# Hadron in Nucleus 2020 (HIN20)

# Report of Contributions

Contribution ID: **18** Type: **not specified**

# charmonium in nuclear matter and nuclei

*Wednesday 10 March 2021 09:30 (20 minutes)*

Results for $\eta_c$- and $J/\Psi$-nucleus bound state energies for various nuclei are presented. These results are obtained using effective Lagrangians at the hadronic level. Essential input for the calculations, namely the medium-modified $D$ and $D^*$ meson masses, as well as the density distributions in nuclei, are calculated within the quark-meson coupling (QMC) model. The attractive potentials for the $\eta_c$ and $J/\Psi$ mesons in the nuclear medium originate, respectively, from the in-medium enhanced $DD^*$ and $D\bar{D}r$ loops in the $\eta_c$ and $J/\Psi$ self energies. Our results suggest that the $\eta_c$ and $J/\Psi$ mesons should form bound states with all the nuclei considered. Some of the results presented were recently published in J.J. Cobos-Martinez et al, Phys.Lett.B 811 (2020) 135882

**Presenter:** COBOS-MARTINEZ, Javier (Physics Department, University of Sonora, Mexico)

Contribution ID: **19** Type: **not specified**

# Kaonic atoms spectroscopy at DAFNE: overview and perspectives

*Wednesday 10 March 2021 18:10 (20 minutes)*

I shall present experiments devoted to the study of the kaonic atoms at the DAFNE Collider at the LNF-INFN, Frascati (Roma) laboratory. Combining the excellent quality kaon beam delivered by the DA⊠NE collider in Frascati (Italy) with new experimental techniques, as fast and very precise X ray detectors, like the Silicon Drift Detectors, we have already performed unprecedented measurements in the low-energy strangeness sector in the framework of the SIDDHARTA Collaboration. The kaonic atoms, as kaonic hydrogen and kaonic deuterium, provide the isospin dependent kaon-nucleon scattering lengths from the measurement of X rays emitted in the de-excitation process to the fundamental 1s level of the initially excited formed atom. The most precise kaonic hydrogen measurement was performed by the SIDDHARTA collaboration, which realized, as well, the first exploratory measurement for kaonic deuterium ever. Presently, a major upgrade of the setup, SIDDHARTA-2 is being installed on DAFNE and is ready to measure kaonic deuterium in 2021. In the same time we propose future kaonic atoms measurements with various apparatuses, post-SIDDHARTA-2, which I am going to introduce and discuss. Kaonic atoms studies represent an opportunity to, finally, unlock the secrets of the QCD in the strangeness sector and understand the role of strangeness in the Universe, from nuclei to the stars.

**Presenter:** CURCEANU, Catalina Oana (INFN-LNF)

Contribution ID: **20** Type: **not specified**

# Measurements of Hypernuclei with the WASA detector and the Fragment Separator at GSI

*Monday 8 March 2021 20:30 (20 minutes)*

The next phase of hypernuclear experiment with heavy ion beams proceeding the HypHI experiment will contribute to solve two significant puzzles in few-body physics, that are revealed by the results of the HypHI Phase-0 experiment at GSI Helmholtz Centre for Heavy Ion Research (Darmstadt, Germany) in 2009. The first puzzle is on the possible unprecedented existence of the nnLambda (two neutrons and Lambda hyperon) bound state, that cannot be reproduced by the current theoretical models. The second puzzle is related to the measured short lifetime of hypertriton and the discrepancies in the experimental results obtained previously by HypHI, STAR and ALICE collaborations. The next experiment proceeding the HypHI experiment will implement a unique idea based on production of the hypernuclei resulting from reaction of Lithium beam on Carbon target at 2 A GeV at the mid-focal plane (S2) of the FRagment Separator (FRS) at GSI. Hypernuclei of interest will be observed by detecting particles produced by their two-body decay with creation of pi- and positively-charged residues. The second half of the FRS will be employed as a forward high momentum-resolution spectrometer to measure positively-charged residues with a momentum resolving power of 10^-4, while pi- will be measured by using a magnetic spectrometer with large acceptance and good momentum resolution located at the mid-focal plane. As a magnetic spectrometer at S2 we employs the central part of the WASA detector which was previously operated at the CELSIUS ring in Uppsala (Sweden) and COSY ring in Jülich (Germany) and the preparation and the commissioning of all devices are in progress. The central part of the WASA detector consists of the superconducting solenoid magnet, the Mini Drift Chamber (MDC), the Plastic Scintillator Barrel (PSB), plastic scintillator endcaps (PSFE) and the Scintillator Electromagnetic Calorimeter (SEC). In addition, six stations of scintillating fiber detector arrays have already been developed to measure charged particles in front and behind the WASA detector. The hypernuclear experiment with the WASA and the FRS will be conducted in cooperation with the eta-prime experiment both scheduled to be performed in 2022 at GSI. In this presentation, the status and the outlook of the hypernuclear project with the WASA and the FRS will be discussed.

**Presenter:** DROZD, Vasyl (Energy and Sustainability Research Institute Groningen, University of Groningen, the Netherlands /// GSI Helmholtz Center for Heavy Ion Research, Darmstadt, Germany)

Contribution ID: **21** Type: **not specified**

# Faddeev calculations for light $YY$-hypernuclei

*Monday 8 March 2021 21:10 (20 minutes)*

Recently the $\Omega N$ $\left({}^5S_2\right)$ and the $\Omega\Omega$ $\left({}^1S_0\right)$ interacting potentials at nearly physical quark masses ($m_\pi \simeq$ 146 MeV and $m_k \simeq 525$ MeV) has been calculated in the lattice QCD simulations by the HAL QCD Collaboration. Here, we explored hypothetical multi-strangeness nucleus ${}^{6}_{\Omega\Omega}He$ in $\Omega\Omega\alpha$ cluster model using the method of hyperspherical harmonics making use of the latest HAL QCD Collaboration $\Omega N$ and $\Omega\Omega$ s-wave interactions.

**Presenter:** ETMINAN, Faisal (University of Birjand)

Contribution ID: **22** Type: **not specified**

# Hyperon-Nucleon Interaction studies with correlation techniques at the LHC

*Tuesday 9 March 2021 16:50 (20 minutes)*

Hadrons interact via a residual strong force that is unmeasured for most hadron species. The measurement and quantitative understanding of the strong interaction among hadrons is considered to be one of the frontiers within the standard model of nuclear and particle physics. Scattering experiments and spectroscopy studies of stable and unstable nuclei allowed us to quantify the residual nuclear force among nucleons rather precisely, but for unstable hadrons as baryons containing strange quarks (hyperons) such measurements are extremely difficult. The ALICE collaboration recently demonstrated that by combining excellent particle identification and a momentum correlation analysis method applied to pp and p-Pb collisions at the LHC, it is possible to measure the strong interaction among all hadrons containing strange quarks and protons. The case in point discussed in the recent publication by ALICE concerns the correlation between a proton and the rarest of hyperons: the Omega(sss). The precisely measured proton-Omega correlation clearly evidences an attractive strong interaction among the two hadrons and tests theoretical predictions by first principle calculations based on lattice gauge theory methods for the first time. These measurements open a new avenue in nuclear physics, with the potential of accessing the strong force between any hadron pair. Future perspectives for further interaction studies involving strange baryons in Run 3 and the potential extension to 3-body systems will be discussed.

**Presenter:** FABBIETTI, laura (Technische Universität München)

Contribution ID: **23** Type: **not specified**

# The phi meson in nuclear matter from a transport approach

*Monday 8 March 2021 14:20 (30 minutes)*

While 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 an extremely dense environment such as nuclear matter. To study how the phi meson behaves at finite density has been the goal of several recent and near future experiments at multiple facilities [1-3]. Theoretically, many works have been conducted with the aim of studying the phi meson in nuclear matter. Connecting theoretical results with experimental measurements is, however, not a trivial task, as the phi meson in nuclear matter is usually produced in relatively high-energy pA reactions, which are generally a non-equilibrium processes. In this presentation I will report on an ongoing project [4], attempting to simulate pA reactions in which the phi meson is produced in nuclei, making use of a transport approach [5]. First results of simulations of 12 GeV p+C and p+Cu reactions will be presented and comparisons between obtained dilepton spectra and experimental data of the E325 experiment at KEK [1] will be made. [1] R. Muto et al., Phys. Rev. Lett. 98, 042501 (2007). [2] A. Polyanskiy et al., Phys. Lett. B 695, 74 (2011). [3] S. Ashikaga et al., (J-PARC E16 Collaboration), JPS Conf. Proc. 26, 024005 (2019). [4] P. Gubler and E. Bratkovskaya, in progress. [5] W. Cassing and E.L. Bratkovskaya, Nucl. Phys. A 831, 215 (2009).

**Presenter:** GUBLER, Philipp (JAEA)

Contribution ID: **24** Type: **not specified**

# Towards understanding near-threshold structures

*Wednesday 10 March 2021 14:30 (30 minutes)*

**Presenter:** GUO, Feng-Kun (Institute of Theoretical Physics, CAS)

Contribution ID: **25** Type: **not specified**

# Flavor hadron interactions from effective field theory

*Tuesday 9 March 2021 16:20 (30 minutes)*

I report on investigations of the baryon-baryon interaction for baryons with different flavors (strangeness, charm), based on chiral effective field theory (EFT). With regard to systems in the strangeness sector (Lambda-N, Sigma-N, Xi-N) the approximate SU(3) flavor symmetry of QCD is exploited to relate the interactions in those channels with each other and to the accurately known nucleon-nucleon interaction. Empirical constraints as provided by available data on reaction cross sections for Lambda-N and Sigma-N are taken into account. In the charm sector (Lambda_c-N, Sigma_c-N) lattice QCD simulations by the HAL QCD Collaboration for unphysical quark masses are used as starting point. The interaction at the physical point is derived via an extrapolation guided by chiral EFT. Results for phase shifts and cross sections will be presented. Furthermore, predictions for few- and many-body systems involving hyperons and charmed baryons will be reported. Finally, the possibility to constrain those interactions by information on two-particle momentum correlation functions as measured in heavy ion collisions or in high-energetic proton-proton collisions will be addressed.

**Presenter:** HAIDENBAUER, Johann (Forschungszentrum Juelich GmbH)

Contribution ID: **26** Type: **not specified**

# Towards the continuum limit of two-baryon interactions from lattice QCD

*Wednesday 10 March 2021 10:40 (30 minutes)*

Despite the first two-baryon studies from lattice QCD being performed several decades ago, the parameters describing two-baryon interactions computed from various collaborations are still in tension. The many significant efforts from the community signal the difficulty of the problem at hand. Baryons suffer from a poor signal-to-noise ratio, often times leaving only a small window in which systematic effects have died out but a clear signal remains. To overcome this limitation, several techniques have been utilized in the literature. I will start by giving a summary of the most recent calculations from various groups, emphasizing some of these techniques as well as the different setups used. I will then show our latest results in various two-baryon systems. The first of these calculations are performed at the SU(3)-flavor-symmetric point corresponding to $m_\pi \approx 714$ MeV. Here we find no evidence of a bound state in either two-nucleon isospin channel. The second set of calculations are also performed at the SU(3)-flavor-symmetric point, but with $m_\pi \approx 420$ MeV, and with five values of the lattice spacing. This allows for a continuum limit to be taken, and we find strong dependence on the lattice spacing in the $H$-dibaryon system. While this analysis can help to explain the tension in the literature, more investigations are needed.

**Presenter:** HANLON, Andrew (Brookhaven National Laboratory)

Contribution ID: **27** Type: **not specified**

# Kaonic atom experiments at J-PARC

*Wednesday 10 March 2021 17:50 (20 minutes)*

Two kaonic atom experiments are on-going in the J-PARC hadron experimental facility. One is E62, a precision measurement of kaonic helium-3 and helium-4 X-rays to investigate the Kbar-nucleus potential. In June 2018, we conducted data taking of the kaonic helium experiment using transition-edge-sensor microcalorimeters. The other one, E57, aims at the first measurement of X-rays from kaonic deuterium to extract the iso-spin dependent KbarN scattering amplitude. We performed a pilot experiment in 2019 to study our experimental approach using silicon drift detector arrays. In this contribution, we will present the latest status of the two experiment, focusing on the results of the kaonic helium experiment.

**Presenter:** HASHIMOTO, Tadashi (JAEA)

Contribution ID: **28** Type: **not specified**

# Chiral effective field theory for nuclear matter and neutron stars

*Wednesday 10 March 2021 08:40 (30 minutes)*

The first confirmed observation of a binary neutron star merger through its gravitational wave and associated electromagnetic emissions has opened a new window into understanding ultra-dense matter. In this talk I will describe recent progress in modeling the strong interaction physics of neutron stars and supernovae based on the low-energy realization of QCD, chiral effective field theory. Despite the large uncertainties in the high-density equation of state, our present nuclear physics models give constraints on neutron star radii and tidal deformabilities that are competitive (if not stronger) with those from current neutron star observations. Future observational campaigns, however, have the potential to significantly constrain nuclear theories and forces.

**Presenter:** HOLT, Jeremy (Texas A&M University)

Contribution ID: **29** Type: **not specified**

# In-Medium Pion Properties in Isospin-Asymmetric Nuclear Matter

*Wednesday 10 March 2021 15:00 (20 minutes)*

Dynamical symmetry breaking of QCD's chiral symmetry is the mechanism responsible for the bulk of all hadron mass in the universe. One of the order parameters of chiral symmetry breaking is the chiral quark condensate. Theoretical model-independent calculations have shown that the absolute value of this quark condensate is reduced in nuclear medium [1]. This might be an indication of (at least partial) restoration of the chiral symmetry compared to the vacuum. The linear-order density dependence of this process is well known. If we knew higher orders of this density dependence, we might be able to extrapolate to even higher densities, e.g. as they appear in neutron stars. The goal of our work is to investigate the density dependence of certain pion properties in isospin-antisymmetric nuclear matter using in-medium chiral perturbation theory [2] up to the next-to-leading order of the density expansion [3]. To this end, we calculate the pion self-energy and decay constant in proton and neutron matter, where their relative densities can be adjusted. We describe this asymmetry using the ratio ρ_n / ρ_p of their respective densities. Hence for example a ratio of 1.5 corresponds to a neutron-to-proton ratio commonly found in heavy nuclei. References: [1] T.D. Cohen, R.J. Furnstahl, D.K. Griegel, Phys. Rev. C 45, 1881 (1992); E. G. Drukarev and E. M. Levin, Prog. Part. Nucl. Phys. 27, 77 (1991); D. Jido, T. Hatsuda, T. Kunihiro, Phys. Lett. B 670, 109–113 (2008). [2] J. A. Oller, Phys. Rev. C 65, 025204 (2002). [3] S. Goda, D. Jido, PTEP 2014, 033D03 (2014).

**Presenter:** HUEBSCH, Stephan (東京工業大学)

Contribution ID: **30** Type: **not specified**

# Theoretical study of $\Omega(2012)$ and $Z_{cs}(3985)$ with the coupled channels approach

*Tuesday 9 March 2021 21:00 (20 minutes)*

I report the results for $\Omega(2012)$ and $Z_{cs}(3985)$ of Refs.[1,2]. We have studied the $\Omega(2012)$ which was measured in the Belle experiment. We conduct a study of the interaction of the $\bar{K}\Xi^*$, $\eta\Omega$($s$-wave) and $\bar{K}\Xi$($d$-wave) channels within a coupled channel unitary approach. We find that all data including the Belle experiment on $\Gamma_{\Omega^*\to\pi\bar{K}\Xi}/\Gamma_{\Omega^*\to\bar{K}\Xi}$, are compatible with the molecular picture stemming from meson baryon interaction of these channels. We also have studied the $e^+e^- \to K^+(D_s^{*-}D^0 + D_s^- D^{*0})$ reaction recently measured at BESIII, from where a new exotic $Z_{cs}$ state has been reported. We study the interaction of $\bar{D}_s D^*$ with the coupled channels $J/\psi K^-$, $K^{*-}\eta_c$, $D_s^- D^{*0}$, $D_s^{*-}D^0$. The coupled channels help to build up strength in the $D_s^- D^{*0}+D_s^{*-}D^0$ diagonal scattering matrix close to threshold and, although the interaction is not strong enough to produce a bound state or resonance, it is sufficient to produce a large accumulation of strength at the $\bar{D}_s D^*$ threshold in the $e^+e^- \to K^+(D_s^{*-}D^0 + D_s^- D^{*0})$ reaction in agreement with experiment. [1] N. Ikeno, G. Toledo and E. Oset, Phys. Rev. D \textbf{101}, 094016 (2020). [2] N. Ikeno, R. Molina and E. Oset, arXiv:2011.13425 [hep-ph].

**Presenter:** IKENO, Natsumi (Tottori University)

Contribution ID: **31** Type: **not specified**

# ηd threshold structure from the γd→π<sup>0</sup>ηd reaction

*Wednesday 10 March 2021 16:40 (20 minutes)*

The eta;d threshold structure has been experimentally studied in the gamma;d→pi;<sup>0</sup>eta;d reaction at incident photon energies ranging from the reaction threshold to 1.15 GeV. An enhancement is observed near the eta;d threshold in dsigma;/dM<sub>eta;d</sub>. The measured angular distribution of deuteron emission dsigma;/dOmega;<sub>d<\sub> is rather flat, which cannot be reproduced by the calculations based on the kinematics of quasi-free pi;<sup>0</sup>eta; production with deuteron coalescence even if the eta;d final-state interaction is incorporated. The spin-parity of 1<sup>minus;</sup> is consistent for the enhancement with the pi;<sup>0</sup> and eta; angular distributions for the events with M<sub>eta;d</sub><2.47 GeV.Its Breit-Wigner mass and width are limited to 2.34~2.35 and 0~0.06 GeV, respectively, at 99% confidence level, suggesting a possible eta;d bound state. In this talk, we present the eta;d threshold enhancement, and its properties.

**Presenter:** ISHIKAWA, Takatsugu (Research Center for Electron Photon Science, Tohoku University)

Contribution ID: **32** Type: **not specified**

# Experimental study of spectral change of vector mesons in nuclear medium at J-PARC

*Monday 8 March 2021 13:50 (30 minutes)*

The chiral symmetry is dynamically broken in the QCD vacuum. Hadrons as elementary excitations of the vacuum reflect its property and a large portion of their mass is generated due to the symmetry breaking. The order parameter of the chiral symmetry such as $\langle \bar{q}q \rangle$ is expected to change as a function of temperature and density of the medium thus the in-medium hadron spectra are also expected to change. The in-medium hadron spectra in the hot medium produced by high-energy heavy-ion collisions and in a nucleus have intensively been studied. Our experiment, J-PARC E16, will measure mass spectra of low-mass vector mesons, $\rho$, $\omega$, and $\phi$ in a nucleus using $p + A \to \rho/\omega/\phi + X$ reactions. The invariant mass of vector mesons is reconstructed with $ee$ decay in order to avoid the distortion of the spectra due to the final state interaction. The branching ratio of $ee$ decay is very low and a thin target of ∼0.5\% radiation length must be used to reduce $ee$ pairs from gamma conversion inside the target. Thus, a spectrometer with a large acceptance and high-intensity beam are required to collect a sufficient number of vector mesons. We have developed the spectrometer and have constructed a new beam line for the experiment at J-PARC. As the experiment J-PARC E16, we are allocated 320 hours beam time for a commissioning of the spectrometer and the beam line. The first 160 hours beam time was completed in Jun. 2020 and the left beam time is going to start in Feb. 2021. We discuss the expected physics results and report the current status of the beam line and the experiment.

**Presenter:** KANNO, Koki (RIKEN)

Contribution ID: **33** Type: **not specified**

# Prospect of hadron spectroscopy at Belle II

*Tuesday 9 March 2021 14:40 (30 minutes)*

The discovery of X(3872) by KEKB/Belle experiment opened new door in the hadron spectroscopy. After that, many charmonium and bottomonium like states which can not be identified as simple bound state of quark and anti-quark pair are discovered. In order to have concrete understanding of these hadrons, more detailed study such as determination of quantum number or measurement of decay branching fractions for each hadron is necessary. SuperKEKB/Belle II is the next generation B-factory experiment which aim to accumulate 50 times more data than Belle. Many new measurements for exotic hadron candidates will be possible. The physics run was started on 2019. In this talk, current status of SuperKEKB/Belle II experiment and prospect of hadron spectroscopy is presented

**Presenter:** KATO, Yuji (KMI, Nagoya University)

Contribution ID: **34** Type: **not specified**

# Nonperturbative quark-flavor violation in topological susceptibility at hot QCD

*Monday 8 March 2021 17:40 (20 minutes)*

The topological susceptibility is a crucial probe in studying the QCD theta-vacuum structure and the axial anomaly. So far, some analyses on the topological susceptibility have been done based on chiral effective models. However, the flavor singlet nature for the theta-parameter has not been taken into account, so that the topological susceptibility in the previous studies would have a lack of the underlying property of QCD. In this talk, we will discuss the thermal property of the topological susceptibility by taking into account the flavor singlet nature. We will then show that the topological susceptibility nonperturbatively gets a significant flavor violation signaled by a sizable strange-quark condensate-contribution at around the chiral crossover.

**Presenter:** KAWAGUCHI, Mamiya (Fudan University)

Contribution ID: **35** Type: **not specified**

# Weak-binding relation in the zero range limit

*Tuesday 9 March 2021 15:10 (20 minutes)*

The ordinary hadrons consist of two quarks for mesons or three quarks for baryons. The hadrons with the other structures such as the multi-quark states or the hadronic molecular states are called exotic hadrons. Here, we would like to determine the structure of exotic hadrons using the weak-binding relation for the near-threshold hadrons. In the weak-binding relation, we can determine compositeness of the hadron X defined as the weight of the hadronic molecule component. The relation is expressed by the observables such as the scattering length a_0 and the radius R. Determining X from the observables, we can analyze the internal structure of exotic hadrons without any model calculations. The relation has the correction terms, which are estimated by the typical length of the interaction R_typ. Therefore the corrections terms vanish in the exact zero range limit R_typ=0. We show that there are exceptional cases which violate the weak-binging relation, when the zero range limit is taken with a fine tuning of parameters. We propose a suitable modification of the correction terms of the weak-binging relation with the redefinition of R_typ, so that the relation is valid also in the zero range limit. Originally, R_typ was given by the interaction range R_int, but we define R_typ as the largest value among R_int and R_eff. R_eff is defined as the length scale in the effective-range expansion expect for the scattering length a_0. We apply the modified weak-binding relation to the concrete model and evaluate the correction terms. We expect that the the system with large R_eff such as Lambda_c(2595) can be analyzed with the modified weak-binding relation.

**Presenter:** KINUGAWA, Tomona (Department of Physics, Tokyo Metroporitan University)

Contribution ID: **36** Type: **not specified**

# Vector meson mass in the chiral symmetry restored vacuum

*Monday 8 March 2021 13:10 (40 minutes)*

I will discuss the effects on chiral symmetry breaking in the vector mesons mass. This is accomplished by separating the four quark operators appearing in the vector and axial vector meson sum rules into chiral symmetric and symmetry breaking parts depending on the contribution of the fermion zero modes. We then identify each part from the fit to the vector and axial vector meson masses. By taking the chiral symmetry breaking part to be zero while keeping the symmetric operator to the vacuum value, we find that the chiral symmetric part of the rho and a1 meson mass to be between 550 and 600 MeV. Similar calculation for the K*and K1 reveals similar reduction. Implications of vector meson mass in nuclear medium will be discussed. Prospects of K1 and K* meson mass from a nuclear target experiment at JPARC will also be discussed.

**Presenter:** LEE, Su Houng (Yonsei University)

Contribution ID: **37** Type: **not specified**

# Strangeness S = −3 and S = −4 baryon-baryon interactions in relativistic chiral effective field theory

*Tuesday 9 March 2021 17:10 (20 minutes)*

The strangeness S = −3 and −4 baryon-baryon interactions are investigated in the relativistic chiral effective-field theory at leading order. First, the 12 tree-level low-energy constants contributing to the S = −1 hyperon-nucleon interaction are fixed by fitting to the 36 hyperon-nucleon scattering data. Then the S = −3 and −4 baryon-baryon interactions are derived from that of S = −1 assuming that the corresponding low-energy constants are related to each other via SU(3) flavor symmetry. The comparison with the state-of-the-art lattice QCD simulations, show, however, that SU(3) flavor symmetry-breaking effects cannot be neglected. To take into account these effects, we re-determine two sets of low-energy constants by fitting to the lattice QCD data in the XiSigma and XiXi channels, respectively. The fitting results demonstrate that the lattice QCD S-wave phase shifts for both channels can be described rather well. Without any additional free low-energy constants, the predicted phase shifts for the 3D1 channel and the mixing angle ε1 are also in qualitative agreement with the lattice QCD data for the S = −3 channel, while the results for the S = −4 channel remain to be checked by future lattice QCD simulations. With the so-obtained low-energy constants, the S-wave scattering lengths and effective ranges are calculated for these two channels at the physical point. Finally, in combination with the S = 0 and −2 results obtained in our previous works, we study the evolution of the irreducible representation "27"in the baryon-baryon interactions as a function of increasing strangeness. It is shown that the attraction decreases dramatically as strangeness increases from S = 0 to S = −2, but then remains relatively stable until S = −4. The results indicate that the existence of bound states in the XiSigma and XiXi channels is rather unlikely.

**Presenter:** LIU, Zhi-Wei (School of Physics, Beihang University)

Contribution ID: **38** Type: **not specified**

# Towards solving the hypertriton lifetime puzzle with direct lifetime measurement: current status of J-PARC E73 experiment

*Monday 8 March 2021 20:50 (20 minutes)*

As the lightest hypernucleus, the hypertriton (3ΛH) provides essential knowledge for our understanding for the YN interaction. For a long time, hypertriton is expected to possess a similar lifetime as free Λ hyperon because it is a very loosely bound system (BΛ=130±50 keV). However, several recent heavy ion collision experiments announced surprisingly shorter lifetime (up to ~40%) for 3ΛH mesonic weak decay, which is regarded as the hypertriton lifetime puzzle. As a complementary approach of the heavy ion based experiment, we proposed a direct measurement for 3ΛH lifetime with 3He(K-, pi0)3ΛH reaction as J-PARC E73 experiment. This presentation will introduce the current status of J-PARC E73 experiment.

**Presenter:** MA, Yue (RIKEN)

Contribution ID: **39** Type: **not specified**

# Accessing the coupled-channels dynamics with femtoscopy correlations at LHC

*Monday 8 March 2021 16:10 (30 minutes)*

Systems as K−p and baryon–antibaryon (BBbar) are both characterised by the presence, already at the production threshold, of strong inelastic channels which can affect the properties and the formation of bound states and resonances.The Λ(1405), just below the antikaon-nucleon (KbarN) threshold, arises from the interplay between the KbarN and the coupled Σπ channel. This resonance is currently accepted as a molecular state but in order to provide a full description of its nature and properties, experimental constraints on the relative contribution of the Σπ coupled-channel in the strong KbarN interaction are needed. Baryon–antibaryon systems are characterised, as well, by the dominant contribution of several mesonic channels related to the presence of annihilation processes acting below 1 fm. Several predictions on possible baryonia states are present, but currently the possible existence of such bound states is still under debate due to a limited amount of data for the p−p system available, and either scarce or absent experimental data for BBar systems containing strangeness.Recently, the femtoscopy technique, which measures the correlation of particle pairs at low relative momentum, has been used in pp, p–Pb and Pb–Pb collisions at ALICE and provided high precision data on different baryon—baryon pairs indicating a great sensitivity to the underlying strong potential. In femtoscopy, only the final state (KbarN, BBar) is measured and different initial states are allowed. This translates into an extreme sensitivity of the correlation function to the introduction of the different coupled-channels, which affect both shape and magnitude of the femtoscopic signal.In this talk we will present results from pp collisions at$\sqrt{s}$= 13 TeV, separately for data samples obtained with minimum-bias and high-multiplicity triggers. In particular, we will show results on the K−p correlation function which for the first time provide experimental evidence of the opening of the coupled isospin breaking channel K0bar−n and on the Σπchannel contributions. Finally, results from baryon–antibaryon pairs (ppbar, pΛbar and ΛΛbar) will be shown for the first time.The effect of annihilation channels on the correlation function and a quantitative determination of the inelastic contributions in the three different pairs will be discussed.

**Presenter:** MANTOVANI SARTI, Valentina (TUM)

Contribution ID: **40** Type: **not specified**

# Exotic Hadron Detection with Alice at the LHC

*Tuesday 9 March 2021 20:00 (30 minutes)*

Heavy ion collisions at LHC energies offer a unique opportunity to study the formation of complex QCD bound states such as pentaquarks, tetraquarks, hadron molecules or multi-baryon states. Thermal and coalescence models are able to describe light nuclei and hypernuclei production in ultrarelativistic heavy ion collisions. Such theoretical scenarios can also be used to predict the production yield of more exotic bound states at the same energies. The ALICE experiment has a unique capability to identify hadrons in a wide momentum range allowing for interesting measurements also in the exotic sector. In the first data taking periods already several interesting results on hypernuclei and light nuclei production have been obtained and among them a crucial one is the hypertriton lifetime measurement. Result on the measured hypertriton lifetime and future improvements will be discussed. The future upgrade of the ALICE experiment and the upgrade of the LHC luminosity will provide larger data samples and a better precision in rare signal detection. Latest results on (hyper)nuclei and strange dibaryons measurements with ALICE will be shown and the prospects for searches for exotic states after the LHC luminosity upgrade will also be discussed.

**Presenter:** MASTROSERIO, Annalisa (Università di Foggia and INFN, Italy)

Contribution ID: **41** Type: **not specified**

# Precision spectroscopy of pionic atoms at RIBF

*Wednesday 10 March 2021 15:20 (20 minutes)*

An established approach for quantitative investigation of the partial restoration of chiral symmetry in finite density is study of deeply bound pionic atoms. We are planing to perform spectroscopy of pionic atoms via (d,3He) reaction at RIBF. In the next experiment using several tin isotopes as a target, we are intended to evaluate quantitatively density dependence of the quark condensate.

**Presenter:** MATSUMOTO, Shota (Kyoto University)

Contribution ID: **42** Type: **not specified**

# Constructing neutron star equations of state by connecting a parity doublet nuclear model and Nambu—Jona-Lasinio type model: observational constraints on the nucleon chiral invariant mass

*Monday 8 March 2021 17:20 (20 minutes)*

The mass of a nucleon consists of chiral variant and invariant components. Since their medium properties are different, the composition can be examined through matter in extreme conditions. For this purpose neutron stars are one of the ideal laboratories. Using a parity double model for nuclear matter, we study the mass composition of nucleons through construction of neutron star equations of state, where we assume crossover from nuclear to the color-flavor-locked quark matter. Confronting the neutron star masses and radii in our model with the observational data of LIGO-Virgo and of NICER, we found that the chiral invariant mass is more than 80% of the mass of nucleon. We discuss how the chiral condensate changes from nuclear to quark matter.

**Presenter:** MINAMIKAWA, Takuya (Nagoya Univ.)

Contribution ID: **43** Type: **not specified**

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

*Tuesday 9 March 2021 21:20 (20 minutes)*

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

**Presenter:** MOLINA PERALTA, Raquel (IFIC-UV)

Contribution ID: **44** Type: **not specified**

# Low-energy neutron-neutron scattering studied with pion photoproduction on the deuteron

*Monday 8 March 2021 16:40 (20 minutes)*

The low-energy neutron-neutron scattering has been studied by analyzing the final $nn$ interactions in $nd \to nnp$ ($n$,$p$,$d$ are neutron, proton and deuteron, respectively) and $\pi^- d \to nn\gamma$ data. The resulting neutron-neutron scattering length ($a_{nn}$) differs from the proton-proton one ($a_{pp}$), indicating the charge symmetry breaking of the nuclear force. However, the situation is not conclusive enough because the result from $nd \to nnp$ does not agree with that from $\pi^- d \to nn\gamma$. Also, the analysis of $nd \to nnp$ could suffer from three-nucleon force effects which have not been well-established yet, while the $\pi^- d \to nn\gamma$ data have a hard-to-control uncertainty of the neutron detection efficiency. Thus an independent and different determination of $a_{nn}$ is highly desirable. We discuss the possibility of extracting $a_{nn}$ and effective range $r_{nn}$ from cross section data ($d^2\sigma/dM_{nn}/d\Omega_\pi$), as a function of the $nn$ invariant mass $M_{nn}$, for $\pi^+$ photoproduction on the deuteron ($\gamma d \to \pi^+ nn$). The analysis is based on a $\gamma d \to \pi^+ nn$ reaction model in which realistic elementary amplitudes for $\gamma p \to \pi^+ n$, $NN \to NN$, and $\pi N \to \pi N$ are built in. We show that $M_{nn}$ dependence (lineshape) of a ratio $R_{\rm th}$, $d^2\sigma/dM_{nn}/d\Omega_\pi$ normalized by $d\sigma/d\Omega_\pi$ for $\gamma p \to \pi^+ n$ and the nucleon momentum distribution inside the deuteron, at the kinematics with $\theta_\pi = 0^\circ$ and $E_\gamma \sim 250$ MeV is particularly useful for extracting $a_{nn}$ and $r_{nn}$ from the corresponding data $R_{\rm exp}$. It is found that $R_{\rm exp}$ with 2% error, resolved into the $M_{nn}$ bin width of 0.04 MeV (corresponding to the $p_\pi$ bin width of 0.05 MeV/$c$), can determine $a_{nn}$ and $r_{nn}$ with uncertainties of $\pm 0.21$ fm and $\pm 0.06$ fm, respectively, for the case of $a_{nn} = -18.9$ fm and $r_{nn} = 2.75$ fm. The requirement of such narrow bin widths indicates that the momenta of the incident photon and the emitted $\pi^+$ have to be measured with high resolutions. This can be achieved by utilizing virtual photons of very small $Q^2$ from electron scattering at Mainz MAMI facility. The proposed method for determining $a_{nn}$ and $r_{nn}$ from $\gamma d \to \pi^+ nn$ has a great experimental advantage over the previous one utilizing $\pi^- d \to \gamma nn$ for being free from the formidable task of controlling the neutron detection efficiency and its uncertainty. This presentation is based on our recent work [1].
[1] S.X. Nakamura, T. Ishikawa, and T. Sato, arXiv:2003.02497.

**Presenter:** NAKAMURA, Satoshi (University of Science and Technology of China)

Contribution ID: **45** Type: **not specified**

# Current knowledge and future prospect on double hypernuclei

*Wednesday 10 March 2021 11:10 (30 minutes)*

We have been promoting experiments to search for double hypernuclei using nuclear emulsion at KEK and J-PARC. Although not many samples have been interpreted in a unique way, they provide a glimpse of characteristics on two Lambda binding energies (B_LL) in the nucleus and the internal structure of the Xi hypernucleus. In this talk, we will focus on the atomic mass-number dependence of B_LL and the ground and excited states of 15C-Xi hypernuclei. We will also discuss the exploration method that can be expected to yield a further tenfold increase in statistics over the next few years.

**Presenter:** NAKAZAWA, Kazuma (Physics Department, Gifu University)

Contribution ID: **46** Type: **not specified**

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

*Wednesday 10 March 2021 17:00 (20 minutes)*

In a recent work with Raquel Molina, and Natsumi Ikeno, we have found an explanation for the peak observed in the pn -> pi+ pi- d reaction (pi0 pi0 d) that has been associated to a dibaryon d*(2380) so far. A sequential mechanism of single pion production pn-> pp pi- followed by pp -> pi+ d (plus pn -> nn pi+ followed by nn -> pi- d) reproduces the observed peak in strength, position and narrow width. The two ingredients entering the calculation are the pn -> pp pi- cross section in isospin I=0, recently measured, and the pp -> pi+ d cross section, well known, but only now identified as a consequence of a triangle singularity , which gives it an abnormal large strength compared to other fusion reactions. The picture explains why the "d*(2380)" peak is not seen in the gamma d -> pi+ pi- d reaction and is also not observed in the pp mass distribution of the BESIII e+ e- -> p p pbar pbar reaction.

**Presenter:** OSET BAGUENA, Eulogio (IFIC- University of Valencia-CSIC)

Contribution ID: **47** Type: **not specified**

# Low-energy kaon-nucleon/nuclei interaction studies by AMADEUS

*Wednesday 10 March 2021 17:20 (30 minutes)*

The strong interaction theory in the low energy regime, is still missing fundamental experimental results in order to achieve a breakthrough in its understanding. Among these, the investigation of the low-energy kaon-nucleon/nuclei processes plays a key-role, with important consequences going from particle and nuclear physics to astrophysics. The kaon-nuclei interactions are being measured by the AMADEUS collaboration by using the KLOE detector. The K- single and multi-nuclear absorptions on H, 4He, 9Be and 12C, both at-rest and in-flight (for a kaon momenta up to 120 MeV/c), are investigated with the aim to determine the nature of the controversial Λ(1405), the non-resonant hyperon pion formation amplitude below the K-N threshold, the yields and cross sections of K- multi-nucleon absorptions (intimately related to the antikaon multi-nucleon clusters properties) and the K- scattering cross sections on light nuclear targets. The results of the AMADEUS analyses will be shown.

**Presenter:** PISCICCHIA, Kristian (Enrico Fermi Research Center, LNF (INFN))

Contribution ID: **48** Type: **not specified**

# Strange Systems at PANDA

*Monday 8 March 2021 20:00 (30 minutes)*

The "Facility for Antiproton and Ion Research"(FAIR) is an accelerator-based international research, which presently is under construction in Darmstadt, Germany. The PANDA experiment intends to do basic physics research on various topics around the weak and strong forces, exotic states of matter and the structure of hadrons by colliding stored antiprotons with nuclear targets. Since the beginning, strangeness nuclear physics is one of the four pillars of the PANDA experiment. The PANDA physics program, the relevant observables and the experimental setup will be discussed.

**Presenter:** POCHODZALLA, Josef (Mainz University)

Contribution ID: **49** Type: **not specified**

# The Future Hypernuclear Program at Jefferson Lab

*Wednesday 10 March 2021 10:10 (30 minutes)*

**Presenter:** REINHOLD, Joerg (Florida International University)

Contribution ID: **50** Type: **not specified**

# Internal structure of the Roper resonance in terms of the pi N coupled channels

*Tuesday 9 March 2021 15:30 (20 minutes)*

In this talk I explain how we can evaluate the fractions of the pi N and other meson-baryon molecular/cloud components for the N*and Delta* resonances from the pi N scattering amplitude in terms of the compositeness. Then I construct a simple model to discuss the internal structure of the Roper resonance N(1440) with the meson-baryon compositeness.

**Presenter:** SEKIHARA, Takayasu (Kyoto Prefectural University)

Contribution ID: **51** Type: **not specified**

# Search for Eta'-mesic nuclei in 12C(p, dp) reaction with WASA detector at GSI-FRS.

*Wednesday 10 March 2021 14:10 (20 minutes)*

We plan to conduct an experiment for exploring eta'-mesic nuclei by using the Wide Angle Shower Apparatus (WASA) detector at the fragment separator (FRS) in GSI. We aim at producing and observing eta'-mesic nuclei in 12C(p, dp) reaction by employing 2.5 GeV proton beams. We use the WASA detector to detect protons from decays of eta'-mesic nuclei and the FRS to measure the momenta of the deuterons. In this talk, we report present status of the preparation for the experiment.

**Presenter:** SEKIYA, Ryohei (Kyoto University)

Contribution ID: **52** Type: **not specified**

# Search for eta-mesic nuclei with WASA-at-COSY facility

*Wednesday 10 March 2021 16:10 (30 minutes)*

The existence of eta-mesic nuclei in which the eta meson is bound in a nucleus by means of the strong interaction was postulated more than 30 years ago, however, it has not been yet confirmed experimentally. The discovery of this new kind of an exotic nuclear matter would be very important as it might allow for a better understanding of the eta meson structure and its interaction with nucleons. The search for eta-mesic helium is carried out with high statistics and high acceptance with the WASA detector, installed at the COSY accelerator in the Research Center Juelich. The search is performed via the measurement of the excitation function for selected decay channels of the 4He-eta and 3He-eta systems. The talk will include a description of the experimental method used at WASA and the status of the data analysis.

**Presenter:** SKURZOK, Magdalena (Jagiellonian University)

Contribution ID: **53** Type: **not specified**

# $\Lambda_c N$ interaction in leading order covariant chiral effective field theory

*Tuesday 9 March 2021 17:50 (20 minutes)*

We study the $\Lambda_c N$ interaction in the covariant chiral effective field theory (ChEFT) at leading order. All the relevant low-energy constants are determined by fitting to the lattice QCD simulations from the HAL QCD Collaboration. Extrapolating the results to the physical point, we show that the $\Lambda_c N$ interaction is weakly attractive in the $^1S_0$ channel, but in the $^3S_1$ channel, it is only attractive at extremely low energies and soon turns repulsive for larger laboratory energy. Furthermore, we show that the neglect of the $^3S_1 - {}^3D_1$ coupling provided by the leading order covariant ChEFT would result in an attractive interaction in the $^3S_1$ channel at the physical point, which coincides with the previous non-relatistic ChEFT study. As a byproduct, we predict the $^3D_1$ phase shifts and the mixing angel $\varepsilon_1$, which can be checked by future lattice QCD simulations. In addition, we compare the $\Lambda_c N$ interaction with the $\Lambda N$ and $NN$ interactions to study how the baryon-nucleon ($BN$) interactions evolve as a function of the baryon mass with the replacement of a light quark by a strange or charm quark in the baryon ($B$).

**Presenter:** SONG, Jing (Beihang University)

Contribution ID: **54** Type: **not specified**

# Novel pentaquark picture of single-heavy baryons in chiral effective model

*Tuesday 9 March 2021 14:00 (20 minutes)*

We propose a new type of structure of single-heavy baryons made of one heavy and four light quarks, namely $Qqq\bar{q}q$ state, in addition to the conventional $Qqq$ state. It is proven that the inclusion of $Qqq\bar{q}q$ state is inevitable to explain the observed mass spectrum of heavy-quark spin-singlet and flavor-antisymmetric single-heavy baryons. Based on chiral symmetry of the light quarks inside the baryons, we find $\Lambda_c(2765)$ and $\Xi_c(2967)$ are mostly $Qqq\bar{q}q$ state while $\Lambda_c(2286)$ and $\Xi_c(2470)$ are mostly $Qqq$ state. In addition, the mass of negative-parity single-heavy baryons are predicted. We also derive a sum rule and the Goldberger-Treiman–like relation for which the masses of single-heavy baryons satisfy. Our findings provide useful information for not only future experiments on heavy baryons but also future lattice simulations on diquarks.

**Presenter:** SUENAGA, Daiki (RCNP, Osaka University)

Contribution ID: **55** Type: **not specified**

# Lattice QCD analysis of hidden-charm pentaquarks

*Tuesday 9 March 2021 20:30 (30 minutes)*

Recently, LHCb collaboration has reported three resonance states in the J/\psi p invariant mass spectrum from a weak decay of \Lambda_b. The states, P_c(4312), P_c(4440) and P_c(4457), are expected to be pentaquarks with flavor structure of uudc\bar{c}. In this work, we analyze the J/\psi p scattering by lattice QCD at m_\pi=700, 570, 410 MeV. We determine the spin-dependent J/\psi p potentials, as well as the coupled-channel potentials of open-charm meson-baryon systems through the HAL QCD method.

**Presenter:** SUGIURA, Takuya (RIKEN iTHEMS)

Contribution ID: **56** Type: **not specified**

# Search for the kaonic nuclei at LEPS2-solenoid experiment

*Monday 8 March 2021 15:20 (20 minutes)*

Kaonic nuclei give us a good opportunity to study the interaction between anti-kaon and nuclei. Recently, the existence of three-body kaonic nuclei, the K-pp bound state, was confirmed in several experiments in J-PARC. In those experiments, kaon and pion beams were used to produce the K^-pp bound state. As a complementary probe, photo-induced reaction is important to study the production mechanism of the K-pp bound state. In the LEPS2 solenoid experiment in SPring-8, a high intensity multi-GeV photon beam is used to study a hadron photo-production mechanism. One of the missions of LEPS2 solenoid experiment is to study the production mechanism and the decay branching ratio of the K-pp bound state. We can measure all the decay products with a large acceptance spectrometer system sensitive to both charged and non-charged particles. In addition, isospin partners of the K-pp bound state can be searched for. In this talk, we report the preparation status of LEPS2 solenoid experiment, and discuss the yield estimation of kaonic nuclei by using photo-induced reaction.

**Presenter:** TOKIYASU, Atsushi (Tohoku Univeristy)

Contribution ID: **57** Type: **not specified**

# Results of the search for eta'-nucleus bound states in the LEPS2/BGOegg experiment

*Wednesday 10 March 2021 13:40 (30 minutes)*

Study of eta'(958) meson property in nuclear medium is fascinating because it may probe into the mechanism of hadron mass generation. A large mass reduction of eta' meson in nuclear medium owing to its UA(1) anomaly is expected in several model calculations. If the eta' mass is reduced in a nucleus, the eta' meson and the nucleus can form a bound state. We searched for the eta'-nucleus bound states via missing mass spectroscopy of the 12C(gamma, p) reaction. The experiment was carried out in the LEPS2 beam line at SPring-8 using GeV photon beam. Produced particles were measured using the BGOegg detector system. Suppression of background events arising from multiple meson productions is a key to observe eta'-bound states. For this purpose, we tagged an eta-proton pair, which is expected to be emitted in the eta'N->etaN absorption process of a bound eta' in a nucleus. We report the experimental results and comparisons with theoretical calculations.

**Presenter:** TOMIDA, Natsuki (RCNP, Osaka University)

Contribution ID: **59** Type: **not specified**

# Search for short-range correlation in atomic nuclei

*Monday 8 March 2021 17:00 (20 minutes)*

Atomic nucleus is a unique many-body quantum system in which nucleons/hadrons interact via the forces that origins from fundamental strong interaction. The nucleon-nucleon interaction is a result of the interplay between the long-range attraction and the short-range repulsion. Due to the complex nature, the understanding of interaction among nucleons (protons and neutrons) is still challenging. Conventionally, nucleons are approximated as independent particles subjected to a mean field in nucleus and all the nucleons have momenta are lower than the fermi momentum. However, as revealed by the electron-scattering experiments, about 20%, as a result of density fluctuations in nuclei, two nucleons come close enough to form a short-range correlated (SRC) pair that defies the mean-field description. The momentum of the SRC pair is higher than the fermi momentum, resulting a high-momentum tail in the momentum distribution. Moreover, the existence of SRC pair shows that two-body interaction, which is missing in the conventional understanding, is expected to be the key ingredient to describe how nuclear matter is bound. Despite such great importance of SRC pair, experimental data are however very limited. So far, studies on SRC pairs are only for stable nuclei with inclusive measurements. Aiming at bringing new insights from experimental investigations on the short-range correlated pair in the nuclear systems with an extreme of neutron-proton asymmetry, we present here a new experimental method, which will use proton as a probe to directly tag the SRC pair by measuring the whole kinematics using beams of exotic nuclei in inverse kinematics via proton-induced reaction. The experiment will be performed at SAMURAI spectrometer at RIKEN RI beam factory. In this talk, the detailed consideration for the new method as well as the design of the experiment and development on the new detection system will be presented.

**Presenter:** WANG, He (RIKEN)

Contribution ID: **60** Type: **not specified**

# Study of the heavy pentaquark states

*Tuesday 9 March 2021 14:20 (20 minutes)*

In this talk, we talk about our investigation on the heavy pentaquark states, found in the LHCb collaboration. With the coupled channel approach, and combined with the heavy quark spin symmetry and local hidden gauge symmetry, we study the coupled channel interactions of $\bar{D}^{(*)}\Sigma_c^{(*)}$ and $\bar{D}^{(*)}\Xi_c^{(*,\prime)}$, where threee $P_c$ states and $P_{cs}(4459) were dynamically produced, respectively. Thus, we conclude that they are bound states of certain channel (molecular states).

**Presenter:** XIAO, Chu-Wen (School of Physics and Electronics, Central South University, Changsha 410083, China)

Contribution ID: **61** Type: **not specified**

# Two-pion exchange contributions to the nucleon-nucleon interaction in covariant baryon chiral perturbation theory

*Tuesday 9 March 2021 17:30 (20 minutes)*

Employing the covariant baryon chiral perturbation theory, we calculate the leading and next-to-leading order two-pion exchange (TPE) contributions to $NN$ interaction up to order $O(p^3)$. We compare the so-obtained $NN$ phase shifts with $2 \leq L \leq 6$ and mixing angles with $2 \leq J \leq 6$ with those obtained in the nonrelativistic baryon chiral perturbation theory, which allows us to check the relativistic corrections to the medium-range part of $NN$ interactions. We show that the contributions of relativistic TPE are more moderate than those of the nonrelativistic TPE. The relativistic corrections play an important role in F-waves especially the $^3F_2$ partial wave. Moreover, the relativistic results seem to converge faster than the nonrelativistic results in almost all the partial waves studied in the present work, consistent with the studies performed in the one-baryon sector.

**Presenter:** XIAO, Yang (BEIHANG UNIVERSITY & PARIS-SACLAY UNIVERSITY)

Contribution ID: **62** Type: **not specified**

# Observation of the K^-pp bound state in J-PARC E15

*Monday 8 March 2021 14:50 (30 minutes)*

The existence of an exotic nuclear bound state containing an anti-kaon and nucleons (kaonic nucleus) has been believed for a long time since the strong attractive KbarN interaction was confirmed. The simplest kaonic nucleus , K^-pp bound state, is particularly important to establish the existence of the kaonic nucleus, and has been searched for by many experiments. We performed an experiment to measure the K^-pp using in-flight K^- reaction at J-PARC hadron experimental facility, and finally observed a clear signal of K^-pp. The details of the experiment and analysis will be shown in this talk.

**Presenter:** YAMAGA, Takumi (RIKEN)

Contribution ID: **63** Type: **not specified**

# Heavy hadronic molecules with pion exchange and coupling to multiquarks

*Tuesday 9 March 2021 13:30 (30 minutes)*

Recently exotic hadrons including a $c\bar{c}$ component have been reported in experimental researches. The exotic states cannot be explained by the ordinary hadron picture, namely a baryon as a three-quark state, and a meson as a quark-antiquark state, while a multiquark component would be dominated in their structure. Since the discovery of $X(3872)$ in 2003, the exotic mesons called $X$, $Y$, $Z$, appearing above the $D^{(*)}\bar{D}^{(*)}$ thresholds, have been investigated. As the exotic baryon states, the hidden-charm pentaquark $P_c$ considered to be a $uudc\bar{c}$ state has attracted a lot of interest, which was reported by the LHCb collaboration. There have been many discussions about a structure of the $P_c$ states such as the compact $uudc\bar{c}$ state, the meson-baryon hadronic molecules, triangle singularity. We investigate the $P_c$ pentaquarks as a $\bar{D}^{(*)}\Lambda_c - \bar{D}^{(*)}\Sigma_c^{(*)}$ hadronic molecule coupling to a $qqqc\bar{c}$ compact core. The coupling to the core plays an short-range interaction ($5q$ potential) between the meson and baryon, generating an attraction. The relative strength for the meson-baryon channels is determined by the color-flavor-spin structure of the core states. In addition, the one pion exchange potential (OPEP) as a long-range interaction is introduced by the effective lagrangians satisfying the chiral and heavy quark spin symmetries. The OPEP has been known as a driving force to bind atomic nuclei, where the tensor term leading the coupled-channel effect generates a strong attraction. The mass degeneracy of heavy hadrons due to the heavy quark spin symmetry enhances the OPEP derived by the $\pi D^{(*)}\bar{D}^{(*)}$ and $\pi\Sigma_c^{(*)}\Sigma_c^{(*)}$ couplings. Our model can consistently explain the masses and widths of the $P_c$ states reported by LHCb in 2019. The role of the interactions employed in this model is investigated, and we find that the structure of the energy level is determined by the $5q$ potential, while the decay width by the tensor term of the OPEP.

**Presenter:** YAMAGUCHI, Yasuhiro (Japan Atomic Energy Agency)

Contribution ID: **64** Type: **not specified**

# $\Upsilon$ and $\eta_b$ mass shifts in nuclear matter and the nucleus bound states

*Wednesday 10 March 2021 09:10 (20 minutes)*

We estimate, for the first time, the $\Upsilon$ and $\eta_b$ mass shifts in symmetric nuclear matter. The estimate for the $\Upsilon$ is made using an SU(5) effective Lagrangian, studying the $BB$, $BB^*$, and $B^*B^*$ meson loop contributions for the self-energy. As a result, we include only the $BB$ meson loop contribution as our minimal prediction. As for the $\eta_b$, we include only the $BB^*$ meson loop contribution in the self-energy to be consistent with the minimal prediction for the $\Upsilon$ mass shift. The in-medium masses of the $B$ and $B^*$ mesons appearing in the self-energy loops are calculated by the quark-meson coupling model. Form factors are used to regularize the loop integrals with a wide range of the cutoff mass values. A detailed analysis on the $BB$, $BB^*$, and $B^*B^*$ meson loop contributions for the $\Upsilon$ mass shift is made by comparing with the corresponding $DD$, $DD^*$, and $D^*D^*$ meson loop contributions for the $J/\Psi$ mass shift. Based on the analysis for the $\Upsilon$, our prediction for the $\eta_b$ mass shift is made on the same footing as that for the $\Upsilon$, namely including only the $BB^*$ meson loop. The $\Upsilon$ mass shift is predicted to be -16 to -22 MeV at the symmetric nuclear matter saturation density with the cutoff mass values in the range 2000 - 6000 MeV using the $\Upsilon BB$ coupling constant determined by the vector meson dominance model, while the $\eta_b$ mass shift is predicted to be -75 to -82 MeV with the SU(5) universal coupling constant determined by the $\Upsilon BB$ coupling constant and for the same range of the cutoff mass values. Furthermore, we present some initial results for the $\Upsilon$- and $\eta_b$-nucleus bound states for some nuclei.

**Presenter:** ZEMINIANI, Guilherme (Laboratório de Física Teórica e Computacional - Universidade Cruzeiro do Sul / UNICID)

Contribution ID: **65** Type: **not specified**

# Opening

*Monday 8 March 2021 13:00 (10 minutes)*

Contribution ID: **66** Type: **not specified**

# Closing

*Wednesday 10 March 2021 18:30 (10 minutes)*

Contribution ID: **67** Type: **not specified**

# Mesons in nuclei and partial restoration of chiral symmetry

*Wednesday 10 March 2021 13:10 (30 minutes)*

**Presenter:** JIDO, Daisuke