Hadron in Nucleus 2025 (HIN25)

Wednesday, April 2, 2025 - Friday, April 4, 2025

Yukawa Institute for Theoretical Physics, Kyoto University

Book of Abstracts

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Plenary Session / 3

[KEYNOTE] Toward Understanding Dense QCD Matter

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I will overview the role of symmetries and vacuum structure of QCD in understanding strongly interacting matter. I will focus on the phenomenon of spontaneous chiral symmetry breaking and examine how it affects hadron properties. After discussing insights from finite-temperature QCD, I will address the current theoretical challenges in the dense regime, including the sign problem, and introduce recent developments such as tensor network methods and quantum computing as novel approaches to dense QCD.

Plenary Session / 4

Heavy meson properties in dense matter: the Tcc(3875) and Ds0*(2317) cases (invited talk)

We discuss the modification of the properties of heavy mesons under extreme conditions of density present in heavy-ion collisions at CBM/FAIR energies. We pay a special attention to the behavior of Tcc(3875) and Ds0(2317) as well as their corresponding antiparticles in a dense nuclear environment, so as to show that the charge-conjugation asymmetry in nuclear matter could become an interesting tool to disentangle the nature of these states.

Plenary Session / 5

Chiral symmetry and hadrons in matter (invited talk)

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We summarize the relationship between chiral symmetry breaking and the masses of hadrons. Next, we discuss the behavior of vector mesons in matter. Finally, we demonstrate why K1 and K* are appropriate chiral partners that can be realistically measured in experiments.

Plenary Session / 6

Quark, Diquark and Baryon in Chiral Symmetry (invited talk)

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Plenary Session / 7

Femtoscopy with hyperons as a gateway to study neutron stars (invited talk)

Femtoscopy is a powerful technique for studying final-state interactions between hadrons, employing two- and three-body correlations to analyze the emission source and final-state interactions of particles with low relative momentum. Recent research by the ALICE collaboration has demonstrated the realization of a common baryon-baryon emission source in pp collisions, opening new avenues for studying the properties of the final-state interaction (FSI). In particular, the pΛ system has been measured with unprecedented precision, allowing for better constraints on existing theoretical models.

This talk will present the results of a combined analysis of femtoscopy and scattering involving pΛ, along with the impact on the allowed scattering parameters, the in-medium U_Λ potential as a function of density, and the consequences for the nuclear equation of state, as well as the appearance of hyperons within neutron stars. The talk will conclude with an overview of the latest relevant two- and three-body results and the prospects they bring for the future.

Parallel Session (A) / 8

Experimental research on the spectral modifications of vector mesons in nuclear medium at J-PARC (invited talk)

Hadrons are elementary excitations of the QCD vacuum and reflect its fundamental properties. A large fraction of their mass originates from chiral symmetry breaking, which is expected to be partially restored under high-temperature or high-density conditions. In such environments, the modification of hadron mass spectra is expected.
To investigate in-medium modifications of hadron masses, experimental studies have been conducted in high-energy heavy-ion collisions and nuclear environments.
The J-PARC E16 experiment aims to measure the mass spectra of vector mesons (ρ,ω,ϕ) produced via the p+A⟶ρ,ω,ϕ+X reaction in nuclei. In dense nuclear matter, vector mesons are expected to exhibit reduced masses compared to their vacuum states. Their decay into e^+ e^- pairs is particularly suitable for this study, as the dilepton channel avoids final-state interactions and preserves the in-medium spectral information.
The E16 spectrometer has been developed to achieve high-mass resolution and collect large-statistics data through a combination of large acceptance and high-intensity beams. After completing development and commissioning runs, the experiment is moving toward the data-taking phase to study in-medium hadron modifications.
The current status, particularly on the data collected in 2024, will be presented.

Parallel Session (B) / 9

Lattice QCD studies on Kbar-N interactions and Lambda(1405) in the flavor SU(3) limit

We perform a numerical study in lattice QCD on $\Lambda(1405)$ in the flavor SU(3) limit. Previous studies based on the chiral symmetry have suggested that the spectrum corresponding to $\Lambda(1405)$ observed in experiments may be explained by a combination of two poles. To elucidate such property from lattice QCD, the HAL QCD method is employed, in which hadron interactions are extracted as potentials. Employing configurations in the flavor SU(3) limit, we calculate meson-baryon potentials in the octet and singlet channels, in which the poles corresponding to Lambda(1405) are expected to appear. We find that local potentials both in octet and singlet channels have singular behaviors, which prevent us from reliably extracting binding energies. To avoid such singular behaviors, we introduce a separable potential instead of the standard local approximation. Our results of potentials in both channels show attraction to produce bound states.

Parallel Session (A) / 10

Mass Degeneration of Chiral Partner at J-PARC E16

The spectral functions of chiral partners should become degenerate when the QCD chiral symmetry is restored. The axial-vector spectra are experimentally more challenging to construct than those of vector mesons that directly couple to virtual photons and then to dileptons.
Chiral mixing of the vector with axial-vector mesons is thus a key phenomenon to probe in-medium modifications of vector spectrum due to the onset of chiral symmetry restoration carried by the axial-vector counterpart. The mixing effect is expected to be stronger at higher density due to a mechanism driven by chiral anomalies, in striking contrast to the vanishing mixing at chiral crossover driven by thermal pions. This feature encourages us to perform the experimental search in the high-density regime, where the recent experimental trend has begun to shift toward.

We propose that experiments at medium energies with paying attention to the new mixing mechanism, may provide a direct evidence of the chiral symmetry restoration. In this presentation, we focus on the density-induced mixing and the spectral functions of ϕ and its chiral partner $f_1(1420)$. We present the invariant mass distribution of dileptons using a transport approach under the conditions of the J-PARC E16 experiment as a prime example.

We find that the $f_1(1420)$ meson is visible with about 2 σ credibility in dilepton production in a range of mixing strength in our study when the expected statistics at E16 Run-2 are utilized. We advocate that the E16 experiment at J-PARC has discovery potential for the mass degeneracy of chiral partners at finite density as a signature of chiral symmetry restoration.

Parallel Session (A) / 11

Mass modification of Phi mesons through dileptons, and Kaons in proton induced reactions

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The possibility of observing mass and width modifications of phi mesons in dense matter is an important tool to better understand the behaviour of strongly interacting matter in extreme conditions. Here, I used a BUU transport approach to examine the mass modification of phi mesons and its consequences on the dilepton and kaon invariant mass spectra in several proton-induced reactions with Cu and Pb targets at 12 GeV and 30 GeV bombarding energies. The simulations indicate that the dilepton spectra give a cleaner signal on the mass modifications; however, the kaon yields and the shape of their invariant mass distribution strongly depend on the applied mean fields; therefore, by examining both spectra, we could obtain information not just on the mass modifications but also on the kaon mean fields.

Parallel Session (A) / 12

ϕ -N Interaction via $\pi^- p \to \phi n$ at J-PARC P95

Recently, there has been active research on how the properties of the ϕ meson change in nuclear matter. Understanding the ϕ-nucleon interaction is essential for clarifying the behavior of the ϕ meson in a nuclear environment. Also, the ϕ-N interaction is a unique hadronic system where quark exchange is forbidden at the first order, making gluon exchange the dominant mechanism. While ϕ photoproduction experiments suggest a weak ϕ-N interaction, correlation function analyses from

pp scattering and lattice QCD calculations indicate a possible strong attraction. These conflicting results leave the strength of the interaction uncertain.

To address this, we propose the J-PARC P95 experiment to measure the cross-section of $\pi^- p \to \phi n$. This reaction provides direct access to the s-channel ϕ-N interaction, allowing us to investigate nucleon resonances and the potential existence of hidden-strangeness pentaquark states. In this talk, we will discuss the experimental approach and its implications for understanding hadron interactions.

Parallel Session (A) / 13

The phi-N and phi-nucleus interaction from theory and experiment

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While the phi meson vacuum properties, such as mass and width, are well known, it is not clear how these properties will change once it is put in a dense environment such as nuclear matter.
To study how the phi meson behaves at finite density has been the goal of several past and near future experiments at KEK, COSY-ANKE and J-PARC. Recently, ALICE has obtained novel experimental data constraining the phi-N interaction, at the same time as new lattice QCD calculations about the phi-N potential are also becoming available.
In this talk, I will discuss how these data can be interpreted from a theoretical point of view, and how they possibly can be used to constrain the nuclear matter properties of the phi meson and its longitudinal and transverse polarization modes, which due to the
breaking of Lorentz symmetry in nuclear matter, can be modified differently. I will review theoretical predictions for the in-medium modifications of these quantities and discuss how they could be measured at the future J-PARC E16 and E88 experiments.

Parallel Session (B) / 14

Dbar-N interaction from Lattice QCD

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Knowledge of the Dbar-N interaction is important for studying charmed nuclei or pentaquarks including charm. In this talk, I will present results of the Dbar-N potential and scattering quantities (e.g., phase shift, scattering length) obtained from (2+1)-flavor lattice QCD simulations at physical point, which utilize gauge configurations generated by the HAL Collaboration on a $96^3 \times 96$ lattice with pion mass $m_\pi \simeq 137$ MeV and lattice spacing $a \simeq 0.0844$ fm.

Parallel Session (B) / 15

Exploring Baryon-Baryon Interactions Using Lattice QCD

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Baryon-baryon interactions are crucial for understanding phenomena at nuclear length scales and beyond. Advances in lattice QCD have enabled detailed studies of these interactions, particularly at heavier quark masses. In this talk, I will present recent progress in the field, focusing on our work

with systems entirely composed of charm quarks, including baryons and dibaryons. Utilizing state-of-the-art lattice methodologies, we explore the dynamics of these heavy-quark systems, providing new insights into their interactions.

Parallel Session (B) / 16

Threshold cusp structure in multi-channel scattering

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Near-threshold exotic hadrons are studied actively. In order to understand the nature of them, it is necessary to determine the scattering length from experimental data, because the scattering length governs the near-threshold scatterings. The cusp structure of cross sections reflects the value of the scattering length.

In this work, we study the behavior of threshold cusp in multi-channel scattering using the general scattering amplitude near the threshold [1]. As a result, we show that while there are four kinds of cusps in general case, only two of them are possible in two and three channel cases because of the constraints from the unitarity.

[1] K. Sone and T. Hyodo, arXiv:2405.08436 [hep-ph].

Parallel Session (B) / 17

Two-color QCD as a laboratory to explore diquark dynamics in medium

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In addition to the applicability of lattice simulations in dense medium, two-color QCD world has another advantage that diquark dynamics can be directly observed since diquarks are color-singlet for Nc=2. In this talk, first I explain how a chiral model, i.e., linear sigma model, for Nc=2 and Nf=2+1 is constructed. Then, based on it, I present diquark mass modifications at finite temperature particularly focusing on the mass hierarchy of [sq] and [qq] diquarks, from the viewpoints of chiral restoration and U(1) anomaly effects. Finally, I also discuss connections to singly heavy baryons in our real-life world in hot medium.

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Exploring the Hadron Mass Spectrum at Finite Density with Two-Color Lattice QCD

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We analyze hadron masses for 2-color 2-flavor QCD at low temperatures and finite densities using lattice numerical simulations.
Based on the previous study [1], we complete the extrapolation of the diquark source term to zero, enabling rigorous measurements of hadron masses. This allows us to obtain more detailed and conclusive results for hadron property. In the superfluid phase, meson masses exhibit distinct behavior:

The pseudo-scalar meson mass (namely pion in QCD) increases linearly with density, while the vector meson mass decreases. As a result, the pseudo-scalar becomes heavier than the vector meson in the superfluid phase. Another notable result is that the mass of diquark with $I = 0$, $J^P = 0^+$ is observed to approach zero in the same region. This phenomenon indicates a characteristic of NG boson, which is caused by the breaking of $U(1)_B$ symmetry. Furthermore, we discuss the hadron mixing associated with the hadron-superfluid phase transition.
Reference
[1] K.Murakami, D.Suenaga, K.Iida, E.Itou, arXiv:2211.13472

Parallel Session (A) / 19

Gravitational form factors of nucleons in the scale-Invariant chiral effective theory (invited talk)

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Elucidating the mechanisms by which quarks and gluons are confined within hadrons is one of the most fundamental challenges in QCD. Addressing this problem requires an understanding of the role of non perturbative properties, such as chiral and gluon condensates, as well as the associated spontaneous and anomaly-induced symmetry breaking, in hadron formation. Recently, the stress distribution inside the proton has become experimentally measurable through its extraction from gravitational form factors, which characterize the matrix elements of the energy-momentum tensor for the proton. This stress distribution directly represents the forces that confine quarks and gluons within hadrons, providing a new perspective on this fundamental problem.
In this talk, I will discuss the gravitational form factors and stress distributions of nucleons using the extended Skyrme model, which faithfully incorporates the properties of not only chiral symmetry but also scale symmetry in QCD. In particular, I will investigate how the scale anomaly contributes to the pressure distribution inside the nucleon and discuss its crucial role in ensuring nucleon stability.

Parallel Session (A) / 20

Electromagnetic and axial structure of baryons in dense nuclear matter

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We study the electromagnetic and axial structure of the octet baryons in a nuclear medium in terms of the nuclear matter density ρ. The experimental information about the internal structure of baryons in nuclear medium is very scarce. Theoretical studies are then fundamental for the understanding of environments with dense nuclear matter, from the high energy nucleus-nucleus collisions to the cores of compact stars. The electromagnetic and axial form factors of the octet baryons are determined by combining a covariant quark model, developed for free space, with the quark-meson coupling model in the extension to the nuclear medium. We conclude that, the nuclear medium modifies the baryon properties differently (quenched or enhanced) according to the flavor content of the baryons. In general, the effects of the nuclear medium are stronger for lighter baryons than for heavier baryons. The numerical values for the electromagnetic and axial form factors are used to calculate the neutrino-nucleon and antineutrino-nucleon cross sections for bound nucleons. We also discuss the extension of the model for nuclear densities above the normal nuclear matter $\rho_0 = 0.15$ fm^{-3} up to $\rho = 3\rho_0$.

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Pseudoscalar and vector mesons in cold nuclear matter

We present updated and extended results mass shift and nuclear bound states pseudoscalar and vector mesons in nuclear matter and nuclei.
The mass shift for these mesons are computed using the quark-meson coupling model and effective lagrangians, while the nuclear bound state energies are obtained by solving the Schrödinger and Klein-Gordon equations with complex optical potentials, for a wide range of nuclei.
The nuclear potentials are obtained in the local density approximation from the mass shift of these mesons in nuclear matter
Our results show that the mesons studied are expected to form mesic nuclei with all the nuclei considered. However, the signal for the formation of the mesic nuclei may be difficult to identify experimentally due to possible large widths.

Parallel Session (A) / 22

Correlation functions with resonance states: the p f_1(1285) case

Plenary Session / 23

[KEYNOTE] Hadron-Hadron Interactions from Lattice QCD

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I will summarize recent progress in the study of hadron-hadron interactions using lattice QCD near the physical pion mass (146 MeV), focusing on the HAL QCD method and its connection to experimental data. In particular, we highlight several key interaction channels: (i) Baryon-Baryon Interactions in the S=-2 sector, (ii) Meson-Meson Interactions in the D*-D (Tcc) channel, and (iii) Meson-Baryon Interactions in the phi-N, J/psi-N, and eta_c-N channels. The role of two-pion exchange in (iii) will also be discussed.

Plenary Session / 24

Hyperon potentials in dense matter from chiral EFT evaluated via heavy-ion collisions (invited talk)

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The hyperon single-particle potential (hyperon potential) is a key ingredient for discussing the properties of hyperons in a dense environment, including their existence in neutron stars. In this talk, we will introduce the hyperon potential in nuclear matter based on the baryon forces within modern chiral effective field theory. We will then discuss the validity of these potentials by implementing them into the heavy-ion collision simulator JAM2 and comparing the results with observables.

Plenary Session / 25

Λp scattering experiment at BL33LEP in SPring-8 (invited talk)

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Hyperon-proton scattering experiment is one of the most direct methods to study the hyperon-nucleon (YN) interaction, as in the case of the NN interaction.
Although it had been experimentally difficult for a long time due to short lifetime of hyperons, we successfully performed high-statistics Σ±p scattering experiment at J-PARC.
More YN scattering data for various channels and observables is essential to establish realistic baryon-baryon interaction theories such as the chiral effective field theory extended to the YN interaction.
As the next step, we are now preparing Λp scattering experiment using photo-produced Λ at BL33LEP at SPring-8.
we aim at measuring the differential cross section of the Λp scattering with good precision of 15% in the Λ momentum range of 300-600 MeV/c.
In this experiment, we combine the target surrounding detector system CATCH, which worked well in the previous YN scattering experiment, and the spectrometer system used in the LEPS experiment.
In this talk, I will introduce the overview of the Λp scattering experiment at BL33LEP and preparation status.

Plenary Session / 26

H-Dibaryon near Lambda Lambda and Xi- p Thresholds (invited talk)

This talk will cover preliminary results from E42 on the H-dibaryon search near the Lambda Lambda and Xi- p mass thresholds. The E42 has collected nearly seven thousand Lambda Lambda production events from (K-, K+) reactions off 12C at 1.8 GeV/c. We are approaching the final stage of data anlysis to open the box. The presentation will discuss the nature of the H-dibaryon with only a small fraction of the dataset.

Plenary Session / 27

Constraints from hypernuclei on a deeply bound H dibaryon (invited talk)

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"Treating the NAGARA emulsion event in a realistic L-L-4He three-body model, it is found that the LL6He -> H + 4He strong-interaction lifetime becomes much longer than hypernuclear weak-interaction decays for H dibaryon mass below m(L)+m(n), so that a deeply bound H is not in conflict with hypernuclear data.

Using EFT methods, it is found that the H -> nn weak-decay lifetime
for m(H) < m(L) + m(n) is less than 1 year, much too short to qualify H
for a dark-matter candidate.

Ref. – A. Gal, PLB 857 (2024) 138973, arXiv:2404.12801"

Parallel Session (A) / 28

compositeness analysis of the molecular states

Parallel Session (A) / 29

Effect of eigenstates on spectra in coupled-channel scattering with the chiral unitary method

"In recent years, as experimental data on the excited states of Xi, Xi(1620) and Xi(1690), have been collected, theoretical analyses have also been actively conducted.
In our previous study, we have constructed theoretical models with the chiral unitary method based on the Belle and ALICE results [1-3].

In this work, we classify the eigenstates in order to investigate the physical origin of poles in each model. We also perform the model extrapolation to reveal the relationship between the poles in different theoretical models. By calculating the invariant mass spectra of pi^+Xi^- in Xic->pipiXi decay with poles of different models to examine how the classified eigenstates affect the actual spectra.

[1]T. Nishibuchi and T. Hyodo, Phys. Rev. C 109, 015203 (2024).
[2]M. Sumihama et al. (Belle), Phys. Rev. Lett. 122, 072501 (2019) .
[3]S. Acharya et al. (ALICE), Phys. Rev. C 103, 055201 (2021)."

Parallel Session (A) / 30

Scattering amplitude and effective range expansion with complex potential

Since most hadrons are unstable, we study nature of hadrons using complex potentials. In general, an eigenmomentum of the system is expressed as a pole of the scattering amplitude that is analyticaly continued to the complex momentum plane. Bound states are described by real potentials and their pole appears on the positive imaginary axis. By using complex potentials, we can describe unstable quasibound states with a decay width.
In this study, to investigate the effect of the decay width on the transition from bound state to resonance, we calculate the trajectory of the pole of the scattering amplitude varying the real part of the potential. In addition, we compare the position of the pole obtained exactly with that estimated by the effective range expansion and discuss the validity of the effective range expansion. We discuss these results also from the viewpoint of coupled channel potential models with the explicit decay channel.

Parallel Session (B) / 31

Kaonic Nucleus Search via ^{12}C(K^-, p) Reaction at J-PARC

"Recent theoretical and experimental studies have provided insights into the properties of the $\bar{K}N$ interaction. Theoretically, it has been argued that the formation of a molecular-like quasi-bound state, Λ(1405), arises from the strong attraction between $\bar{K}$ and nucleon with isospin I = 0 channel. Experimentally, the K-pp three-body system, the lightest Kaonic nucleus, was observed at J-PARC[1,2]. To further understand the many-body dynamics involving $\bar{K}$ and nucleons , it is essential to investigate Kaonic nuclei across a wide range of mass numbers, which also contributes to discussions on the presence of $\bar{K}$ in neutron star cores[3].

The J-PARC E05 experiment studied the $\bar{K}$-nucleus interaction by measuring an inclusive ^{12}C(K^-, p) spectrum, which determined the $\bar{K}$-nucleus optical potential[4]. Additionally, they observed a significant excess in the spectrum around 90 MeV in the $\bar{K}$ binding energy region, which suggests a possible contribution from a bound state involving an excited hyperon (Y^*) in the core nucleus.

We can analyze the event excess, which was observed in the previous J-PARC E05 experiment, using the dataset in the J-PARC E42 experiment. We used a GEM-based Time Projection Chamber, HypTPC, to measure decay-charged particles. This coincidence measurement will significantly enhances the signal-to-noise ratio, enabling the identification of the event excess as a clear bump structure.

In this talk, we will present the status of our analysis. We have confirmed the consistency of the inclusive spectrum with the previous J-PARC E05 result. Additionally, we will show an analysis measuring decay particles using the HypTPC, allowing us to investigate the exclusive spectra for various decay modes. Currently, we are focusing on the identification of $Lambda$ or $Lambdap$ decay modes in which we are interested in the event excess search. We will report on the correlations between various physical quantities, such as Kaon binding energy, $Lambdap$ opening angle, and the momentum of decay particles, and compare the data analysis with simulation.

Ref.

[1] S.Ajimura *et al.* Phys. Let. B **789** (2019) 620-625

[2] T. Yamaga *et al.* Phys. Rev. C **102**, 044002 (2020)

[3] T. Muto et al., PTEP, 2022, 093D03 (2022)

[4] Y. Ichikawa et al., PTEP **2020**, 123D01 (2020)"

Parallel Session (B) / 32

Antinucleon-nucleon/nucleus interactions studied with antiprotonic atom X-ray spectroscopy and scattering

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Nucleon-antinucleon interactions have been extensively studied. Recently, it is pointed out that the p-pbar enhancement and X(1835) resonance, observed in the BESIII experiment, may be related to low-energy nucleon-antinucleon interaction. We propose a new experiment of low-energy antineutron-proton scattering, which is free from the Coulomb interaction effect. We also address open questions on antinucleon-nucleus interactions, mainly studied through antiprotonic atom X-ray spectroscopy, and discuss possible experiments, such as X-ray spectroscopy with Transition Edge Sensor and antineutron-nucleus scattering [1].

[1] A. Filippi, H. Fujioka, T. Higuchi, L. Venturelli, https://arxiv.org/abs/2503.06972

Parallel Session (B) / 33

Strangeness Studies with HADES within the FAIR Phase-0 Program

Hyperons serve as powerful probes for investigating various aspects of quantum chromodynamics (QCD). As part of the FAIR Phase-0 program, HADES (High-Acceptance Di-Electron Spectrometer) at GSI has collected high-statistics data using a proton beam with a kinetic energy of 4.5 GeV impinging on a proton target. The beam energy enables the production of hyperons close to threshold, facilitating studies of hyperon-hyperon interactions and searches for intermediate resonances. Currently, the Λ-Λ reaction is being analyzed to extract crucial information on Λ-Λ interactions in p-p collisions which is expected to be essential to understand the interiors of neutron stars. The N-Λ interaction is also being investigated in A-A collisions. Furthermore, the first-time measurements of the Dalitz decay of the Σ0 will provide insights into transition form factors and thereby the electromagnetic structure of the Σ0. The study of Ξ- production as well as Λ(1405) and Sigma+/-(1385) in proton-proton collisions is valuable to shed light on the production mechanisms and nature of the states. This talk will highlight the ongoing hyperon physics analyses at HADES and present selected results. Prospects of measuring hypernuclei with PANDA at FAIR in the future will also be discussed.

Parallel Session (A) / 34

Modeling proton–deuteron interactions for the femtoscopic correlation method using exact calculations of two-body dynamic.

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One of the most compelling topics in interaction studies in recent years is the investigation of the proton-deuteron (\textit{p-d}) system. This system is of particular interest because it involves interactions between three nucleons, as the deuteron is composed of both a proton and a neutron. Therefore, it serves as a valuable laboratory for exploring many-body physics. A widely used method for investigating such interactions is femtoscopy, which analyzes momentum correlations between particles. However, modeling \textit{p-d} system is particularly challenging. Due to the deuteron's large size, the interaction can extend over several femtometers, raising questions about the extent to which it can be described as a two-body problem and highlighting the limitations of commonly used approximations. In this work, two approaches for describing \textit{p-d} correlations are examined: the Lednick\'{y}-Lyuboshits formalism and exact, fully numerical solutions of the Schr\"odinger equation. The study reveals significant differences between the two methods. Furthermore, it demonstrates advanced improvements in two-body description by incorporating higher-order partial waves into the calculations.

Parallel Session (A) / 35

Insights into the Baryon Correlation Puzzle from Multiplicity-Dependent Two-Particle Angular Correlations at LHC Energies

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One of the most effective techniques for investigating the mechanism of baryon production is the study of angular correlations between two particles. Angular correlations represent a convolution of various physical processes, such as mini-jets, Bose-Einstein quantum statistics, conservation of momentum, resonances, and other phenomena that contribute to the unique behavior observed for different particle species.
Experimental results from proton-proton collisions at 7 TeV have revealed a pronounced anticorrelation, a phenomenon that any Monte Carlo model had not replicated. This triggered a series of studies that helped create what is called the "baryon correlation puzzle".

In this work, the first ALICE measurements of the angular correlation functions for identical particles (such as $\pi^{\pm}$, $K^{\pm}$, and pp) in pp, p–Pb and Pb–Pb collisions at LHC energies in various multiplicity/centrality classes are presented.
This new puzzle piece enhances the understanding of anticorrelation and raises new questions. This will prompt theorists to implement and improve existing theoretical models for new answers.

Parallel Session (A) / 36

Femtoscopy correlation functions and mass distributions from production experiments

[based on Phys.Rev.D 110 (2024) 114052]

We discuss the relation between the Koonin-Pratt femtoscopic correlation function (CF) and invariant mass distributions from production experiments. We show that the equivalence is total for a zero source-size and that a Gaussian finite-size source provides a form-factor for the virtual production of the particles. Motivated by this remarkable relationship, we study an alternative method to the Koonin-Pratt formula, which connects the evaluation of the CF directly with the production mechanisms. The differences arise mostly from the T−matrix quadratic terms and increase with the source size. We study the case of the D0D*+ and D+D*0 correlation functions of interest to unravel the dynamics of the exotic Tcc(3875)+, and find that these differences become quite sizable already for 1 fm sources. We nevertheless conclude that the lack of coherence in high-multiplicity-event reactions and in the creation of the fire-ball source that emits the hadrons certainly make much more realistic the formalism based on the Koonin-Pratt equation. We finally derive an improved Lednicky-Lyuboshits (LL) approach, which implements a Lorentz ultraviolet regulator that corrects the pathological behavior of the LL CF in the punctual source-size limit.

Parallel Session (A) / 37

Three-baryon forces probed by deuteron-Xi femtoscopy

The correlation function between deuteron and Xi particles produced in high-energy nuclear collisions has attracted attention as a quantity that provides information on the spatial distribution of these particles and the interaction between them. The two-baryon and three-baryon forces acting on subsystems of the three-baryon system are considered as possible interactions, but the role of the three-baryon force on the correlation function has not yet been elucidated. In this talk, I will employ the baryon three-body force based on the SU(3) chiral effective field theory and explain how it affects the correlation function.

Parallel Session (B) / 38

Exploring the U(1) axial anomaly in extreme QCD environments: model analysis of topological susceptibility and comparison with lattice QCD observations

The U(1) axial anomaly is a fundamental aspect of QCD, and its properties can be examined through topological susceptibility. Recent first-principle calculations, such as lattice QCD studies with two or three colors, have investigated the topological susceptibility at finite temperature and finite quark chemical potential. While these results are expected to provide valuable insights into the role of the U(1) axial anomaly in extreme environments, the lattice results have not been fully interpreted yet. In this talk, I will discuss the role of the U(1) axial anomaly at finite temperature in three-color QCD and finite quark chemical potential in two-color QCD by analyzing topological susceptibility within effective model approaches, guided by the Ward-Takahashi identities of QCD. I will then compare our results with lattice QCD observations and discuss which contributions play a significant role in the temperature and density dependence of the topological susceptibility.

Parallel Session (B) / 39

Two-flavored heavy and heavy-light mesons nuclear bound states

We calculate the D_s-, B-, D- and K-nucleus bound state energies and coordinate space radial wave functions by solving the Klein-Gordon equation in momentum space.
The attractive strong potentials for the mesons in nuclei are calculated from the mass shifts of these mesons in nuclear matter in the local density approximation.
The mass shift of the B, D, and K mesons are calculated within the quark-meson coupling (QMC) model.
This negative mass shift may be regarded as a signature of partial restoration of chiral symmetry in an empirical sense, because the origin of the negative mass shift in the study is not directly related to the chiral symmetry mechanism.

Parallel Session (B) / 40

Mesic-nuclei bound states

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We study the possibility of the formation of mesons ($K,\ D,\ B$ as well as ϕ, charmonia, and bottomonia) bound in atomic nuclei.
The open strange and open heavy flavor mesic-nuclei are studied using the mass modifications of the mesons in nuclear matter within the quark meson coupling model [1,2].
The hidden-flavor (ϕ) meson-nucleus bound states are studied with the mass modification of ϕ meson using the tree level $\phi K \bar{K}$ lagrangian with the in-medium masses of K and $\bar{K}$ mesons as calculated within the QMC model.
On the other hand, masses of the hidden heavy flavor mesons are calculated using a generalized linear sigma model, due to medium modification of the dilaton field, which simulates the gluon condensates of QCD [3].
These studies are relevant for the experimental investigation of the strong interaction in the low-energy regime in understanding the low-energy meson-baryon interaction with implications in diverse fields, from the search for exotic mesic nuclear bound states, to the structure of compact astrophysical objects like neutron stars.
The upcoming PANDA at FAIR, J-PARC-E29, J-PARC-E88, and JLab experiments will be particularly significant for such studies.

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Parallel Session (B) / 41

The study for the Kbar-NN state in photoproduction with LEPS2 spectrometer

The behavior of kaons and anti-kaons in dense matter is an important topic in nuclear and particle physics, as their properties are closely related to the mechanism of symmetry breaking in low-energy QCD. $\overline{K}NN$ has attracted significant attention as the simplest kaonic nucleus.
In this presentation, I will report on our study of the $\overline{K}NN$ bound state in photoproduction. Our experiment utilizes high-energy (1.5–2.4 GeV), high-intensity γ beams, and a solenoid spectrometer capable of covering large angular ranges. An important feature of this study is the simultaneous measurement of proton and hyperon emitted at large angles over a wide kinematic coverage. As a result, this study provides valuable insight into the production process of the “”K^-pp”” bound state. The concentration of events shows up below the K^-pp threshold in the $\gamma d \to K^0\Lambda p$ reaction. I will discuss its origin.

Parallel Session (B) / 42

High precision spectroscopy of pionic atoms in tin isotopes by (d, 3He) reaction at RIBF

We conducted high-precision pionic atom spectroscopy experiments at RIBF using the (d, 3He) reaction. A pionic atom is a system in which π- mesons are deeply bound to the atomic orbitals of nuclei by attractive Coulomb forces and repulsive strong forces.

Evaluation of the partial restoration of chiral symmetry in finite density has been successfully performed at GSI and RIBF. Both experiments showed that the quark condensation, an order parameter of chiral symmetry, is reduced by about 40% in normal nuclear density compared to vacuum (T. Nishi, K. Itahashi et al., Nature Phys. (2023) doi:10.1038/s41567-023-02001-x).

We aim to investigate the density dependence of quark condensation. In order to search density region as wide as possible, we take advantage of long isotope chain of tin. High-statistics measurements were performed on 6 nuclei (112, 115, 117, 119, 122, 124Sn) by using a high-intensity primary beam at RIBF and BigRIPS as a spectrometer with a large-angle acceptance. Since the effective density region which these pionic atoms probe is limited, the experimental resolution must be improved in order to extract the density dependence of quark condensation precisely. We estimate that the binding energies and widths of the pionic atoms can be determined with unprecedented accuracy by applying dispersion-matching optics to BigRIPS and reconstructing 3He trajectories using a low-pressure 3-layer staggered MWDC.

In this presentation, we will report on the current status of data analysis of this measurement performed in June 2021 and introduce future plans of systematic research on pionic atoms using inverse kinematics.

Parallel Session (A) / 43

Towards a Comprehensive Model of Two-Pion Photoproduction at CLAS

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The photoproduction of π+π− pairs at forward angles has traditionally been attributed to Pomeron exchange. However, recent analyses of CLAS data at photon energies below 4 GeV reveal that for

|t|⊠0.5 ~GeV^2, this mechanism alone fails to fully describe the observed angular moments. To address this, we develop a new theoretical model incorporating both two-pion and pion-nucleon resonant contributions within the Regge framework. The model accounts for the dominant ρ(770) resonance as well as subleading contributions from scalar and tensor mesons such as f0(500), f0(980), f0(1370), and f2(1270), which influence the S- and D-wave components. Additionally, deviations from s-channel helicity conservation at high |t| suggest the relevance of nontrivial partial wave dynamics. After fitting free parameters to CLAS data, the model successfully reproduces the low moments of the angular distribution and provides insights into the underlying production mechanisms. Further investigation of the t-dependence of Regge residues offers a deeper understanding of subdominant exchange contributions.

Plenary Session / 44

Gluons in the etaprime-nucleon and etaprime-nucleus systems (invited talk,remote)

Gluonic effects are important in etaprime physics. In this talk I shall discuss the role of gluonic degrees of freedom in possible etaprime bound states in nuclei as well as in the etaprime-nucleon interaction. If experiments see evidence for an etaprime bound state, how do we interpret that it in terms of gluon related parameters? Might the possible very narrow and close to threshold resonance hinted at in fits to etaprime photoproduction data be associated with gluonic mediated production?

Plenary Session / 45

Theoretical studies of η' mesic nuclei formation and $\eta' N$ interaction

We study theoretically the feasibility of the semi-exclusive ^{12}C$(p, dp)X$ reaction for the observation of η' mesic nuclei using the transport model JAM. The semi-exclusive measurements of the (p, d) reaction with protons from η' absorption are found to be significant for the observation of the η' bound states.
Especially, the measurements of the energetic protons from η' non-mesic two-body absorption ($\eta' NN \to NN$) are critically important.

We also study the $\eta' p$ correlation function to determine the $\eta' N$ interaction. We find that the $\eta' p$ correlation function is a good observable to determine the sign of the $\eta' p$ scattering length, which was not determined yet for the other experiments so far.

Plenary Session / 46

Experimental search for η'-mesic nuclei by missing-mass spectroscopy in 12C(p,dp) reaction with the WASA detector at GSI-FRS (invited talk)

The η' meson has an extraordinary large mass among the light pseudo-scalar meson nonet.
The large mass is considered to originate from the non-trivial vacuum structure associated with chiral symmetry breaking and the axial U(1) anomaly in the QCD.

In a nuclear medium, where the chiral symmetry is partially restored, the mass reduction of the η' meson is predicted by 37−150~MeV/c^2 depending on theoretical models.
Since such a mass reduction leads to an attractive potential of η' meson to the nucleus, bound state of η' mesons and nuclei (=η'-mesic nuclei) is expected to exist.

We performed an experimental search for η'-mesic nuclei by missing-mass spectroscopy in $^{12}\mathrm{C}(p, dp)$ reaction using the WASA detector at the FRS in 2022 February, which was a coincidence measurement of forward deuterons and protons from decay of η'-mesic nuclei ($\eta' NN \rightarrow NN$).
We employed 2.5~GeV proton beams with an intensity of $\sim 3 \times 10^8/s$ and placed a $^{12}\mathrm{C}$ target at FRS-F2 focal plane.
The decay products of η'-mesic nuclei were measured with the WASA detector installed at the FRS-F2 focal plane and the forward deuteron momenta were analyzed by the FRS.

In this presentation, we will present details of the experiment and the current status of the analysis.

Parallel Session (B) / 47

Status of Ξ-atomic X-ray hunting at J-PARC (invited talk)

Multi-strangeness systems, such as Ξ hypernuclei and double Λ hypernuclei, are of crucial importance for understanding baryon-baryon interactions and
the nuclear matter equation of state. Xi-atoms, where a Ξ^- is trapped in atomic states around a nucleus, is a good playground to investigate the optical potential
a Ξ^- feels in nuclei and thus to study the ΞN interaction and ΞN-$\Lambda\Lambda$ coupling strength by precise measurements of emitted X rays.

At J-PARC, a series of experiments have been performed to observe X rays from Ξ atoms. First, emulsion nuclides (such as Ag and Br) were used for Xi^- stopping targets as a byproduct of E07 experiment. Additionally, we also searched for Xi-C X rays from the diamond target of E07 experiment. Second, in E03 experiment, we are searching for Xi-Fe X rays. Presently, E96 experiment is running to observe Xi-C X rays by tagging stopped Xi^- in the active scintillation fiber target. I will show (preliminary) results and status of these experiments.

Parallel Session (B) / 48

Compositeness of near-threshold states with Coulomb plus short range interaction

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In hadron physics, the near-threshold exotic hadrons have been actively studied, motivated by the recent experimental reports. One of the possible internal structures of exotic hadrons is the hadronic molecular state, which is the composite state of two hadrons. The fraction of the hadronic molecular component in the wavefuction is called the compositeness [1]. Through an analysis of the internal structure using the compositeness, the universal nature of near-threshold states has been studied. It is shown that when hadrons scatter through the short-range interaction, the shallow bound states near the threshold are usually dominated by the hadronic molecular component, which is consistent with the expectation from the low-energy universality [2]. In contrast, near-threshold resonances which exist above the threshold are found to have the completely different structure from shallow bound states [3].

In addition to the short range interaction, the Coulomb force acts between the charged hadrons. In contrast to the case with the short-range interaction, the general internal structure of near-threshold states of the Coulomb plus short-range interaction have not been understood yet. In hadron physics, Coulomb force is usually neglected because the short-range interaction is much stronger. However, in addition to the short-range interaction, also the long-range Coulomb force is expected to play an important role in the near-threshold energy region. In fact, with the presence of the Coulomb force, the low-energy scatterings exhibit different properties compared to the case with the short range interaction [4].

In this work, we focus on the near-threshold states with the Coulomb plus short range interaction. The universal nature of the systems with the Coulomb plus short-range interaction can be described with the zero-range model whose length scales are given by the Coulomb scattering length a_s and the Bohr radius a_B [5]. Here we adopt the low-energy scattering theory with the Coulomb effective range r_e in Ref. [6] to describe the scatterings in the larger momentum region. We investigate the scattering length dependence of the eigenenergy both for the Coulomb attractive and repulsive cases. We demonstrate that the bound state directly turns into the resonance with the variation of the scattering length for Coulomb repulsive case [5]. We then calculate the compositeness, and find that the near-threshold nature is determined by the competition of the short-range interaction and the Coulomb interaction. If the Bohr radius a_B is larger than the magnitude of the Coulomb effective range |r_e|, it is expected that the low-energy universality associated with the short-range interaction emerges before the Coulomb interaction becomes dominant, as the binding energy is decreased. In this case, the compositeness increases near the threshold as the remnant of the short-range universality. On the other hand, when a_B < |r_e|, we show that the compositeness does not increase even near the threshold, because the system does not exhibit the universal nature due to the Coulomb interaction. As an application of this framework, we discuss the internal structure of hadrons, nuclei, and atoms.

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Parallel Session (B) / 49

Effect of Coulomb interaction on bound state by strong interaction

Compared to the strong interaction, the binding energy of the Coulomb interaction is about 1/1000, so it is usually neglected. However, the binding energy of X(3872) is extremely small compared to many other hadrons, suggesting that the effect of the Coulomb interaction must be considered. In this talk, we consider the bound state using Coulomb plus square well potential model. We numerically investigate the change in the binding energy when the attractive and repulsive Coulomb potential is added to an attractive well potential of range b. Focusing on the wave function, we clarify the nature of the bound state.

Parallel Session (B) / 50

Antikaon absorption in the nuclear medium: the role of hadron self-energies and implications for kaonic atoms (invited talk,remote)

Plenary Session / 51

in memory of Prof. Toshimitsu Yamazaki

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Plenary Session / 52

[KEYNOTE] A consideration on KbarN and KbarNN quasi-bound states found in the kaon-induced reactions on deuteron and helium-3

Recently, experimental studies of the kaon-induced reactions on deuteron and helium-3 were carried out at J-PARC. The former experiment reported a resonance pole below the KbarN mass threshold in the deduced S-wave KbarN scattering amplitude in the isospin = 0 channel [1]. The pole is naturally interpreted as a KbarN bound state. The latter experiment reported a bump structure below the KbarNN mass threshold in the Lambda-p invariant mass spectrum, which is naturally interpreted as a KbarNN bound state [2,3]. Based on the measured spectral shapes, a relation between the two observed states will be considered in terms of the KbarN and KbarNN interaction potentials in this presentation.

Plenary Session / 53

Prospects of kaonic nuclei and kaonic atoms at J-PARC (invited talk)

Anti-kaon is one of the promising candidates for forming mesic nuclear-bound states. After many experimental efforts, we have finally found the simplest state, the so-called "K-pp", via the K- induced nucleon knockout reaction on helium-3. The validity of this reaction is also verified by the Lambda(1405) study using a deuterium target. Now, we are developing a new detector system to further extend the successful method to other kaonic nuclei and other decay modes to investigate the nature of kaonic nuclei.
In addition, X-ray spectroscopy of kaonic atoms is of complemental importance. We already explored a precision frontier by introducing a novel superconducting X-ray detector, TES. We also challenge a sensitivity frontier for kaonic deuterium, which is necessary to determine the isospin-dependent KbarN amplitude but is still missing except for the recent data in SIDDHARTA-2.
In this contribution, after a short review of the achievements in the last decade, we would like to discuss the forthcoming experiments with an upgraded solenoid spectrometer and an upgraded K-beamline at J-PARC.

Plenary Session / 54

Building a Model to Understand the Singular Behavior of the Kbar N Potential in the HAL QCD Method

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The HAL QCD method has been established as a reliable method to study hadron-hadron interactions.

However, singular behavior around the origin has been observed in the Kbar N potential, which dynamically generates the Lambda(1405) as the bound state. In order to clarify the cause of such behavior in the HAL QCD method, we calculate the NBS wave functions and R correlators in an effective model of hadron-hadron interactions and compare it with the Kbar N potential in the HAL QCD method.

Plenary Session / 55

The quest for kaonic atoms'measurements: technological challenges and future perspectives

The precise measurements of X-ray emissions from kaonic atoms represent one of the most valuable contributions to our knowledge of low-energy strangeness strong interactions.
The SIDDHARTA Collaboration at the INFN Laboratories of Frascati, thanks to the powerful combination of the unique low-momentum Kaon beam delivered by the DAΦNE e+e- collider and the implementation of cutting-edge X-ray detection systems, has played a crucial role in completing such precise measurements in the last decades.
After performing the most precise measurement of the strong interaction-induced shift and width of the 1s energy level in kaonic hydrogen in 2009, the collaboration is now providing a new fundamental brick for a better understanding of this low-energy strong interaction.
The SIDDHARTA-2 experiment at the INFN-LNF DAΦNE collider is now advancing our understanding by performing the first-ever determination of the strong-interaction induced shift and width of the 1s energy level in kaonic deuterium, a crucial step toward resolving antikaon-nucleon scattering lengths in both isospin channels.
In parallel, utilizing DAΦNE's superior low-energy kaon beam and cutting-edge radiation detection technologies, such as Silicon Drift Detectors (SDDs), High Purity Germanium (HPGe), and Cadmium-Zinc-Telluride (CdZnTe) detectors, the SIDDHARTA-2 collaboration performed other important measurements on various kaonic atoms, including helium and neon. These efforts, essential for probing the strong interaction at the strangeness frontier and for testing fundamental symmetries, are anticipated to have significant implications for the low-energy strangeness sector and represent a solid ground for future kaonic atoms measurements both at DAFNE and at J-PARC.
This contribution will outline the physics motivation, describe the experimental apparatus, highlight several promising results obtained so far with different kaonic atoms, provide an update on the current status of the kaonic deuterium measurement, and offer an overview of the forthcoming kaonic atom measurements planned by the collaboration.

Plenary Session / 56

Re-analysis of spectral modification in nuclei using the PHSD transport approach

In the KEK-PS E325 experiment, significant modification of the spectra of ϕ mesons in/out nuclei were observed and parameters for the spectral modification were derived.
In the present analysis, these parameters were reanalyzed using the PHSD transport approach, with more detailed simulations.
In this talk, the analysis methods and preliminary results will be discussed.

Parallel Session (A) / 57

Decays of Exotic Double-Heavy Hadrons into Pairs of Heavy Hadrons

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Until recently, it was widely believed that every hadron is a composite state of either three quarks or one quark and one antiquark. In the last 20 years, dozens of exotic heavy hadrons have been discovered, and yet no theoretical scheme has unveiled the general pattern. For hadrons that contain more than one heavy quark or antiquark, the Born-Oppenheimer approximation for QCD provides a rigorous approach to the problem. In this approximation, a double-heavy hadron corresponds to an energy level in a potential that increases linearly at large interquark distances. Pairs of heavy hadrons, on the other hand, correspond to energy levels in potentials that approach a constant at large interquark distances. In this talk, I will discuss decays of double-heavy hadrons into pairs of heavy hadrons, which are mediated by couplings between the respective Born-Oppenheimer potentials. I will show that conventional and exotic double-heavy hadrons follow different decay patterns dictated by the symmetries of QCD with two static color sources. As case studies, I will compare selection rules and branching ratios for the decays of quarkonium and quarkonium-hybrid mesons into the lightest pairs of heavy mesons. I will also discuss the corresponding decays of double-heavy tetraquarks.

Parallel Session (A) / 58

Study of multi-quark states with strangeness

Based on the recent findings of the pentaquark states and tetraquark states in the experiments, we exploit the coupled channel formalism to investigate the mass spectrum of these multiquark states. In our results, we explain the molecular nature for the Pc and Pcs states within the coupled channel interactions. Furthermore, we extrapolate our study to the meson systems with the strangeness, where we find some different dynamics in the strangeness sector.

Plenary Session / 59

Test the molecular picture of the X(3872) in $\bar{B}_{(s)} \to \bar{K}^{(*)}(\eta, \eta', \phi)X$ decays

We study the decays $\bar{B}^0 \to \bar{K}^0\,X$, $B^- \to K^-\,X$, $\bar{B}^0_s \to \eta(\eta')\,X$, $\bar{B}^0 \to \bar{K}^{*0}\,X$, $B^- \to K^{*-}\,X$, $\bar{B}^0_s \to \phi\,X$, with $X \equiv X(3872)$, from the perspective of the $X(3872)$ being a molecular state made from the interaction of the $D^{*+}D^-$, $D^{*0}\bar{D}^0$ and $c.c.$ components. We consider both the external and internal emission decay mechanisms and find an explanation for the $\bar{K}^0\,X$ and $K^-\,X$ production rates, based on the mass difference of the charged and neutral $D^*\bar{D}$ components. We also find that the internal and external emission mechanisms add constructively in the $\bar{B}^0 \to \bar{K}^0\,X$, $B^- \to K^-\,X$ reactions, while they add destructively in the case of $\bar{B}^0 \to \bar{K}^{*0}\,X$, $B^- \to K^{*-}\,X$ reactions. This feature explains the decay widths of the present measurements and allows us to make predictions for the unmeasured modes of $\bar{B}^0_s \to \eta(\eta')\,X(3872)$ and $B^- \to K^{*-}\,X(3872)$. The future measurement of these decay modes will help us get a better perspective on the nature of the $X(3872)$ and the mechanisms present in production reactions of that state.

Parallel Session (A) / 60

A Study of Singly Bottom Compact Tetraquarks via Diquark-Antidiquark Approach

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Motivated by recent advancements in tetraquark studies, we analyze the mass spectra and decay properties of singly bottom tetraquarks using the diquark-antidiquark formalism. By examining various internal quark configurations and color structures, we calculate the mass spectra within a non-relativistic framework. Additionally, several resonances are proposed as potential candidates for these tetraquarks. To further explore their rearrangement decays, we investigate the mass spectra and decay channels of related mesons. This study aims to enhance the understanding of singly heavy tetraquarks in the heavy-light sector.

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Pole analysis for the \boldmath $D^*\bar{K}$-$D\bar{K}^*$ coupled-channel system

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By solving the Lippmann-Schwinger equation, possible hadronic molecules in the $D^*\bar{K}$-$D\bar{K}^*$ coupled-channel system are investigated with the one-meson exchange potentials, where both vector and pseudoscalar mesons are considered as exchange particles. We find an S-wave virtual state with mass $M = 2487$~MeV, and a resonance with $M = 2759$ and width $\Gamma = 18$~MeV. In the $D^*\bar{K}$ invariant mass distribution, the virtual state appears as a cusp at the $D^*\bar{K}$ threshold, while the resonance potentially manifests as a dip. In particular, we take into account the $D\bar{K}\pi$ three-body dynamics due to the on-shell pion exchange and the finite decay width for $\bar{K}^*$. Additionally,
the SU(4) breaking effect in the coupling between charmed and light mesons is investigated in our work.
Our results also indicate that the accurate measurement for the decay width of the $D\bar{K}^*$ resonance can help us to evaluate this effect in the future.

Parallel Session (A) / 62

Internal structure of X(3872) by compositeness with coupled channel potential

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We study the properties of the hadron-hadron potentials and quark-antiquark potentials from the viewpoint of the channel coupling[1]. We introduce the effective hadron-hadron potential with coupled to the quark channel.
As an application, we construct a coupled-channel model of $c\bar{c}$ and $D\bar{D}$ to describe exotic hadron $X(3872)$[2].

To investigate the internal structure of the $X(3872)$, we introduce the direct 4-point interaction of the hadron channel, in addition to the contribution of the coupling to the quark channel. We study the dominant compornent of the $X(3872)$ by annalyzing wavefunctions, compositteness, scattering length, effective range, and phase shift. We study the changes of these quantities by varying model parameters such as quark channel enrgy, cut-off, and potential strength of hadron channel in addition to a physical obsearvable binding energy.

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Parallel Session (B) / 63

High-Precision Decay Pion Spectroscopy at MAMI – progress in mass calibration with novel beam energy measurement –

The hypertriton (${}^{3}_{\Lambda}$H) is the lightest Lambda-Hypernucleus, consisting of one proton, one neutron, and a Lambda.
Its mass and lifetime have been measured using emulsion techniques and heavy-ion collision experiments.
Their relationship has been observed to deviate from theoretical predictions, which is known as the 'hypertriton puzzle'.
The accuracy of measured Lambda-binding energies remains approximately 100 keV, which is insufficient to resolve the puzzle.
An accurate and independent measurement is therefore crucial for understanding the 'hypertriton puzzle'.

In October 2022, we conducted decay pion spectroscopy experiments on s-shell hypernuclei at the Mainz Microtron MAMI in Germany, followed by spectrometer calibration in March 2024.
The method was originally established in the 2010s, and in 2016, the mass of ${}^{4}_{\Lambda}$H was successfully measured with an accuracy of approximately 80 keV .
To suppress the systematic error and achieve higher accuracy for hypertriton, we have been developing a new beam energy measurement technique called undulator radiation interferometry.
This technique achieved a beam energy precision of 20 keV in the 200 MeV region, and will reduce the systematic error in hypernuclear mass measurements to 10-20 keV.

In this talk, I will present our experimental methods, including calibration procedures, and report on the current analysis status.

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Investigating the Λ-Λ system: Insights into hyperonic interactions and neutron star cores

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Hyperons, baryons containing at least one strange quark, are pivotal to advancing our understanding of matter under extreme conditions.
They are hypothesized to play a crucial role in the dense cores of neutron stars, where their emergence is expected at densities exceeding nuclear saturation.
Among hyperons, Λ hyperons are of particular interest as they have been shown to significantly soften the equation of state (EoS) under the absence of strong repulsive two or three-body forces.
This softening leads to pronounced effects on the maximum mass and radius of neutron stars, introducing discrepancies between observational data and theoretical predictions.
The so-called "hyperon puzzle" is therefore a key topic in nuclear astrophysics.
A deeper comprehension of hyperon-hyperon interactions, is essential to address these challenges.

This study focuses on the production and interaction of Λ-Λ pairs, a doubly strange baryonic system, in proton-proton collisions at $\sqrt{s} = 3.46$ GeV.
Using data from the High Acceptance Di-Electron Spectrometer (HADES) at GSI, the reaction channel $pp \rightarrow \Lambda\Lambda K^{+}K^{+}$ was analyzed.
As a foundational step, the near-threshold ($\Delta\sqrt{s_{th}} = 0.24$ GeV) production cross-section is determined.

In this talk, I will detail the experimental methods, analysis procedure and share preliminary results on the production cross-section.
Additionally, I will discuss the Λ-Λ momentum correlations derived from the experimental data.
These findings besides providing a such data-point for near-threshold production cross-section of

double strangeness, have broader implications for exploring dense baryonic matter, hypernuclear states, and the underlying QCD-driven interactions in extreme astrophysical environments such as neutron star interiors.

Parallel Session (B) / 65

Nuclear Matter properties from the ladder resummation method

In this talk I will present a method to compute the properties of dilute nuclear matter from quantum field theory at finite density. This approach provides a parameter-free calculation of the energy per particle of nuclear matter relying only on experimental nucleon-nucleon phase shifts. This method can be used to compute the equation of state of dilute symmetric and neutron matter. As practical application I will show how to use the result for dilute neutron matter to calculate the equation of state of neutron stars.

Parallel Session (B) / 66

Neutron skin

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Topic of neutron skin is interesting aspect of nuclear physics. Experiments like NA61/SHINE, PREX II and others may give us data for deeper understanding of this area of physics, helping to improve the theory. Different elements of the theory, like slope parameter, can be explored better by both - simulations and experiment.
In my talk I would like to focus on the theoretical results related to collision of nuclei+nuclei (for Pb-Pb,Sn-Sn, Dy-Dy) or nucleus+particle (Pb+p, Pb+antiproton) at high and very high energy collisions. Different quantities like ratio of numbers of positive and negative pions (as a function of Feynmann variable) can show some aspects of this topic. Different calculations for both types: skin and halo, would be presented.

Michał Palczewski

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Parallel Session (B) / 67

Diffusion dynamics of QCD matter in nuclear collisions

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Relativistic nuclear collisions serve as a powerful tool for exploring the QCD matter in the vicinity of the quark-hadron crossover. We investigate diffusion dynamics in the hot and dense QCD matter based on the numerical hydrodynamic model with a state-of-the-art equation of state at finite densities.

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Holographic Segre formula in heavy meson physics

In this study, we investigate the applications of a result derived from WKB theory, specifically the Segre-Fermi Rule in its non-relativistic form, within the context of bottom-up holographic QCD. The Holographic Segre formula enables us to compute decay constants based on the holographic confining potential. This data serves as a critical input for extracting quark mass from the decay width associated with a specific process. We employ this methodology to examine electromagnetic decays of vector mesons and determine the corresponding constituent quark mass. Our findings indicate that the computed masses for charm, bottom, and strange quarks exhibit less than 10% deviation from experimental data.

Plenary Session / 69

High precision hypernuclear mass measurement with decay pion spectroscopy –from MAMI to JLab– (invited talk)

Hypernucleus is a many-body system with strangeness and is an important probe for discussing nuclear matter based on SUf(3).
In recent years, there have been significant advancements in experimental and theoretical studies for few-body hypernuclei. Discussions of the charge symmetry breaking effect and Sigma mixing effect are currently underway.

Plenary Session / 70

K-Long Facility at Jefferson Lab

The outline of K-long Facility (KLF) at Jefferson Lab will be presented. It has been approved by PAC48 to run for 200 days of the beamtime to measure CQM and LQCD predicted but not established dozens of hyperon states. This facility also allows to study hyperons in nuclei.

Plenary Session / 71

Photon beams at SPring-8-II

We have been conducting hadron physics experiments using laser-induced Compton-scattering photons at SPring-8 with a circulating energy of 8 GeV. To have 100 times the brightness of the synchrotron radiation, SPring-8 will be upgraded to SPring-8-II. Owing to this modification, the coverage of incident photon energies drastically changes. We will present the expected photon beams at SPring-8-II, and briefly introduce some possible experiments at SPring-8-II.

Plenary Session / 72

J-PARC Hadron Hall Extension Project (invited talk)

The J-PARC Hadron Experimental Facility was established to investigate the origin and evolution of matter in the universe through experiments utilizing the world's most intense particle beams. Over the past decade, the facility has made significant advancements in particle and nuclear physics. To further expand its research scope and explore uncharted areas of physics, an extension of the Hadron Experimental Facility is currently under active discussion and planning. This presentation will highlight the achievements to date and the potential contributions of the extended facility to strangeness nuclear physics, hadron physics, and flavor physics.