QCD result on the baryon electric charge correlation.
Lastly, I discuss some recent progress to include inelastic effects and $N > 2$-body scatterings.

Model predictions of hadron production measurements using proton-carbon interactions at high energies

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The primary interactions of protons and the secondary interactions of protons, Kaons and pions with the target and the beam-line material dominate the uncertainty in the flux of neutrino beams. Hadron production measurements from a comprehensive set of interactions which will allow modern neutrino experiments to make more precise neutrino cross section and oscillation measurements. In this work, comprehensive results on the double differential yield of π± and k± mesons, protons and antiprotons as a function of laboratory momentum are presented. These hadrons are produced in proton-carbon interaction at high energies. EPOS 1.99, EPOS-LHC and QGSJETII-04 models are used to perform simulations. The simulation results of these three models are compared in order to conclude about the best model for the description of the particles produced in primary and secondary interactions at SPS energies. Hadron production measurements are of significant importance for a precise prediction of the neutrino beam used in the neutrino experiment and for the interpretation of Extensive Air Shower (EAS) data.

$\alpha + d \rightarrow {}^6\mathrm{Li} + \gamma$ astrophysical S-factor and its implications for Big Bang Nucleosynthesis

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The $\alpha + d \to {}^6\mathrm{Li} + \gamma$ radiative capture is studied in order to predict the ^{6}Li primordial abundance. Within a two-body framework, the α particle and the deuteron are considered the structureless constituents of ^{6}Li. Five $\alpha + d$ potentials are used to solve the two-body problem: four of them are taken from the literature, only one having also a tensor component. A fifth model is here constructed in order to reproduce, besides the ^{6}Li static properties as binding energy, magnetic dipole and electric quadrupole moments, also the S-state asymptotic normalization coefficient (ANC). The two-body bound and scattering problem is solved with different techniques, in order to minimize the numerical uncertainty of the present results. The long-wavelength approximation is used, and therefore only the electric dipole and quadrupole operators are retained. The astrophysical S-factor is found to be significantly sensitive to the ANC, but in all the cases in good agreement with the available experimental data. The theoretical uncertainty has been estimated of the order of few % when the potentials which reproduce the ANC are considered, but increases up to $\simeq 20\%$ when all the five potential models are retained. The effect of this S-factor prediction on the ^{6}Li primordial abundance is studied, using the public code PArthENoPE. For the five models considered here we find $^6\mathrm{Li/H} = (0.9 - 1.8) \cdot 10^{-14}$, with the baryon density parameter in the 3-σ range of Planck 2015 analysis, $\Omega_b h^2 = 0.02226 \pm 0.00023$.

Luminosity Determination for the Quasi-Free Nuclear Reaction in the WASA-at-COSY Experiment

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The scientific aim of our research is experimental confirmation of the existence of mesic-nucleus: a new exotic kind of nuclear matter consisting of nucleons and mesons. Already in 1986, Haider and Liu [1] postulated the hypothesis of a η-mesic nucleus. Since then, many tries have been undertaken to experimentally confirm its existence but without any conclusive result. The discovery of this new kind of an exotic nuclear matter would be very important as it might allow for a better understanding of the η meson structure and its interaction with nucleons [2,3].
Three experiments dedicated to the search of η-mesic helium has been performed by the WASA-at-COSY Collaboration at the Forschungszentrum Jülich (Germany). The measurements were carried out with high statistics and high acceptance with the WASA detection setup in deuteron-deuteron (^{4}He-η) [4,5] and proton-deuteron (^{3}He-η) [6] fusion reactions.
The measurements were performed using the ramped beam technique. During an acceleration cycle the luminosity could vary. In order to determine the luminosity dependence on the beam momentum we used the quasi-elastic proton-proton scattering, for which the cross sections were already experimentally established. In the proton-deuteron collisions, the protons from the beam scatter on the protons in the deuteron target. The neutrons from the deuterons play the role of spectators. The cross-sections for the elastic proton-proton scattering are taken from the SAID partial-wave analysis [7].

The poster will include a description of the simulation of the quasi-free $pp \to pp$ reaction, the calculation of the integrated luminosity and the determination of the luminosity dependence of the excess energy.

[1] Q. Haider, L. C. Liu, Phys. Lett., 1986, B 172, 257-260.
[2] T. Inoue, E. Oset, Nucl. Phys., 2002, A 710, 354-370.
[3] S. D. Bass, A. W. Thomas, Acta Phys. Pol., 2010, B 41, 2239-2247.
[4] P. Adlarson, et al., Nucl. Phys. A 959, 102 (2017).
[5] P. Adlarson et al., Phys. Rev. C 87, 035204 (2013).
[6] M. Skurzok, W. Krzemien, O. Rundel and P. Moskal, Acta Phys. Polon., 2016, B 47, 503-508.
[7] http://gwdac.phys.gwu.edu/

Design of a detector for studies of S = -2 baryon interaction induced by stopped $\bar{p}$ annihilation

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The experimental determination of the baryon-baryon interaction within the baryon octet allows for the development of improved hyperon-nucleon potentials and investigation of SU(3) flavor symmetry. While for the NN-system an extended data base exists, the hyperon sector is much less explored and studies of strangeness -2 systems are practically limited to searches for the H-particle [1].
The idea of the experiment is the investigation of the strangeness -2 baryonic interactions using Ξ baryons [2,3]. The low energy phase space cooled antiproton beam which will be available from ELENA or FLAIR will allow for initiation of a reaction chain resulting in the production of a Ξ hyperon with a low recoil momentum down to zero MeV/c. This can be done by annihilation of stopped antiprotons via the double strangeness exchange reaction $(\bar{K}^*, K^{(*)})$ and further interaction of $\bar{K}^*$: $\bar{K}^* N \to K\Xi$.
Experimentally, complete kinematic reconstruction can be done with a relatively simple detection setup and efficient triggering is possible due to three delayed decays of the strange particles and high multiplicity of charged particles in the final state. This, however, requires a high-resolution tracking system and a well-defined target vertex.
In this contribution, the foreseen detector setup will be presented together with preliminary results of the MC simulations focusing on the design of the target for the efficient stopping of antiprotons.

[1] R.L. Jaffe, Phys. Rev. Lett., **38**, 195 (1977).
[2] K. Kilian, *Proc. 4th LEAR Workshop*, Villars-sur-Ollon, Switzerland, 1987, ed. C. Amsler et al., Harwood Academic Publishers Chur London, 529 (1988).
[3] D. Grzonka, AIP Conference Proceedings **793**, 190 (2005).

Drift chamber calibration and particle identification in the P-349 experiment

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The goal of the P-349 experiment is to determine polarization of antiprotons produced in pA collisions [1]. Experimentally this is done by the measurement of the left-right asymmetry of elastic antiproton scattering on a liquid hydrogen target in the Coulomb-nuclear interference region.
According to preliminary calculations, the maximum of the analyzing power A_y equal to about -4.5% is reached for a four-momentum transfer $|t| = 0.003$ GeV/c [2] which corresponds to a scattering angle in the laboratory frame in the range of 10 - 20 mrad. Therefore, the required track reconstruction precision expected to be sufficient for the asymmetry determination is equal to about 1 mrad.
The experiment was performed in the PS test beam East Area, CERN in 2014 and 2015 and the data analysis is ongoing [3]. Currently, the main goals are reaching the desired track reconstruction precision and elimination of the dominant pionic background.
In this contribution the current status of the analysis will be presented with a focus on the drift chambers calibration, track identifiaction and reconstruction and particle identification with DIRC.

1. D. Grzonka et al., Acta Phys. Pol. B 46, 191 (2015).
2. J. Haidenbauer, private communication.
3. D. Alfs et al., Acta Phys. Pol. B 48, 1938 (2017).

Feasibility studies of production and electromagnetic decay studies of hyperons for HADES

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The spectrum of excited states of single- and double-strange hyperons is poorly known. The internal structure of such hyperons is controversially discussed within various models, e.g. quark, bag and molecular models [1]. The most famous example is $\Lambda(1405)$. In this context, radiative decays are predicted to be an ideal tool to discriminate between various predictions [2]. Moreover, Ξ^- production yields measured by the high Acceptance Di-Electron Spectrometer (HADES) in Ar+KCl@1.76 GeV and p+Nb@3.5GeV experiments [3] strongly overshoot model predictions and thus require more detailed studies of elementary collisions.
HADES is a versatile detector installation optimized for dilepton detection and with excellent tracking capabilities useable for strangeness measurements at SIS18 energies. HADES has been recently upgraded by an electromagnetic calorimeter, a new RICH photon detector and a forward detector. All these improvements, combined with the improved SIS18 operation of proton beams at maximum energy 4.5 GeV, opens up new experimental possibilities. In our poster, we show results of feasibility studies of the

cascade production close to the threshold and also the radiative decays of the excited hyperon states. Two benchmark channels, $pp \to \Lambda(1520)K^+p \to \Lambda(1115)e^+e^-K^+p$ and $pp \to \Xi^-K^+K^+p$, have been put into extensive simulations together with the most significant background channels. We show the results including expected count rates and signal-to-background ratios.

[1] E. Kaxiras et al., Phys. Rev. D 32, Aug 1985
[2] R.A. Williams et al., Phys. Rev. C 48, 1318 (1993)
[3] G. Agakishiev et al., Phys. Rev. Lett. 103, 132301 (2009)

Study of the performance of FT - EMC combined subsystems by measuring cosmic rays

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Straw tube detector developed for the PANDA experiment[1], will be used for tracking charged particles in the Forward Tracker (FT) for the identification of protons, pions and kaons based on the energy loss information. It will complement a high precision electromagnetic calorimetry(EMC), tracking and particle identification in the central region by means of the target spectrometer.The detector will be operated with interaction rates up to 20 MHz and read-out by a Data AcQuisition system (DAQ) performing on-line event selection according to various algorithms[2]. Synchronization Of Data Acquisition Network (SODAnet) is the protocol used to synchronize individual subsystems by providing a common clock signal and timestamps. The reconstruction of events out of many fragments is done with the Burst Building Network. The first tests of the FT-EMC combined DAQ system, have provided data sets that allow to analyze the performance of the subsystems for cosmic rays. Those tests allow to evaluate detectors as well as synchronization and processing systems. The reconstruction of particle tracks has been developed and crosschecked with the use of both detecting subsystems. The results on the track reconstruction, spatial resolution and energy loss via Time over Threshold (TOT) will be presented together with the DAQ performance.

Time Over Threshold as a measure of energy response of plastic scintillators used in the J-PET detector

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Discrete symmetries C (charge conjugation), P (parity) and T (time reversal) have been studied for decades in order to answer the question of inequality between matter and antimatter. So far most of such studies were focused on the mesons and nuclei [1,2]. But studies on discrete symmetries in the leptonic system is very scarce. Jagiellonian-Positron Emission Tomograph (J-PET) is the first of its kind constitutes of 192 plastic scintillators arranged in three layers which are positioned in a cylindrical shape [3]. Characteristic

features of the plastic scintillators (small light attenuation, high angular, and excellent time resolution) and optimized locally developed data acquisition based on FPGA, justify the JPET utilization in measuring the expectation values of the symmetry-odd operators which eventually can be used to test the discrete symmetries in positronium atom decays [3-7]. In the frame of J-PET, the charge collection is replaced with time over threshold (TOT) measurements [8,9]. In plastics due to the nonlinearity between energy deposition by incident gamma quanta and TOT values, there is a strong necessity to develop a relationship between these two quantities in order to exhaust the utilities of J-PET detector to study the discrete symmetries [5]. The geometrical acceptance of J-PET allows studying the scattering of incident gamma. By knowing the incident gamma energy and its scattering angle, the energy deposition in the scintillator can be estimated. Thus for a gamma quanta hitting the plastic scintillator one can know its scattering angle, energy deposition, and corresponding TOT values. Results obtained from the data analysis aiming to develop the relationship between energy loss by incident gamma quanta and TOT values in pursuit to study the discrete symmetries will be presented.

[1] J. L. Lees et al., Phys. Rev. Lett. 109(2012) 211801
[2] C.S. Wu et al., Phys.Rev. 105, 1413 (1957)
[3] E. Czerwinski et al., Acta Phys. Polon. B48 no. 10 (2017) 1961
[4] B. C. Hiesmayr, P. Moskal, Nature: Scientific reports 7, 15349 (2017)
[5] P. Moskal et al., Acta Phys. Polon. B 47 (2016) 509
[6] D. Kaminska et al., Eur. Phys. J. C 76(2016) 445
[7] A. Wieczorek et al., PLOS ONE 12(11): e0186728 (2017)
[8] M. Palka et al., JINST 12 (2017) P08001
[9] G. Korcyl et al., Acta Phys. Polon. B 47 (2016) 491

Study of the space charge effect and cross-talk in straw tube detectors for the PANDA experiment

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The PANDA experiment will be built at the FAIR facility to perform high precision tests of the strong interaction through $\bar{p}p$ and $\bar{p}$-A annihilations. To track charge particles, PANDA uses two straw tube trackers : cylindrical Central Tracker and planar Forward Tracker. The PANDA straws consist of very thin (27 μm) aluminized-mylar foil and are self-supporting thanks to the application of 1 bar over-pressure of the working gas. The straws will work at very high particle fluxes reaching up to 20 kHz/cm^2. We have studied gas gain drop due to the space charge produced at high rates. For this we irradiated the straws with X-rays from a strong Fe-55 source. For the studies we used a prototype straw tube module for the PANDA Forward Tracker. We have also measured electronic cross-talk between neighbouring straws in the module. Details of the applied experimental method and obtained results will be presented.

Search for the eta-mesic helium in non-mesonic decays

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The existence of mesic nuclear matter was postulated thirty years ago, however, until now it has not been confirmed experimentally. In this talk, we will report on the status of the search for the eta-mesic nuclei with the WASA-at-COSY detector. Such system in the form of the eta mesic-helium may be created for example in the deuteron-deuteron or proton-deuteron fusions. The talk will be focused on the status and perspectives of the search for the eta-mesic helium with the emphasis on new results from the studies of the non-mesonic decay channels.
P. Adlarson et al., Nucl. Phys. A 959, 102 (2017) 102
P. Adlarson et al., Phys. Rev. Lett. 120 (2018) 022002

Low-energy $K^{-}{}^{12}\mathrm{C} \to \Lambda p R$ correlated production studies by AMADEUS

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The measurement of the K^- multi-nucleon absorptions branching ratios and low-energy cross sections in both the Λp and $\Sigma^0 p$ channels are performed by the AMADEUS collaboration, exploiting the low-momentum $K^- p_K \sim 127$ MeV/c) beam produced at the DAΦNE collider. The KLOE 2004-2005 data are analyzed by reconstructing the Λp final state produced by the K^- interactions with the inner wall of the KLOE drift chamber, which is an almost pure carbon target. Such measurements are fundamental to investigate the in-medium modification of the K^- potential, which is attractive in-medium due to the partial restoration of chiral symmetry and whose behaviour in the KbarN subthreshold region is theoretically debated. Possible existence of Kbar-multinucleon bound state, whose properties are related to the controversial $\Lambda(1405)$ nature, is also experimentally debated. In kaon induced reaction the exotic state formation overlaps with the multi-absorption processes over a broad range of phase space rendering their measurements mandatory. In this work the yields of the K^- two and three nucleon absorptions (2NA and 3NA) are measured with unprecedented accuracy. The signal emitted by the intermediate formation of the exotic $K^- pp$ bound state, decaying through the Λp channel, is also critically investigated.

Open public lecture

Open public lecture: Physics and technology for proton cancer therapy

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Cancer is the second killer in Europe leading to about 30% of the number of deaths. The basic factor which determines the success of radiotherapy of cancer is delivering the highest possible dose of ionizing radiation to the tumor volume while sparing the neighboring critical organs and healthy tissues. Protons with energies from about 60 MeV to 250 MeV are useful for cancer treatment because of the phenomenon of the Bragg peak i.e. increasing of energy deposition the at the end of protons path in tissue. The proton energy can be selected in such a way that the particles range slightly exceeds the position of the tumor, which keeps save healthy tissues laying deeper. A big advantage of protons is that the unwanted doses to healthy organs are largely reduced as compared to high energy X-rays used in conventional radiotherapy. This is of particular importance to pediatric patients in whom the probability of later radiation-induced cancer should be minimized.

Progress in proton radiotherapy and the fast growing number of Proton Therapy Centers is closely related to the latest developments in the acceleration techniques, methods of beam delivery, dosimetry, quality control and diagnostics. One of the most significant innovations was the introduction of scanning proton beams, which eliminated patient specific collimators and compensators and allowed for irradiations with excellent dose distribution. Small superconducting synchrocyclotrons were introduced to reduce the cost and the space of installation. Intensive research is performed for PET and prompt gamma-rays verification of the dose delivered, development of the new methods for dosimetry as well as the patient positioning. The spin-off of research in nuclear and particle physics opens the new perspectives for improved cancer treatment.

Plenary session MONDAY

Overview on Strong Interaction from Kaonic Atoms

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Less than a decade after the first observation of X-rays from kaonic atoms, strong interaction level shifts and widths were measured directly, in addition to transition yields that indirectly provide informaion on level widths. Experiments between the mid-1970s and mid-1980s provided good quality data for 24 nuclear species from Li to U, that serve up to now as the data-base for studies of low energy K^- interaction with nuclei. Puzzles with early results on kaonic atoms of hydrogen and He were resolved by new precision experiments at KEK and Frascati between 1997 and 2007.
Early optical model analyses indicated departure of potentials from the geometry of charge distribution of nuclei, thus leading to density-dependent phenomenological interaction models that produced good fits to the data. Conflicting results were obtained from attempts to relate experiments to more fundamental K^- -nucleon interaction.
As early as in 1971 it was suggetsed that sub-threshold energies were relevant for kaonic atoms, but only since 2011 a self- consistent sub-threshold kinematics model has been applied systematically in analyses of kaonic atom data. In the last 10 years several chiral models for the K^-N interaction provided K^-N scattering amplitudes based on fits to low energy K^-N data including the latest results for kaonic hydrogen from the SIDDHARTA collaboration. Potentials based on such amplitudes within the sub-threshold kinematics model could not fit the kaonic atom data, unless an additional phenomenological term was included, interpreted as representing multi-nucleon processes. Seven mixed chiral-phenomenological models produced almost equally good fits to the data although different models predicted widely different behavior for the K^-N amplitudes below threshold.
Very recently it was shown that one could distinguish between different models by comparing predictions to experimental values of single-nucleon absorption fractions at threshold. Only two out of seven models tested were able to fit both kaonic atom data and absorption fractions. This way long-standing ambiguities regarding the K^- - nucleus potentials are now resolved, with consequences for possible binding of K^- mesons in nuclei and possible K^- condensation in astrophysical scenarios.

Low Energy Antikaon-nucleon/nuclei interaction studies by AMADEUS

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The AMADEUS collaboration is performing experimental investigations in the low energy strangeness QCD sector.
The K− nuclear absorbtion processes on light nuclear targets are studied, taking advantage of the monochromatic low-momentum negatively charged kaons produced by the DAFNE collider and exploiting the KLOE detector as an active target. The K− single and multi-nuclear absorptions on H, 4He, 9Be and 12C, both at-rest and in-flight (for a kaon momentum of 100 MeV/c), are investigated with the aim to determine the nature of the controversial Λ(1405), the non-resonant hyperon pion formation amplitude below the K^-N threshold, the yields and cross sections of K− multi-nucleon absorptions (intimately related to the antikaon multi-nucleon clusters properties) and the K− scattering cross sections on light nuclear targets.

Pion Production in NN Collisions and the Issue of Dibaryons *)

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Since pions are the lowest-mass messengers of subnucleonic degrees of freedom, the production of one or more pions in nucleon-nucleon collision processes is outstandingly suited to search for resonances in the two-baryon system. Already in the fifties, first experiments on single-pion production found first indications for a resonance near the ΔN threshold. But it took until the beginning of this millennium when the first non-trivial, narrow dibaryon resonance could be established by WASA at COSY. The dibaryon resonance $d^*(2380)$ with $I(JP) = 0(3+) - -$ first observed in the double-pionic fusion to the deuteron – has meanwhile been detected by WASA in all relevant two-pion production channels. In addition, its resonance pole has been revealed in neutron-proton scattering. Theoretical calculations describe this state either as a compact hexaquark or a dilute molecular-like object. Whereas the d^* decay into two-pion channels does not discriminate between these two scenarios, the decay into single-pion channels is very discriminatory. In the hexaquark case, this decay is heavily suppressed with a branching less than 1%. In the molecular-like case a branching of as much as 18% is expected. In order to clarify this situation, we have measured the isoscalar single-pion production in the energy region of $d^*(2380)$. As a result, we find no evidence for such a decay with an upper limit of 9%. This is in support of a compact hexaquark system being the dominant configuration. Reexamining the $pp \to pp\pi^+\pi^-$ reaction at higher beam energies we find evidence for an isotensor dibaryon resonance near the ΔN threshold. It fits very well to the calculations of Gal and Garcilazo as well as to the predictions of Dyson and Xuong. It is remarkable that now five out of the six dibaryon states predicted by Dyson and Xuong have been observed. For the sixth state with $I = 3$ so far only upper limits have been deduced from four-pion production, but this needs further, more detailed investigations. Whereas all these resonances are asymptotically composed of baryons in relative s-wave, ANKE at COSY has recently found evidence for ΔN resonances, where the two constituents are in relative p-wave. This demonstrates that there are much more possibilities to form resonances in the system of two baryons than thought before – and there may be still many surprises to come in the dibaryon issue.

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Search for the Kaonic Bound State $\bar{K}NN$ at J-PARC

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The possible existence of strongly-bound $\bar{K}$ nuclear-states has been widely discussed as a consequence of the strongly attractive $\bar{K}N$ interaction in I = 0 channels. Experimentally, however, available information is not sufficient to discriminate between a variety of conflicting interpretations so far. To break through this situation, we have performed an experimental search for the simplest kaonic nuclear bound state, $\bar{K}NN$, by the in-flight K^- + ^{3}He reactions at 1 GeV/c (J-PARC E15). The experiment investigates the $\bar{K}NN$ state both in the formation via $^3\mathrm{He}(K^-, n)X$ missing-mass spectroscopy and its decay via invariant-mass spectroscopy using $^3\mathrm{He}(K^-, \Lambda p)n$ channel.
The physics data-taking was performed at the K1.8BR beam-line in 2013 and 2015. With the data-set, we have observed a significant bump structure below the K^-pp mass-threshold in the Λp invariant-mass spectrum. In addition, we have successfully observed $\Lambda(1405)pn$ final state in K^- + ^{3}He reactions by reconstructing $\pi^{\mp}\Sigma^{\pm}pn$ events, which is of special importance to understand the production mechanism of the $\bar{K}NN$ state such as theoretically predicted $\Lambda(1405)N \to \bar{K}NN$ doorway process.
We will discuss the possible existence of the $\bar{K}NN$ state from both aspects of production and decay: $\bar{K}NN$ and $\Lambda(1405)N$ production, and Λp non-mesonic and $(\pi\Sigma)^0 p$ mesonic decay, respectively.

New results on hadron spectroscopy from JPAC

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The mission of the Joint Physics Analysis Center (JPAC) is to provide theoretical support for analysis and interpretation of data from hadron physics experiments, with primary focus on the operations at JLab12. In this talk I will give an overview of the projects and present results of a few key analysis carried out recently at JPAC.

Spectroscopy of Excited Baryon Resonances at CLAS: A Review of the 6-GeV Program

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One of the most striking phenomenon of QCD is the formation of the nucleon out of massless gluons and almost massless quarks. This system of confined quarks and gluons serves as the basic constituent of ordinary baryonic matter and exhibits the characteristic spectra of excited states, which are sensitive to the details of quark confinement. Complementary to nucleon structure studies, nucleon excitations provide a unique opportunity to explore the many facets of non-perturbative QCD. The last few years have seen significant progress toward mapping out the nucleon spectrum. The rapidly growing database of high-quality experimental results on exclusive meson photo- and electroproduction off the nucleon from experimental facilities around the world allow us to determine the scattering amplitudes in the underlying reactions and to identify nucleon resonance contributions with minimal model dependence. In this presentation, I will review recent results from the experimental program at Jefferson Lab in the 6-GeV era using the CEBAF Large Acceptance Spectrometer (CLAS) and provide an overview on our progress in understanding the nucleon resonance spectrum.

COMPASS: Meson Spectroscopy and Low-Energy Meson Dynamics

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Within the broad physics programme of the COMPASS collaboration at CERN SPS, soft reactions of high-energy hadron beams on different nuclear targets are investigated. Aiming at a better understanding of the strong interaction, novel results range from tests of chiral symmetry breaking to properties of diffractively produced meson resonances studied in their multi-particle decays, such as the $a_1(1420)$ with unusual properties. The talk will highlight the challenges of the employed experimental techniques, and as well of the analysis methods that have to be developed to a large extent along with the analysis of the world's largest data sets in the field.

Aspects of Baryon Spectroscopy at ELSA

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Hadron Spectroscopy experienced a renaissance over the last decade in both meson and baryon sectors, initially triggered by the discovery of the enigmatic X, Y, Z states. The discussion on unconventional quark-gluon compositions to understand their internal structure is in meanwhile expanded to other baryonic states in the charm sector, e.g. the pentaquark candidates observed at LHCb. Old problems and recent findings in the strange sector may suggest similar structures to exist there as well. In this light, I will discuss recent results and ongoing experiments at ELSA, especially the new BGO-OD experiment.

Parallel session A5

Mesons in NA61/SHINE

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The NA61/SHINE experiment at the CERN SPS pursues a two-fold physics programme: (1) measurements of hadron spectra in hadron-nucleus collisions for neutrino and cosmic rays experiments; and (2) study of strongly interacting matter via a two-dimensional beam momentum and system size scan, including correlations, fluctuations and hadron spectra. This contribution presents recent results on meson production from both parts of the programme, which provide important input to tune hadron production models.
The results include spectra of π^+, π^- and K^+, K^- mesons in $p+p$, p+C, Be+Be and Ar+Sc collisions at 5 beam momenta per nucleon from 20 to 158 GeV/c. They are compared with predictions of several models, none of which gives a satisfactory description of the data in all phase space regions. In particular, a surprising system size dependence of K/π ratio is observed, that cannot be described by any model.
Furthermore, spectra of ϕ mesons in $p+p$ collisions at 40, 80 and 158 GeV/c, K^0_S in p+C at 31 GeV/c, as well as ρ^0, ω and K^{*0} in π^-+C at 158 GeV/c and 350 GeV/c are presented. A spectacular failure of considered models is observed for ϕ, ρ^0 and K^{*0} production. Also, a very peculiar system size dependence of the longitudinal evolution of ϕ production, contrasting with all other measured hadrons, is shown.
Finally, preliminary results on spectator-induced electromagnetic effects in π^+, π^- production in Ar+Sc at 150A GeV/c are presented, bringing information on space-time evolution of the hot and dense matter created in the collision.

Central exclusive production of K^+K^- pairs in proton-proton collisions

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We discuss central exclusive diffractive production of light mesons in the reactions $pp \to pp\pi^+\pi^-$ and $pp \to ppK^+K^-$. The calculation is based on a tensor pomeron model [1] and the amplitudes for the processes are formulated in an effective field-theoretic

approach. We include a purely diffractive dipion continuum, and the scalar and tensor resonances decaying into pseudoscalar meson pairs including both pomeron and reggeon exchanges [2, 3]. We discuss how two pomerons couple to tensor meson $f_2(1270)$ and the interference effects of resonance and dipion continuum. We consider also the ρ^0 and Drell-Söding photoproduction mechanism [4]. We discuss also the $pp \to pp\pi^+\pi^-\pi^+\pi^-$ reaction via the intermediate $\sigma\sigma$ and $\rho\rho$ states [5] and our recent results on the $pp \to pp\phi\phi$ reaction which leads to the $ppK^+K^-K^+K^-$ final state [6]. The theoretical results are compared with existing WA102, ISR, COMPASS, STAR, CDF, and CMS experimental data and predictions for planned or being carried out experiments STAR, ALICE, ATLAS+ALFA, CMS+TOTEM, LHCb are presented. The distributions in rapidities and transverse momenta of outgoing protons and pions, the distributions in dimeson invariant mass, in a special "glueball filter variable", as well as correlations in the azimuthal angle between outgoing particles are presented. We show the influence of the experimental cuts on the integrated cross section and on various differential distributions for outgoing particles.

1. C. Ewerz, M. Maniatis, O. Nachtmann, Annals Phys. 342 (2014) 31
2. P. Lebiedowicz, O. Nachtmann, A. Szczurek, Annals Phys. 344 (2014) 301
3. P. Lebiedowicz, O. Nachtmann, A. Szczurek, Phys. Rev. D93 (2016) 054015
4. P. Lebiedowicz, O. Nachtmann, A. Szczurek, Phys. Rev. D91 (2015) 074023
5. P. Lebiedowicz, O. Nachtmann, A. Szczurek, Phys. Rev. D94 (2016) 034017
6. P. Lebiedowicz, publication in preparation.

New Results On Energy and Momentum Conservation in Meson Production for A+A Collisions at SPS Energies

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Our presentation will be based on our recent paper [1].
We construct a new, simple model of the heavy ion collision, local in the impact parameter plane, and appropriate for the SPS energy range. This model can be regarded as a new realization of the "fire-streak" approach, originally applied to studies of lower energy nucleus-nucleus reactions.
Starting from local energy and momentum conservation, we nicely describe the centrality dependence of the light meson rapidity distribution in Pb+Pb collisions at $\sqrt{s_{NN}} = 17.3$ GeV. In particular, we also explain the broadening of this distribution when going from central to peripheral collisions.
The results of our calculations are compared with SPS experimental data. We discuss the resulting implications on the role of energy and momentum conservation for the dynamics of meson production in heavy ion collisions.
A specific space-time picture emerges, where the longitudinal evolution of the system strongly depends on the position in the impact parameter (b_x, b_y) plane. In non-central

collisions, we predict the existence of "streams" of excited matter moving very close to the spectator system in configuration (x, y, z) space.
This picture is consistent with our earlier findings on the longitudinal evolution of the system as deduced from electromagnetic effects on charged pion directed flow [2], and can provide an explanation for specific low-p_T phenomena seen in the fragmentation region of Pb+Pb collisions which we also address in this talk. We present our conclusions on the link between the initial stages of the A+A collision and the final state observables connected to strong and electromagnetic phenomena on charged meson emission.
References:
[1] A. Szczurek, M. Kielbowicz and A. Rybicki, Phys. Rev. C 95 (2017), 024908.
[2] A. Rybicki and A. Szczurek, Phys. Rev. C 87 (2013), 054909.

Importance of mesons in light-by-light scattering in ultra-peripheral lead-lead collisions at the LHC

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We will report on our results for light-by-light scattering in ultraperipheral lead-lead collisions at the LHC. We calculate cross section for the elementary $\gamma\gamma \to \gamma\gamma$ subprocess taking into account the following contributions:

- box mechanisms with leptons and quarks in the loops,
- s-channel $\gamma\gamma \to$ pseudoscalar/scalar/tensor mesons which contribute to the $\gamma\gamma \to \gamma\gamma$ process and
- background from $\gamma\gamma \to \pi^0(\to \gamma\gamma)\pi^0(\to \gamma\gamma)$ process.

Our calculations of the corresponding UPC process are based on equivalent photon approximation in the impact parameter space. We use so-called realistic charge form factor of nuclei which is a Fourier transform of the charge distribution in nuclei. Our estimate shows that the $\gamma\gamma \to \gamma\gamma$ collisions can be measured at the LHC by ALICE and LHCb experiments for diphoton invariant mass > 2 GeV. We also discuss a possibility to study the $\gamma\gamma \to \eta$, $\eta 0 \to \gamma\gamma$ resonance scattering at the LHC. In our calculations we try to include several conditions and experimental limitation on, e.g. photon pseudorapidity, transverse momentum and energy of outgoing photons as well as experimental energy resolution. We predict that the $\gamma\gamma \to \eta$, $\eta 0 \to \gamma\gamma$ resonance scattering can be measured with rather good statistics. We will present many interesting differential distributions. We will discuss several trials how to reduce the $\pi^0\pi^0$ background.
This talk will be based on our analyses which will be presented in Ref. [1].
References:
[1] M. Kłusek-Gawenda, R. McNulty, R. Schicker and A. Szczurek, Measurements of light-by-light scattering in UPC of heavy ions at the LHC - smaller diphoton collision energies, paper in preparation.

Parallel session B5

Study of e+e- annihilation to hadrons at the VEPP-2000 collider

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In 2017 the SND and CMD-3 experiments resumed to take data at the VEPP-2000 e^+e^- collider after its upgrade. Using are a new positron source allows significantly increase collider luminocity. We present current status of the SND and CMD-3 experiments and recent result of data analysis, in particular, on the processes $e + e- \to \pi^+\pi^-$, $K\bar{K}$, $n\bar{n}$, $\pi^+\pi^-\eta$, $\pi^+\pi^-\pi^0\eta$, $K_SK_L\pi 0$, $\pi^0\gamma$, etc.

Recent results of the hadronic cross section measurements with the CMD-3 detector

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In 2017-2018 the CMD-3 detector continued collecting data at the electron-positron collider VEPP-2000. After upgrading the positron injection facility, an average luminosity increased by a factor of three. In 2017 the scan was performed in the center-of-mass energy range from 1 to 2 GeV while in 2018 we scanned the energy region below 1 GeV to measure the pion form factor and omega meson parameters more accurately. The beam energy was monitored continuously during data taking with precision about 100 keV using Compton backscattering techniques. The analysis of the collected data confirmed our previous result - sharp behavior of the six pion cross section near the threshold for nucleon-antinucleon pair production. In addition, we observed for the first time a similar anomaly in the cross section for the process $e^+e^- \to K^+K^-\pi^+\pi^-$ in the same energy region. Preliminary results for some other hadronic channels are also presented.

The chiral anomaly and the heterochiral and homochiral classification for mesons

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The chiral anomaly refers to the classical axial symmetry of QCD broken by quantum fluctuations. For pseudoscalar mesons, the chiral anomaly generates a sizable mixing of nonstrange and strange components, leading to the physical states $\eta(547)$ and $\eta(958)$ (the mixing angle is about $-42°$). Yet, what about mesons with different quantum numbers? We present a classifications of meson chiral multiplets into "heterochiral" and "homochiral". We find that for heterochiral multiplets, such as (pseudo)scalar states mentioned above, but also for pseudovector and pseudotensor states (and their chiral partners), the chiral anomaly generates a (possibly sizable) strange-nonstrange mixing. Besides the large mixing in $\eta(547)$ and $\eta(958)$, present decay data for the pseudotensors $\eta_2(1645)$ and $\eta_2(1870)$ shows also a large (and up to now unexplained) strange-nonstrange mixing of about $-40°$ (similar to the pseudoscalar sector). On the other hand, for so-called homochiral multiplets, such as (axial-)vector mesons as well as tensor mesons (and their chiral partners), no chirally anomalous mixing is possible, hence a very small strange-nonstrange mixing is expected. In this way, one can explain why the measured mixing in the vector mesons $\omega(782)$ and $\phi(1024)$ and in the tensor mesons $f_2(1270)$ and $f_2'(1525)$ is very small ($-3°$ and $+3°$, respectively). In turn, $\omega(782)$ and $f_2(1270)$ are mostly $\sqrt{1/2}(\bar{u}u + \bar{d}d)$ and $\phi(1024)$ and $\phi(1024)$ mostly $\bar{s}s$, respectively. The very same classification also explains a small mixing for $J = 3$ mesons.

Study of baryonic resonances and the ρ meson production in the reaction $pp \to pp\pi^+\pi^-$ at 3.5 GeV with HADES

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Pion production in NN collisions is one of the sources of information on the NN interaction and on the contribution of nucleon resonances. In particular, two-pion production in the few energy range, carries information both on $\pi\pi$ dynamics and on single and double baryon excitation. The High Acceptance Di-Electron Spectrometer (HADES)[1] installed at GSI Helmholtz-Zentrum für Schwerionenforschung in Darmstadt, designed to investigate dielectron production in heavy-ion collisions in the range of kinetic beam energies 1-2 A GeV is also an excellent detector for charged hadron detection, due to its tracking capabilities. Recently, differential and integrated cross sections for the reactions $pp \to pp\pi^0$, $pp \to pn\pi^+$ [2-3-4], $pp \to pp\pi^+\pi^-$, $pn \to pn\pi^+\pi^-$ [5], $pn \to d\pi^+\pi^-$ have been investigated with HADES at kinetic energies 1.25, 2.2 and 3.5 GeV. This talk will focus on the analysis of the $pp \to pp\pi^+\pi^-$ channel at 3.5 GeV, using results from $pp \to pp\pi^0$, $pp \to pn\pi^+$ [3] and $pp \to pK\Lambda$ [6] measured at the same energy by HADES. The contributions of the excitation of one or two baryonic resonances with masses up to 1.9 GeV and of the ρ production can be quantified. The results are compared with two theoretical models [7-8]. The results of this study provide strong constraints on the pion production mechanisms and on the various resonance contributions ($\Delta(1232), N^*(1440), ...$), as well as on the double resonance excitation and

the direct ρ production. These aspects are closely related to the interpretation of the dielectron spectra measured by the HADES collaboration. Baryonic resonances are indeed important sources of dileptons through two mechanisms: the Dalitz decay (e.g. $R \to Ne^+e^-$) and the mesonic decay with subsequent dielectron production.

[1] G. Agakishiev et al., Eur. Phys. J. A41, 243-277 (2009).
[2] G. Agakishiev et al. Eur.Phys.J. A48 (2012) 74.
[3] G. Agakishiev et al. Eur.Phys.J. A50 (2014) 82.
[4] G. Agakishiev et al. , Eur.Phys.J. A51 (2015), 137.
[5] G. Agakishiev et al., Phys.Lett. B750 (2015) 184.
[6] G. Agakishiev et al. Phys.Lett. B742 (2015) 242-248.

Parallel session C5

Discrete symmetries studies at KLOE-2

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The KLOE and KLOE-2 experiments at the Laboratori Nazionali di Frascati (Italy) collected almost 8 fb^{-1} of integrated luminosity at the ϕ-meson mass energy. The excellent time resolution of the electromagnetic calorimeter and the very good accuracy on both momentum and vertex reconstruction of the tracking system allow to study discrete symmetries to the utmost precision as well as light meson spectroscopy, dark forces searches, hadronic cross-section measurements and studies of gamma gamma-physics. CPT symmetry test with the lepton charge asymmetry measured in K_S semileptonic decays with 1.7 fb^{-1} of KLOE data, tests of Time reversal and CPT in transitions in $\phi \to K_S K_L \to \pi e \nu$, $3\pi^0(2\pi^0)$ decays and search for the CP violating $K_S \to 3\pi^0$ decay with newly acquired data with the KLOE-2 detector will be presented and discussed.

The search for symmetry violating η decays

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A continued interest in forbidden decay modes of light mesons comes from the idea that there are mechanisms which would allow a violation of the standard law of physics at a very small level. The experimental challenge for such kind of physics is mostly in the accumulated experimental statistics needed for those mesons to reach the necessary sensitivity in searching for such violations. The A2 Collaboration at the Mainz Microtron, MAMI, has collected 6.2×10^7 η mesons, produced via the $\gamma p \to \eta p$ reaction. This large statistics data set allows further improvement of the existing upper limits for branching ratio (BR) of several forbidden decays of the η meson into neutral final states.
New results for the CP violating decay mode, $\eta \to 4\pi^0$ and, for the C violating decay modes, $\eta \to 3\gamma$ and $\eta \to \pi^0\gamma$ will be presented.

Dielectron pairs from η meson decays at WASA detector

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We present the analysis of $\eta \to e^+e^-\gamma$, $\eta \to e^+e^-$ and $\eta \to \pi^0e^+e^-$ decays. Our data set was collected in proton-proton collisions at 1.4 GeV using the WASA-at-COSY experimental setup. We discuss the extraction procedure of the η meson transition form factor and show an attempt to search for physics beyond the Standard Model setting an upper limit on the coupling between photons and hypothetical dark boson. Estimates of branching ratio upper limits for very rare $\eta \to e^+e^-$ and $\eta \to \pi^0e^+e^-$ decays are also presented.

Tests of discrete symmetries in positronium decays with the J-PET detector

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Positronium is a unique laboratory to study discrete symmetries with precision limited, in principle, only by the effects due to the weak interactions expected at the level of 10^{-14} [1] and photon-photon interactions expected at the level of 10^{-9} [2]. Violation of T or CP invariance in purely leptonic systems has never been seen so far [3] and the experimental limits on CP and CPT symmetry violation in the decays of positronium are set at the level of 10^{-3} [4,5] and limits on charge conjugation violation are set at the level of 10^{-7} [6-8]. Thus, there is still a range of six orders of magnitude as regards T and CP, and two orders of magnitude as regards the C symmetry, where the phenomena beyond the Standard Model can be sought for by improving the experimental precision in investigations of decays of positronium atoms.

The newly constructed Jagiellonian Positron Emission Tomograph (J-PET) is a first PET tomograph built from plastic scintillators [9-14] and was optimized for the registration of photons from the electron-positron annihilations. It enables tests of discrete symmetries in decays of positronium atoms via the determination of the expectation values of the discrete-symmetries-odd operators [15-17].

In the talk, we will present the capability of the J-PET detector to improve the current precision of testing CP, T and CPT symmetries in the decays of positronium atoms and report on results from the first data-taking campaigns.

[1] M. Skalsey, J. Van House, Phys. Rev. Lett. 67, 1993 (1991).

[2] B. K. Arbic et al., Phys. Rev. A 37, 3189 (1988); W. Bernreuther et al., Z. Phys. C 41, 143 (1988).

[3] V. A. Kostelecky and N. Russell, 2018 update to Rev. Mod. Phys. 83, 11 (2011).

[4] T. Yamazaki, T. Namba, S. Asai, T. Kobayashi, Phys. Rev. Lett. 104, 083401 (2010).

[5] P. A. Vetter, S.J. Freedman, Phys. Rev. Lett. 91, 263401 (2003).

[6] J. Yang et al., Phys. Rev. A 54, 1952 (1996).

[7] A. P. Mills, S. Berko, Phys. Rev. Lett. 18, 420 (1967).

[8] P. A. Vetter, S. J. Freedman, Phys. Rev. A 66, 052505 (2002).

[9] J-PET: P. Moskal et al., Nucl. Instr. and Meth. A 764, 31 (2014).
[10] J-PET: P. Moskal et al., Nucl. Instr. and Meth. A 775, 54 (2015).
[11] J-PET: P. Moskal et al., Phys. Med. Biol. 61, 2025 (2016).
[12] J-PET: L. Raczynski et al., Phys. Med. Biol. 62, 5076 (2017).
[13] J-PET: M. Palka et al., Journal of Instrumentation 12, P08001 (2017).
[14] J-PET: Sz. Niedzwiecki et al., Acta Phys. Polon. B 48, 1567 (2017).
[15] J-PET: P. Moskal et al., Acta Phys. Polon. B 47, 509 (2016).
[16] J-PET: A. Gajos et al., Nucl. Instr. and Meth. A 819, 54 (2016).
[17] J-PET: D. Kaminska et al., Eur. Phys. J. C 76, 445 (2016).

Parallel session A6

Measurement of the helicity dependence of single π^0 photoproduction on deuterons.

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The study of the properties of the baryon resonances gives essential constraints on models for nucleon structure. The pion-photoproduction is a powerful tool to excite the nucleon to an intermediate resonant state and, in combination with polarised beam/target polarisation, plays an important role in the investigation of the nucleon resonances. The data for the polarisation observables accessible using a polarised photon beam and/or polarised nucleon targets are scarce in many channels, especially in those involving a neutron target. A systematic measurement is performed at the the Mainz facility by the A2@MAMI collaboration. This talk will focus on the experiment performed at the Mainz Microtron, using a circularly polarised photon beam and a longitudinally polarised deuteron target, in conjunction with the large acceptance Crystal Ball/TAPS detection setup. An overview of the status of the experiment will be given, together with the preliminary results of polarised cross section from deuteron and of the double polarization observable E for the single π^0 photoproduction reaction from the quasi-free proton and quasi-free neutron.

Triangular singularity in the reaction $\gamma p \to p\pi^0\eta$.*

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It is shown that a triangular singularity [1-4] occurs in the reaction $\gamma p \to p\pi^0\eta$ at incident photon energies in the range of 1300 - 1550 MeV. A Δ^* resonance populated in the reaction decays into an η and the $\Delta(1232)$ resonance which subsequently decays into a proton and a π^0. If the π^0 is emitted collinear with the η meson it catches up with the η meson and rescatters. Experimental evidence for this process is discussed based on recent data on the $\gamma p \to p\pi^0\eta$ reaction obtained by the CBELSA/TAPS collaboration.

[1] C. Schmid, Phys. Rev. 154 (1967) 1363.
[2] M. Mikhasenko, B. Ketzer, A. Sarantsev, Phys. Rev. D 91 (2015) 094015.
[3] M. Bayar et al., Phys. Rev. D 94 (2016) 074039.
[4] V. R. Debastiani, S. Sakai, E. Oset, Phys. Rev. C 96 (2017) 025201.
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Resonances in forward \piˆ+\piˆ- photoproduction on hydrogen

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The production amplitude is known to be dominated by mechanisms related to singularities which are closest to the physical region of the reaction. Thus the forward $\pi^+\pi^-$ photoproduction on hydrogen is dominated by one-pion exchange in the t channel. The 3-particle final state in this reaction has a complicated dynamics both in the $\pi\pi$ and πp subsystems, with a rich spectrum of resonances emerging in the latter. To account for this we use the SAID parametrisation of the πp scattering amplitudes and embed them in a gauge invariant $\gamma p \to \pi^+\pi^- p$ amplitude. As a check of our approach we have calculated the cross sections and beam asymmetries for $\gamma p \to \pi^-\Delta^{++}$ reaction at various photon energies. In order to describe the resonance spectrum in the $\pi^+\pi^-$ system we have made the partial wave expansion of the photoproduction amplitude in the $\pi^+\pi^-$ center of mass system and included the final state interaction effects. With this approach we have obtained a very good agreement with the S- and D-wave $\pi\pi$ mass distributions which are dominated by the $f_0(980)$ and $f_2(1270)$ signals, respectively.

1. R.L.Workman, R.A.Arndt, W.J.Briscoe, M.W.Paris, I.I.Strakovsky, Phys. Rev. C 86, 035202 (2012); http://gwdac.phys.gwu.edu/

Measurement of $\pi^0\pi^{+/-}$ Photoproduction off the Deuteron and D-butanol targets

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The research work of Nuclear and Particle Physics group at the University of Basel is centered around Hadron Physics sector. Photoproduction of Mesons provides an efficient tool for the study of decays of nucleon resonances and the excitation spectrum of hadrons tells about the internal degrees of freedom. Thus to know the internal structural details of nucleons and mesons, investigation of excited nucleon states via photoproduction of mesons and the modification of the properties of nucleon resonances and mesons are being studied quite extensively.

Our group is involved in some international collaborations among which the research works related to photon induced meson production are carried out in Crystal Ball A2 with MAMI(Mainz) and Crystal Barrel ELSA(Bonn) collaborations.
In the presentation, research involved in the Crystal Ball experiment in MAMI as well as my analysis work including couple of preliminary results in the context of photoproduction of double pions with unpolarized and polarized targets will mainly be discussed.

Parallel session B6

Partial Wave Analysis of HADES Data for Two-Pion Production in Pion-Nucleon Reactions

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The High Acceptance Di-Electron Spectrometer (HADES) [1], installed at GSI Helmholtzzentrum in Darmstadt, was designed to measure dielectrons in the 1-3.5 AGeV energy range. The experimental program of HADES focuses on two main goals: (I) measurements of dielectron emission of a compressed baryonic matter formed in heavy ion collisions and investigate in-medium hadron properties, and (ii) the study of dielectron production in elementary proton–proton (pp) and pion–proton (πp) collisions and taking data about hadron electromagnetic structure as well. Both objectives are complementary in a sense that the understanding of the in-medium effects involves also investigations of the dielectron invariant mass spectra in elementary πp, pp reactions. The elementary collisions, especially those with pion beams, also offer a great opportunity to unambiguously fix the description of baryonic resonances and their coupling to the light vector mesons ρ and ω, which plays an essential role for the in-medium modifications. Therefore, to understand resonances production mechanisms a systematic energy scan and high precision data are needed. In 2014 a large dataset of π-p scattering have been obtained at the four pion beam momenta 0.656, 0.69, 0.748 and 0.8 GeV/c. The data have been included into the multichannel Partial Wave Analysis (PWA) developed by the Bonn-Gatchina group [2]. Separations of cross sections of the two pion final states ($\pi^+\pi^-$ and $\pi^0\pi^-$) into dominant channels will be presented and compared to other data. In particular the role of ρN coupling will be emphasized in connection to electromagnetic form factors of baryonic resonances in the timelike region and dielectron production measured in the same experiment [3].
[1] G. Agakichiev et al. (HADES Collab.), Eur. Phys. J. A 41 (2009) 243.
[2] A.V. Sarantsev, JPS Conf. Proc. 10 (2016) 010005.
[3] W. Przygoda, EPJ Web of Conferences 130 (2016) 01021.

Partial wave analysis of pion production with fixed-t analyticity and finite energy sum rules

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I present partial wave analysis for pion photoproduction based on a dual representation: the high-energy Regge background is smoothly continued into the resonance region by means of an energy-dependent suppression factor, the resonances in the s-channel and Born contribution are added on top. This representation allows for a natural and economical way to incorporate the fixed-t analyticity. The lowest multipoles are unitarized using $\pi - N$ phases and inelasticities, and exact balance between the resonance parameters and the background is achieved by means of finite energy sum rules which ensure matching between the two. A crucial ingredient in this analysis is the use of saturated Regge trajectories that allow for a matching of the Regge asymptotics that is an essentially forward phenomenon, and wide-angle scattering regime that is governed by quark exchange and has a different scaling behavior.

Recent progress in the partial-wave analysis of the $\pi^-\pi^+\pi^-$ final state at COMPASS

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One of the main goals of the COMPASS experiment is to study the spectrum of light mesons. COMPASS has collected large data sets for a diffractive production of various final states using a 190 GeV negative hadron beam on a liquid hydrogen target. The flagship channel of this data is the process $\pi^- p \to \pi^-\pi^+\pi^- p$, for which 46×10^6 exclusive events were recorded.
This dataset was subjected to a partial-wave analysis (PWA) using a large set of 88 partial waves and splitting the data into narrow bins of the reduced squared four-momentum transfer t' from the beam to the target. This partial-wave decomposition resolves the contributions to the process with an unprecedented level of detail. The PWA result was further analyzed by performing a resonance-model fit to extract the masses and widths of the contributing 3π resonances in a novel approach, using the information on the t' dependence of the partial wave amplitudes. One of the resonances that were included in the fit is the spin-exotic π_1 resonance, which was disputed in previous analyses.

Pion radiative capture on 2H, 3H and 3He

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Radiative pion capture has been studied theoretically and experimentally for many years and for information on earlier achievements see Ref. [1]. In particular, the $\pi^- + d \to \gamma + n + n$ reaction has attracted a lot of attention, because this process can be used to extract the neutron-neutron scattering length. This issue is discussed in detail in Ref. [2], where also important references to earlier and more recent theoretical calculations can be found.

Recently, we have calculated capture rates for the $\mu^- + d \to \nu + n + n$, $\mu^- + {}^3\mathrm{He} \to \nu + {}^3\mathrm{H}$, $\mu^- + {}^3\mathrm{He} \to \nu + n + d$, $\mu^- + {}^3\mathrm{He} \to \nu + n + n + p$ [3] and $\mu^- + {}^3\mathrm{H} \to \nu + n + n + n$ [4] reactions. It is clear that the pion radiative capture can also be treated within our momentum space framework. In this contribution, the $\pi^- + {}^2\mathrm{H} \to \gamma + n + n$, $\pi^- + {}^3\mathrm{H} \to \gamma + n + n + n$, $pi^- + {}^3\mathrm{He} \to \gamma + n + d$ and $\pi^- + {}^3\mathrm{He} \to \gamma + n + n + p$ capture reactions are studied with realistic nucleon-nucleon and three-nucleon potentials under full inclusion of final-state interactions. We assume that the full initial state consists of the atomic K-shell pion wave function and the initial nucleus state. Our calculations are performed with traditional nuclear forces and a simple single-nucleon transition operator but they represent a solid base for future calculations with input from chiral effective field theory. We plan further investigations of pion radiative capture processes using the transition operator from Ref. [5].

References:

[1] Helmut W. Baer, Kenneth M. Crowe, Peter Truoel, Adv. Nucl. Phys. 9, 177 (1977).
[2] Anders Gardestig, J. Phys. G36, 053001(2009).
[3] J. Golak et al., Phys. Rev. C90, 024001 (2014)
[4] J. Golak et al., Phys. Rev. C94, 034002 (2016).
[5] Harold W. Fearing et al., Phys. Rev. C62, 054006 (2000).

Parallel session C6

Hyperon emffactors and CP tests @BESIII

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Hyperons (B) is a powerful diagnostic tool that sheds light on some of the most challenging questions in contemporary physics. One is how and why the strong force confines quarks and gluons into composite systems, e.g. protons. Strange systems probe the strong interaction in the confinement domain which makes hyperons particularly interesting. Electromagnetic form factors (EMFF's) is currently the best way to study hyperon structure. In the time-like region, the EMFF's can be complex with a relative phase. A non-zero phase polarizes the final state even when the initial state is unpolarized. Hyperons have the advantage compared to protons that their polarization is experimentally accessible by the angular distributions of their decay products. A dedicated data sample collected by the BESIII experiment for this purpose, therefore, provides new insights. Those hyperons can be produced in a polarized state makes it possible to simultaneously measure angular distributions of hyperons and anti-hyperons ($\bar{B}$) and test CP symmetry directly. This can be done e.g. via the process $e^+e^- \to J/\Psi \to B\bar{B}$. BESIII has collected the world's largest J/Ψ data sample with an ongoing experimental campaign to further increase the statistics. In addition, due to symmetric, excellent detector conditions and low hadronic background the experiment offers a clean environment for CP-violation tests using $B\bar{B}$. In this talk, I will give an outline of the methods, present the latest results and prospects for the future from the BESIII experiment.

The NPDGamma experiment: A new era in Hadronic Parity Violation

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Parity violation (PV), first observed in semileptonic decays, has been determined precisely for quarks and leptons as part of the standard model. At the hadronic level, it offers a unique probe of nucleon structure and the underlying low-energy behavior of non-perturbative QCD. The hadronic weak interaction is characterized in terms of five spin and isospin dependent S-P transition amplitudes. There is an active program to

determine these low energy couplings from hadronic PV observables using cold neutron beams at the Spallation Neutron Source (ORNL) and the NCNR reactor (NIST). These experiments are carried out in few-body observables, for which the nuclear wave functions are exactly calculable, but the effects are dominated by the strong interaction by seven orders of magnitude. The NPDGamma experiment recently completed a measurement of the PV directional gamma asymmetry with respect to the neutron spin in the reaction $n+p \to d+\gamma$. We will report this result, which is sensitive to the $\Delta I = 1$, ${}^3S_1 - {}^3P_1 N - N$ transition amplitude, a major milestone in the road to mapping out the spin and isospin dependence of the hadronic weak interaction.

Hot Medium effects on Pseudotensor η_2, π_2 and K_2 Mesons

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The investigation of mesons in hot medium can give valuable information about the nature of QCD vacuum and deconfinement phase transition. In this study, thermal properties of light-light pseudo tensor $\eta_2(1645)$, $\pi_2(1670)$ and $K_2(1770)$ mesons are examined via QCD sum rules at finite temperature. Masses and decay constants of these light unflavored mesons with $J^P = 2^-$ are estimated up to dimension-five by considering the new operators emerging at finite temperature. Our numerical results manifest that after a certain point the decay constants and masses decrease significantly due to the hot medium effects. The attained results at $T = 0$ and $T \neq 0$ might be observed in future heavy ion collision experiments.

Semiexclusive production of vector mesons in proton-proton collisions with electromagnetic dissociation of protons

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We will discuss the semiexclusive production of vector mesons in proton-proton collisions with electromagnetic dissociation of one of the protons. Several differential distribution in missing mass (M_X), or single-particle variables related exclusively to the produced vector meson are calculated for pp center-of-mass energies 7 and 13 TeV. The cross sections and distributions are compared to the cross section of the purely exclusive reaction $pp \to pVp$. For electromagnetic dissociation the important property is that the $p\gamma^\star \to Xp$ transitions are given by the electromagnetic structure function of proton. In our calculations we used different parametrizations of this function and discuss how it is constrained by data on virtual photoabsorption on a proton.
The talk is based on papers

1. Anna Cisek, Wolfgang Schaefer and Antoni Szczurek Semiexclusive production of J/ψ mesons in proton-proton collisions with electromagnetic and diffractive

dissociation of one of the protons Phys. Lett. {\bf B769} (2017) 176-186; e-Print: arXiv:1611.08210 [hep-ph]

2. paper on semiexclusive production of vector mesons (Υ, ϕ) in preparation

Plenary session TUESDAY

Search for the η-mesic bound states with the WASA-at-COSY detector

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The possible existence of η-mesic nuclei where the η meson is bound with nucleus via the strong interaction, initially postulated by Haider and Liu [1] over thirty years ago, is intensively debated by the scientific community. Some theories predict that ηN interaction is strong enough to form bound states even for the light nuclei like helium, however there are still no model independent calculations which would really help to judge whether this exotic kind of nuclear matter exists or not. The bound states have been searched in many experiments. Nevertheless, till now there is no clear evidence confirmed empirically its existence. There are only signals which might be interpreted as indications of the η-mesic nuclei.
The experiments dedicated to the search for η-mesic helium were performed with high statistics using WASA detection setups installed at the COSY accelerator in the Research Center Juelich. The search for the η-mesic bound states is conducted via the measurement of the excitation function for selected decay channels of the He-η systems using unique ramped beam technique [2,3]. In the talk, we present experimental method and recent status of the data analysis.
[1] Q. Haider, L.C. Liu, Phys. Lett. B172 (1986) 257.
[2] P. Adlarson, et al., Phys. Rev. C87, 035204 (2013).
[3] P. Adlarson, et al., Nucl. Phys. A959, 102 (2017).

Eta and Etaprime Photoproduction on the Nucleon with EtaMAID

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The isobar model EtaMAID has been updated with new high precision data on proton and neutron from MAMI, ELSA, GRAAL and CLAS. The background is described in a recently developed Regge-cut model. The resonance sector receives contributions from up to 21 N* resonances, up to 12 show also decays into the etaprime channel. A new method is discussed to avoid double counting in the overlap region of Regge and Resonances. In a detailed nucleon resonance analysis, Breit-Wigner and pole positions are compared.

Recent results from LEPS and status of LEPS2

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Two high-energy photon beamlines, LEPS and LEPS2, have been operated at SPring-8. In both beamlines, linearly polarized photon beams up to 2.9 GeV produced by laser-induced backward Compton scattering from 8 GeV electrons have been used to study quark-nuclear physics via the photoproduction of hadrons. The LEPS experiments have been carried out mainly using the forward charged-particle spectrometer since 2000, while in the new LEPS2 facility, two large acceptance detectors, the BGOegg calorimeter and the LEPS2 solenoid spectrometer, have been prepared to measure precisely both the production process and decay process simultaneously. We report on the recent LEPS results, including the Theta+ study and the coherent phi photoproduction from 4He, and on the current status of the LEPS2 experiments.

Meson Investigations by the MAMI A2 Collaboration

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for the A2 Collaboration

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The A2 Collaboration has endeavored to improve the understanding of the structure of mesons and nucleons by studying the photoproduction of the former off of the latter. These studies were performed in the A2 hall at the Mainz Microtron (MAMI), where tagged photons, unpolarized or either linearly or circularly polarized, up to energies of 1.6 GeV impinge upon proton or deuteron targets, also either unpolarized or polarized, or a range of other targets. Beyond looking at just the cross section, various polarization observables are accessible with the inclusion of these polarized initial states. The resulting photoproduced mesons are detected in the nearly 4π steradian system composed of the Crystal Ball and TAPS detectors. The combination of the Bremsstrahlung distribution of photon energies from the selectable initial electron beam energy has provided the ability to investigate the excitation spectrum of the nucleon down to the thresholds of the η and π mesons, among others. This talk will give an overview of the studies that have been performed and those that are planned for the future.

Quarkonium pair production in high-energy proton-proton collisions

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Recently there has been much interest in the pair production of quarkonia (charmonia, bottomonia). There are two main motivations behind these studies: first, these processes may help to differentiate between different proposed production mechanisms via color-octet and color-singlet $Q\bar{Q}$-pair production.

Second, the production of quarkonium pairs is expected to receive an important contribution from double parton scattering (DPS) processes. There remain a number of open problems, especially with the CMS and ATLAS data.
In the kinematics of these experiments, the leading order of $\mathcal{O}(\alpha_S^4)$ is clearly not sufficient. The double parton scattering (DPS) contribution was claimed to be large or even dominant in some corners of the phase space, when the rapidity distance Δy between two J/ψ mesons is large. However the effective cross sections σ_{eff} found from empirical analyses are about a factor 2.5 smaller than the usually accepted $\sigma_{\text{eff}} = 15\,\text{mb}$.
We will discuss, which single-parton-scattering mechanisms can mimic the behaviour of DPS induced production. Here especially the production of χ-pairs is important.

Central exclusive production at LHCb

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LHCb is an ideal detector for the investigation of central exclusive production (CEP), as it is fully instrumented between pseudorapidities of 2 and 5, operates in low pile-up conditions and has special low-multiplicity triggers for muons and hadrons. In 2015, a new sub-detector, HeRSCheL, consisting of five planes of scintillators was installed on both sides of LHCb in the LHC tunnel in order to veto backgrounds where the proton dissociates. I will review the CEP programme at LHCb and present a new measurement of the CEP of J/ψ and $\Psi(2S)$ mesons in pp collisions at a centre-of-mass energy of 13 TeV. The use of HeRSChel has reduced the backgrounds in the analysis by a factor two compare to previous results and significantly improved the precision of the measurement. Its impact will be felt in future CEP analyses in pp, proton-lead and lead-lead collisions.

Progress on Hadronic Molecules

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85 years after the first hadronic molecule, the deuteron, was discovered, now we have a few candidates for its analogies. I will review some recent progress in this field.

Light hadron decays at BESIII

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The BESIII experiment at the electron positron collider BEPCII in Beijing is successfully operating since 2008 and has collected large data samples in the τ-mass region, including the world's largest data samples at the J/ψ and ψ' resonances. In particular decays of these two resonances provide a rich and clean environment to study hadrons consisting out of light quarks and search for exotics.

The collaboration has recently started a campaign to understand the nature of the $X(18xx)$ states near the $p\bar{p}$r mass threshold, and $Y(2175)$ resonances, which are debated to be exotic matter. Besides, several isospin-violated processes were observed, in related to which the $a_0(980) - f_0(980)$ mixing was observed for the first time. Important observations have also been archived in baryon spectroscopy, where the analyses benefit from the well defined initial state in e^+e^- collisions. Further, decays of $\eta\prime$ mesons are studied to deepen our knowledge of their structure and possible symmetry breaking effects in their decays. In this presentation recent results of the light hadron physics program will be highlighted.

Outlook

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Outlook