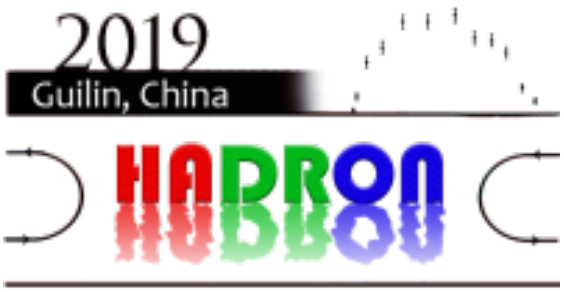
XVIII International Conference on Hadron Spectroscopy and Structure (HADRON2019)

Friday, August 16, 2019 - Wednesday, August 21, 2019

Guilin Bravo Hotel, Guilin, China



Book of Abstracts

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Session 2: Baryon sepctroscopy / **1**

Heavy excited baryons with heavy-quark spin symmetry

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The LHCb Collaboration has discovered five excited Ω_c states with masses between 3 and 3.1 GeV [1], four of them recently corroborated by the Belle Collaboration [2]. Moreover, the LHCb Collaboration has recently reported one $\Xi_b(6227)$ state [3], whereas several Ξ_c states are described in the PDG. Indeed, one Ξ_c at 2930 MeV was first reported by the BaBar Collaboration [4] and recently confirmed by the Belle Collaboration [5].

We analyze the dynamical generation of Ω_c as well as Ξ_c and Ξ_b states within a molecular baryon-meson model that is consistent with both chiral and heavy-quark spin symmetries. Earlier predictions within this model found several Ω_c, Ξ_c and Ξ_b states with masses below the experimental observations [6,7]. Thus, in order to study the possible identification of any of these states with the experimental ones in the correct energy region, we explore the effect of the renormalization scheme. We analyze which states could be dynamically generated and identified with the experimental ones while having spin-parity $J = 1/2^-$ or $J = 3/2^-$ [8,9].

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Session 3: Exotic hadrons and candidates / **2**

Properties of X(3872) beyond the effective range expansion

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We proposed a more general two-body scattering amplitude than the effective range expansion. Based on this new method, we found many new features on the exotic meson X(3872)
that is not realized previously. It can either be a bound state of $\bar{D}D^*$ or a virtual state, or a simultaneous virtual and bound state in the physical and unphysical Riemann Sheet. We also found it can

correspond to a higher-order S-matrix pole, which may be the first example of such case in hadron physics.

Session 3: Exotic hadrons and candidates / **3**

LHCb results on exotic hadrons

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The quark model, proposed in the 1960s, predicts exotic hadrons beyond the conventional quark-antiquark mesons and three quark baryons. However, it was less than 15 years ago that exotic candidates were observed. Since then a number of exotic states have been discovered. LHCb has reported on tetraquark candidates such as the X(3872) as well as the discovery of pentaquark resonances in 2015. Many theoretical approaches, including hadronic molecules and tightly bound tetra- and penta-quarks, aim to describe the nature and properties (mass/quantum numbers) of these states, also predicting that these exotic candidates may be part of a larger multiplet of exotic states. The discovery of further exotic hadrons and measurement of their properties will help to scrutinize these theoretical models and determine the internal structure of these states. 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 along with prospects for the Run 3 data, where, the pace of progress in this field is likely to accelerate.

Session 6: QCD and hadron structure / **4**

A study of excited nucleons' space-time properties with Bose-Einstein Correlations

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The space-time properties of the excited nucleons may provide useful information to test the non-perturbative QCD models attempting to describe the hadron production process. In this work we attempt to measure the excited baryon Δ(1232) 's radius using Bose-Einstein correlations (BEC) between two neutral pions from photo-production off a hydrogen/deuterium target at the incident photon energies around 1 GeV carried out at the Research Center for Electron Photon Science (ELPH) in Tohoku University with a 4π electromagnetic calorimeter complex, named FOREST. For this end, we try to establish a new BEC observing model to extract radius information from BEC effects in the presence of resonance decays and to develop an event mixing technique for measuring low-multiplicity BEC effects through adding additional mixing constraints to delicately deal with the influence of non-BEC correlations arising from global conservation laws and resonance decays.

Session 4: Hadron decays, production and interactions / **5**

Semileptonic and leptonic charm decays at BESIII

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BESIII has collected data samples corresponding to luminosities of 2.93 fb-1 and 3.19 fb-1 at center-of-mass energies of 3.773 and 4.178, respectively. We report the measurements of the decays D(s)+ -> l+v (l=mu, tau), D0(+) -> K-bar(pi)l+v (l=e,mu), D0(+) -> K-bar(pi)pie+v, D0(+) -> a0(980)e+v, Ds+ -> eta(')e+v and Ds+ -> K(*)0e+v. From these analyses, the decay constants fD(s)+, the semileptonic form factors f^P_+(0) [P=K, pi, eta(')], the CKM matrix elements |Vcs(d)| are determined precisely. These results can verity the LQCD calculations of fD(s)+ ,f^P_+(0) and the CKM matrix unitarity. Precision tests of lepton flavor universality are also made via D(s)+ -> l+v and D0(+) -> K-bar(pi)l+v, decays.

Session 4: Hadron decays, production and interactions / **6**

Hadronic charm decays at BESIII

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BESIII has collected data samples corresponding to luminosities of 2.93 fb-1, 3.19 fb-1 and 0.567 fb-1 at center-of-mass energies of 3.773, 4.178, and 4.6 GeV, respectively. The data set collected at 3.773 GeV contains quantum-correlated D0D0bar pairs that allow to access the phase differences between amplitudes. We report the measurements of strong phase differences in D0(-bar) decays, especially for K_S/Lpi+pi-, which can reduce the gamma/phi3 measurement uncertainty at LHCb and Belle II. In addition, we report the measurements of the absolute branching fraction and amplitude analysis of D+, D0, Ds+ and Lambda_c+

Session 1: Meson spectroscopy / **7**

Recent results of light hadron spectroscopy from BESIII

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With the world’s largest sample of J/psi 1.3 billion events accumulated at the BESIII detector offers a unique opportunity to study light hadron spectroscopy and decays. In this presentation, recent results of the light hadron physics at BESIII will be highlighted. The BESIII experiment has made significant progresses on the light hadron spectroscopy in the J/psi decays, including the amplitude analyses of J/psi radiative and hadronic decays.

Session 3: Exotic hadrons and candidates / **8**

New results of X(3872)

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X(3872) has been observed for more than 15 years ago, but its nature is still unclear. It is considered as an unconventional charmonium candidate. BESIII has collected about 12 fbˆ{-1} data at center of mass energies from 4.15 to 4.60 GeV. Using these data samples, the decay of X(3872) has been studied extensively, including pi0 chi_cJ, omega J/psi, pi pi J/psi, and gamma psi(1,2S). New results from these studies will be presented.

Session 3: Exotic hadrons and candidates / **9**

New results of the vector charmoniumlike states

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The vector charmoniumlike (such as Y(4260), Y(4360), and Y(4660)) states are observed in exclusive processes in electron-positron collider, but not appear in the total hadronic cross section. Understanding of these vector charmoniumlike states is a challenge. BESIII has collected more than 13 fbˆ{-1} data samples at center of mass energies from 3.8 to 4.6 GeV, including 13 energy points with luminosity larger than 500 pbˆ{-1} each, which makes the study of the small production rate or low efficiency processes possible. In this talk, new results on the vector states are presented, such as e e -> pi pi psi(3770), D1(2410) D, omega chi_c0, etaˆ(') psi(1,2S), and light hadron final states.

Session 4: Hadron decays, production and interactions / **10**

Observation of new charmonium decays at BESIII

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psi(2S) provides good opportunities for the study of chi_cJ, eta_c, and h_c decays. These studies can be used to verify QCD based models, which provide predictions for the decay mechanism. With the world's largest sample of 4.48*10ˆ8, progress on the charmonium decays has been made. In the talk, we report the new results, such as the first measurement of the branching ratioof chi_c1,2 to mu+ mu-; observation of chi_c1 to omega phi; observation of the h_c hadronic decays; the study of eta_c hadronic decay.

Session 6: QCD and hadron structure / **11**

Study of baryon form factors at BESIII

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Electromagnetic form factors of baryons provide fundamental information about their structure and dynamics. They constitute a rigorous test of non-perturbative QCD as well as of phenomenological models. However, results in the time-like region have large uncertainties. The production cross section and form factors of hyperons are hardly explored. Based on 500 pbˆ-1 of data collected with the BESIII detector between 2.0 GeV and 3.08 GeV, and data collected at the peak of the psi(3770) resonance and higher energies, we report measurements of the proton form factor in the time-like region applying the energy scan method and the initial state radiation technique. In this talk, the line-shape of the Born cross sections of hyperon pairs for Lambda and Lambda_c baryons are included, where a non-zero cross section near threshold is discerned. The relative phase angle between electromagnetic form factors G_E and G_M of Lambda is also reported.

Session 1: Meson spectroscopy / **12**

Study of phi(2170) at BESIII

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The nature of phi(2170) is still unclear. phi(2170) is proposed to be a traditional s s-bar state, an s s-bar g hybrid, a tetraquark state, a Lambda Lambda-bar bound state, or a phi KK resonance state. The predicted decay width of the individual explanations is quite different. Information from experiments on the known decay modes of phi(2170) is limited, and the measured values of mass and width of phi(2170) are inconsistent. With 500 pbˆ-1 data collected by the BESIII detector between 2.0GeV and 3.08GeV, we measure the line-shape of e+e- -> K+K-/2(K+K-)/phi eta/phi eta’/omega pi0/omega eta/K+K-pi0pi0, and extract resonance parameters by fitting the Born cross sections of the exclusive decay modes

Session 4: Hadron decays, production and interactions / **13**

Light meson decays at BESIII

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Since the high production rate of light mesons in J/psi decays, the sample of 1.3 billion Jpsi events accumulated at BESIII offer a unique laboratory for investigating light meson decays. Recently many progresses on light meson decays, e.g., eta/etaprime/omega, were achieved at BESIII, including the observation of eta’ -> rho+ pi-, precision study of eta’ ->gamma pi pi decay dynamics and the observation of a0(980)-f0(980) mixing.

Session 3: Exotic hadrons and candidates / **14**

Exotic hadrons from Dyson-Schwinger equations

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I review recent results on exotic hadrons such as glueballs and tetraquarks
obtained in the framework of functional Dyson-Schwinger and Bethe-Salpeter equations.
First results for quenched glueballs in this framework have been published in 2012; I
present an update of these results and discuss preliminary results in the unquenched case. For tetraquarks, based on our earlier results on the light scalar mesons we have generalized our approach to include heavy-light states with two charm and two light (anti-)quarks. I discuss results in the scalar and axialvector channel.

Session 1: Meson spectroscopy / **15**

Spectroscopy of the J/ψ family including charmoniumlike Y states

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Deciphering the complicated structure around 4.2 GeV observed by many experiments, we embed only one charmoniumlike state $Y(4220)$ into the J/ψ family, which plays a role of a scaling point when constructing higher charmonia above 4 GeV. To test this scenario, we provide the detailed decay properties of $Y(4220)$, and predict its partner as $\psi(4380)$ in a $4S$-$3D$ mixing scheme, whose evidence is found by analyzing the $e^+e^- \to \psi(3686)\pi^+\pi^-$ data from BESIII. Utilizing the similar idea, we study another charmoniumlike state $\psi(4415)$ via a $5S$-$4D$ mixing scheme, and predict its partner as $\psi(4500)$, whose detailed decay properties are provided to be checked with future experiments at BESIII and BelleII.

Session 1: Meson spectroscopy / **16**

Tetraquark mixing framework to explain the two light-meson nonets

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We propose a tetraquark mixing framework for the two light-meson nonets in the $J^P = 0^+$ channel, the light nonet $f_0(500)$, $f_0(980)$, $a_0(980)$, $K_0^*(800)$ and the heavy nonet $f_0(1370)$, $f_0(1500)$, $a_0(1450)$, $K_0^*(1430)$. According to this framework, one can introduce two types of tetraquark with different spin configuration, $|J, J_{12}, J_{34} = |000\rangle, |011\rangle$, where J is the spin of the tetraquark, J_{12} the diquark spin, J_{34} the antidiquark spin. They differ by the color configuration also but both have the same flavor structure. The two tetraquark types seem to have interesting correspondence with the two nonets in PDG. Indeed, the two tetraquarks mix strongly through the hyperfine color-spin interaction and

the eigenstates that diagonalize the hyperfine masses can be identified with the two nonets in PDG. We report that their hyperfine mass splitting can generate the mass gap between the two nonets qualitatively. We also discuss interesting signatures in the decays of this tetraquark model.

References:

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Session 7: Hadrons in hot and nuclear environment including hypernuclei / **17**

Quarkonia production in heavy ion collisions at LHCb

Author: Zhenwei Yang[1]

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LHCb results on quarkonia production in proton-lead collisions, using the data collected in 2016 at 8.16 TeV nucleon-nucleon centre-of-mass energy, in the forward region (pseudorapidity between 2 and 5) are presented, covering forward (pPb configuration) and backward (Pbp configuration) rapidities. Measurements include charmonia, where the prompt and from-b-decay components are disentangled, and bottomonia states. The large increase in size of the heavy flavour sample, compared to the 5 TeV sample collected in 2013, allows a remarkable improvement in the accuracy of the studies of nuclear matter effects. Coherent production of Jpsi in PbPb collisions are also presented.

Session 7: Hadrons in hot and nuclear environment including hypernuclei / **18**

Production of open heavy flavour hadrons in pPb and fixed-target collisions LHCb

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A rich set of open heavy flavour states is observed by LHCb in pPb collisions collected at 5 and 8.16 TeV nucleon-nucleon center-of-mass energies. Thanks to the LHCb forward acceptance that is complementary to general purpose detectors, heavy-flavor hadrons can be studied down to zero pT. Presented in this talk is the measurements of production of beauty hadrons and open charm states including heavy baryons, through cleanly reconstructed exclusive decays. Nuclear effects are studied, quantified by the nuclear modification factors, forward-to-backward production ratios and baryon-to-meson ratios.
LHCb has the unique capability to study collisions of the LHC beams on fixed targets. Internal gas targets of helium, neon and argon have been used so far to collect samples corresponding to integrated luminosities up to 0.1 pb-1. An upgraded target, allowing a wider choice of target gas species and to increase the gas density by up to two orders of magnitude, is going to be installed for the LHC Run 3. Results and prospects on open and hidden charm productions will be presented, which can provide crucial constraints on cold nuclear matter effects and nPDF at large x.

Session 3: Exotic hadrons and candidates / **19**

Stable heavy tetraquarks from the lattice

Author: Kim Maltman[1]

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We review recent lattice results from our collaboration (1) predicting strong-interaction-stable doubly heavy tetraquarks, and (2) investigating singly heavy exotic tetraquark channels where tetraquark candidates may be more easily accessible to experimental detection.

Session 5: Analysis tools / **20**

$Z_c(4430)$, $Z_c(4200)$, $Z_1(4050)$ and $Z_2(4250)$ as triangle singularities

Author: Satoshi Nakamura[1]

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Recent experimental observations of charged charmonium- and bottomonium-like structures have brought lots of excitements in the field of hadron spectroscopy. If these structures are associated with the existence of the corresponding hadrons, these states includes minimally two quarks and two antiquarks, being objects clearly beyond the conventional quark model picture. Such charged charmonium-like state candidates include $Z_c(4430)$ discovered by the Belle and confirmed by the LHCb in $\bar{B}^0 \to \psi(2S)K^-\pi^+$, $Z_c(4200)$ found in $\bar{B}^0 \to J/\psi K^-\pi^+$ by the Belle, and $Z_1(4050)$ and $Z_2(4250)$ observed in $\bar{B}^0 \to \chi_{c1}K^-\pi^+$ by the Belle. Existing theoretical models, which had not been ruled out by the experiments, all interpreted these candidates as four-quark states, until we recently identified a compelling alternative; this new scenario is what I am going to discuss in my presentation. I discuss that kinematical singularities in triangle loop diagrams induce a resonance-like behavior that can consistently explain the properties (such as spin-parity, mass, width, and Argand plot) of $Z_c(4430)$, $Z_c(4200)$, $Z_1(4050)$ and $Z_2(4250)$ from the experimental analyses. Also, in terms of the triangle singularities, we can naturally understand interesting experimental findings such as the appearance (absence) of $Z_c(4200)(Z_c(4430))$-like contribution in $\Lambda_b^0 \to J/\psi p\pi^-$, and the highly asymmetric shape of the spectrum bump for $Z_1(4050)$; the other theoretical models have not successfully addressed these points. Even though the proposed mechanisms have uncertainty in the absolute strengths which are currently difficult to estimate, otherwise the results are essentially determined by the kinematical effects and thus robust. This contribution is based on two recent papers: arXiv:1901.07385, 1903.08098.

Plenary session / **21**

Light meson spectroscopy at e+e- experiments

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The study of light hadrons is central to the understanding of confinement–a unique property of QCD. The quark model describs mesons as bound
states of quarks and antiquarks. LQCD and QCD-motivated models for hadrons, however, predict a richer spectrum of mesons that takes into account not only the quark degrees of freedom but also the gluonic degrees of freedom.
Recent progress in the light-quark sector with unprecedented high-statistics data sets from e+e- experiments will be reviewed.

Session 1: Meson spectroscopy / **22**

Quark model explanation of Upsilon(10860)

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The explanation of the large $e^+e^- \to \pi^+\pi^-\Upsilon\,(ns)$ $(n = 1, 2, 3)$ widths at
$\sqrt{s} = 10.866 \pm 0.002$ GeV near the $\Upsilon\,(10860)$
peak [1], about two orders of magnitude larger than those for $\Upsilon\,(ns) \to \pi^+\pi^-\Upsilon\,(1s)$
$(n = 2, 3, 4)$, has been in recent years a
theoretical challenge (see for example [2]) despite the quite natural
(according to its mass) asignment of
$\Upsilon\,(10860)$ to the
standard $\Upsilon\,(5s)$ quark model state. Moreover, the
experimental production rates of
$\Upsilon\,(10860) \to \pi^+\pi^- h_b\,(np)$
$(n = 1, 2)$ and
$\Upsilon\,(10860) \to \pi^+\pi^-\Upsilon\,(ns)$ are of the same order of magnitude whereas the calculated
$\Upsilon\,(5s) \to \pi^+\pi^- h_b\,(np)$ rates are suppressed
against
$\Upsilon\,(5s) \to \pi^+\pi^-\Upsilon\,(ns)$ ones by Heavy Quark Spin Symmetry.

We show that a good quantitative description of the
$\Upsilon\,(10860)$ mass, its
e^+e^- leptonic width and its
$\pi^+\pi^-\Upsilon\,(ns)$ production rates, as well as a qualitative
understanding of its
$\pi^+\pi^- h_b\,(np)$ production rates can be obtained under the assumption that
$\Upsilon\,(10860)$ is a mixture of the conventional
$\Upsilon\,(5s)$ quark model state with a small proportion of the lowest
1^{--} hybrid state [3].

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Session 3: Exotic hadrons and candidates / **23**

Exotic and Conventional Quarkonium Physics Prospects at Belle II

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The Belle II experiment at the SuperKEKB energy-asymmetric e^+e^- collider is a substantial upgrade of the B factory facility at the Japanese KEK laboratory. The design luminosity of the machine 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 its predecessor. From February to July 2018, the machine has completed a commissioning run and main operation of SuperKEKB has started in March 2019. Belle II is uniquely capable of studying the so-called "XYZ" particles: heavy exotic hadrons consisting of more than three quarks. First discovered by Belle, these now number in the dozens, and represent the emergence of a new category within quantum chromodynamics. This talk will present the prospects of Belle II to explore both exotic and conventional quarkonium physics.

Session 3: Exotic hadrons and candidates / **24**

Sensitivity to the X(3872) total width at the Belle II experiment

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The Belle II experiment at the SuperKEKB energy-asymmetric e^+e^- collider is a substantial upgrade of the B factory facility at the Japanese KEK laboratory. The design luminosity of the machine 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 its predecessor. From February to July 2018, the machine has completed a commissioning run and main operation of SuperKEKB has started in March 2019. The X(3872) is an exotic hadron candidate and studying the X(3872) partial widths is a good probe for the internal structure of this hadronic state. However, in order to derive partial widths, a measurement of its total width is needed. The large Belle II data set will provide an ideal environment to measure the X(3872) total width since it will be possible to use the $X(3872) \to D^0\bar{D}^0\pi^0$ decay, $which has a better mass resolution than$X(3872)\to J/\psi\pi^+\pi^-$ used in earlier work. In this presentation, we will give an overview of the analysis and the expected sensitivity to the X(3872) total width.

Session 1: Meson spectroscopy / **25**

Belle II Status and first results

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The Belle II experiment at the SuperKEKB energy-asymmetric e^+e^- collider is a substantial upgrade of the B factory facility at the Japanese KEK laboratory.
The design luminosity of the machine 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 its predecessor.
With this data set, Belle II will be able to measure the Cabibbo-Kobayashi-Maskawa (CKM) matrix,

the matrix elements and their phases, with unprecedented precision and explore flavor physics with B and charmed mesons, and τ leptons.We also expect exciting results in the study of exotic quarkonium states.
From February to July 2018, the machine has completed a commissioning run, achieved a peak luminosity of 5.5×10^{33} cm^{-2}s^{-1}, and Belle II has recorded a data sample of about 0.5 fb^{-1}.
Regular operations, with the full detector, started in March 25 2019.
In this presentation, we will review the status of the experiment and will present the first results of the 2019 run, together with the near-term prospects for quarkonium studies.

Session 5: Analysis tools / **26**

The vector-vector approach and its recent relativistic extensions

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The vector-vector approach is revisited. In the original formalism, some approximations are made, considering the vector meson to have small momenta comparing to its mass. In the $\rho - \rho$ scattering, and for Isospin$= 0$, the potential obtained is much more attractive in $J = 2$ than for $J = 0$, and thus, two bound states are found, where the one with $J = 2$ is more bound. These are identified with the $f_0(1370)$ and $f_2(1270)$. Recently, some efforts have been made to try to extend the vector-vector formalism to a fully relativistic covariant approach. In the approach of G\"ulmez et al., the on-shell factorization of the potential is done in a region where the potential is singular and develops a large discontinuous and unphysical imaginary part, and leads to the disappearance of the pole of the $f_2(1270)$. The improved approach, where an approximated N/D method is used, gets to similar findings regarding the presence of this pole. We study this in detail and discuss the convergence of the method based on dispersion relations used. We show that the method cannot be used to extrapolate the results in the energy region where the $f_2(1270)$ appears, due to the artificial singularity stemming from the on-shell factorization of the potential. Finally, we show that if the on-shell factorization is avoided, or the decay width of the rho meson is taken into account through the proper convolution of the potential, the singularity and artificial imaginary part below threshold disappear, and then, one still gets a pole around the energy of the $f_2(1270)$.

Session 1: Meson spectroscopy / **27**

Light- and strange-quark mass dependence of the $\rho(770)$ meson revisited

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Recent lattice data on smaller strange quark mass than the physical one allow us to study the strangeness dependence of connected observables as pseudoscalar decay constants and ($I = J = 1$)

-$\pi\pi$ -phase shifts for the first time. Moreover, we perform a global analysis on TrM $= c$ and $m_s = c$ trajectories, which guide new predictions on trajectories like $m_u = c$. Unitarized one-loop Chiral Perturbation Theory (or the so-called Inverse Amplitude Method),
is used to determine the quark mass dependence of these observables. As a result, precise values of the Low-Energy-Constants are given.

Session 3: Exotic hadrons and candidates / **28**

The role of charged exotic states in $e^+e^- \to \psi(2S)\,\pi^+\pi^-$

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In this work, we use the dispersion theory to provide a physical description of recent BESIII data on the reaction $e^+e^- \to \psi(2S)\,\pi^+\,\pi^-$ [1].
Taking into account explicitly the effects of charged exotic intermediate states in the t- and u-channels as well as the two-pion final state interaction, we describe the invariant mass distribution for four different e^+e^- center-of-mass energies. The effects of the $\pi\pi$ rescattering are accounted for within a model-independent single channel approach which is found to explain the $\pi\pi$-invariant mass distributions at all e^+e^- center-of-mass energies. For $q = 4.226$ GeV and $q = 4.258$ GeV the already established charged exotic state $Z_c(3900)$ is considered as the intermediate state, whereas for $q = 4.358$ GeV the rescattering of pions dominates the fits. For the highest energy, $q = 4.416$ GeV, a heavier charged exotic state with mass $m_{Z_c} = 4.016(4)$ GeV and width $\Gamma_{Z_c} = 52(10)$ MeV is essential to describe the experimental data. Although the mass of this state is consistent with the established $Z_c(4020)$, its width is significantly larger.

[1] D.A.S. Molnar, I. Danilkin, M. Vanderhaeghen, arXiv:1903.08458

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Role of a four-quark and a glueball state in pion-pion and pion-nucleon scattering

Authors: Dirk Rischke[1]; Francesco Giacosa[2]; Justin Mauldin[3]; Phillip Lakaschus[4]

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We consider the two-flavor version of the extended linear sigma model (eLSM), which contains (pseudo)scalar and (axial-)vector quark-antiquark mesons, a scalar glueball [predominantly corresponding to f0(1710)], as well as the nucleon and its chiral partner. We extend this model by the additional light scalar meson f0(500), predominantly a putative four-quark state. We investigate various interaction terms of the four-quark and glueball states with the other particles, some of which preserve and some of which explicitly break the U(1)A symmetry. We test our model by performing a global fit to masses and decay widths of the scalar resonances and pion-pion scattering lengths. We also discuss the influence of the scalar four-quark state and the glueball on the baryon sector by

evaluating pion-nucleon scattering parameters. We find that the inclusion of f0(500) improves the description of pion-pion and pion-nucleon scattering lengths.

Session 4: Hadron decays, production and interactions / **30**

Measurement of the CP-violating phase phi_s at LHCb

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Decays of the Bs meson via b ->c cbar s transitions such as Bs0 -> J/psi K K and Bs0 -> J/psi pi pi are sensitive to the CP-violating phase phi_s, which is known with a good precision from global fits based on the Standard Model. Physics beyond the Standard model can affect the Bs0-Bs0bar oscillations or contribute to second-order processes, introducing a sizable shift in phi_s and providing evidence for new dynamics. In addition, the Bs0 decay width and the decay width difference between the Bs0 mass eigenstates can be measured precisely in b -> c cbar s transitions. We present the first Run 2 measurements of these quantities at LHCb.

Session 3: Exotic hadrons and candidates / **31**

Nature of the Y(4260): A light-quark perspective

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In this work, we try to gain insights into the structure of the $Y(4260)$ from the light-quark perspective.
We study the dipion invariant mass spectrum of the $e^+e^- \to Y(4260) \to J/\psi\pi^+\pi^-$ process and the ratio of the cross sections
$\sigma(e^+e^- \to J/\psi K^+K^-)/\sigma(e^+e^- \to J/\psi\pi^+\pi^-)$. In
particular, we consider the effects of different light-quark SU(3)
eigenstates inside the $Y(4260)$. The strong pion–pion final-state interactions
as well as the $K\bar{K}$ coupled channel in the S-wave
are taken into account in a model-independent way using dispersion
theory. We find that the SU(3) octet state plays a significant
role in these transitions, implying that the $Y(4260)$ contains a
large light-quark component.
Our findings suggest that the $Y(4260)$ is neither a hybrid nor a conventional charmonium state, and they are consistent with the $Y(4260)$ having a sizeable $\bar{D}D_1$ component which, however, is not completely dominant.

Session 5: Analysis tools / **32**

Triangle singularity in the J/psi to K K f0(980) decays

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We study the J/ψ to K K f0(980) reaction and find that the mechanism to produce this decay develops a triangle singularity at K f0 invariant mass around 1515 MeV. We find the branching ratio obtained for this decay to be of the order of 10ˆ{−5}, accessible in present facilities.

Plenary session / **33**

Measurements of hadronic cross sections at low-energy e+e- colliders

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The low-energy e+e- colliders provide important information on hadronic cross sections from e+e- annihilation.
Besides rich dynamics involved in hadron production itself, such measurements also give an input to the calculation of various fundamental quantities like muon g-2, running alpha and others from various QCD applications.
A review of recent results from the Novosibirsk e+e- experiments will be presented.
The projects of the Super C-Tau factories in Novosibirsk and in China will be also
briefly discussed.

Session 6: QCD and hadron structure / **36**

Access to decoupled information of Generalized Parton Distributions (GPDs) via Double Deeply Virtual Compton Scattering (DDVCS)

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The Generalized Parton Distributions (GPDs) are the appropriate framework for a universal description of the partonic structure of the nucleon. Encoding the correlations between the elementary constituents of the nucleon, GPDs allow a 3-dimensional imaging of the nucleon from the dynamical link between the transverse position and the longitudinal momentum of partons. Double Deeply Virtual Compton Scattering (DDVCS) corresponds to the scattering from the nucleon of a virtual photon that finally generates a lepton pair $eN \to eN\gamma^* \to eNl\bar{l}$ where the final leptons can be either an e^+e^- or a $\mu^+\mu^-$ pair. The virtuality of the final photon allows to investigate the dependences of the GPDs on the initial and transferred momentum in a decorrelated way [1,2]. This unique feature of DDVCS is of relevance, among others, for the determination of the transverse parton densities and the distribution of nuclear forces.

This presentation will discuss a future "full-scale" DDVCS experiment in the context of JLab 12 GeV, model-predicted pseudo-data, and extraction of the relevant GPDs information based on a fitter algorithm.

Session 4: Hadron decays, production and interactions / **37**

Recent results on CP Violation in charm sector by LHCb

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The LHCb experiment at the LHC is a dedicated heavy flavour experiment studying hadrons containing bottom and charm quarks. During Run I (2010-2012) and Run II (2015-2018) LHCb has collected the world's largest sample of charmed hadrons which enables many studies of Charge-Parity violation (CPV) in the charm system with the highest precision up to this date.
This talk will present current results of direct and indirect CPV searches in the charm sector at LHCb with a special focus on the recent discovery of direct CPV in $D^0 \to K^-K^+/\pi^-\pi^+$ decays.

Session 5: Analysis tools / **38**

Effects of a triangle singularity on the production of Λ(1405) through πp and pp reactions

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In this work we study the effects of a triangle singularity in the cross sections of the $\pi p \to K^0\pi\Sigma$ and $pp \to pK^+\pi\Sigma$ reactions. The triangle mechanism is generated the following way: the initial scattering creates the N*resonance that decays into KΣ*, then, the K*decays into πK and the π fuses with Σ to create the Λ(1405). From this mechanism, a peak associated with the triangle singularity is expected to appear at Minv(KΛ(1405))= 2140 MeV, but in fact appears at Minv(KΛ(1405)) = 2100 MeV, due to the presence of the resonance peak of the N.* The position of the Λ(1405) is also shifted bellow 1400 MeV in the invariant mass of πΣ, as is seen in the $pp \to p\,K^+\pi\Sigma$ HADES experiment.
[Based on Phys. Rev. C 97 035203 (2018)]

Session 2: Baryon sepctroscopy / **39**

The Ω(2012) as a dynamically generated state from coupled channels

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In this work we study the possibility that the newly observed Ω(2012) is a molecular state dynamically generated from the KΞ, *ηΩ and KΞ channels. Using this picture, we find a state that has a*

large coupling to KΞ, which can be observed in the Ω(2012) → KπΞ decay. This three body decay is automatically incorporated in our chiral unitary approach by considering the mass distribution of Ξ*when calculating the KΞ* loop function. Another interesting result obtained is that, although the KΞ* channel is largely dominant, the ηΩ channel is needed for the system to bind. We conclude that the picture proposed in this work provides a natural explanation for the properties of the Ω(2012) state.
[Based on Eur. Phys. J. C78 (2018) no.10, 857]

Session 3: Exotic hadrons and candidates / **40**

The Ξc and Ξb excited states generated from meson–baryons interaction in coupled channels

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Many Ξc and Ξb resonances have been observed during past few of years. This works focus on studying several Ξc and Ξb dynamically generated states from meson-baryon interactions in coupled channels, using an extension of the local hidden gauge approach that we then unitarize using the Bethe-Salpeter equation. We are then able to identify several of our poles in the charm sector with some of the observed Ξc states [Ξc(2790), Ξc(2930), Ξc(2970), Ξc(3055) and Ξc(3080)], as well as two poles in the bottom sector that have masses and widths consistent with the newly observed Ξb(6227) resonance.
[Based on Eur.Phys.J. C79 (2019) no.2, 167]

Session 1: Meson spectroscopy / **41**

Regge trajectories in light and heavy mesons: the pattern of appearances and possible dynamical explanations

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We will briefly review the Regge approach to the hadron spectrum and advocate a dynamical emergence of principal quantum number in the known spectrum of light non-strange mesons. Further we show how the linear radial trajectories with universal slope can be extended to heavy quarkonia and give a qualitative string interpretation. After that we propose a novel and non-string mechanism leading to a natural appearance of linear Regge trajectories and explaining many mass relations.

Session 4: Hadron decays, production and interactions / **43**

CP violation in charmless B decays at LHCb

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Charmless b decays are CKM suppressed in the Standard Model and the tree amplitudes are comparable with corresponding loop amplitudes. Hence, new particles not foreseen in the SM that appear in the loops may alter observables of these decays. The violation of CP symmetry represents a promising opportunity to search for possible physic beyond the SM. In this talk, we present the most recent measurements of CPV in charmless b decays performed by LHCb.

Plenary session / **44**

Excited light baryons from quark-gluon-level calculations

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The task of mapping and explaining the spectrum of baryons and the structure of these states in terms of quarks and gluons is a longstanding challenge in hadron physics, which is likely to persist for another decade or more. We review the progress made in this topic using a functional method that combines Dyson-Schwinger equations with hadronic bound-state equations, namely Bethe-Salpeter and Faddeev equations. This framework provides a non-perturbative, Poincaré-covariant continuum formulation of Quantum Chromodynamics which is able to extract novel insight on baryon properties since the physics at the hadron level is directly related with the underlying quark-gluon substructure, via convolution of Green functions. Since the approach provides access to all momentum scales, it is particularly suited to study baryon elastic and transition form factors as well as generalized parton distributions; therefore, a recent application to the nucleon's structure functions shall be discussed.

Session 2: Baryon sepctroscopy / **45**

Study of light baryons in the Lambdac decays

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A Σ^* resonance with spin-parity $J^P = 1/2^-$ and mass in the vicinity of the $\bar{K}N$ threshold has been predicted in the five quark ficture and the unitary chiral approach. In this talk, based on the dominant Cabibbo favored weak decay mechanism, we perform a study of Λ_c^+ decays for studying the possible Σ^* state decaying into $\pi\Lambda$ or $\pi\Sigma$. We show that these Λ_c^+ decays can be used to study the possible Σ^* state.

Session 3: Exotic hadrons and candidates / **46**

Three pentaquark states or more?

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The LHCb collaboration has reported recently three pentaquark states found in the $J/\psi N$ mass distribution. Based on the constraints of the heavy quark spin symmetry combined with the local hidden gauge symmetry, we investigate the $\bar{D}^{(*)}\Sigma_c^{(*)}$ interactions, together with $J/\psi N$ and other coupled channels, using a coupled channel approach. From the poles found in the second Riemann sheets, we dynamically reproduce the three states identified with the masses and the widths. Thus, we determine their quantum numbers and approximate molecular structure as $1/2^-$ $\bar{D}\Sigma_c$, $1/2^-$ $\bar{D}^*\Sigma_c$, and $3/2^-$ $\bar{D}^*\Sigma_c$, and isospin $I = 1/2$. In our research procedure, we also predict some other states: (1) one $3/2^-$ $\bar{D}\Sigma_c^*$ state with the mass of around 4374 MeV, for which indications appear in the experimental spectrum; (2) two other near degenerate states of $1/2^-$ $\bar{D}^*\Sigma_c^*$ and $3/2^-$ $\bar{D}^*\Sigma_c^*$, found around 4520 MeV; (3) a $5/2^-$ $\bar{D}^*\Sigma_c^*$ state, appeared at the same energy. Our findings also serve as a guide for further experimental studies.

Session 1: Meson spectroscopy / **47**

The role of X(4140) and X(4160) in the reactions of B+ to Jpsi phi K and e+e- to Jpsi phi gamma

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Session 3: Exotic hadrons and candidates / **48**

First evidence of B -> h_c K and Recent Results on X and Y from Belle

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X(3872) and Y(4260) are famous for their exotic nature. We present search for $B \to Y(4260)K$, $B \to X(3872)(\to \chi_{c1}\pi^0)K$ and

$B \to X(3915)(\to \chi_{c1}\pi^0)K$ at Belle based on the full data sample accumulated by the Belle experiment at KEKB asymmetric energy e^+e^- collider. As no signal is found, upper limit on the product branching fraction is provided.
We also report evidence of $B \to h_cK$ along with first observation of the decay $\eta_c(2S) -> p\bar{p}\pi^+\pi^-$ in Belle.

Session 1: Meson spectroscopy / **49**

e+e- -> Upsilon(nS)pi+pi- scan and observation of e+e- -> gamma chi_c1 at Belle

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We report a new measurement of the $e^+e^- \to \Upsilon(nS)\pi^+\pi^-$ ($n = 1, 2, 3$) cross sections at energies from 10.52 to 11.02 GeV,
where we observe a new structure in the energy dependence of the cross sections and find evidence for the $\Upsilon(1S)\pi^+\pi^-$ production below the $B\bar{B}$ threshold.
Along with this we also present observation of $e^+e^- \to \gamma\chi_{c1}$ and search for $e^+e^- \to \gamma\chi_{c0}$, $\gamma\chi_{c2}$ and $\gamma\eta_c$ at Belle.
The results are based on the data sample collected by the Belle detector at the asymmetric energy e^+e^- collider KEKB.

Session 2: Baryon sepctroscopy / **50**

Measurement of absolute branching fraction of Xi_c baryon at Belle

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The branching fractions of ground state charmed baryon are not measured so far except for the Λ_c. Only the branching fractions relative to the primary decay modes are measured.
The measurement is important to test our understanding of weak decay of baryons and measurement of absolute production cross sections.
We report first measurement of the absolute branching fraction of Ξ_c^0 decaying into $\Xi\pi$, $\Lambda K\pi$, and $pKK\pi$
and Ξ_c^+ decaying into $\Xi\pi\pi$ and $pK\pi$.
The measurement is based on Belle data set with an integrated luminosity of 711 fb^{-1} collected at the $\Upsilon(4S)$ resonance.

Session 2: Baryon sepctroscopy / **51**

Observations of new hyperons at Belle

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The spectrum of hyperon with S=-2,-3 are still not well known.
The large data sample accumulated by the Belle experiment at KEKB asymmetric energy e^+e^- collider provide
a unique opportunity to study these hyperons.
In this presentation, we report observation and evidence of $\Xi(1620)$ and $\Xi(1690)$ in the $\Xi_c \to \Xi\pi\pi$ decay,
and observation of new excited Omega- baryon decaying into Xi K produced from bottomonium decay.

Session 5: Analysis tools / **52**

Global analysis of the Delta(1232) contribution in the pion photoproduction off nucleons

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We study the effects of the $\Delta(1232)$ resonance as an effective degree of freedom in a global analysis of the pion photo-production off nucleons. Cross sections and polarization observables have been calculated for charged and neutral pion channels in relativistic chiral perturbation theory up to third order in the δ counting. We compare our model with a large database containing the available experimental data. This allows us to strongly constrain some little known low-energy constants and even see the effect of those that are still unknown. We find that the $\Delta(1232)$ inclusion leads to an improved convergence of the chiral series. Finally, we compare our results with the low-energy constants previously determined in related calculations such as nucleon EM form factors, axial charged current and the EM $\Delta(1232)$ decay.
Our aim is to use these values for low-energy constants as inputs for further calculations involving electromagnetic and weak interactions for hadron processes in order to have a more complete and accurate description at the low energy regime of the hadronic physics.

Session 6: QCD and hadron structure / **53**

Configuration mixing of positive parity excited baryons in the large Nc limit

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The asymptotic freedom in QCD allows for accurate calculations at high energy using perturbation theory. At low energies, typical of hadronic systems, a perturbative approach using the coupling

constant as the expansion parameter is not appropriate. Baryon spectroscopy has been essential for our understanding of QCD in the low-energy, strong-coupling regime. In this context, the quark model which is based on the spin-flavor group O(3)×SU(2Nf) has since a long time been a useful tool to analyze the spectrum and properties of excited baryons. This symmetry is not something that follows from the fundamental QCD theory.
An analytic scheme to study the phenomenology of baryons and their excited states, whose connection with QCD is clearly stated, can be obtained by generalizing QCD from three colors and an SU(3) gauge group to Nc colors and an SU(Nc) gauge group.
In this talk, I will present a complete analysis of the masses of the positive parity excited baryons in the quark model O(3)×SU(6) multiplets contained in the N=2 band in the large Nc limit. We find that the mixing of the spin-flavor states is much simpler than what is naively expected in the quark model. The obtained mass degeneracies and mixing pattern constitute a signature of the contracted spin-flavor symmetry for baryons in this limit.

Session 1: Meson spectroscopy / **54**

Low energy hadron physics at KLOE/KLOE-2

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The KLOE-2 experiment completed its data-taking at the e+e- DAPHNE collider in Frascati, achieving the integrated luminosity goal of more than 5 fb-1 at the phi peak. KLOE-2 represents the continuation of KLOE with an upgraded detector and an extended physics program, which includes the study of light meson properties and decay dynamics with unprecedented statistics. The new data sample, together with the KLOE one, corresponds to more than 3x10ˆ8 eta meson events. This statistics has been used to search for the P, CP violating decay eta->pi+pi-, obtaining the most stringent upper limit for this decay.

The eta -> pi0 gamma gamma decay is an important test of ChPT because of its sensitivity to the pˆ6 term on both the branching ratio and the M(gg) spectrum. A preliminary KLOE measurement, based on 450 pb-1, provided a 4 sigma's lower value w.r.t. the most accurate determination of the BR from Crystal Ball. A new analysis with a larger data sample is in progress to confirm this result. The same five photon final state is used to search for the B boson, a postulated leptophobic mediator of dark forces.

The new four stations installed in KLOE-2 to tag electrons and positrons from the reaction e+e- -> e+e-gamma*gamma* -> e+e-X, will give the opportunity to investigate gamma-gamma physics at the phi resonance. Single pseudoscalar production will improve the determination of the two-photon decay widths of these mesons. The analysis for the pi0 final state is in progress, aiming to achieve an accuracy of O(1%). Preliminary results will be presented.

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Studies of the ISR process e+e- -> pi+pi-pi0gamma at the phi mass with the KLOE detector

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Experimental measured value of the muon magnetic moment
$a_\mu = \frac{g_\mu - 2}{2}$
has a long-standing and well known discrepancy comparing with Standard Model prediction that has been narrowed down within a range $3.2 - 3.6\,\sigma$ after years of efforts made by experimentalists and theoreticians. Previous results of dipion cross section $\sigma_{\pi\pi} = \sigma(e^+e^- \to \pi^+\pi^-)$ from KLOE have provided comprehensive and substantial studies on the largest experimental input from hadronic contribution. In order to deepen the understand of theoretical uncertainty for a_μ, it is natural to extent the studies to three pion cross section, which is the second largest hardronic contribution to a_μ.

The initial state radiation (ISR) process $e^+e^- \to 3\pi$ has been studied at a center-of-mass energy $\sqrt{s} \approx 1.019$ GeV close to the ϕ resonance using a $1.7\ \mathrm{fb}^{-1}$ data sample collected with KLOE detector at the DAΦNE year 2004/2005. In this analysis, we have studied the visible section $\sigma_{3\pi}^{\mathrm{vis}}$ of process $e^+e^- \to \pi^+\pi^-\pi^0$ for the effective center-of-mass energy $\sqrt{s'}$ corresponds to omega mass range $M_{3\pi} \in [720, 900]\ \mathrm{MeV}/c^2$.
With the same dataset, a further study of $\mathcal{C}$-violating decay $e^+e^- \to \phi \to \omega\gamma$ is being performed based on a careful investigation of the ISR process, which is the major background with identical 3π final state.

Session 2: Baryon sepctroscopy / **56**

Studies of Lambda_c(2765)^+ quantum number and other charmed baryons at Belle

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$\Lambda_c(2765)^+$ (or $\Sigma_c(2765)$) is the lightest charm baryon of which presumable identification by quark models is not known.
Currently, its properties are poorly known: J^P and isospin are not determined and no uncertainty is given in the width measurement.
With 980 fb^{-1} e^+e^- collision data collected with Belle detector, we perform the determination of quantum number.
In this presentation, detail and result of the analysis are presented. We also report recent measurements on other charmed baryons at Belle.

Session 4: Hadron decays, production and interactions / **57**

On the quark-mass dependence of meson masses and decay constants

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We study the dependence of meson masses and decay constants on
the up, down and strange quark masses [1,2,3]. The role of dynamical vector
meson degrees of freedom is scrutinized in terms of an effective chiral
Lagrangian based on the hadrogenesis conjecture. At the
one-loop level, we derive the chiral corrections to the self-energies of
the Goldstone bosons and vector mesons as well as the decay constants
of the Goldstone bosons. It is illustrated that an order-by-order
renormalizability arises once specific conditions
on the low-energy constants are imposed. We consider QCD lattice data from PACS,
QCDSF-UKQCD and HSC on the vector meson masses.
Particular attention is paid to the $\omega - \phi$ mixing phenomenon,
which is demonstrated to show a strong mass dependence.
The pion and kaon decay constants on lattice ensembles of HPQCD,
CLS and ETMC are well reproduced. It is illustrated that dynamical
vector mesons lead to significant impact on Gasser and Leutwyler' s LECs.

[1] R. Bavontaweepanya, X.-Y. Guo, M.F.M. Lutz, Phys.Rev.D98 (2018) 056005.

[2] X.-Y. Guo, M.F.M. Lutz, Nucl.Phys.A in print, arXiv:1810.07376 [hep-lat].

[3] X.-Y. Guo, M.F.M. Lutz, Nucl.Phys.A in print, arXiv:1811.00478 [hep-lat].

Session 2: Baryon sepctroscopy / **58**

Production of $N^*(1535)$ and $N^*(1650)$ in $\Lambda_c \to \bar{K}^0\eta p$ (πN) decay

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In order to study the properties of the $N^*(1535)$ and $N^*(1650)$ we calculate the mass distributions of MB in the $_c \to \bar{K}^0 MB$ decay, with $MB = \pi N(I = 1/2)$, ηp and $K\Sigma(I = 1/2)$. We do this by calculating the tree-level and loop contributions, mixing pseudoscalar-baryon and vector-baryon channels using the local hidden gauge formalism. The loop contributions for each channel are calculated using the chiral unitary approach. We observe that for the ηN mass distribution only the $N^*(1535)$ is seen, with the $N^*(1650)$ contributing to the width of the curve, but for the πN mass distribution both resonances are clearly visible. In the case of $MB = K\Sigma$, we found that the strength of the $K\Sigma$ mass distribution is smaller than that of the mass distributions of the πN and ηp in the $\Lambda_c \to \bar{K}^0\pi N$ and $\Lambda_c \to \bar{K}^0\eta p$ processes, in spite of this channel having a large coupling to the $N^*(1650)$. This is because the $K\Sigma$ pair production is suppressed in the primary productionfrom the Λ_c decay.

Plenary session / **59**

Experimental status of the XYZ structures

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Starting from the last decade of this century, many charmonium-like (also called as XYZ) states have been discovered at different experiments, including the two B-factories, BESIII,CDF, CMS, D0 and LHCb. These states are located at the charmonium region, but carry properties that can not be explained as conventional hadrons. They are considered as good candidates of exotic hadronic states which are beyond the simple configurations of hadrons in quark model. Huge amount of activities both experimentally and theoretically are made to understand the nature of these states.
Recent experimental activities will be presented in this talk, including the new information of the X(3872), new measurement of the vector states (Y) from the e^+e^- hadronic cross sections, new results of the charged Z states in B decays and e^+e^- machine.

Session 1: Meson spectroscopy / **60**

Line shape and $D^{(*)}\bar{D}^{(*)}$ probabilities of $\psi(3770)$ from the $e^+e^- \to D\bar{D}$ reaction

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We have performed a calculation of the DD$^-$, DD$^-$, DD$^-$, DD^- components in the wave function of the ψ(3770). For this we make use of the P03 model to find the coupling of ψ(3770) to these components, that with an elaborate angular momentum algebra can be obtained with only one parameter. Then we use data for the e+e-$\longrightarrow$DD$^-$ reaction, from where we determine a form factor needed in the theoretical framework, as well as other parameters needed to evaluate the meson-meson self-energy of the ψ(3770). Once this is done we determine the Z probability to still have a vector core and the probability to have the different meson components. We find Z about 80%–85%, and the individual meson-meson components are rather small, providing new empirical information to support the largely qq$^-$ component of vector mesons, and the ψ(3770) in particular. A discussion is done of the meaning of the terms obtained for the case of the open channels where the concept of probability cannot be strictly used.

Session 4: Hadron decays, production and interactions / **61**

Simulation study of the $\bar{p}p \to \bar{\Sigma}^0\Lambda$ reaction with PANDA at FAIR

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The PANDA experiment is one of the pillars of the new Facility for Antiproton and Ion Research (FAIR), currently under construction in Darmstadt, Germany. PANDA stands for antiProton ANnihilation at Darmstadt, and it will be a fixed-target experiment which will allow the study of non-perturbative phenomena of the strong interaction. These will be probed in antiproton-proton collisions in the beam momentum range of 1.5
- 15 GeV/c. Within the PANDA physics program, strangeness production will be addressed through

$\bar{p}p \to \bar{Y}Y$ processes, where Y denotes a hyperon and $\bar{Y}$ an antihyperon. Measurements of the $\bar{p}p \to \bar{\Sigma}^0\Lambda$ channel for its comparison with the existing data of the $\bar{\Lambda}\Lambda$ channel give the possibility to study the role of isospin symmetry in hadron production dynamics. This work consists of a simulation study focused on the feasibility of measuring the $\bar{p}p \to \bar{\Sigma}^0\Lambda$ reaction at PANDA. Reconstruction efficiencies and rates are presented for two antiproton beam momenta: 1.771 GeV/c and 6 GeV/c.

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Initial-final state strong interaction corrections to the B-> D l nu (tau nu) decays

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By means of the effective theory used to take into account final state interaction in weak decays with two hadrons in the final state, which sometimes leads to resonant states, we take into account the loop corrections connecting the B and D mesons via pseudoscalar or vector exchange, having intermediate (B,D), (Bs,Ds), (B,*D*) or (B*s*,*D*s) states. We find corrections that modify the strength of the B -> D l nu and B -> D tau nu decay widths and discuss the corrections to the present standard model calculations that can come from there for the ratio of widths for these reactions.

Session 3: Exotic hadrons and candidates / **63**

$\Sigma_c\bar{D}^{(*)}$ interaction in chiral perturbation theory

Authors: Bo Wang[1]; Lu Meng[2]

Co-authors: Guang-Juan Wang [1]; Shi-Lin ZHU [1]

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We employ the heavy hadron chiral perturbation theory (HHChPT) to calculate the $\Sigma_c\bar{D}^{(*)}$ potentials to the next-to-leading order. The contact, the one-pion exchange and the two-pion exchange interactions are included. We keep the mass splittings between the heavy quark spin symmetry (HQSS) multiplets in calculation. We show that neglecting the heavy quark symmetry (HQS) violation effect may be misleading to calculate the charmed hadron potential. We give three scenarios to do numerical analysis. In the first scenario, we relate the low energy constants (LECs) for contact terms of $\Sigma_c\bar{D}^{(*)}$ to those of nucleon systems. We reproduce the $P_c(4312)$ and $P_c(4440)$ as loosely bound states. In the second scenario, we vary the unknown LECs and find a small parameter regions in which $P_c(4312)$, $P_c(4440)$ and $P_c(4457)$ can coexist as molecular states. In the third scenario, we include the couple channel effect on the basis of scenario II. We can reproduce the three P_c states simultaneously in a large region of parameters as molecular states. Our numerical results for now is rough without the experimental data as input. We call for the lattice QCD simulation on the $\Sigma_c\bar{D}^{(*)}$ potentials. Our analytical results can be used for the chiral extrapolation. With the lattice QCD results as input, identification of P_c states and prediction in this work can be more precise.

Session 7: Hadrons in hot and nuclear environment including hypernuclei / 64

Studying the phi meson in nuclear matter from simulated pA reactions

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The behavior of the ϕ meson in nuclear matter has attracted renewed interest because of (recent and future) experiments that aim to study its properties in nuclei [1-3]. Theoretically, many works have however been conducted assuming infinite nuclear matter [4-5], which is not realistic from an experimental point of view. To relate theoretical predictions with experimental observables, a thorough understanding of the actual reaction, in which the ϕ meson is produced in a nucleus, is required. For the past E325 experiment at KEK [1] and the future E16 experiment at J-PARC, this is a pA reaction with initial proton energies between 10 and 30 GeV. To simulate such a reaction, we make use of the PHSD transport code, which is based on a covariant microscopic transport model [6]. In this framework, the ϕ meson spectral function obtained theoretically as a function
of density, can be used as an input, while the output of the simulation can be compared with experimentally observed dilepton spectrum.
In this presentation, I will give an overview of first results obtained in simulations of the reactions probed
at the E325 and E16 experiments.

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Session 7: Hadrons in hot and nuclear environment including hypernuclei / 65

Dense nuclear matter based on a chiral model with parity doublet structure

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I will summarize our recent works on the study of nuclear matter based on a chiral model with parity doublet structure.
In our model, we construct a chiral model including four light nucleons, N(939), N(1440), N(1535) and N(1650) based on the parity doublet structure.
We first determine the model parameters by fitting them to available experimental values of masses, widths and the axial charges including the results of lattice analyses.
Next, we apply this model to symmetric nuclear matter and neutron star matter in a mean field approximation.
We find that model parameters are restricted by requiring that the saturation properties: saturation

density, binding energy, incompressibility and the symmetry energy at normal nuclear density, are satisfied. We also find that model parameters are further constrained by the tidal deformability which was recently measured by the observation of neutron star merger.

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Session 4: Hadron decays, production and interactions / **66**

Recent results from the SND experiment at the VEPP-2000 collider

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The Spherical Neutral Detector (SND) collect data at the VEPP-2000 e^+e^- collider in Novosibirsk. In this talk we present latest SND results on study of processes of e^+e^- annihilation into exclusive hadronic states at c.m. energy below 2 GeV. In particular, we discuss measurement of the $e^+e^- \to \pi^+\pi^-$ cross section in the c.m. energy 0.52 - 0.88 GeV and the $e^+e^- \to n\bar{n}$ cross section near nuclon anti-nuclon production threshold, study of the $e^+e^- \to \pi^0\gamma$ in the c.m. energy 1.075 - 2.00 GeV, and search for the direct production of the C-even resonances η and f_1 in e^+e^- annihilation.

Session 7: Hadrons in hot and nuclear environment including hypernuclei / **67**

Catalytic effects of monopoles in QCD on the phase transitions

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The existence of monopoles has been theoretically predicted since P. A. M. Dirac introduced the magnetic monopole in quantum mechanics. Moreover, a large number of experiments to observe monopoles have been conducted. Recently, in the field of condensed matter physics, a research group has reported that they created magnetic monopoles in the Bose-Einstein condensate and observed it in the laboratory. In the high energy experiment, observations of monopoles and dyons have been attempted at the Monopole and Exotics Detector at the LHC, however, monopoles have not been detected yet.

The purpose of this research is to find a clue to observe monopoles, which condense in the QCD vacuum and relate to the color confinement, by experiments. In order to find the clue, we add the classical fields of the monopole and the anti-monopole to the QCD vacuum and calculate the Dirac operator of the overlap fermion which preserves the exact chiral symmetry in the lattice gauge theory, from the QCD vacuum. We then estimate catalytic effects of the additional monopole and anti-monopole on the physical quantities by the numerical calculations.

In the study using the configurations of the low temperature, we have already found the additional monopole and anti-monopole form the long loops and create instantons and anti-instantons which closely relate to spontaneous chiral symmetry breaking. We have shown that the value of the chiral condensate (defined as the minus value) decreases, the pion decay constant increases, and the masses

of the light quarks and the mesons become heavy, by varying the values of the magnetic charges of the additional monopole and anti-monopole. Finally, we have discovered that the decay width of pion becomes wider and the lifetime of pion becomes shorter than the experimental results, by varying the values of the magnetic charges of the additional monopole and anti-monopole. These are the catalytic effects of monopoles in QCD (arXiv:1807.04808).

In this research, we add the monopole and anti-monopole to the configurations of the finite temperature and investigate catalytic effects of monopoles in QCD on quark confinement-deconfinement phase transition, and chiral symmetry breaking and the restoration. We find that the additional monopole and anti-monopole increase the temperature of quark confinement-deconfinement phase transition, moreover, the restoration of chiral symmetry breaking does not occur, by varying the values of the magnetic charges of the additional monopole and anti-monopole.

In this talk, I would like to present our preliminary results about the catalytic effects of QCD monopoles in the finite temperature.

Session 6: QCD and hadron structure / **68**

The DVCS experiment in Hall C at Jefferson Lab with the new NPS detector

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Deeply Virtual Compton Scattering (DVCS) is the simplest exclusive process to access Generalized Parton Distributions (GPDs). GPDs encode the correlation between the spacial distribution of partons inside the nucleon and their momentum. An upcoming DVCS experiment in Hall C at Jefferson Lab (Virginia, U.S.A.) will provide the highest precision data in a vast Q^2-x_B region accessible by a 11 GeV electron beam. It will further test the leading twist dominance of the observables and get more precise data in lower x_B region needed for the full mapping of GPDs. A Neutral Particle Spectrometer (NPS) is being developed for this experiment. It consists of an electromagnetic calorimeter made of 1080 PbWO4 crystals. We will present the status of the detector R&D and construction, as well as simulation results of its performance.

Session 1: Meson spectroscopy / **69**

Heavy K* meson with hidden charm

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We report a robust prediction of heavy K^* meson, which can be viewed as the excited Kaon state with hidden charm, through a study of the three-body system $KD\bar{D}^*$ using the fixed-center approximation to the Feddeev equations [1]. The two-body interactions are stringently constrained by the experimental as well as theoretical investigations. Concrete coupled channel three-body calculations yield the heavy K^* meson, $4307 \pm 2 - i9 \pm 2$ MeV, with $I(J^P) = 1/2(1^-)$. With the motivation to investigate the properties of $K^*(4307)$, which can be observed in experiments, we further perform a study of the decay processes of $K^*(4307)$ to two-body and three-body channels [2]. We hope that our findings could inspire the experimental community to investigate this exotic K^* meson and to study the so far unexplored heavy strange physics, help improve our understanding of nonperturbative strong interactions.

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Session 7: Hadrons in hot and nuclear environment including hypernuclei / **70**

On the stability of $\Lambda(1405)$-matter

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We report on our recent study of systems composed solely of $\Lambda(1405)$ (denoted by Λ^*) baryons [1] in which we test a hypothesis of absolutely stable strange hadronic matter [2]. We employed a broad range of $\Lambda^*\Lambda^*$ interaction strengths compatible with binding energy of 2 Λ^* system $B(2\Lambda^*) = 40$ MeV given by the phenomenological energy-independent $\bar{K}N$ interaction model by Yamazaki and Akaishi (YA) [3]. We performed calculations of Λ^* few-body systems within the Stochastic Variational Method (SVM) and many-body systems within the Relativistic Mean-Field (RMF) approach. We found that within the RMF calculations the binding energy per Λ^*, B/A, saturates for $A \geq 120$ with values of B/A considerably below 100 MeV, leaving Λ^* matter highly unstable against strong decay to Λ and Σ hyperon aggregates. The central density of Λ^* matter is found to saturate as well, at roughly twice nuclear matter density. Moreover, we demonstrate that the YA interaction model [3] fails to reproduce the K^- single-nucleon absorption fractions at rest from bubble chamber experiments [4,5,6].

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Session 3: Exotic hadrons and candidates / **71**

On decays of $X(3872)$ to $\chi_{cJ}\pi^0$ and $J/\psi\pi^+\pi^-$

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By describing the $X(3872)$ using the extended Friedrichs scheme, in which $D\bar{D}^*$ is the dominant component, we calculate the decay rates of the $X(3872)$ to π^0 and a P-wave charmonium χ_{cJ} state with $J = 0, 1,$ or 2, and its decays to $J/\psi\pi^+\pi^-$ where $\pi^+\pi^-$ are assumed to be produced via an intermediate ρ state. The decay widths of $X(3872) \to \chi_{cJ}\pi^0$ for $J = 0, 1, 2$ are of the same order. However, this model calculation exhibits that the decay rate of $X(3872)$ to $\chi_{c1}\pi^0$ is one order of magnitude smaller than its decay rate to $J/\psi\pi^+\pi^-$.

Session 2: Baryon sepctroscopy / **73**

Decay properties of bottom and doubly charmed baryons in light-cone sum rules

Authors: Atsushi Hosaka[1]; Er-Liang Cui[2]; Hua-Xing Chen[2]; Hui-Min Yang[2]; Shi-Lin ZHU[3]; Wei Chen[4]; Xiang Liu[3]

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In this talk, I would like to report our recent study on decay properties of a few heavy favor baryons, including the excited bottom baryons, $\Sigma_b(6097)^{\pm}$, $\Xi_b(6227)^-$ and the doubly charmed baryons Ξ_{cc}^{*++}. We utilize the method of light-cone sum rules, which is widely used to study the hadron decays in recent years. Our estimations suggest that the bottom baryons $\Sigma_b(6097)^{\pm}$ and $\Xi_b(6227)^-$ both belong to the P-wave bottom baryon doublet $[\mathbf{6}_F, 2, 1, \lambda]$, whose color is symmetric $\mathbf{6}_F$, the total angular momentum of light system is 2, the spin of light system is 1 and it is λ-type excitation. We also calculate the electromagnetic transition widths of the doubly heavy baryon Ξ_{cc}^{*++}, Ξ_{cc}^{*+}, Ω_{cc}^{*+}, Ξ_{bb}^{*0}, Ξ_{bb}^{*-} and Ω_{bb}^{*-}. The decay width of the process $\Xi_{cc}^{*++} \to \Xi_{cc}^{++}\gamma$ is estimated to be $13.7^{+17.7}_{-7.9}$ keV, which is large enough to be measured in future LHCb and BelleII experiments.

Session 6: QCD and hadron structure / **74**

Basis Lightfront Approach to Hadron Structure

Author: Xingbo Zhao[1]

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Field theories quantized on the lightfront have long been considered as a viable framework for hadron structure. In this talk I will give an overview of Basis Lightfront Quantization (BLFQ), a non-perturbative approach to hadron structure and mass spectrum based on the Hamiltonian formalism of the lightfront dynamics and the modern developments in *ab initio* nuclear structure calculations. I will report the current development status of BLFQ through a series of applications to different systems, including the positronium in QED, the heavy quarkonium, the light meson and baryon systems in QCD. I will present the observables such as the form factors and (generalized) parton distribution functions for these systems and compare them with experimental data wherever available. Finally, I will introduce our roadmap for future developments.

Session 5: Analysis tools / **75**

Amplitude Analysis at JPAC

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I will review recent results on hadron spectroscopy analyses from JPAC

Session 7: Hadrons in hot and nuclear environment including hypernuclei / **76**

Experimental study of double hypernuclei at J-PARC

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Double Λ hypernuclei and Ξ hypernuclei, collectively called “double hypernuclei”, have come to play important roles in hadron nuclear physics as valuable information sources of baryon-baryon interaction. The most effective method to investigate them is event-by-event analysis with photographic emulsion sheets. An emulsion experiment to detect double hypernuclei has been performed in the J-PARC hadron facility in 2016-17.
By this experiment, quantitative data on ΛΛ or Ξ*N* interaction in a nucleus are being accumulated successfully. A new nuclide of double hypernucleus, _{ΛΛ}Be, was observed in this experiment. This event was interpreted as the production and decay of ¹⁰_{ΛΛ}Be, ¹¹_{ΛΛ}Be, or ¹²_{ΛΛ}Be* via Ξ⁻ capture in Oxygen-16.
Several other interesting events have been found and further event search is going on.

Session 6: QCD and hadron structure / **77**

GPD and TMD in proton with chiral effective theory

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We calculate the generalized and transverse momentum dependent parton distribution function with chiral effective theory. The results are comparable with experimental results.

Session 7: Hadrons in hot and nuclear environment including hypernuclei / **78**

Study of $\bar{K}N$ interaction from the hadron-hadron correlation in high-energy nuclear collisions

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We discuss the $\bar{K}N$ correlation in high-energy nuclear collisions and its relation to the $\bar{K}N$ interaction. Given the source function, the hadron-hadron correlation can be useful to investigate the interaction. Recently, it has been shown by the ALICE collaboration that the effect of the threshold difference due to the isospin symmetry breaking is important for more detailed determination of the $\bar{K}N$ interaction. In this study, we construct the method to calculate the correlation including all the effects of coupled-channel, Coulomb force and the threshold difference. With the results of the K^-p correlation calculated using the local potential constructed based on chiral dynamics, we show the significance of taking these effects into account and we discuss the low energy region of $\bar{K}N$ interaction.

Session 4: Hadron decays, production and interactions / **79**

Three body open flavor decays of higher charmonium and bottomonium

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We study the Okubo-Zweig-Iizuka
(OZI) allowed three body open flavor
decay properties of higher vector charmonium and bottomonium states
with an extended quark pair creation model. For the bottomonium
system, we get that (i) the $BB\pi$ and $B^*B^*\pi$ partial decay
widths of the $\Upsilon(10860)$ state are consistent with the
experiment, and the $BB^*\pi$ partial decay width of the
$\Upsilon(10860)$ state is smaller but very close to the Belle's
experiment. Meanwhile, (ii) the $BB^*\pi$ and $B^*B^*\pi$ decay
widths of $\Upsilon(11020)$ can reach $2 \sim 3$ MeV. In addition,
(iii) for most of the higher vector charmonium states, the partial

decay widths of the $DD^*\pi$ and $D^*D^*\pi$ modes can reach up to several MeV, which may be observed in future experiments.

Session 7: Hadrons in hot and nuclear environment including hypernuclei / 80

Studying strong interaction at DAFNE and J-PARC

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Studies with kaonic atoms offer the unique opportunity to perform experiments at vanishing relative energies between the antikaon and the nucleon, because their atomic binding energies are in the keV range, far below the lowest energies of extracted beams for scattering experiments. Of particular interest are kaonic hydrogen atoms, because they offer an ideal framework to study strong-interaction processes, which will give access to the basic low-energy parameters, like the antikaon-nucleon scattering lengths.

The antikaon hydrogen reaction is well understood from the recent results obtained from KpX at KEK, DEAR and finally from SIDDHARTA at DAFNE, along with theoretical calculations based on these results. An appropriate framework to describe antikaon nucleon interaction at low-energy is Chiral Effective Field Theory (ChEFT), a systematic approach describing the interactions of the pseudo-scalar Nambu-Goldstone bosons amongst each other and with baryons. At present, there are no lattice QCD calculations of antikaon-nucleon scattering lengths, although a theoretical framework has been proposed.

The importance of antikaon deuterium atom X-ray spectroscopy has been well recognized, no experimental results have yet been obtained due to the difficulty of the X-ray measurement. The planned antikaon deuterium experiment at Laboratori Nazionali di Frascati (Italy) and at the Japan Proton Accelerator Research Complex (J-PARC, Japan) will be described, including first test measurements at J-PARC with the new developed X-ray spectroscopy device.

Session 3: Exotic hadrons and candidates / 81

Flavor-singlet strange pentaquarks with hidden heavy quark pairs

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The recent experiments by LHCb indicates that the NJ/ψ-$\Lambda_c\bar{D}$-$\Sigma_c\bar{D}$ or $q^3c\bar{c}$ systems have a rich spectrum [1].
Theoretically also, it has been found that a quark cluster model, or a hadron model which includes the five-quark mode, gives narrow resonances or cusps in the $Y_c\bar{D}$ scattering [2,3].
Such a structure appears because the three light quarks in the system can take a color-octet isospin-1/2 spin-3/2 configuration, in which the color-magnetic interaction becomes attractive comparing

to the relevant threshold.
Here we discuss the strange pentaquark systems with the hidden heavy quark pair. The three light quarks now can also form a color-octet flavor-singlet spin-1/2 configuration. Then, the color magnetic interaction is more attractive than the isospin-1/2 case and causes a baryon-meson bound state. We argue that the pentaquarks with strangeness can be candidates of the exotic baryons.

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Session 6: QCD and hadron structure / **82**

Measurement of Longitudinal Spin Asymmetries for Weak Boson Production at STAR

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The production of $W^{\pm}$ bosons in longitudinally polarized proton-proton collisions at RHIC provides a direct probe for the spin-flavor structure of the proton through the parity-violating single-spin asymmetry, A_L. At STAR, the leptonic decay channel $W \rightarrow e\nu$ can be effectively measured with the electromagnetic calorimeters and time projection chamber. STAR has measured the $A_L(W)$ as a function of the decay-electron's pseudorapidity from datasets taken in 2011 and 2012, which has provided significant constraints on the helicity-dependent PDFs of $\bar{u}$ and $\bar{d}$ quarks.
In 2013 the STAR experiment collected an integrated luminosity of $\sim$250 pb^{-1} at $\sqrt{s} = 510$ GeV with an average beam polarization of $\sim$56\%, which is more than three times larger than the total integrated luminosity of previous years. The final results from 2013 dataset for W-boson A_L as well as for Z-boson A_L and W-boson double-spin asymmetry A_{LL} will be reported. Also the impacts of STAR data on our knowledge of the sea-quark spin-flavor structure of the proton will be discussed.

Session 2: Baryon sepctroscopy / **83**

Hadron spectroscopy with HypTPC at J-PARC

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A time-projection chamber, HypTPC has been developed at J-PARC
for hadron spectroscopy experiments. HypTPC has a large
acceptance thanks to the internal target system and a
high-rate capability up to 1 MHz or even higher.
So far, three experiments are planned with HypTPC,
namely, H-dibaryon search experiment (E42),
baryon spectroscopy experiment with (pi,pipi) reactions (E45),
and a new exotic Lambda resonance search (E72).
The status of these 3 proposed experiments and other possible
future experiments will be introduced in this talk.

Session 4: Hadron decays, production and interactions / **84**

Theoretical description of the J/psi->eta(eta')h_1(1380),J/psi->eta(eta')h_1(1170), J/psi->piˆ0b_1(1235)ˆ0 and chi_{cJ}->phi h_1(1380) reactions

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We have made a study of the $J/\psi \to \eta' h_1$, ηh_1 (with h_1 being $h_1(1170)$ and $h_1(1380)$), $J/\psi \to \pi^0 b_1(1235)^0$ and $\chi_{cJ} \to \phi h_1(1380)$ assuming the axial vector mesons to be dynamically generated from the pseudoscalar-vector meson interaction.
For the J/ψ decays, we obtain fair agreement with experimental data and provide an explanation on the recent BESIII measurement on $K\bar{K}\pi$ distribution in $J/\psi \to \eta' h_1(1380), h_1(1380) \to K^{*+}K^- + c.c.$.
For the χ_{cJ} decay, the molecular picture of $h_1(1380)$ can easily explain the difference of χ_{c0} and $\chi_{c1,2}$ production and a dip seen in the $K^+\pi^0 K^-$ distribution observed by BESIII Collaboration.

Session 4: Hadron decays, production and interactions / **85**

Status and perspectives for low energy kaon-nucleon interaction studies at DAFNE collider: from SIDDHARTA to SIDDHARTA-2

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The study of the antikaon-nucleon system at very low energies plays a key role in the understanding of the strong interaction between hadrons in the strangeness sector. The information provided by the low energy kaon-nucleon interaction is accessible through the study of kaonic atoms. The lightest atomic systems, namely the kaonic hydrogen and the kaonic deuterium, provide the isospin dependent kaon-nucleon scattering lengths by measuring the X-rays emitted during their de-excitation to the 1s level. Until now, the most precise kaonic hydrogen measurement and an exploratory measurement of kaonic deuterium were carried out at the DAFNE collider by the SIDDHARTA collaboration, combining the excellent quality kaon beam delivered by the collider with new experimental techniques, as fast and very precise X-ray detectors, like the Silicon Drift Detectors. Today, the most important experimental information missing in the field of the low-energy antikaon-nucleon interactions is the experimental determination of the hadronic energy shift and width of kaonic deuterium and will be measured by the new SIDDHARTA-2 experiment, which just finished the installation in DAFNE and is ready to start the data taking campaign. The experimental challenge of the kaonic deuterium measurement is the very small x-rays yield, the even larger width (compared to kaonic hydrogen) and the difficulty to perform x-rays spectroscopy with weak signals in the high radiation environment of DAFNE. It is, therefore, crucial to develop a new large area X-rays detector system to optimize the signal and to control and improve the signal-to-background ratio by gaining in solid angle, increasing the timing capability and as well implementing an additional charge particle tracking veto systems.
In the talk, I shall review the kaonic atoms measurements performed by SIDDHARTA, the status and plans of SIDDHARTA-2 and future perspectives to measure other kaonic atom systems at the DAFNE collider.

Session 5: Analysis tools / **86**

Identification of a visible narrow cusp structure in $\Lambda_c^+ \to pK^-\pi^+$

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A resonance-like structure as narrow as 10 MeV is observed in the K^-p invariant mass distributions in $\Lambda_c^+ \to pK^-\pi^+$. This precise measurement is based on a data sample of about 1.5 million events, and the bin width of K^-p invariant mass is only 1 MeV. The narrow peak precisely lies on the $\Lambda\eta$ threshold, because of which it is natural to identify it as a threshold cusp. Being different from the common two-body unitary cusp, we find that the narrowness of this cusp can be induced by a nearby triangle singularity of the Λ-$a_0^+(980)$ or η-$\Sigma(1660)$ rescattering process.

Session 5: Analysis tools / **87**

Dispersion techniques for processes gammaˆ(*) gammaˆ(*) -> pi pi/pi eta

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In my talk, I will present our recent dispersive analysis of the gamma*gamma* -> pipi/ pieta processes from the threshold up to 1.4 GeV in the two-photon invariant mass. These amplitudes serve as an important input to constrain the hadronic piece of light-by-light scattering contribution to (g-2) and support the current experimental program at BESIII.

Session 5: Analysis tools / **88**

Freed-Isobar Analysis of Light Mesons at COMPASS

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Modern hadron-spectroscopy experiments such as COMPASS collect data samples of unprecedented size, so that novel analysis techniques

become possible and necessary. One such technique is the freed-isobar partial-wave analysis (PWA). In this approach, fixed parametrizations for the amplitudes of intermediate states–commonly modeled using Breit-Wigner shapes–are replaced by sets of step-like functions that are determined from the data. This approach not only reduces the model dependence of partial-wave analyses, but also allows us to study the amplitudes of the intermediate states and their dependence on the parent system.

Since such an approach leads to a dramatic increase in degrees of freedom of the PWA model, continuous mathematical ambiguities may appear in fits to data. We will show, how these ambiguities can be identified and resolved without spoiling the advantage of model-independence.

We will also present results of a freed-isobar PWA performed on the large data set on diffractive production of three charged pions collected by the COMPASS experiment, which consists of 46×10^6 exclusive events. We will focus on results for the wave with spin-exotic quantum numbers $J^{PC} = 1^{-+}$, in particular on its decay into $\rho(770) + \pi^-$. Here, the freed-isobar PWA method provides insight into the interplay of three- and two-particle dynamics.

Session 6: QCD and hadron structure / **89**

Positronium on the Light-front

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Basis Light-front Quantization (BLFQ) is a newly developed nonperturbative approach, aiming for solving relativistic bound systems based on the Hamiltonian formalism of the lightfront dynamics. In this work, we introduce its application to the positronium system with a dynamical photon mediating the interaction between the positron and the electron. we show the nonperturbative Hamiltonian renormalization procedure we use to cancel the fermion self-energy effect. we present results of the numerical calculation such as the mass spectrum, the wave function and the distribution of the photon inside the positronium. we also illustrate how these quantities depend on the regulators of the theory. Finally, we introduce the next step of our research.

Session 7: Hadrons in hot and nuclear environment including hypernuclei / **90**

Light flavour baryon production from small to large collision systems at ALICE

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Studies of light hadron and nuclei production are fundamental to characterise the hot and dense fireball created in ultra-relativistic heavy ion collisions and to investigate hadronisation mechanisms at the LHC. Studies performed as a function of the charged particle multiplicity in proton-proton and proton-lead collisions have shown features not expected and qualitatively similar to what is observed in larger size colliding systems.
The ALICE experiment, exploiting its excellent tracking and PID capabilities, has performed an extensive and systematic study of strange and non-strange hadrons, short-lived hadron resonances and light (anti-)(hyper-)nuclei. A critical overview of these results will be presented through comparison with statistical hadronisation and QCD-inspired models, trying to emphasis the impact of these studies on our understanding of hadronisation processes.

Session 2: Baryon sepctroscopy / **91**

Low-energy constants from charmed baryons on QCD lattices

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We study the light quark-mass dependence of charmed baryon masses as measured by various QCD lattice collaborations. A global fit to such data based on the chiral SU(3) Lagrangian is reported on. All low-energy constants that are relevant at next-to-next-to-next-to-leading order ($\mathrm{N^3LO}$) are determined from the lattice data sets where constraints from sum rules as they follow from large-N_c QCD at subleading order are considered[1, 2]. The expected hierarchy for the low-energy constants in the $1/N_c$ expansion is confirmed by our global fits to the lattice data. With our results the low-energy interaction of the Goldstone bosons with the charmed baryon ground states is well constrained and the path towards realistic coupled-channel computations in this sector of QCD is prepared.

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Session 2: Baryon sepctroscopy / **92**

Strangeness photoproduction at the BGO-OD experiment

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Hadron spectroscopy is used to investigate the degrees of freedom of the constituents of the nucleon. Since the conception of the quark model, there have been descriptions of baryons and mesons with more then three and two valence quarks respectively. Such hadrons could manifest as penta- and tetraquarks, or as meson-meson and meson-baryon molecular like states. Candidates for such exotic matter were found in recent years in the charm sector, and there is evidence that similar configurations may exist in the light, strange sector. To study such effects in photoproduction experiments, access to a low momentum exchange region, where the meson is produced at forward angles is crucial.

The BGO-OD experiment at the University of Bonn's ELSA accelerator facility in Germany is ideally suited for this endeavor. It combines a highly segmented BGO electromagnetic calorimeter at central angles and an Open Dipole magnetic spectrometer in the forward direction. This allows the detection of forward going kaons, and complex final states of mixed charge from hyperon decays.

New, key results in this low momentum exchange region indicate a cusp-like structure in the $\gamma p \to K^+\Sigma^0$ cross section at the $\Lambda(1405)$ production threshold, and line shape measurements and differential cross sections for $\Lambda(1405)$ photoproduction.

*Supported by DFG (PN 50165297).

Session 1: Meson spectroscopy / **93**

Spectroscopy of a_1 mesons from lattice QCD with the truncated overlap fermions

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We study the the ground state for a_1 meson and the next radial excitation of a_1 meson from a quenched lattice QCD simulation with the truncated overlap fermions formalism based on the domain wall fermions. Our results are consistent with the experimental values.

Session 3: Exotic hadrons and candidates / **94**

Role of the tensor force in the heavy hadronic molecules

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Exotic hadrons close to the hadron-hadron threshold have been one of the interesting topics in the hadron and nuclear physics. Especially, in the heavy quark sector, some of the quarkonium-like states called XYZ and the hidden-charm pentaquark Pc near the thresholds have been discussed as a hadronic molecule. The hadronic molecules is realized as a loosely bound state of a hadron composite system. In the formation of such molecules, the one-pion exchange potential (OPEP) working as a long range force is considered to have an important role. The tensor force of the OPEP is well-known as the driving force of atomic nuclei, and is emphasized in the heavy quark sector thanks to the heavy quark spin symmetry.
In this talk, we study the hadronic molecules of heavy meson and heavy baryon, which can be compared with the pentaquark Pc reported by LHCb. The coupled channel Schr\"odinger equations of the heavy meson and heavy baryon are solved. Due to the heavy quark symemtry, various meson-baryon channels are mixed in the systems. The full coupled channel analysis including channels with large orbital angular momenta are performed, because the tensor force of the OPEP yields an attraction in the mixing of those channels. We investigate the formation mechanism of the hadronic molecules in the heavy quark sector and estimate the role of the tensor force.

Session 7: Hadrons in hot and nuclear environment including hypernuclei / **95**

Fate of Heavy Quark Bound States inside Quark-Gluon Plasma

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The production of heavy quarkonium in heavy ion collisions has been used as an important probe of the quark-gluon plasma. The initial insight was that due to the plasma screening effect, the color attraction between the heavy quark pair is significantly suppressed at high temperature and thus no bound states can exist, i.e., they "melt". However, experimental measurements have shown that a large amount of quarkonia survived the evolution inside the high temperature plasma. It is realized that the in-medium recombination of unbound heavy quark pairs into quarkonium is as crucial as the quarkonium melting and dissociation. Thus, phenomenological studies using transport equations have to account static screening, dissociation and recombination in a consistent way. In recent years, another approach based on the open quantum system formalism started being used. It is learnt that the dissociation can be understood as a decoherence of the wavefunction of the heavy quark pair. Recombination is automatically included in this framework.

In this talk, I will present a connection between the open quantum system formalism and the transport equation. I will discuss new insights about the quarkonium dynamics inside quark-gluon plasma from the perspective of quantum information. I will show that under the weak coupling and Markovian approximations, the Lindblad equation turns to a Boltzmann transport equation after a Wigner transform is applied to the system density matrix. I will demonstrate how the separation of physical scales justifies the approximations, by using effective field theory of QCD. Finally, I will show some phenomenological results based on the derived transport equation.

Session 4: Hadron decays, production and interactions / **96**

Photoproduction of the S-, P- and D-wave resonances on protons in the π+π- channel

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The study of resonance photoproduction is essential for both fundamental and practical reasons. On the one hand the structure of resonances is directly related to basic properties of QCD like the confinement. On the other hand reliable models are needed to describe the wealth of the resonance photoproduction data to be expected in near future from JLab, ELSA, MAMI, BESIII and SPring-8 experiments. Of many accessible photoproduction channels the $\pi^+\pi^-$ pair production is of particular interest as this is the only reaction where the photoproduction of scalar f_0 resonances has been observed so far. Moreover, this reaction provides unique opportunity to embed the well known hadronic amplitudes of πp scattering into the amplitudes of electromagnetic process.

We simultaneously describe the photoproduction of resonances in several partial waves, namely S, P and D [1]. In our approach the photoproduction amplitude consists of two mechanisms. The long range mechanism (diffuse source) is dominated by one pion exchange related to the dynamical singularity which is nearest to the physical region. The short range mechanism (compact source) collectively includes contributions related to singularities located far away from the physical region. To describe the long rage mode we have combined the Deck model with SAID parametrisation of the πp scattering amplitude. Such approach makes the description of the long range mode essentially parameter free. The short range mode, which includes eg. the exchange of heavier mesons and quark/gluon processes can be parameterized in terms of smooth functions. In this respect we have chosen the 1-st order polynomials in the $\pi\pi$ energy. The coefficients of these polynomials were then fitted to experimental mass distributions.

We found a very good agreement of $\pi^+\pi^-$ mass distributions for S, P and D partial waves with fits made by CLAS collaboration [2]. Our mass distributions are consistent with the fact that the S, P and D waves are dominated by resonances $f_0(980)$, $\rho(770)$ and $f_2(1270)$, respectively. We have also found that strengths of the short range components of the P and D waves are much larger than for the S wave. Thus the $\rho(770)$ and $f_2(1270)$ resonances are photoproduced from the compact source while the $f_0(980)$ from the diffuse source. This in turn is in accord with the expectation that $\rho(770)$ and $f_2(1270)$ are conventional $q\bar{q}$ states while the $f_0(980)$ is a more loosely bound four quark state.

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Session 4: Hadron decays, production and interactions / **97**

Eta Decay Program at GlueX

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The GlueX detector in the experimental Hall D at Jefferson Lab was designed to search for gluonic excitations in the spectra of light mesons using photon beams. The detector provides a unique capability to perform a precision measurement of the eta -> gamma gamma decay width via the Primakoff effect (PrimEx D experiment) and study rare decays of eta mesons.

Measurement of the eta decay width is essential for the determination of fundamental properties such as the ratios of the light quark masses and the eta - eta' mixing angle, and will provide an important test of chiral symmetry breaking in QCD. The physics of rare eta decays spans from critical tests of chiral perturbation theory to the search for lepto-phobic dark matter candidates.

I will give an overview of the ongoing PrimEx D experiment and the physics program of rare eta decays, and discuss GlueX plans for the future.

Session 6: QCD and hadron structure / **98**

three dimension imaging of proton from BLFQ

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Basis Light-front Quantization (BLFQ) is a non-perturbative method for solving bound state problems in the light-front Hamiltonian formalism. It has already been used to study QED and QCD systems like the positronium and quarkonium. In this work, we apply BLFQ to investigate the baryon system. We restrict ourselves to the valence sector and adopt an effective Hamiltonian which contains the confining potential in both the longitudinal and the transverse directions as well as a one-gluon exchange interaction. Through diagonalizing the effective light-front Hamiltonian we obtain the light-front wave function in the valence sector. I will present various observables of the proton such as the electromagnetic form factors, PDFs, and GPDs calculated from the obtained light-front wavefunction. We find a reasonable agreement between our results and the experimental data.

Session 6: QCD and hadron structure / **99**

On light mesons Parton distribution functions from basis light front quantization

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We study the parton distribution functions of the pion and the kaon from the eigenstates of a light front effective Hamiltonian in the constituent quark-antiquark representation suitable for low-momentum scale applications.
By taking these scales as the only free parameters, the valence quark distribution functions of the pion, after QCD evolution, are consistent with the experimental data from the E615 experiment at Fermilab. The ratio of the up quark distribution of the kaon to that of the pion also agrees with the NA3 experiment at CERN.

Session 4: Hadron decays, production and interactions / **100**

Neutral Pion Lifetime-Final Result from PrimEx

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As the lightest and the simplest hadronic particle, the neutral pion plays a crucial role in understanding the symmetries of QCD at low-energy. The $\pi 0 \rightarrow \gamma\gamma$ decay width offers a fundamental test of the QCD predictions based on the chiral anomaly and spontaneous chiral symmetry breaking. The theoretical calculations over the past two decades have reached 1% precision in the decay amplitude of

the π0 into two photons. The experimental measurement of this fundamental parameter with a comparable accuracy will provide a stringent test of QCD. The PrimEx collaboration at Jefferson Lab has developed and performed two experiments (PrimEx I&II) to measure the π0 radiative decay width via the Primakoff effect. The published result from the first experiment (PrimEx-I) reached 2.8% in the total uncertainty that has led to an improvement of the average value in Particle Data Group by more than a factor of two and half. Data analysis for the second experiment (PrimEx-II) is recently completed with significantly improved precision than the PrimEx-I result. The final PrimEx result has reached 1.5% accuracy in the π0⟶γγ decay width. This result agrees to the chiral anomaly prediction and is 2σ lower than the high order low-energy QCD predictions. The details of the PrimEx experiment and the physics impacts will be discussed.

Session 6: QCD and hadron structure / **101**

Quark Wigner distributions Using Light-front Wave Functions

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The quasi-probabilistic Wigner distributions are the quantum mechanical analog of the classical phase-space distributions. We investigate quark Wigner distributions for a quark state dressed with a gluon, which can be thought of as a simple composite and relativistic spin-1/2 state with a gluonic degree of freedom. We calculate various polarization configurations, namely unpolarized,longitudinally polarized and transversely polarized quark and the target state using light-front wave functions in this model. At leading twist, one can define 16 quark Wigner distributions,however, we obtain only 8 independent non-zero Wigner distributions in our model. We compare our results with other model calculations.

Session 7: Hadrons in hot and nuclear environment including hypernuclei / **102**

Strong Absorption of Hadrons with Hidden and Open Strangeness probed with Pion-Nucleus Collisions at 1.7 GeV/c

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The modification of hadron properties in the strongly interacting environment resulting from heavy ion collisions (HIC) has been extensively studied for decades. However, in such highly dynamic processes it is difficult to address fundamental aspects. In fact, in-medium effects, which are expected to be present already at normal nuclear matter (ρ_0), can be studied in hadron-nucleus collisions in which the dynamics are less complex.

Pion-nucleus collisions are particularly well suited. Due to the large inelastic πN cross section, hadron production takes place in the vicinity of the nucleus surface, which on average leads to a longer path within nuclear matter of these produced hadrons. In total, 1.3×10^8 and 1.7×10^8 events have been collected with HADES in $\pi^- + C$ and $\pi^- + W$ at $p_{\pi^-} = 1.7$ GeV/c, respectively.

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 ($K^-N \rightarrow Y\pi$) or more nucleons ($K^-NN \rightarrow YN$). The data supports sizable K^-

absorption in the heavier target (W) compared to lighter one (C). In addition, the ϕ absorption in the nuclear medium is studied by comparing the production in both nuclear environments. Our measurement provides for the first time evidence of a non-negligible absorption for both mesons, K^- and ϕ, in a model-dependent way. Comparisons to state-of-the-art transport model calculations will be presented as well. Besides, a comparative discussion of these results with respect to Au(1.23 GeV/u)+Au collisions measured with HADES will be shown.
* supported by the DFG cluster of excellence "Origin and Structure
of the Universe" and SFB 1258

Session 7: Hadrons in hot and nuclear environment including hypernuclei / **103**

In-medium properties of Λ in π^--Induced Reactions at 1.7 GeV/c

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The precision measurement of two solar mass neutron stars (NS) and recent observation of the neutron star merger give stringent constraints to the equation of states (EOS) of models describing such dense objects.

While the allowed phase space is reduced by all these experimental observations, the hyperon puzzle, that question the presence of hyperons within NS, is still unresolved.

For all these EOS, the interaction of the hyperons with (normal) nuclear matter is a crucial ingredient.

The Λ hyperon having the lowest rest mass among all hyperons is expected to appear first.

So far, the ΛN interaction is constraint by scattering experiments and the existence of hypernuclei demonstrates its attractive nature, but no differential study of lambda propagation within nuclear matter has been performed yet.

In 2014 the HADES collaboration performed a dedicated campaign with secondary pion beams $\pi^- + A$ (A = C, W) with a π^- momentum of $p_{\pi^-} = 1.7$ GeV/c.

Since the reaction cross-section of the π^- is sizable, the production of hyperons is likely to occur close to the upstream surface of the nucleus.

Thus πA reactions provide an ideal environment to study the in-medium properties of the produced hyperons, since the average path length inside the nucleus is quite large.

In our experimental approach we select the semi-exclusive channel of $\pi^- + p \rightarrow \Lambda + K^0 + X$ reconstructed in terms of its associated dominant charged decay channel in a light (C) and heavy (W) nuclear environment.
Our data sample contains also the Σ^0 production channels ($\pi^- + p \rightarrow \Sigma^0 + K^0 + X$, $\Sigma^0 \rightarrow \Lambda + \gamma, BR \approx 100\%$) as from experimental point of view without electromagnetic calorimeter we cannot distinguish
between both hyperons.

To test different scenarios of the hyperon interaction with nuclear matter the GiBUU model has been employed.
As the hyperons are produced together with a K^0 the KN interaction is addressed as well.

For the first time we test the repulsive potential of Σ^0, predicted by the χ-effective theory.
We will report on the results of the analysis and present our sensitivity to the different scenarios of hyperon interaction with nuclear matter.

Session 7: Hadrons in hot and nuclear environment including hypernuclei / **104**

Highlights from nuclear collisions studied by the STAR experiment

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I will represent selected results on hadron production in heavy-ion collisions at RHIC-STAR. I will focus on the hyper nuclear data and also discuss a little bit of the future plan.

Session 5: Analysis tools / **105**

Considerations on the Schmid theorem for triangle singularities

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We investigate the Schmid theorem, which states that if one has a tree level mechanism with a particle decaying to two particles and one of them decaying posteriorly to two other particles, the possible triangle singularity developed by the mechanism of elastic rescattering of two of the three decay particles does not change the cross section provided by the tree level. We investigate the process in terms of the width of the unstable particle produced in the first decay and determine the limits of validity and violation of the theorem. One of the conclusions is that the theorem holds in the strict limit of zero width of that resonance, in which case the strength of the triangle diagram becomes negligible compared to the tree level. Another conclusion, on the practical side, is that for realistic values of the width, the triangle singularity can provide a strength comparable or even bigger than the tree level, which indicates that invoking the Schmid theorem to neglect the triangle diagram stemming from elastic rescattering of the tree level should not be done. Even then, we observe that the realistic case keeps some memory of the Schmid theorem, which is visible in a peculiar interference pattern with the tree level.

Session 4: Hadron decays, production and interactions / **106**

Pseudoscalar or vector meson production in non-leptonic decays of heavy hadrons

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We have addressed the study of non-leptonic weak decays of heavy hadrons (Λ _b, Λ _c, B and D), with external and internal emission to give two final hadrons, taking into account the spin-angular momentum structure of the mesons and baryons produced. A detailed angular momentum formulation is developed which leads to easy final formulas. By means of them we have made predictions for a large amount of reactions, up to a global factor, common to many of them, that we take from some particular data. Comparing the theoretical predictions with the experimental data, the agreement found is quite good in general and the discrepancies should give valuable information on intrinsic form factors, independent of the spin structure studied here. The formulas obtained are also useful in order to evaluate meson-meson or meson-baryon loops, for instance of B decays, in which one has PP, PV, VP or VV intermediate states, with P for pseudoscalar mesons and V for vector meson and lay the grounds for studies of decays into three final particles.

Session 3: Exotic hadrons and candidates / **107**

Molecular Ω_c states generated from coupled meson-baryon channels

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We have investigated Ωc states that are dynamically generated from the meson-baryon interaction. We
use an extension of the local hidden gauge to obtain the interaction from the exchange of vector mesons.
We show that the dominant terms come from the exchange of light vectors, where the heavy quarks are
spectators. This has as a consequence that heavy quark symmetry is preserved for the dominant terms in
the (1/mQ) counting, and also that the interaction in this case can be obtained from the SU(3) chiral Lagrangians. We show that for a standard value for the cutoff regulating the loop, we obtain two states with
JˆP= 1/2− and two more with JˆP=3/2−, three of them in remarkable agreement with three experimental
states of LHCb in mass and width. We also make predictions at higher energies for states of vector-baryon nature.

Session 1: Meson spectroscopy / **108**

Strange-Meson Spectroscopy at COMPASS

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COMPASS is a multi-purpose fixed-target experiment at CERN aimed at studying the structure and spectrum of hadrons. The two-stage spectrometer has a large acceptance over a wide kinematic range. Thus, it can be used to investigate a wide range of reactions. Diffractive production of mesons is studied with a negative hadron beam with a momentum of 190 GeV/c.
So far, COMPASS has studied mainly isovector resonances of the a_J and π_J families with high precision, using the dominating π^- component of the beam.
Using the smaller K^- component of the beam allows us to investigate also the spectrum of strange mesons in various final states.
The flagship channel is the $K^-\pi^-\pi^+$ final state, which in principle gives access to study all kaon states, i.e. K_J and K_J^* mesons.
In order to disentangle the produced mesons by their spin-parity quantum numbers, we employ the method of partial-wave analysis.
COMPASS has acquired a large dataset of exclusive $K^-\pi^-\pi^+$ events, which is more than four times larger than any dataset collected by previous experiments at BNL, CERN, or SLAC.
The size of our dataset enables us to perform the analysis in bins of the squared four-momentum transfer t'. Thus, the t' dependence of the various signals in the data can be studied.

Session 7: Hadrons in hot and nuclear environment including hypernuclei / **110**

Uncertainty Quantification of Hypertriton Binding Energy

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We perform the Hypernuclear No-Core Shell Model (NCSM) calculations to study the uncertainty of hypertriton binding energy. In particular, we employ a family of nucleon-nucleon (NN) nuclear interactions at next-to-next-to-leading-order (NNLO) in chiral effective field theory to approximate the uncertainty of the nuclear interaction in combination with a fixed leading-order (LO) chiral hyperon-nucleon (YN). The three-body calculations are performed in the relative Jacobi coordinates Harmonic-Oscillator (HO) basis in model spaces up to Nmax=70 MeV to obtain the well-converged energy. As a result, we provide a prediction for the model uncertainties of the hypertriton system by propagating the quantified uncertainties of the nuclear interaction. Based on our finding of small sensitivity of hypertriton binding energy to the uncertainty of NN interaction, we claim that this bound-state observable can be used in a fitting procedure to constrain the YN interaction.

Session 1: Meson spectroscopy / **112**

Production of X Resonances in Bˆ-_c Decays

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We investigate the semileptonic B−c⟶¯νll X decays with X(=X(3930),X(3940),X(4160)) resonances. We take into account these resonances as dynamically generated from the vector−vector interaction in the charm sector. The X(3930) and X(3940) states are D∗¯D∗ molecules and the X(4160) is

D∗s¯D∗s molecule. We also look at the production of D∗¯D∗ and D∗s¯D∗s close to threshold and we make predictions of the ratio of this differential mass distribution to the rate of production of the X resonances.

Session 4: Hadron decays, production and interactions / **113**

PHYSICS BEYOND SM WITH KAONS FROM NA62

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The decay K+⟶π+νν¯, 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 the CERN SPS is designed to measure the branching ratio of the K+⟶π+νν¯ with a decay-in-flight technique. NA62 took data so far in 2016-2018. Statistics collected in 2016 allowed NA62 to reach the Standard Model sensitivity for K+⟶π+νν¯, entering the domain of 10-10 single event sensitivity and showing the proof of principle of the experiment. Thanks to the statistics collected in 2017, NA62 surpasses the present best sensitivity. The analysis strategy is reviewed and the preliminary result from the 2017 data set is presented. A large sample of charged kaon decays into final states with multiple charged particles was collected in 2016-2018. The sensitivity to a range of lepton flavour and lepton number violating kaon decays provided by this data set improves over the previously reported measurements. Results from the searches for these processes with a partial NA62 data sample are presented.

Session 5: Analysis tools / **115**

The first observation of narrow peak and isospin-violating Lambda(1405) production

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In this talk I will discuss the triangle mechanism in Lambda_c decay and isospin-violating Lambda(1405).This process is prohibited by the isospin symmetry, but the decay into this channel is enhanced by the contribution of the triangle diagram, which is sensitive to the mass of the internal particles. Interestingly, a first narrow peak was observed in the pi0 Sigma0 invariant mass distribution, which originates from the Lambda(1405) amplitude, but is tied to the mass differences between the charged and neutral Kbar or N states. The observation of the unavoidable peak of the triangle singularity in the isospin-violating Lambda(1405) production would provide further support for the hadronic molecular picture of the Lambda(1405) and further information on the Kbar N interaction.

Session 5: Analysis tools / **116**

Combining Physics and Bayesian Statistics to Validate Models and Infer Their Parameters

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Physical models can suffer from systematic deficiencies due to omitted physics, which can bias parameter estimates and predictions. Such simplifications may be unavoidable, but physicists often have some idea of what is missing from their models. I discuss how physical knowledge of model discrepancy can be encoded into the language of Bayesian statistics, and how the inclusion of this uncertainty affects the parameter fitting protocol. Further benefits of this Bayesian formulation include the ability to (1) validate the model's performance and (2) make explicit all assumptions for reproducible research. Recent developments in probabilistic programming make it easier than ever before to provide a full accounting of uncertainty in the Bayesian paradigm. Applications are discussed.

Session 4: Hadron decays, production and interactions / **118**

An novel approach in semileptonic decays and its application on helicity amplitudes

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First I will present an novel approach on semileptonic decays of meson with charm or beauty flavors. This novel approach was recently developed and we used a different method than in conventional approaches. Using only one experimental decay rate in the B or D sectors, the rates for the rest of decay modes are predicted and they are in good agreement with experiment.

Then an interesting application will be presented on the different helicity amplitudes. We extend the formalism to a general case, with the weak operator that can accommodate different models beyond the standard model. We find some interesting results and one magnitude sensitive and useful to test different models beyond the standard model.

Session 4: Hadron decays, production and interactions / **120**

Associated quarkonium production at ATLAS

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The associated production of vector boson with quarkonia is a key observable for understanding the quarkonium production mechanisms, including the separation of single and double parton scattering

components. This talk will present the latest measurements from ATLAS on quarkonium production, including associated production.

Session 5: Analysis tools / **122**

Partial wave analysis with the PAWIAN software package

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PAWIAN is a powerful, user-friendly and highly modular partial wave analysis software package with the aim to support analyses for a multitude of different physics cases at hadron physics experiments. Real data originating from the pbar p annihilation process and from e+ e- reactions are currently under investigation with PAWIAN. The software is written in C++ and follows an object-oriented approach with a wide range of flexibility. The code therefore allows to be easily extended for further decay models, complete amplitudes or other descriptions for the dynamics.

After an overview of the general features and capabilities of PAWIAN, some recent improvements concerning the treatment of analyticity and unitarity as well as the extraction of pole positions will be discussed on the example of a coupled channel analysis based on pbar p annihilation data together with pipi-scattering data.

Session 1: Meson spectroscopy / **123**

Overview of the GlueX physics program

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The GlueX experiment, which is focused on studying the hadron spectrum using polarized photoproduction, completed its initial phase of data taking in the fall of 2018. These data will provide the opportunity to study production mechanisms of mesons as well as searches for new states in the hadron spectrum, including those with gluonic degrees of freedom. In addition, the GlueX collaboration has collected a dedicated dataset to measure the two-photon width of the eta using Primakoff production. This talk will summarize the status of these analysis activities as well as present the plans future data collection with enhanced particle identification capability that will enable a study of mesons with strange quarks.

Session 4: Hadron decays, production and interactions / **125**

Weak decays of doubly heavy baryons

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The first observed double-heavy baryon, Ξ_{cc}^{++}, was discovered by its weak decays. The discovery channel, $\Xi_{cc}^{++} \to \Lambda_c^+ K^- \pi^+ \pi^+$, and the confirmed mode, $\Xi_{cc}^{++} \to \Xi_c^+ \pi^+$, were both predicted in theory by the factorization approach with the rescattering mechanism for the final-state-interaction effect. We will report the recent progress on the studies of weak decays of doubly heavy baryons.

Session 6: QCD and hadron structure / **126**

Partonic structure of neutral pseudoscalars via two photon transition form factors

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In this talk, I will present the study on two photon transition form factors of neutral pseudoscalar mesons with a continuum approach. It delivers an understanding of the distribution of valence-quarks within mesons. A unified picture for transition form factors of mesons connecting pion, flavor mixing states and heavy quarkonia will be drawn.

Session 4: Hadron decays, production and interactions / **127**

Transition form factors of doubly heavy baryons

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The discovery of doubly heavy baryon provides us with a new platform for precisely testing the SM and exploring the new physics. Based on our previous works, we investigate the form factors of the transition $b \to c, u, d, s$ and $c \to d, s$ of double heavy baryons using the light-front quark model. Then we apply the these transition form factors to predict the partial widths for the semi-lepton decays of doubly heavy baryons.

Session 6: QCD and hadron structure / **128**

Unveiling the inner structure of mesons

Author: Raya Khepani[1]

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Dynamical chiral symmetry breaking and confinement are two emergent phenomena of QCD, orchestrating the observed spectrum of hadrons and their properties. The running of the corresponding mass function reflects itself in several physical observables such as form factors and parton distribution functions inside hadrons. This study can be naturally carried out through QCD's fundamental field equations, namely, Dyson-Schwinger equations.

I present the development of a consistent analysis based upon a symmetry-preserving Dyson-Schwinger and Bethe-Salpeter equations to compute meson electromagnetic elastic and transition form factors, parton distribution amplitudes and parton distribution functions. The empirically observed hadron properties are faithfully reproduced and many predictions are made for future experiments.

Session 4: Hadron decays, production and interactions / **129**

Overview of Light Meson Results from the GlueX Experiment

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The GlueX experiment in Hall D at Jefferson Lab consists of a well-instrumented photon beamline in conjunction with a solenoidal spectrometer providing near-hermetic coverage for charged particles and photons. Since 2016, the experiment has had several run periods with a 9 GeV linearly polarized photon beam on a 30cm liquid hydrogen target, completing its initial low-intensity program. Light (i.e., < 1.05 GeV/c2) meson studies have been critical to commissioning the GlueX detector, elucidating the photo-production reaction mechanism in this photon energy range, and testing the event selection techniques needed to search for exotic hybrid mesons. We have measured the beam asymmetries for photo-production of pseudo-scalar mesons including π, η, and η', and have preliminary results for the Spin Density Matrix Elements (SDMEs) for the vector mesons ω, ρ, and ϕ. Cross-section determinations are in progress for all these mesons, usually in more than one decay branch, and with 3-7 particles exclusively detected in the final state. The outlook appears encouraging for GlueX to measure precise, competitive Dalitz plots for $\eta -> 3\pi$ and $\eta' -> \eta\, 2\pi$. The latter $\eta' -> \eta\, 2\pi$ studies are synergistic with exploratory studies of the continuum M($\eta 2\pi$) mass spectrum between 1.5 and 2.5 GeV/c2 where we plan to search for hybrid exotic mesons.

Plenary session / **130**

Experimental review of baryons with two heavy quarks (including Pc)

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The recent experimental results on the doubly-charmed baryons and pentaquark candidates will be reviewed.

Session 7: Hadrons in hot and nuclear environment including hypernuclei / **131**

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

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Our experimental knowledge on hadron-hadron interactions is based mostly on scattering data and, in the case of systems with strangeness, the characterization of hypernuclei. The femtoscopy technique, by measuring the correlations between particle pairs with low relative momentum, has been used to measure the size of the QGP fireball created in relativistic heavy-ion collisions. Now we show how femtoscopy can be used to study the effects of the strong interaction between particle pairs, delivering complementary and, in general, more precise information when compared to the traditional measurements.

Small collision systems, like pp and p-Pb, with source sizes of the order of 1 fm, prove to be particularly sensitive to the short-ranged strong potentials. Using an analytical solver for the Schrödinger equation, femtoscopy can be used to test the potentials of the interaction between different kind of hadrons.

In this contribution, we present measurements performed using ALICE data from pp collisions at √s=7 and 13 TeV and p–Pb collisions at √s_{NN}=5.02 TeV. The proton-proton correlation function is used to constrain the size and shape of the particle emitting source and results from baryon-hyperon (p-Λ, p-Σˆ0, p-Ξˆ- and p-Ωˆ-), hyperon-hyperon (Λ-Λ) and baryon-meson (p-Kˆ-) correlations are shown. The high precision of the data allow us to test with high sensitivity the predictions from the most recent models of such interactions, including chiral, meson exchange models, and Lattice QCD calculations. The consequences for the equation of state for neutron-rich matter including hyperons and for the possible existence of exotic di-baryons are discussed.

Session 3: Exotic hadrons and candidates / **132**

First measurement of near-threshold J/ψ photoproduction and search for the LHCb Pc+ states

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Photoproduction of charmonium near threshold gives an excellent probe for studying the gluonic structure of the nucleon. Of more recent interest is the possibility of producing the P_c^+ pentaquark candidates reported by LHCb in the s-channel reaction: $\gamma p -> P_c^+ \to pJ/\psi$. We report on the measurement of the total cross section $\sigma(\gamma p \to pJ/\psi)$ in 10 bins of photon beam energy down to the threshold of $E_\gamma = 8.2$ GeV using a tagged photon beam with the GlueX experiment at Jefferson Lab. We find the cross section as a function of beam energy to fall less steeply near threshold than expectations from lowest-order calculations. We also find no evidence for the photoproduction of the Pc states and set upper limits on their production and $\mathcal{B}(P_c^+ -> J/\psi p)$. We will also discuss the future prospects for extending these measurements at GlueX.

Plenary session / **134**

Final-state Interactions in Three-body hadronic heavy meson decays

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Three-body decays of heavy-flavoured hadrons into light particles are sequential processes, dominated by intermediate resonant states that requires a full amplitude analysis to be determined. These decays are a natural source of information about two-body scattering amplitudes, as an alternative to the early scattering data. However,
the determination of the two-body amplitudes requires the understanding of the role of final-state interactions (FSI) and strong phases from the primary weak vertex. This is also a crucial step to understand the massive localized CP violation observed in $B^+ \to h_1^- h_2^+ h_3^+$ ($h_i \equiv \pi, K$) decays from LHCb.
The gigantic samples of B and D decays collected by the LHCb, BES-III and, in the near future, Belle II experiments motivated theoretical efforts in the past decade towards building models that are based on more solid grounds. These models improve essentially the description of FSI by using coupled-channels formalism and imposing two-body unitarity, in the framework of dispersion relations and chiral perturbation theory. Most models are based on the quasi-two-body (2+1) approximation, in which interactions with the third particle are neglected. Three-body FSI, however, may play significant role, especially in D decays as for the $D^+ \to K^-\pi^+ + \pi^+$ decay. In this talk an overview of these models will be presented. In particular, two important results will be discussed, namely $D^+ \to K^-K^+K^+$ and $B^+ \to K^-K^+K^+$.
In the first case, the focus
is on the determination of the K^-K^+ scattering amplitudes, whilst in the second decay, the focus is on the underlying mechanisms of the CP asymmetries pattern observed in the Dalitz plot.

Session 4: Hadron decays, production and interactions / **135**

Status of quarkonium production

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Heavy quarkonium production processes provide good tests of perturbative and nonperturbative aspects of QCD. We review the status of heavy quarkonium production phenomenology based on effective field theory methods. We give an overview of the nonrelativistic effective field theory treatment of exclusive and inclusive quarkonium production processes.

Session 2: Baryon sepctroscopy / **136**

Hyperon resonances and meson-baryon interactions

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In this talk we present our latest study on pseudoscalar-baryon and vector baryon coupled channel interactions. The formalism consists of calculations of s-, t, and u-channel diagrams for all channels and use the sum of such diagrams as kernels to solve Bethe Salpeter equation. The vertices, to calculate the lowest order amplitudes, are taken from chiral and hidden local symmetry Lagrangians. The divergent loops are regularized using the dimensional regularization method and the subtraction constants have been fitted to reproduce cross section data on several relevant processes, as well as to reproduce the energy level shift and width of the 1s state of the kaonic hydrogen measured by the SIDDHARTA collaboration. With these constrained amplitudes, we study the properties of resonances in the complex plane.

Session 3: Exotic hadrons and candidates / **137**

Multiple charm and hidden charm mesons with strangeness

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In a recent work we have studied three-body scattering, considering the DDK system, in a coupled channel approach. All input two-body scattering matrices have been obtained by solving Bethe-Salpeter equations for different channels coupling to same quantum numbers. The lowest order amplitudes for the two-body subsystems are obtained from a Lagrangian based on the heavy quark symmetry. We have investigated the contributions of three-body contact terms and find that there exists a cancellation among the different sources of contact terms. Such a test has been made with Lagrangians based on heavy quark as well as $SU(4)$ symmetries. The resulting amplitude shows that a three-body bound state should exist, with double charm and positive strangeness.

In a separate study we have investigated a hidden charm and positive strangeness system $D\bar{D}^*K$, which we treat as $KX(3872)$ and $KZ(3900)$ coupled channels, where we find a heavy K^* state formed. The results from both studies will be discussed in the talk.

Session 3: Exotic hadrons and candidates / **138**

Exotics in QCD sum rules

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In this talk I shall review our QCD sum rule studies on exotic hadrons. In the past decade many charmonium-like states were observed experimentally, and various theoretical methods/models were applied to study them. The method of QCD sum rules is one of them, and has also been widely applied to study the mass spectra, production and decay properties of exotic hadrons.

Session 2: Baryon sepctroscopy / **139**

On the study of dibayon resonance d*(2380)

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In this presentation, we briefly review the study of newly observed dibaryon resonance d*(2380) (IJP=03+), and in particular, the recent studies of this resonance based on a chiral constituent quark model. The model calculations for its mass and wave function exhibit that it may be assigned as a compact hexaquark system with a dominant hidden-color component. The good explanations for the strong double pionic as well as single pionic decays of this dibaryon resonance support this inner structural interpretation. Further investigations for distinguishing this structure, such as observables like its electromagnetic form factors, its production from Upsilon(nS) decays in the e+e- annihilation as well as photo-absorption on the deuteron target contributed by d*(2380) are also discussed.

Session 7: Hadrons in hot and nuclear environment including hypernuclei / **140**

The chiral phase transition temperature in (2+1)-flavor QCD

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The chiral phase transition temperature T_c^0 is a fundamental quantity of QCD. To determine this quantity we have performed simulations of (2 + 1)-flavor QCD using the Highly Improved Staggered Quarks (HISQ/tree) action on $N_\tau = 6, 8$ and 12 lattices with aspect ratios N_σ/N_τ ranging from 4 to 8.
In our simulations the strange quark mass is fixed to its physical value $m_s^{\rm phy}$, and the values of two degenerate light quark masses m_l are varied from $m_s^{\rm phy}/20$ to $m_s^{\rm phy}/160$ which correspond to a Goldstone pion mass m_π ranging from 160 MeV to 55 MeV in the continuum limit.
By investigating the light quark mass dependence and the volume dependence of various chiral observables, e.g. chiral susceptibilities and Binder cumulants, no evidence for a first order phase transition in our current quark mass window is found.
Two estimators T_{60} and T_δ are proposed to extract the chiral phase transition temperature T_c^0 in the chiral and continuum limit and our current estimate for T_c^0 is 132^{+3}_{-6} MeV.

Session 3: Exotic hadrons and candidates / **141**

Implications of spin symmetry for XYZ states

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In the last decade, numerous states have been observed which contain a heavy quark-antiquark pair, but demonstrate properties at odds with a simple quarkonium assignement. Such states are conventionally denoted as exotic states and traditionally labelled by the letters X, Y and Z.
Due to the presence of the heavy quraks, properties of various exotic states can be related through the Heavy Quark Spin Symmetry (HQSS). We build an Effective Field Theory approach to exotic molecular states in the spectrum of bottomonium which respects HQSS and fix all the parameters directly from the existing experimental data for the Zb(10610) and Zb(10650) resonances. Then the properties, such as the line shapes and the poles position, of their spin partners WbJ (JˆPC=Jˆ++, J=0,1,2) are predicted in a parameter-free way.

Session 5: Analysis tools / **142**

Three-body Finite-Volume Spectrum in Lattice QCD

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Lattice QCD calculations provide an ab initial access to hadronic process. These calculations are usually performed in a small cubic volume with periodic boundary conditions. The infinite volume extrapolations for three-body systems are indispensable to understand many systems of high current interest. We derive the three-body quantization condition in a finite volume using an effective field theory in the particle-dimer picture. This work shows a powerful and transparent method to read off three-body physical observables from lattice simulations.

Session 5: Analysis tools / **144**

The Development of Hamiltonian Finite Volume Method of Two Body System within Partial Wave Mixing in Rest System

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Hamiltonian effective field theory has been used for explaining Lattice data. We develop it within partial waves mixing in the rest frame. The dimension of the Hamiltonian can be highly reduced with the partial wave cut-off and rotation symmetry. We apply this method to extract the Pion-Pion s-, d- and f-wave phase shifts within Isospin=2 case.

Session 3: Exotic hadrons and candidates / **145**

The spin structure of pentaquark states

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Since Pc(4380) and Pc(4450) were discovered by LHCb collaboration in 2015, the nature of two pentaquarks is still veiled. Recently, three pentaquark states, Pc(4312), Pc(4440),
Pc(4457) were discovered by LHCb with more precision, which inspired us to explore the nature of three pc states. In this talk, I will discuss the implementation of effective field theory to describe the three pentaquark states Pc(4312), Pc(4440),
Pc(4457) in terms of molecular picture, and also compared our results with one boson exchange model to analysis the issue of spin of Pc(4440) and Pc(4457), besides a series of molecular states emerged in a complete heavy-quark spin symmetry multiplet of charmed mesons and baryons are also presented.

Session 5: Analysis tools / **146**

Triangle singularity in J/ψ to $\eta\pi^0\phi$

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BESIII Collaboration has reported the observation of $a_0^0(980) - f_0(980)$ mixing. From the Dalitz plot of BESIII's paper for the decay $\eta \to \gamma\gamma$, one can see that there is a peak around 1.4 GeV on $\pi^0\phi$ distribution. In general, this peak can be interpreted as a dynamically resonance state or a kinematic effect. In this paper, by using the effective Lagrangian method to calculate a triangle diagram includes $K^*\bar{K}K$ loop for isospin breaking process $J/\psi \to \eta\pi^0\phi$, we show that there is a peak appears in the Dalitz plot where the invariant mass of $\pi^0\phi$ around 1.4 GeV by virtue of the triangle singularity. This may explain the peak around 1.4 GeV of BESIII's experimental results. But whether the peak is the effect of triangle singularity or a resonance state requires further experimental results.

Plenary session / **147**

Coupled-channel effects in heavy hadrons

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Heavy meson spectroscopy was very well described in terms of $Q\bar{Q}$ states since the discovery of the J/ψ in 1974 up to the discovery of the $X(3872)$ in 2003. However the intriguing properties of this meson made evident that higher Fock components were necessary to describe heavy hadron spectroscopy for excited states. The inclusion of two hadron components induce coupled-channel effects that can have important consequences. One example is the deviations from predictions given by well known symmetries like heavy quark spin symmetry (HQSS) or heavy flavour symmetry (HFS) that are due to differences in the relative positions of two hadron thresholds and bare $Q\bar{Q}$ states. In this contribution I will review the most important effects due to coupled channels in the heavy hadron spectrum.

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Study of Heavy Tetraquarks in a Diquark Model

Author: Zahra Ghalenovi[1]

[1] *Kosar University of Bojnord*

A non-relativistic quark model is used to study heavy tetraquarks within a diquark-antidiquark configuration, where the four body system is considered as three subsequent two-body systems. The considered Hamiltonian is a combination of the linear confining, Coulombic and spin-spin interaction terms. Using the perturbation theory, we calculate the heavy meson spectra and then estimate the masses of the bottom tetraquaks. We find that the exotic state $Z_b(10650)$ can be considered as diquark–antidiquark bound state.

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Study of Charm Baryons in a Hypercentral Quark Model

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We study the single charm baryons in a non-relativistic quark model. We use the hypercentral approach to simplify three-body equation of the baryonic system. In our study, the spin-spin, spin-isospin and isospin-isospin interactions are calculated perturbatively. The mass spectra of the single charm baryons are calculated. The radiative decay width and the magnetic moments of the charm baryons are also predicted. A comparison of our results with the experimental data and the predictions of recent models is also presented.

Session 6: QCD and hadron structure / 150

The EIC project in China

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Electron Ion Collider (EIC), regarded as the ” super electron microscope” , can provide the clearest image inside of the nucleon. It is the most ideal tool to understand the internal structure of the nuclear matter, especially the quark-gluon structure of the nucleon and nuclei. Polarized EICs are the next generation ” multi-dimensional electron microscopes” that are most effective in studying the deep structure and strong interactions of particles. Based on the Heavy Ion High Intensity Accelerator Facility which is under construction since the end of 2018 in Huizhou, the IMP is proposing to build a high luminosity polarized EIC facility in China, named ” EicC” , to carry out the frontier research on nucleon structure studies. In this talk, the current status of the EicC will be presented, including the considerations on detector design and the physics programs.

Session 5: Analysis tools / **151**

Wave-Selection Techniques for Partial-Wave Analysis in Light-Meson Spectroscopy

Author: Florian Kaspar[1]

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The light-meson spectrum can be studied by analyzing data from diffractive dissociation of pion or kaon beams. The contributions of the various different states that are produced in these reactions are disentangled by the means of partial-wave analysis. A challenge in these analyses is that the partial-wave expansion has to be truncated, i.e. that only a finite subset of the theoretically infinitely many partial-wave amplitudes can be inferred from the data. In recent years, different groups have applied regularization techniques in order to determine the contributing waves from the data. However, to obtain meaningful results the choice of the regularization term and the tuning of its free parameters are crucial. We will present our recent developments of wave-selection methods for partial-wave analyses based on simulated data for diffractively produced three-pion events.

This work was supported by the BMBF, the DFG Cluster of Excellence "Origin and Structure of the Universe" (Exc 153), and the Maier-Leibnitz-Laboratorium der Universität und der Technischen Universität München.

Session 1: Meson spectroscopy / **152**

Studies of $\eta(')\pi$ Final States Using GlueX Data

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The primary goal of the GlueX experiment at Jefferson Lab is to search for and map the spectrum of light hybrid mesons.
Many experiments have studied and reported evidence of exotic mesons decaying into $\eta\pi$ and $\eta'\pi$ final states.
With a large acceptance to both charged and neutral particles, GlueX has access to both the neutral, $\gamma p \to \eta^{(')}\pi^0 p$, and charged, $\gamma p \to \eta^{(')}\pi^-\Delta^{++}$, exchanges.
This presentation will give an overview of the current studies being performed at GlueX in $\eta^{(')}\pi$ channels, with a focus on the $\eta^{(')}\pi^-$ final states.
It will discuss early physics goals, such as studying $a_0 \to \eta\pi$ and $a_2 \to \eta\pi$ as a function of t, and outline the strategy for an amplitude analysis as GlueX begins its quest to illuminate the light hybrid meson spectrum.

Session 4: Hadron decays, production and interactions / **153**

Interactions between two heavy mesons within heavy meson chiral effective field theory

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Co-authors: Bo Wang [2]; Ning Li [2]; Shi-Lin ZHU [2]; Xiang Liu [3]; hao xu [4]

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We have studied the interactions between two heavy mesons [D-D or B-B] within heavy meson chiral effective field theory and investigated possible molecular states. The effective potentials are calculated with Weinberg's scheme up to one-loop level. At the leading order, four body contact interactions and one pion exchange contributions are considered. In addition to two pion exchange diagrams, we include the one-loop chiral corrections to contact terms and one pion exchange diagrams at the next-to-leading order. The behaviors of effective potentials both in momentum space and coordinate space are investigated and discussed extensively. We notice the contact terms play important roles in determining the characteristics of the total potentials. The possible molecular states are also investigated and the binding energies are provided by solving the Schrodinger equation.

Session 6: QCD and hadron structure / **154**

Simulation of exclusive pion0 electroproduction on EicC

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The kinematical coverage, statistical uncertainties of pion0-DVMP channel on EicC are studied using MC simulation. The detections of the final particles are preliminarily discussed. The low-energy Electron-Ion Collider in China would provide decent statistics of pion0-DVMP events. These data would help constrain the transversity GPDs and the polarized GPDs around small x and small skewness \xi.

Plenary session / **155**

Light-meson spectroscopy at leptoproduction and hadroproduction experiments

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The excitation spectrum of light mesons, which are composed of up, down, and strange quarks, is studied since decades. However, it still holds a number of puzzles and surprises that provide new insights into the nature of the strong interaction.

Recent high-quality data samples from several experiments allow us to not only study the properties of established mesons with unprecedented precision but to also search for new states. These searches in particular aim to resolve the question of the existence of so-called exotic states, such as four-quark states or states with excited gluon fields.

Since light mesons have often large widths and are overlapping, the mapping of their spectrum is challenging and requires large quantities of data on different production and decay modes. The data are analyzed using a framework of interfering quantum amplitudes known as partial-wave analysis (PWA). Most excited meson states decay into multi-particle final states, for which the PWA requires extensive modeling of the dynamics of the final-state hadrons.

In this talk, I will give an overview on ongoing experimental studies of light mesons and discuss possible interpretations. I will also touch on novel analysis techniques and the prospects for future progress.

Plenary session / **156**

Lattice results on dibaryons and baryon-baryon interactions

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After briefly reviewing methodologies to investigate baryon-baryon interactions in lattice QCD, I will present our results on dibaryons using the HAL QCD potential method, which are obtains at almost physical as well as heavier pion masses. In this talk, I will focus on Omega-Omega, N-Omega, Delta-Delta and H-dibaryons.

Session 6: QCD and hadron structure / **157**

Wigner distribution and spin structure of pion from light front holographic QCD

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We investigate the Wigner distributions of the pion using a holographic light-front pion wavefunction with dynamical spin effects to unravel the spatial and spin structure. Using
a universal AdS/QCD scale and constituent quark masses, we find that the dynamical spin effects are maximal in the pion where they lead to an excellent simultaneous description
of a wide range of data: the decay constant, charge radius, spacelike electromagnetic and transition form factors, as well as, parton distribution function. Here, we present the Wigner distributions for

unpolarized and transversely polarized quark in the transverse momentum plane as well as in the transverse impact parameter plane. The leading twist GTMDs, GPD, and TMDs for pion are also presented.

Session 6: QCD and hadron structure / **158**

Mass decomposition of the nucleon

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Higgs boson provides the origin of quark masses. But how it is related to the proton mass and thus the masses of nuclei and atoms is another question. I will present the state-of-the-art understading of the proton mass based on the Lattice QCD calculation of QCD energy momentum tensor, and a outlook on how to access the trace anomaly in the near future.

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The excited nucleon on the lattice: overlap vs clover.

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The notable absence of a low-lying energy level in the positive parity sector of the nucleon excitation spectrum in lattice QCD has been a point of interest for some time. Speculation about the potential role of chiral symmetry in the lattice nucleon spectrum has arisen recently as a possible explanation for this absence. We endeavour to address this issue through a systematic comparison of the clover and overlap fermion actions through direct ratios of mass-matched nucleon correlators and state of the art correlation matrix techniques. In particular, these results have implications for our understanding of the nature of the N*(1440), or Roper resonance.

Session 6: QCD and hadron structure / **160**

TDA measurements based on hard excusive pion electroproduction with CLAS at JLAB

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For the first time, we have measured single beam spin asymmetries to extract $A_{LU}^{sin(\phi)}$ moments from the hard exclusive π^+ channel off the unpolarized hydrogen target in a wide range of kinematics from forward angles to backward angles in the center of mass frame.
While many experiments showed the QCD factorization mechanism in the "nearly forward region" (large Q^2 and small |t|) can be divided into a hard part, described by perturbative QCD (pQCD) and in
two general structure functions, the GPDs for the nucleon and the pion distribution amplitudes (DAs),
describing the complex non perturbative structure of these particles. The recent measurement from CLAS in the "nearly backward" kinematic region (large Q^2 and small |u|) provided the potentially applicable collinear factorized description in terms of a convolution of the non-perturbative nucleonto-pion transitions (TDAs), the nucleon DAs and the hard interaction amplitude from pQCD.
The measured moment in forward angles is known to be sensitive to generalized parton distributions (GPDs), while in backward angles, it is known to be sensitive to transition distribution amplitudes (TDAs). Our results clearly show that the sign of forward beam spin asymmetry measurements is positive whereas that of backward BSA measurements is negative, with the sign transition taking place
around 90 degrees. By performing accurate measurements over a wide range of Q^2, x_B and -t, we can
explore the transition from hadronic to partonic reaction mechanisms.

Session 7: Hadrons in hot and nuclear environment including hypernuclei / **161**

Magnetic field dependence of light baryon properties in a Skyrme model

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The properties of nucleons and Δ isobars in a uniform magnetic field are investigated. In the weak magnetic field region, the general relations between magnetic moment of nucleons and Δ isobars are given.
The estimation shows in the core part of the magnetar, the equation of state fornucleons and Δ isobars depends on the magnetic field, which affects the mass limit of the magnetar.

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The study of four charged pions production with CMD-3 detector at VEPP-2000 collider

Author: Alexandr Korobov[1]

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Since 2010 the VEPP-2000 electron-positron collider has been operated at Budker Institute of Nuclear Physics in the center-of-mass (c.m.) energy range from
$\sqrt{s} = 320$ MeV to 2000 MeV. VEPP-2000 has two interaction
regions in which the Cryogenic Magnetic Detector (CMD-3) and the
Spherical Neutral Detector (SND) are installed.

Production of four charged pions in e^+e^- annihilation has been studied
before with good statistics at the CMD-2 and SND detectors as well as using initial-state radiation (ISR) with BaBar
at which a low systematic uncertainty of about 3% was achieved for the
$e^+e^- \to \pi^+\pi^-\pi^+\pi^-$ cross section in the wide c.m. energy
range.

In this work the cross section of the process $e^+e^- \to \pi^+\pi^-\pi^+\pi^-$ has been measured using an integrated luminosity of 168 pb^{-1} collected with the CMD-3 detector in the c.m. energy range 650-2000 MeV. Also studied
are the internal dynamics of four-pion production. High-precision measurements
of various hadronic cross sections are of great interest in relation with the
problem of the muon anomalous magnetic moment g-2. The $e^+e^- \to \pi^+\pi^-\pi^+\pi^-$ cross section can be also used to test relations between
e^+e^- annihilation and τ lepton decays based on conservation of vector
current.

Session 6: QCD and hadron structure / **163**

Central exclusive meson production in proton-proton collisions in ALICE at the LHC

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Central exclusive production at hadron colliders is characterised by the hadronic state produced at or close to midrapidity, and by the two forward scattered protons, or remnants thereof. No particles are produced between the midrapidity system and the forward going beam particles, and such events can hence be identified experimentally by a double gap topology. At LHC energies, central exclusive production in proton-proton collisions is dominated by pomeron-pomeron fusion. I will review the models to describe such reactions, and will discuss the ongoing efforts in the ALICE collaboration to analyse double gap events taken in Run II at the LHC. The prospects of such data taking in Run III will be presented.

Session 6: QCD and hadron structure / **164**

Effective Light Front QCD Hamiltonian and spectral equation for quark-antiquark states

Authors: Evgeni Prokhvatilov[1]; Mikhail Malyshev[2]

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Light Front (LF) QCD Hamiltonian in LF gauge is used semiphenomenologically to describe quark-antiquark bound states. Quarks and gluons are considered as constituent particles and the Hamiltonian is projected onto the Fock space of these constituent particles. Quark and antiquark in these states are separated in transverse coordinates in gauge invariant way by the "string" constracted with zero mode transverse component of gluon field. Also we add to this Hamiltonian new term which takes into account the contribution of LF zero mode fields semiphenomenologically. We obtain the spectral equation for meson mass squared and solve this equation analitically at large quark masses and discuss possible comparison with experimental spectrum. Also we discuss the generalization for states which can contain in the string one gluon corresponding a nonzero mode of transverse gluon field.

Session 4: Hadron decays, production and interactions / **166**

Determination of resonance properties from lattice energy levels using chiral EFT

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In this talk, I will review our recent developments on the study of using lattice discrete energy levels to determine the resonance properties within the framework of chiral effective field theory. Special attention will be paid to the D*0(2400) in the D-pi, D-eta and Ds-Kbar coupled-channel scattering and the Ds*0(2317) in the DK and Ds-eta scattering.

Session 4: Hadron decays, production and interactions / **167**

Baryon-baryon scattering in manifestly Lorentz-invariant formulation of chiral perturbation theory

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We study baryon-baryon scattering by applying time-ordered perturbation theory to the manifestly Lorentz-invariant formulation of chiral perturbation theory. The diagrammatic rules, for the first time, are worked out for the momentum-dependent interactions and propagators of particles with non-zero spin. We define the effective potential as a sum of two-baryon irreducible contributions of time-ordered diagrams and derive a system of integral equations for the scattering amplitude, which provides a coupled-channel generalization of the Kadyshevsky equation. The obtained leading-order baryon-baryon potentials are perturbatively renormalizable, and the corresponding integral equations have unique solutions in all partial waves. We also discuss the issue of additional finite subtractions required, e.g., in the $^3P_0$ partial waves to improve the ultraviolet convergence of (finite) loop integrals on the nucleon-nucleon and hyperon-nucleon scatterings.

V.Baru, E.Epelbaum, J. Gegelia, X.-L. Ren, arXiv:1905.02116

Session 1: Meson spectroscopy / **168**

Is the $Y(2175)$ a Strangeonium Hybrid Meson?

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QCD Gaussian sum-rules are used to explore the vector ($J^{PC} = 1^{--}$) strangeonium hybrid interpretation of the Y(2175). Using a two-resonance model consisting of the Y(2175) and an additional resonance, we find that the relative resonance strength
of the Y(2175) in the Gaussian sum-rules is less than 5\% that of a heavier 2.9 GeV state. This small relative strength presents a challenge to a dominantly-hybrid interpretation of the Y(2175).

Session 3: Exotic hadrons and candidates / **169**

Decoding the nature of the pentaquarks in LHC

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The updated analysis of LHCb in the
$\Lambda_b^0 \to J/\psi p K^-$ process with nine times data sample
in Run II presents three narrow pentaquark structures instead of
two in the previous analysis.
However, although the large data sample is available,
the quantum numbers of the three pentaquarks and the corresponding
anglular momentum distribution are still missing.
As these three pentaquarks are close to the
$\left(\bar{D}, \bar{D}^*\right) + (\Sigma_c(2455), \Sigma_c(2520))$
thresholds, they could be accepted as hadronic molecular states.
We do an overall fit for the lineshape of these three states
by solving Lippmann-Schwinger equation with dynaimc pion
as well as the inelastic channel to study,
to which extent, these three structures could exist as hadronic
molecular states. Their quantum numbers and the corresponding
angular distributions are also presented for the comparison with
further experimental analysis.

Session 6: QCD and hadron structure / **170**

Valence structures of light and strange mesons from the basis light-front quantization framework

Author: Shaoyang Jia[1]

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We apply the basis light-front quantization framework to solve for the structures of mesons with light and strange valence quarks. Our approach treats mesons as relativistic bound states with quarks confined in both the transverse direction and the light-front longitudinal direction. The spin-orbit interactions of these confined quarks are further specified by the Nambu–Jona-Lasinio model. We address the U(1) axial anomaly by including the Kobayashi-Maskawa-' t Hooft interaction regularized by our basis. We present the structures of the pion, the kaon, the eta meson, and the eta-prime meson in terms of their valence light-front wave functions obtained from the eigenvalue problem of our light-front Hamiltonian.

Session 2: Baryon sepctroscopy / **171**

Possible interpretation of N(1685)

Author: Kai Xu[1]

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$N(1685)$ was firstly reported in the photoproduction of η meson off the quasi-free neutron. Unlike other low-lying nucleon resonances whose Breit-Wigner (BW) widths are at least $100\ \mathrm{MeV}$, the BW width of the $N(1685)$ is less than $30\ \mathrm{MeV}$. The interpretation of the $N(1685)$ is still an open question.

The non-strange pentaquark mass of all quark configurations is evaluated in a constituent quark model, where the Cornell potential is employed and all model parameters
are predetermined by comparing the theoretical and experimental masses of low-lying baryons which are believed to be mainly $3q$ states. The state with the $[31]_{FS}[22]_F[31]_S(q^4\overline{q})$ configuration and quantum numbers $I(J^P) = \frac{1}{2}(\frac{1}{2}^-)$ is predicted to be the lowest pentaquark state. Its mass is derived about $1670\ \mathrm{MeV}$, which encourages one to expect that the $N(1685)$ could be the lowest pentaquark state.

Session 6: QCD and hadron structure / **172**

Minkowski-space solutions of the Schwinger-Dyson equation for the fermion propagator with the rainbow-ladder truncation

Author: Shaoyang Jia[1]

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We solve the Minkowski-space Schwinger-Dyson equation for the fermion propagator in QED with massive photons. Specifically, we work in the quenched approximation within the rainbow-ladder truncation. Loop divergences are regularized either by the Pauli-Villars regularization or by the dimensional regularization. With moderately strong fermion-photon coupling, we find that the analytic structure of the fermion propagator consists of an on-shell pole and a branch cut both located

in the timelike region. Such structures are consistent with the direct solution of the fermion propagator as functions of the complex momentum. With the fermion propagator as an input condition, our method paves the way towards the calculation of the Minkowski-space Bethe-Salpeter amplitude.

Session 7: Hadrons in hot and nuclear environment including hypernuclei / **173**

Comprehensive study of light mesons in nuclear matter with three-flavor extended Linear Sigma Model

Author: Daiki Suenaga[1]

Co-authors: Dirk H. Rischke [2]; Jurgen Schaffner-Bielich [2]; Phillip Lakaschus [2]

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Mass modifications of light scalar, pseudo-scalar, vector, and axial-vector mesons in nuclear matter are studied comprehensively. The mesons are described by the extended Linear Sigma Model which can reproduce vacuum properties such as masses and decay widths, and the nuclear matter is constructed by the two-flavor Parity Doublet Model which can fit the saturation density, binding energy, and incompressibility. We investigate the meson masses in nuclear matter including one-loop corrections in addition to the mean field. As results, reductions of eta and eta' mesons are found. we also find the mass of rho and omega mesons at the normal nuclear matter density do not change significantly. A change of axial anomaly in nuclear matter is also discussed.

Session 4: Hadron decays, production and interactions / **174**

Predictions for Ω_b weak decay and Ξ_{cc} molecular states from meson-baryon interaction

Author: Jorgivan Dias[1]

Co-authors: Eulogio Oset [2]; Ju-Jun Xie [3]; Vinicius Rodrigues Debastiani [4]; Wei-Hong LIANG [5]

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We intend to divide this talk into two parts: in the first one, stimulated by the new experimental LHCb findings associated with the Ω_c states, some of which we have described in previous work as being dynamically generated through meson-baryon interaction, we have extended this approach to make predictions for new Ξ_{cc} molecular states (in the $C = 2$, $S = 0$ and $I = 1/2$ sector). These states manifest themselves as poles in the solution of the Bethe-Salpeter equation in coupled channels. In particular, the kernels of this equation were obtained using the Lagrangians coming from the hidden local gauge symmetry, where the interactions are dominated by the exchange of light vector mesons. The extension of this approach to the heavy sector stems from the realization that the dominant interaction corresponds to having the heavy quarks as spectators, which implies the preservation of the heavy quark symmetry. As a result, we have found several states: two associated with the pseudoscalar meson-baryon interaction with $J^P = 1/2^-$, with masses around 4080 and 4090 MeV. Furthermore, from the vector meson-baryon interaction we get three states

degenerate with $J^P = 1/2^-$ and $3/2^-$ from 4220 MeV to 4330 MeV, and two more states around 4280 MeV and 4410 MeV, degenerate with $J^P = 1/2^-$, $3/2^-$ and $5/2^-$. On the other hand, in the second part of the talk, we present predictions for the weak decay $\Omega_b \to (\Xi_c^+ K^-)\pi^-$, in view of the $\Omega_c(3050)$ and $\Omega_c(3090)$ states, which are generated through the meson-baryon interaction in the ΞD, $\Xi_c K^-$ and $\Xi_c' K^-$ coupled channels. Specifically, we investigate the invariant mass distributions of those channels making predictions that could be confronted with future experiments, providing useful information that could help determine the quantum numbers and nature of these states.

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The proton and $N(1440)$ wave function extracted from the electromagnetic helicity amplitude

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The helicity amplitude of the process $\gamma^* N \to N(1440)$ is evaluated in a relativistic quark model.
The wave functions of the baryons are extracted by fitting the theoretical result to the experimental data.
The findings of the work are consistent with that the $N(1440)$ is mainly a three-quark bound state.

Session 1: Meson spectroscopy / **177**

What's Left to Learn from Mesons with Heavy Quarks?

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I will review the status of mesons with heavy quarks. The insights these states give into QCD dynamics and the outstanding issues will be discussed. Specific examples of theoretical issues and needed experimental inputs are presented for heavy-light, quarkonium-like and possible exotics states.

Session 4: Hadron decays, production and interactions / **178**

Line shape of states in electron–positron annihilation and the role of below-threshold resonance

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We give a parameterizztion of the anomalous line shape of resonances based on a Fano-type formula, which can be widely used to extract properties of resonances from data. We employ it to explain the anomalous line shape of the $e^+e^- \to D\bar{D}$ and $e^+e^- \to \Lambda\bar{\Lambda}$. In both reactions, a below-threshold state is found to play significant role in the measured cross sections.

Session 3: Exotic hadrons and candidates / **179**

Spectrum of the fully-heavy tetraquark state $QQ\bar{Q}'\bar{Q}'$

Authors: Guang-Juan Wang[1]; Shi-Lin ZHU[1]; 璐孟 [2]

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In this work, we systematically calculate the mass spectra of the S-wave fully heavy tetraquark states $bb\bar{b}\bar{b}$, $cc\bar{c}\bar{c}$, and $bb\bar{c}\bar{c}$ in two nonrelativistic quark models. A tetraquark state may be an admixture of a $6_c - \bar{6}_c$ state and a $\bar{3}_c - 3_c$ one, where $6_c - \bar{6}_c(\bar{3}_c - 3_c)$ denotes the color configuration with a 6_c ($\bar{3}_c$) diquark and a $\bar{6}_c$ (3_c) antidiquark. For the tetraquark states $bb\bar{b}\bar{b}$ and $cc\bar{c}\bar{c}$ with $J^{PC} = 0^{++}$, the $6_c - \bar{6}_c$ state is lower than the $\bar{3}_c - 3_c$ one in both the two quark models, while the order of the $bb\bar{c}\bar{c}$ states depend on models. The $6_c - \bar{6}_c$ and $\bar{3}_c - 3_c$ mixing effects are induced by the hyperfine interactions between the diquark and antidiquark, while the contributions from the one-gluon-exchange (OGE) Coulomb or the linear confinement potentials vanish for the $QQ\bar{Q}'\bar{Q}'$ system. With the couple-channel effects, we obtain the similar mass spectra. The numerical results show that the ground $QQ\bar{Q}'\bar{Q}'$ ($Q = b, c$ and $Q' = b, c$) tetraquark states are located above the corresponding scattering states, which indicates that there may not exist a bound state in the scheme of the two quark models.

Session 3: Exotic hadrons and candidates / **180**

Estimation of the low-lying tetraquark mass spectrum

Author: Zheng Zhao[1]

Co-authors: Attaphon Kaewsnod [2]; Ayut Limphirat [3]; Kai Xu [3]; Yupeng Yan [3]

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The mass of tetraquark states of all $q^2\bar{q}^2$ and $q\bar{q}c\bar{c}$ quark configurations is evaluated in a constituent quark model, where the Cornell potential is employed and all model parameters are predetermined by comparing the theoretical and experimental masses of light, charmed and bottom mesons.
The theoretical predictions of the charmed tetraquarks are compared with the observed XYZ particles.

Session 1: Meson spectroscopy / **181**

Relativistic effects in radiative charmonium transitions: A covariant quark model approach

Author: Tomohito MAEDA[1]

Co-authors: Kenji YAMADA [1]; Masuho ODA [1]; Toshihiko KOMADA [1]

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Radiative transitions between charmonium states have been widely studied theoretically and experimentally as probes reflecting their internal structure.
In particular, since the constituent quark model can classify the excited states systematically, it has been useful tools for exploring undiscovered states and determining the quantum number of newly observed states.

In recent years, the BES III collaboration has reported the latest experimental results on $\psi(3770) \to \chi_{cJ}\gamma$, $\psi(3686) \to \chi_{c1,2}\gamma$ and $\chi_{cJ} \to J/\psi\gamma$.
These results clearly show quark models with relativistic-/coupled channel-/higher-order multipole-corrections taken into account better reproduce the experimental data than conventional simple models.

In this work, we investigate the radiative transitions of charmonium system in the framework of the relativistic covariant quark model where the center of mass motion of the system is treated in a manifestly covariant way.
We discuss in detail the corrections caused by boosting of the center of mass, the deformation of the form factor due to the Lorentz contraction, and the contribution of higher-order multipoles, in comparison with the simple non-relativistic model. We will also discuss the verification of our results by future experiments.

Session 3: Exotic hadrons and candidates / **182**

Tri-hadron bound states with heavy flavor

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Through the Born-Oppenheimer Approximation, we have performed a comprehensive investigation of the DD*K, BB*K* and BBB*molecular states. In the framework of One-Pion Exchange model as well as the treatments of the coupled-channel efects and S-D wave mixing, we find loosely bound tri-meson molecular states of these systems with some specific isospin configuration. We also predict that a tri-meson molecular state for the BBB* system is probably existent as long as the molecular states of its two-body subsystem BB* exist.

Session 2: Baryon sepctroscopy / **183**

The pseudoscalar meson and baryon octet interaction with strangeness zero in the unitary coupled-channel approximation

Author: Bao-Xi Sun[1]

Co-authors: Si-Yu Zhao [1]; Xiang-Yu Wang [1]; Zheng-Ran Zhang [1]

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The pion-nucleon interaction is an interesting topic and has attracted more attentions of the nuclear society in the past decades.
There are two very closed excited states of the nucleon in the S_{11} channel, $N(1535)$ and $N(1650)$, which are difficult to be described within the framework of the constituent quark model. However, in the unitary coupled-channel approximation of the Bethe-Salpeter equation, most of the excited states of the nucleon are treated as resonance states of the pseudoscalar meson and the baryon in the $SU(3)$ flavor space, so are these two particles.

The $s-$ channel, $u-$ channel and Weinberg-Tomozawa contact potentials of the pseudoscalar meson and baryon octet in the S-wave approximation are calculated, and it is found that the πN $s-$ channel potential is repulsive and the other $s-$ channel potential are weaker than the πN case, while the $u-$ channel potentials in the S-wave approximation are attractive.
Although the curves for ηN and $K\Sigma$ cases are not smooth when $\sqrt{s} < 1300$MeV, it is far away from the energy region which we are interested in, and we assume that it would not give an effect on the pole position of the amplitude in the calculation.
However, the contact interaction originated from the Weinberg-Tomozawa term is dominant in the pseudoscalar meson and the baryon octet potential, and the correction from the $s-$ channel potential and the S-wave $u-$ channel potential is not important.

A pole is generated dynamically at $1518 - i46$MeV on the complex energy plane of $\sqrt{s}$ by solving the Bethe-Salpeter equation in the unitary coupled-channel approximation with the 19th set of parameters, i.e., $a_{\pi N} = -2.0$, $a_{\eta N} = -1.7$, $a_{K\Lambda} = -3.2$ and $a_{K\Sigma} = -3.2$.

In this work, the interaction of the pseudoscalar meson and the baryon octet is studied within a nonlinear realized Lagrangian. The $s-$, $u-$ channel potentials and the Weinberg-Tomozawa contact interaction are obtained when the three-momenta of the particles in the initial and final states are neglected in the S-wave approximation.

In the sector of isospin $I = 1/2$ and strangeness $S = 0$, a resonance state is generated dynamically by solving the Bethe-Salpeter equation, which might be regarded as counterparts of the $N(1535)$ particle listed in the PDG data.
We find the hidden strange channels, such as ηN, $K\Lambda$ and $K\Sigma$, play an important role in the generation of the resonance state when the Bethe-Salpeter equation is solved in the unitary coupled-channel approximation.
The coupling constants of this resonance state to different channels are calculated, and it is found that it couples strongly to the hidden strange channels.

Session 4: Hadron decays, production and interactions / **184**

Curious link of 3-body Exclusive and Inclusive CP Violation in Charmless B Decays

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The LHCb experiment has measured CP violation (CPV) across the Dalitz plot of charmless decays of B mesons to 3 charged tracks, namely in Kππ, KKK, πππ, and πKK final states, with strikingly large CPV and strong variations with Dalitz variables. If one identifies these processes with b ⟶ sqq(bar), sss(bar) and b ⟶ dqq(bar), dss(bar), where q = u, d, then the "sum rule" that requires two-loop absorptive parts by unitarity works well for inclusive b ⟶ s CPV, but less well for the inclusive b ⟶ d case. The situation is discussed and remedied, making the 30 years old unitarity argument valid to this day, and affirming quark-hadron duality.

Session 7: Hadrons in hot and nuclear environment including hypernuclei / **185**

Newly completed JLab experiment: Determine the unknown Λn interaction by investigating the possible Λnn resonance

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The newly completed JLab experiment E12-17-003 aimed to search for a possible Λnn resonance using the 3H(e, e' K+)(Λnn) reaction. If such a state does exist, the experiment will measure its binding (or excitation) energy and natural width. These measurements will provide extremely important and experimentally determined information, for the first time, that can be used to investigate the unknown Λn interaction.

Direct ΛN scattering data is extremely important and needed based on the newly confirmed Charge-Symmetry-Breaking (CSB) at a level of 270keV from the binding energy difference observed between ground states of 4ΛHe and 4ΛH. Especially, the Λn data does not exist at all, thus the properties of Λn interaction has been assumed to be identical to that of Λp interaction. The resonance of Λnn system can provide a unique and only experimental data that can be used to determine the unknown properties of Λn interaction.

The presentation will give an overview of the physics motivation of the JLab experiment, the experimental technique, and the most updated analysis results which although may still be preliminary.

Session 4: Hadron decays, production and interactions / **186**

Radiative corrections for the decay $\Sigma^0 \to \Lambda e^+ e^-$

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Electromagnetic form factors serve to explore the intrinsic structure of nucleons and their strangeness partners. With electron scattering at low energies the electromagnetic moments and radii of nucleons can be deduced. The corresponding experiments for hyperons are limited because of their unstable nature. Only for one process this turns to an advantage: the decay of the neutral Sigma hyperon

to the Lambda hyperon and the real or virtual photon. Due to the limited phase space, the effects caused by the $\Sigma^0 \to \Lambda$ transition form factors compete with the QED radiative corrections for the decay $\Sigma^0 \to \Lambda e^+ e^-$. In this talk, the complete set of these NLO QED corrections to the Dalitz plot, calculated beyond the soft-photon approximation, are presented.

Session 1: Meson spectroscopy / **187**

A possible prescription for incorporating the Nambu-Goldstone pions within the quark model

Author: Kenji Yamada[1]

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The quark model has been applied with considerable success to mass spectra, strong and electromagnetic decays of hadrons. In these approaches only the degrees of freedom of the valence quark are retained, thus the pions are simply treated as interacting $q\bar{q}$ pairs, which are identical to the ρ mesons except for the spin quantum number. Meanwhile, from the point of view of QCD the pions are pseudo-Nambu-Goldstone bosons associated with the spontaneous breaking of chiral symmetry. The NG boson nature of the pions is not incorporated into the quark model at all. Here we propose a possible prescription for incorporating the Nambu-Goldstone pions within the quark model by extending the Pauli spinors of quarks to the Dirac spinors, where the pion spin wave function is nearly proportional to γ_5.

Session 2: Baryon sepctroscopy / **188**

New spectrum of negative-parity doubly charmed baryons: Possibility of two quasistable states

Authors: Maojun Yan[1]; Xiao-Hai Liu[2]

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The discovery of Ξ_{cc}^{++} by the LHCb Collaboration triggers
predictions of more doubly charmed baryons. By taking into account both the P-wave
excitations between the two charm quarks and the scattering of light pseudoscalar mesons off the ground state doubly charmed baryons, a set of
negative-parity spin-1/2 doubly charmed baryons are predicted already from a unitarized version of leading order
chiral perturbation theory. Moreover, employing heavy antiquark-diquark symmetry the relevant low-energy constants in the next-to-leading order are connected with those describing light pseudoscalar mesons scattering off charmed mesons, which have been well determined from lattice calculations and experimental data. Our calculations result
in a spectrum richer than that of heavy mesons. We find two very narrow $J^P = 1/2^-$ Ω_{cc}^P, which

very likely decay into $\Omega_{cc}\pi^0$ breaking isospin symmetry. In the isospin-1/2 Ξ_{cc}^P sector, three states are predicted to exist below 4.2˜GeV with the lowest one being narrow and the other two rather broad. We suggest to search for the Ξ_{cc}^P states in the $\Xi_{cc}^{++}\pi^-$ mode. Searching for them and their analogues are helpful to establish the hadron spectrum.

Session 2: Baryon sepctroscopy / **189**

Baryon properties from a Poincaré-covariant Faddeev equation

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Nucleons, fundamental blocks of the world, carry almost all mass of the visible Universe. In Standard Model, nucleons are bound states of quarks and gluons via strong interaction which is described by quantum chromodynamics (QCD). Nucleons are members of a large family of baryons. Non-perturbative features of QCD, confinement and dynamical chiral symmetry broken, are the key to understand baryon properties. Dyson-Schwinger equations (DSEs) are a powerful tool of non-perturbative QCD, which have made numerous progress in recent years. In the talk, I will present latest results of DSEs on baryon properties by rigorously solving a Poincaré-covariant Faddeev equation without a diquark assumption, e.g., mass spectrum from light to heavy systems, nucleon tensor charges, nucleon electromagnetic form factors, and etc.

Session 2: Baryon sepctroscopy / **190**

Singly heavy baryons in a pion mean- field approach

Author: Hyun-Chul Kim[1]

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We present briefly a series of recent works on singly heavy baryons in a pion mean field approach. In the limit of infinitely heavy-quark mass, the singly heavy baryon can be considered as a baryon that consists of Nc - 1 light valence quarks. The presence of the Nc - 1 valence quarks create the pion mean fields that arise from the vacuum
polarization. Using this approach, we are able to compute various properties of singly heavy baryons such as the mass spectra, magnetic moments, radiative decays, and electromagnetic and transition form factors. The present approach predicts uniquely the existence of the baryon decapentaplet, which may be found experimentally in near future.

Plenary session / **191**

Round table discussion on exotics: What we understand and what need to be measured at current and future experiments

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Plenary session / **192**

Theoretical review of heavy-light spectroscopy

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This is a review of the theoretical developments in understanding the heavy-light mesons and baryons.

Plenary session / **193**

Experimental review of the spectroscopy of singly-heavy hadrons

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This is an experimental review of the spectroscopy of singly-heavy mesons and baryons.

Plenary session / **194**

Dynamically generated hadronic resonances

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This is a review of dynamically generated hadronic resonances

Plenary session / **195**

Nucleon structure

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This is a review of the recent progress in understanding the nucleon structure, including both the theoretical and lattice developments.

Plenary session / **196**

Analysis tools in searching for resonances

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This talk reviews the recent progress in developing analysis tools for resonances searching.

Plenary session / **197**

Theory aspects of the XYZ and Pc states

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This talk reviews the theoretical aspects of the XYZ and Pc states. Triangle singularities will also be discussed.

Plenary session / **198**

Status and future perspectives of hypernuclear physics

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This talk covers the status and future perspectives of hypernuclear physics.

Plenary session / **199**

Hadron spectroscopy on the lattice

Author: Jozef Dudek[1]

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This is a review on recent progress in lattice QCD calculations of hadron spectroscopy.

Plenary session / **200**

Perspectives of hadron spectroscopy on future facilities

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This talk will discuss perspectives of hadron spectroscopy on future facilities

Plenary session / **201**

Constraining BSM physics by precision hadron calculations

Author: Emanuele Mereghetti[1]

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Low-energy tests of fundamental symmetries are extremely sensitive probes of physics beyond the Standard Model (SM), reaching scales that are comparable, if not higher, than directly accessible at the
energy frontier. The interpretation of low-energy precision experiments and their connection with models of BSM physics relies on controlling the theoretical uncertainties induced by the nonperturbative nature of QCD at low energy and of the nuclear interactions. In this talk I will discuss
how Effective Field Theories techniques can lead to improved predictions for low-energy experiments,
with controlled theoretical uncertainties. I will first introduce an EFT framework for the description of
neutrinoless double beta decay. I will show how the EFT allows to derive a very general parameterization of the double beta rate, which captures but goes beyond the standard scenario of light
Majorana neutrino exchange, and to construct the double beta transition operators in a consistent power
counting. I will then review recent progress in the calculation of electric dipole moments of the nucleon
and of light nuclei, and address the remaining challenges for a smooth connection between experiments
and theories of physics beyond the Standard Model.

Session 7: Hadrons in hot and nuclear environment including hypernuclei / **202**

Capturing some medium effects in the dilaton to study hadrons in AdS / QCD models

Author: Alfredo Vega[1]

Co-author: Miguel Angel Martin [1]

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Although from the gravitational point of view, the metric and the dilaton field define the background, in AdS/QCD models medium effects usually are catched only in metric. Here we discuss two examples where dilatons depending on temperature and/or density can be useful to study hadron properties at finite temperature and / or in a dense medium with AdS / QCD models.

203

A generalization of ideas to get meson wave functions from holographic models

Author: Alfredo Vega[1]

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Based on holographic correspondence Brodsky and de Teramond suggested a procedure to relate AdS modes with meson wave functions. In the original papers authors considered hard wall models and Soft wall models with quadratic dilaton. In this poster we shows alternatives to obtain meson wave functions beyond the traditional cases considering other dilatons.

Session 4: Hadron decays, production and interactions / **204**

Recent progress in the construction of covariant chiral nuclear forces

Author: Lisheng Geng[1]

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Over the past twenty years, one has seen remarkable progress in ab initio studies of nuclear structure and reactions with chiral nuclear forces. In a series of recent studies [1-5], we have shown that it is possible to construct chiral nuclear forces using covariant baryon chiral perturbation theory, which enjoy a number of appealing features. For instance, they are manifestly covariant and therefore can be applied in ab initio studies based on covariant frameworks, such as the Dirac-Brueckner Hartree-Fock approach. Second, they converge relatively faster than their non-relativistic counterparts both in the two-body [1-5] and in the three-body sector [6]. In this talk, we explain in detail how they are built from covariant baryon chiral perturbation theory [1,2], highlight their applications to lattice QCD simulations in the hyperon-nucleon/hyperon sector [3,4], and show the recent progress in going to higher chiral orders in this endeavor [5,7].

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Session 6: QCD and hadron structure / **205**

Parton Distribution Functions today: needs, achievements and challenges

Author: Emanuele Roberto Nocera[1]

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I review recent progress in the determination of the collinear parton distribution functions (PDFs) of the proton. I focus on how the needs for accuracy and precision in current and future programs at high-energy accelerators are addressed in contemporary PDF sets. I discuss the impact on PDFs of the uncertainties coming from the data, the theory and the methodology, and I outline some corresponding challenges in their assessment.

Session 1: Meson spectroscopy / **206**

Vector and baryon spectra via holography in an AdS deformed background

Authors: Alfredo Vega[1]; Danning Li[2]; Eduardo Capossoli[3]; Henrique Boschi-Filho[3]; Miguel Angel Martin Contreras[1]

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In this work we discuss how to construct the Regge trajectories for light mesons and baryons in the context of a bottom-up holographic model consisting on a five-dimensional AdS background deformed with a quadratic function in the holographic coordinate. We fit the scalar meson f_0, vector meson rho, baryons with spin $1/2^+$ and spin $3/2^+$ trajectories. These results are in fine agreement with those exposed in PDG. We also found in this model a universal Regge slope near to 1.1 GeV^2.

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Holographic Description of decay constants in AdS/QCD models: a summary and perspectives

Authors: Alfredo Vega[1]; Miguel Angel Martin-Contreras[2]

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In this talk we discuss the holographic approximation to the calculation of mesonic decay constants in the context of the bottom-up AdS/QCD models such as the soft wall-like approaches. We show some of the technical difficulties and some possible solutions to them.

Session 6: QCD and hadron structure / **208**

Overview and Recent Progress in TMD

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We will provide the recent progress in TMD physics. In particular I will emphasize the recent TMD global analysis of both unpolarized and polarized TMD parton distribution functions in standard SIDIS, Drell-Yan, and e+e- channels. Then I will present the progress on how one can go beyond these processes to probe TMD physics in vector-boson tagged jet production. We finish the talk with the recent progress in probing TMD fragmentation functions inside jets.

Session 3: Exotic hadrons and candidates / **210**

Decay of the tetraquark with double beauty

Author: Jean-Marc Richard[1]

Co-authors: Alfredo Valcarce [2]; Eliecer Hernandez [3]; Javier Vijande [4]

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A detailed study is presented of the flavor-exotic isoscalar
$T_{bb}^- \equiv bb\bar{u}\bar{d}$ tetraquark. with spin and parity $J^P = 1^+$.
In realistic quark models, with a careful treatment of the 4-body problem, the T_{bb}^- is approximately 150 MeV below the strong decay threshold $B^- \bar{B}^{*0}$ and 105 MeV below the electromagnetic decay threshold $B^- \bar{B}^0 \gamma$.

The lifetime of T_{bb} is estimated, as well as the dominant decay modes where the tetraquark might be looked for in future experiments. Its total decay width is

$\Gamma \simeq 79. \times 10^{-15}$ GeV and therefore
its lifetime $\tau \simeq 8.3$ ps. The promising final states are $B^{*-}\, D^{*+}\, l^-\, \bar{\nu}_l$
and $\bar{B^*}^0\, D^{*0}\, l^-\, \bar{\nu}_l$ among the semileptonic decays, and, among the non-leptonic ones,
$B^{*-}\, D^{*+}\, D_s^{*-}$, $\bar{B^*}^0\, D^{*0}\, D_s^{*-}$
$B^{*-}\, D^{*+}\, \rho^-$.

Plenary session / **211**

Status and perspectives of the nucleon structure measurements

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Status and perspectives of the nucleon structure measurements

Plenary session / **212**

Review of light baryon spectroscopy

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This is a review of light baryon spectroscopy

Session 4: Hadron decays, production and interactions / **213**

$\pi\pi$ and $K\pi$ scattering amplitudes from lattice QCD

Author: Marcus Petschlies[1]

Co-authors: Andrew Pochinsky [2]; Giorgio Silvi [3]; Gumaro Rendon [4]; John W. Negele [2]; Luka Leskovec [5]; Sergey Syritsyn [6]; Srijit Paul [7]; Stefan Meinel [4]

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I report on our study of low-lying resonances in $\pi\pi$ and $K\pi$ scattering from lattice QCD.
Based on ab-initio multi-hadron spectroscopy and the Lüscher finite-volume method, we have investigated the elastic scattering amplitudes for $\pi\pi$ P-wave, $K\pi$ S-wave
and P-wave partial waves. A particular focus of the discussion will be the parametrizaton of the amplitudes
with respect to the identification of resonance parameters. The shown results are
obtained for two gauge field ensembles at pion masses 317 MeV and 178 MeV.

Session 6: QCD and hadron structure / **214**

SoLID program at JLab

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An all new detector, Solenoidal Large Intensity Device (SoLID), has been proposed for the Jefferson Lab 12 GeV era. A wide range of experiments were approved for SoLID. They include parity violation in deep inelastic scattering (PVDIS) to test the Standard Model at low energies, semi-inclusive deep inelastic scattering (SIDIS) to study the parton Transverse Momentum Distributions (TMD), Timelike Compton Scattering (TCS) to study the Generalized Parton Distributions (GPD), and J/psi production near threshold to study the QCD gluonic force and proton mass. SoLID will fully utilize the great physics potential of the JLab 12-GeV energy upgrade by combining high luminosities and large acceptance and I will give a brief introduction to the SoLID physics programs. This work is supported in part by U.S. Department of Energy under contract number DE-FG02-03ER41231.

Session 2: Baryon sepctroscopy / **215**

Implication of chiral symmetry on neutral weak pion production off a nucleon

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Neutral current single pion production induced by neutrinos and antineutrinos on nucleon targets has been investigated in manifestly relativistic baryon chiral perturbation theory with explicit $\Delta(1232)$ degrees of freedom up to $\mathcal{O}(p^3)$. At low energies, where chiral perturbation theory is applicable, the total cross sections for the different reaction channels exhibit a sizable non-resonant contribution, which is not present in event generators of broad use in neutrino oscillation and cross section experiments such as GENIE and NuWro.

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e+e- -> gamma X(3872) cross section measurement

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We study the process of e+e- ->gamma omega J/psi with 11.6 fb-1 e+e- annihilation data taken at center-of-mass energies from 4.008 GeV to 4.600 GeV with the BESIII detector at the BEPCII storage ring. X(3872)->omega J/psi is observed with more than 5 sigma significance for the first time. The X(3872) mass is measured to be 3873.3 +- 1.1+- 1.0 MeV. The ratio of the decay rate of X(3872)->omega J/psi to X(3872)->pipiJ/psi is measured to be 1.6+-0.4+- 0.2, which indicates a large iso-spin violation effect. The srqt(s) dependent cross section of is also investigated.

Session 3: Exotic hadrons and candidates / **217**

Deciphering the $X(3872)$ via its polarization in prompt production at the CERN LHC

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Based on the hypothesis that the $X(3872)$ exotic hadron is a mixture of $\chi_{c1}(2P)$ and other states and that its prompt hadroproduction predominately proceeds via its $\chi_{c1}(2P)$ component, we calculate the prompt-X(3872) polarization at the CERN LHC through next-to-leading order in α_s within the factorization formalism of nonrelativistic QCD, including both the color-singlet ${}^3P_1^{[1]}$ and color-octet ${}^3S_1^{[8]}$ Fock states. We also consider the polarization of the J/ψ produced by the subsequent $X(3872)$ decay. We predict that, under ATLAS, CMS, and LHCb experimental conditions, the $X(3872)$ is largely longitudinally polarized, while the J/ψ is largely transversely polarized. We propose that the LHC experiments perform such polarization measurements to pin down the nature of the $X(3872)$ and other X, Y, Z exotic states with non-zero spin.

Session 6: QCD and hadron structure / **218**

Valance quark distribution inside pion using lattice QCD

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I will present recent lattice QCD calculations on x-dependent valance parton distribution function (PDF) of pion. Results for both quasi- and pseudo-PDF using unprecedented fine lattices will be presented. Implications of these QCD-based results on the moments and large-x behavior of the pion light-cone PDF will be discussed.

Session 6: QCD and hadron structure / **219**

GPD Measurements at COMPASS

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Encapsulating the transverse position of partons as functions of their longitudinal momentum, Generalized Parton Distributions (GPDs) go beyond the 1-dimensional description of the partonic structure of the nucleon and provides a 3-dimensional picture of the nucleon. GPDs have drawn considerable theoretical interest and been studied by experimental efforts through processes such as Deeply Virtual Compton Scattering (DVCS) or Hard Exclusive Meson Production (HEMP). At COMPASS, the 160 GeV polarized muon beams were employed for the GPD study in the kinematic domain where sea quarks are expected to contribute significantly. After a successful pilot run during 2012, COPASS proceeded to have dedicated runs in 2016-17 and had about 10 times more data accumulated. In this presentation, some of the resent results on GPD measurements at COMPASS will be given.

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Search for the decay Zc±⟶ρ±ηc

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A study of the e+e− -> π+π−π0 ηc process is performed using data samples collected with the BESIII detector at center-of-mass energies √s= 4.226,4.258,4.358,4.416, and 4.600GeV. The Born cross section times branching fraction product, σB(e+e−⟶π∓Zc(3900)±)× B(Zc(3900)±⟶ρ±ηc), is measured. The corresponding B(Zc±⟶ρ±ηc)/B(Zc±⟶π±J/ψ) ratio, which has been suggested as a useful quantity for distinguishing between molecular and QCD-tetraquark interpretations of the Zc(3900), is reported.

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The χ_{cJ} decay to $\phi K^* \bar{K}, \phi h_1(1380)$ testing the nature of axial vector meson resonances

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We perform a theoretical study of the $\chi_{cJ} \to \phi K^* \bar{K} \to \phi K \pi \bar{K}$ reaction taking into account the $K^* \bar{K}$ final state interaction, which in the chiral unitary approach is responsible, together with its coupled channels, for the formation of the low lying axial vector mesons, in this case the $h_1(1380)$ given the selection of quantum numbers. Based on this picture we can easily explain why in the χ_{c0} decay the $h_1(1380)$ resonance is not produced, and, in the case of χ_{c1} and χ_{c2} decay, why a dip in the $K^+ \pi^0 K^-$ mass distribution appears in the 1550-1600 MeV region, that in our picture comes from a destructive interference between the tree level mechanism and the rescattering that generates the $h_1(1380)$ state. Such a dip is not reproduced in pictures where the nominal $h_1(1380)$ signal is added incoherently to a background, which provides support to the picture where the resonance appears from rescattering of vector-pseudoscalar components.

Plenary session / **222**

Production of heavy hadrons (including heavy quarkonia) at hadron colliders

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An overview of recent results from LHC experiments on production of charm and beauty hadrons, and in particular quarkonia are presented. Experimental results on different production processes are confronted to available theoretical predictions.

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The indirect production of semi-inclusive doubly heavy baryons via Higgs boson and top quark decay

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Within the framework of non-relativistic QCD, the indirect production of semi-inclusive doubly heavy baryons (Ξ_{cc}, Ξ_{bc} and Ξ_{bb}) via four main Higgs decay channels and one main top quark decay channel are presented. The contributions from the intermediate diquark states, $\langle bc\rangle[^3S_1]_{\bar{3}/6}$, $\langle bc\rangle[^1S_0]_{\bar{3}/6}$, $\langle cc\rangle[^3S_1]_{\bar{3}}$, $\langle cc\rangle[^1S_0]_{6}$, $\langle bb\rangle[^3S_1]_{\bar{3}}$, $\langle bb\rangle[^1S_0]_{6}$, have been taken into consideration. Besides, we also discussed the three main source of the theoretical uncertainties, heavy quark masses, the renormalization scale μ_r, and the nonperturbative transition probability and the corresponding differential distributions. There will be a considerable number of events of Ξ_{cc}, Ξ_{bc} and Ξ_{bb} produced per year at the High Luminosity Large Hadron Collider.

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e+ e- -> Ks K pi pi0 / Ks K pi eta cross section measurements

Author: Chengwei Wang[1]

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Using 5.2 fb-1 e+e- annihilation data samples collected with the BESIII detector, we measure the cross sections of e+ e- -> Ks K pi pi0 and KsK pi eta at the center-of-mass energies from 3.90 to 4.60 GeV. In addition, the charmoniumlike resonance Y(4260) and Zc(3900) decay into the two decay modes are also searched for.

Session 6: QCD and hadron structure / **225**

EIC Physics in US

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An Electron Ion Collider (EIC) proposed in the U.S. has received wide support from Nuclear Science Advisory Committee and National Academy of Sciences. With flexible collision energies, high luminosity, and high polarization, EIC will enable us to perform quantum tomography of nucleons and nuclei, and explore a new form of matter - color glass condensate. In this talk, I will highlight these two major science pillars of the EIC. I will also mention other QCD (such as jets) and electroweak opportunities that an EIC can offer.

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Decay behaviors of possible $\Lambda_{c\bar{c}}$ states in hadronic molecule pictures

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In 2010, $\Lambda^*_{c\bar{c}}$ states were predicted as the strange number $S=-1$ partners of $N^*_{c\bar{c}}$, which are well known now as the P_c states and observed experimentally by LHCb Collaboration. We analyze the decay behaviors of $\Lambda_{c\bar{c}}$ as S-wave hadronic molecules within the effective Lagrangian framework by a similar method, which has been applied on P_c states successfully. partial widths of possible decay channels calculated, we find that $\Lambda_{c\bar{c}}(4213)$ and $\Lambda_{c\bar{c}}(4403)$, which are formed as pseudoscalar meson baryon molecules, mainly decay to the $\eta_c\Lambda$ channel. For the two vector meson baryon molecule states, our results show that the total decay width with $J^P=\frac{1}{2}^-$ is by one order of magnitude larger than that with $J^P=\frac{3}{2}^-$. The decay patterns and relative decay ratios are very different for $\Lambda_{c\bar{c}}(4370)$ being a $D_s^{*-}\Lambda_c^+$ or $\bar{D}^*\Xi_c$ molecule state. The main decay channels of $\Lambda_{c\bar{c}}(4550)$ are $\bar{D}^{(*)}\Xi_c^{(*,\prime)}$ because of the pseudoscalar meson exchange mechanism. In addition, $\bar{D}^*\Xi_c$ is the dominant decay channel of $\Lambda_{c\bar{c}}(4490)$ which is assumed as a $\bar{D}\Xi_c^*$ bound state. These decay patterns of the $\Lambda^*_{c\bar{c}}$ states would provide a guidance for their future experimental searches and help us to understand their internal structures.

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Bethe-Salpeter wavefunctions of hybrid charmonia

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The charmonium-like hybrid mesons with $J^{PC} = (0, 1, 2)^{-+}$ and 1^{--} are investigated on anisotropic lattices in the quenched approximation. For these states, we construct spatially extended operators by splitting the $\bar{c}\Gamma cB$-type operators into two parts ($c\bar{c}$ and the chromo-magnetic field strength B) with different spatial distances r. In the Coulomb gauge, the matrix elements of these operators between the vacuum and the corresponding states are interpreted as Bethe-Salpeter (BS) wave functions, which can be extracted by fitting the correlation functions at different r simultaneously. After disentangling from the conventional charmonium states in 0^{-+} ,2^{-+} and 1^{--} channels, the spectrum and the BS wave functions of the hybrid states in the four channels are obtained. It is found that the ground state, the first excited state and even the second excited states of these channels are nearly degenerate in mass and have almost the same BS wave functions. Furthermore, the BS wave functions of the ground state, the first excited state and the second excited state have zero radial node, one radial node and two radial nodes, respectively. In the non-relativistic picture, this observation implies that the hybrid states in these four channels have similar infrastructure and the separation between the $c\bar{c}$ component and gluonic component (depicted by B operator) can be taken as a meaningful dynamical variable.

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Discerning the two $K_1(1270)$ poles in $D^0 \to \pi^+ VP$ decay

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Within the chiral unitary approach, the axial-vector resonance $K_1(1270)$ has been predicted to manifest a two-pole nature.
The lowest pole has a mass of 1195 Mev and a width of 246 Mev and couples mostly to $K^*\pi$, and the highest pole has a mass of 1284 Mev and a width of 146 Mev and couples mostly to ρK. We analyze theoretically how this double-pole structure can show up in the $D^0 \to \pi^+ VP$ decays by looking at the vector-pseudoscalar (VP) invariant mass distribution for different VP channels, exploiting the fact that each pole couples differently to different VP pairs.
We find that the final $\bar{K}^*\pi$ and $\rho\bar{K}$ channels are sensible to the different poles of the $K_1(1270)$ resonance and hence are suitable reactions to analyze experimentally the double pole nature of this resonance.

Session 3: Exotic hadrons and candidates / **231**

Describing the charged charmoniumlike structures in the $e^+e^- \to \pi^+\pi^-\psi(3686)$ process based on the ISPE mechanism

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In 2017, the BESIII Collaboration announced the observation of charged charmonium-like structure in the $\psi(3686)\pi^{\pm}$ invariant mass spectrum of the $e^+e^- \to \psi(3686)\pi^+\pi^-$ process at different energy points, which makes a precise study of the $e^+e^- \to \psi(3686)\pi^+\pi^-$ process based on the initial single pion emission (ISPE) mechanism become possible. In my report, I will show that after performing a combined fit to the experimental data of the cross section of $e^+e^- \to \psi(3686)\pi^+\pi^-$, and the corresponding $\pi^{\pm}\psi(3686)$ and dipion invariant mass spectra, the observed charged charmonium-like structure in $e^+e^- \to \psi(3686)\pi^+\pi^-$ can be reproduced well based on the ISPE mechanism. And the corresponding dipion invariant mass spectrum and cross section can be depicted with the same parameters. In fact, it provides strong evidence to show that the ISPE mechanism can be as underlying mechanism resulting in such novel phenomenon.

Session 2: Baryon sepctroscopy / **234**

Baryon spectroscopy at LHCb

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The LHCb experiment has been continually producing interesting results of heavy baryon spectroscopy, owing to the large data sample of heavy flavor hadrons provided by the LHC and the excellent performance of the delicately designed detector. This talk will present the latest results of conventional heavy baryons from the LHCb experiment, including discoveries of new states and measurements of the properties of known states.

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First Observation of hc->hadrons

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Based on $(4.48 \pm 0.03) \times 10^8$ ψ' events, collected with the BESIII detector at the BEPCII storage ring, five h_c hadronic decays are searched for via the process $\psi' \to \pi^0 h_c$. Three of them, $h_c \to p\bar{p}\pi^+\pi^-$, $\pi^+\pi^-\pi^0$, and $2(\pi^+\pi^-)\pi^0$, are observed for the first time with significances of 7.4σ, 4.6σ, and 9.1σ, and their branching fractions are determined to be $(2.89 \pm 0.32 \pm 0.55) \times 10^{-3}$, $(1.60 \pm 0.40 \pm 0.32) \times 10^{-3}$, and $(7.44 \pm 0.94 \pm 1.52) \times 10^{-3}$, respectively, where the first uncertainties are statistical and the second systematic. No significant signal is observed for the other two decay modes, and the corresponding upper limits of the branching fractions are determined to be $B(h_c \to 3(\pi^+\pi^-)\pi^0) < 8.7 \times 10^{-3}$ and $B(h_c \to K^+K^-\pi^+\pi^-) < 5.8 \times 10^{-4}$ at the 90% confidence level.

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Search for the phi(2170) in the photoproduction reaction

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We have studied the γp→ηϕp reaction within the effective Lagrangian approach by considering the contribution of the intermediate state ϕ(2170) production, and the background contributions of t-channel π0 and η mesons exchanges with the intermediate states N and N(1535). Our calculations show that there may be a peak, at least a bump structure around 2180 MeV associated to the resonance ϕ(2170) in the ηϕ mass distribution. We suggest to search for the resonance ϕ(2170) in this reaction, which would be helpful to shed light on its nature.

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Strong decays of cJ (3P) in the 3P0 model

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Recently, LHCb collaboration has confirmed the state X(4100), with mass M = 4146.5±4.5 MeV, and much larger width = 83±21 MeV, comparing with the previous experimental measurements, which has confused the understanding of its nature. We will investigate the possible c1(3P) $c^{-}c$ explanation of the X(4140), considering the mass spectra predicted in the quark model, and the strong decay properties within the 3P0 model, and we also predict the strong properties of the c0(3P) and c2(3P) charmonium states. Our results shows that the X(4140) state with the small width given in PDG can be explained as the c1(3P) charmonium state in the 3P0 model, and the more precise measurement of the X(4140) width is crucial to understand the nature of the X(4140).

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On holographic relation between radial meson trajectories and deconfinement temperature

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The interrelation between the deconfinement temperature of hadron medium and parameters of radial Regge trajectories within the bottom-up holographic models for QCD is scrutinized. We show that the lattice data on the deconfinement temperature can yield a powerful restriction on the spectrum of excited mesons and glueballs within the framework of holographic approach. The best phenomenological agreement and theoretical self-consistency are achieved if the scalar meson f0(1500) is considered as the lightest glueball.

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Strangeness Nuclear Physics at PANDA

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PANDA at FAIR will address the physics of strangeness in nuclei by several novel measurements. These studies are only made possible by the one-of-a-kind combination of the stored antiproton beam at FAIR and the modular PANDA detector which will be complemented
by a germanium detector array for high-resolution gamma-spectroscopy and a secondary target, in which low-momentum hyperons can be stopped. This setup offers the unique possibility to search for X-rays from very heavy hyperatoms. It will also extend the studies on double hypernuclei by performing high resolution gamma-spectroscopy of these nuclei for the first time. Furthermore, the exclusive production of hyperon-antihyperon pairs close to their production threshold in antiproton-nucleus collisions offers a yet unexplored opportunity to elucidate the behaviour of antihyperons in cold nuclei.

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Status of Hypertriton Binding Energy Measurements at the Mainz Microtron

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In recent years the method of decay-pion spectroscopy was pioneered at the Mainz Microtron (MAMI). This method has the potential to achieve ground state mass measurements of light hypernuclei with unprecedented precision. It is aimed at statistical and systematic uncertainties in the Lambda binding energy of about 20 keV. Ongoing activities for hypertriton measurements at MAMI will be presented. The hypertriton provides several important benchmarks for the strong interaction theory dealing with strange baryons, comparable to the role of deuterium for conventional baryon interactions. A hypernuclear physics campaign with a lithium target is foreseen in the future. It will be complemented by extensive calibration measurements.

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Reggeized model for the photoproduction gamma p -> K* Lambda

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The high-precision differential cross-section data for the reaction gamma p -> K*Lambda are re-analyzed within a Regge-inspired effective Lagrangian approach. The model adopts Regge phenomenology to constrain the t-channel contributions from the kappa, K and K* exchanges. A minimum number of resonances in the s-channel are introduced in constructing the reaction amplitudes in order to describe the data. With the purpose of testing how strongly the reaction mechanism, the extracted resonance contents and the associated resonance parameters depend on the way that the t-channel meson-exchange amplitudes are constructed. It is shown that in both Regge model and the interpolated Regge model, the differential cross-section data for gamma p -> K*Lambda can be satisfactorily described by introducing the only N(2060)5/2- resonance in the s channel, which is quite different from our earlier work performed in an effective Lagrangian approach [A. C. Wang et al., Phys.Rev. C 96, 035206 (2017)], where the amplitudes are computed by evaluating Feynman diagrams and it was found that introducing at least one additional resonance apart from the N(2060)5/2- is indispensable for reproducing the data.
The reaction mechanisms are found to be highly model dependent. In the near threshold region, especially at the center-of-mass energy W = 2041 MeV, the angular distributions are dominated by the K exchange in the Regge model, by the N(2060)5/2- exchange in the interpolated Regge model, and by both the K exchange and N(2060)5/2- exchange in the Feynman model of our previous work. At higher energies, the angular distributions are found to be dominated by the K and N(2060)5/2- exchanges in the Regge model, by the N(2060)5/2- exchange in the interpolated Regge model, and by the K, N(2060)5/2- and the other resonance exchanges in the Feynman model. The K exchange, which plays a very significant role in almost the whole energy range considered in both the Regge model and the Feynman model, provides rather small contributions in the interpolated Regge model. On the contrary, the K* exchange and the interaction current, which are negligible in both the Regge model and the Feynman model, offers considerable contributions in the interpolated Regge model. So one can get the conclusion that with only the differential cross sections available for experimental data, the extracted resonance contents are strongly model depended and further study need take the spin observable data into account.

Session 3: Exotic hadrons and candidates / **242**

Reanalysis of uudc\bar{c} penta-quark states

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The LHCb collaboration published new data on penta-quark states: three narrow states Pc(4312), Pc(4440), Pc(4457) are claimed. All of these states are higher than the threshold of NJ/psi threshold and appeared as narrow resonances in the scattering channel N-J/psi. We had analyzed these states in EPJC(2016)76:624 and PRD99(2019)014010. In this report we will reanalyze these states and the main points are: 1.The measured ones are resonances, it is better to do resonances scattering calculation rather than as bound states; 2.These states are narrow resonances due to coupling of Sigma_c-D, Sigma_c-D*quark cluster states to the N-J/psi scattering states. Their spin-parity are 1/2-, 3/2- and cannot be positive parity ones; 3. There should be other resonances in this energy region due to Sigma_c*-D,Sigma_c-D* coupling; 4.In the N-eta_c scattering channel one should be able to observe similar scattering resonances; 5. There might be Jp=1/2- N-eta_c and 3/2- N-J/psi bound states around 3881-3884 and 3997-3998 MeV.

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Bottom strange molecules with isospin 0

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Using the local hidden gauge approach, we study the possibility of the existence of bottomed strange molecular states with isospin 0. We find three bound states with spin-parity 0+, 1+ and 2+ generated by the K*B* and Omega Bs*interaction, among which the state with spin 2 can be identified as B*s2(5840). In addition, we also study the K*B and Omega Bs interaction and find a bound state which can be associated to Bs1(5830). Besides, the KB* and eta Bs* and KB and eta Bs systems are studied, and two bound states are predicted. We expect that further experiments can confirm our predictions.

Session 6: QCD and hadron structure / **244**

Probe triple partons interaction through three quarkonia associated production at LHC

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We propose that the process of triple prompt J/ψ hadroproduction is a very clean hard probe of multiple-parton scatterings at high-energy hadron colliders, especially the least known triple-parton scattering. A first complete study is carried out by considering single-, double-, and triple-parton scatterings coherently. Our calculation shows that it is a golden channel to probe double- and triple-parton scatterings, as the single-parton scattering is strongly suppressed. The predictions of the (differential) cross sections in proton-proton collisions at the LHC and future higher-energy hadron colliders are given. Our study shows that its measurement is already feasible with the existing data collected during the period of the LHC run 2. A method is proposed to extract the triple-parton scattering contribution, and therefore it paves a way to study the possible triple-parton correlations in a proton.

Session 6: QCD and hadron structure / **245**

Recent results and prospects on ultra-peripheral heavy-ion collisions at LHCb

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At the LHC, in ultra-peripheral heavy-ion collisions the highly boosted electromagnetic field of the beam particles represents a source of quasi-real photon. Vector meson photo-production measurements in Pb-Pb collisions are sensitive to the gluon parton distribution functions in the nucleus. LHCb results on charmonium production in ultra-peripheral Pb-Pb collisions as well as the prospects for future analyses will be presented.

Session 2: Baryon sepctroscopy / **247**

Strong decay model \bar{K}\Xi of \Omega(2012) in \bar{K}\Xi(1530) and \eta\Omega molecular scenario

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We study the $\bar{K}\Xi$ decay mode of the newly observed $\Omega(2012)$ assuming that the $\Omega(2012)$ is a dynamically generated state with spin-parity $J^P = 3/2^-$ from the coupled channel S-wave interactions of $\bar{K}\Xi(1530)$ and $\eta\Omega$. In addition we also calculate its three-body decay width into $K\pi\Xi$. It is shown that the so-obtained total decay width is in fair agreement with the experimental data. We compare our results with those of other recent studies and highlight differences among them.

Session 2: Baryon sepctroscopy / **248**

Strong decays of the latest LHCb pentaquark candidates in hadronic molecule pictures

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We investigate the observed pentaquark candidates $P_c(4312)$, $P_c(4440)$ and $P_c(4457)$ from the latest LHCb measurement, as well as four possible spin partners in the $\bar{D}^{(*)}\Sigma_c^*$ system predicted from the heavy quark spin symmetry with the hadronic molecule scenarios. Similar to the previous calculation on $P_c(4380)$ and $P_c(4450)$, the partial widths of all the allowed decay channels for these P_c states are estimated with the effective Lagrangian method. The cutoff dependence of our numerical results are also presented. Comparing with the experimental widths, our results show that $P_c(4312)$, $P_c(4440)$ and $P_c(4457)$ can be described well with the spin-parity-$1/2^-$-$\bar{D}\Sigma_c$, $1/2^-$-$\bar{D}^*\Sigma_c$ and $3/2^-$-$\bar{D}^*\Sigma_c$ molecule pictures, respectively.

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