Workshop on Electro- and Photoproduction of Hypernuclei and Related Topics 2021

Book of abstracts

Talk title: Studying Λ interactions in nuclear matter with the ^{208}Pb$(e,e'K^+)^{208}_{\Lambda}$Tl reaction
Presenter: Franco Garibaldi

An ambitious and challenging experimental program, aimed at obtaining high-resolution hypernuclear spectroscopy via the $(e,e'K^+)$ reaction, was started at Jefferson Lab 15 years ago. The data, taken in both Hall A and Hall C using p-shell and medium-mass nuclear targets, have provided clear spectra with 0.5 0.8-MeV energy resolution. The process, whose feasibility has been established at JLab, is now widely recognized as a powerful tool to study hypernuclear spectroscopy, in addition to the (K^-,π^-) and (π^+,K^+) reactions. Electron- and hadron-induced reactions are in fact complementary to one another, being predominantly driven by spin-flip and non-spin-flip mechanisms, respectively. Furthermore, the $(e,e'K^+)$ reaction allows us for a much better energy resolution and produces mirror hypernuclei with respect to those produced with hadron probes.

The 6 GeV experiments provided the experience needed to confidently set up a new program for the 12 GeV era. It should be noted that the new optimized experimental design not only widens and deepens the physics investigation range and topics, but also dramatically improves on the data quality and production efficiency, maximizing the physics output.

The recent observation of two-solar-mass neutron stars rules out most of the current models of hyperonic matter equation of state, which favour the appearance of hyperons in the neutron star interior but predict maximum masses (Mmax) incompatible with experimental data. This issue, referred to as "hyperon puzzle", strongly suggests that the present understanding of nuclear interactions involving hyperons is far form being complete.

Owing to the severe difficulties involved in the extraction of the potential describing YN interactions from YN scattering data, the study of hypernuclear spectroscopy appears to be the most effective approach to obtain new information, much needed to unravel the hyperon puzzle.

Talk title: Energy Spectrum of $^{16}_{\Lambda}$O within Equation of Motion Phonon Method
Presenter: Petr Veselý

Equation of Motion Phonon Method (EMPM) has been developed for a de-

scription of nuclear structure beyond the approximation of mean field. We introduce an extension of this method suitable for calculations of hypernuclear energy spectra and structure. We show recent calculations of low-energy spectrum of ${}^{16}_{\Lambda}$O within EMPM. We discuss the effect of beyond mean-field correlations in this hypernucleus. Finally, we discuss plans of further applications of EMPM on calculations of hypernuclei.

Talk title: Studies of the hypertriton Λ-binding energy
Presenter: Patrick Achenbach

Studies of light hypernuclei offer invaluable insights into the strong nuclear force with the strangeness degree-of-freedom. A new experiment is prepared at the Mainz Microtron (MAMI) to determine the hypertriton Λ-binding energy via high-precision decay-pion spectroscopy. The experimental method was successfully pioneered in recent years at MAMI, reaching a statistical precision of 5 keV and a systematic uncertainty of 77 keV for hydrogen-4-Λ. In this experiment, beryllium was used as target material. A novel setup utilizes a high-luminosity lithium target, that was optimized for small energy straggling of the outgoing pions and an increase in luminosity by about a factor of 10. Including a precise electron beam energy determination via the undulator light interference method for a recalibration of the magnetic spectrometers, the combined statistical and systematic error of the experiment could reach 20 keV in binding energy.

As a separate project, a new database is under construction to offer a complete collection of published information on hypernuclei. A key aspect is the combination of measurements to average values in a systematic manner together with a proper treatment of errors. The focus lies on lifetimes, Λ-binding energies and excitation levels of hypernuclei. The capability of the database will be demonstrated for the case of the hypertriton.

The Johannes Gutenberg University Mainz is currently constructing the new continuous-wave multi-turn electron linac MESA (Mainz Energy Recovering Superconducting Accelerator) on the Gutenberg Campus. Its maximum beam energy is designed to be 155 MeV. Will there be many more strangeness production experiments after the completion of the hypertriton decay-pion spectroscopy?

Talk title: Studies of $K^+\Lambda$ photo production and Λ hypernuclear lifetime
Presenter: Sho Nagao

Light Lambda hypernuclei are good to investigate effective ΛN interaction and impurity effect nuclear medium. We have been upgrading the NKS2 spectrometer to study the lifetime and decay width of A=3 and 4 hypernuclei by using the (γ, K^+) missing mass spectroscopy. I will give a talk about our physics motivation investigating ${}^{3}_{\Lambda}$H and ${}^{4}_{\Lambda}$H in addition to its elementary process.

Talk title: p-shell Ξ hypernuclei with antisymmetrized molecular dynamics

Presenter: Masahiro Isaka

In this study, we have applied an extended version of antysimmetrized molecular dynamics to the Ξ hypernuclear systems such as $^{14}\mathrm{N} + \Xi^-$ and $^{12}_{\Xi}\mathrm{Be}$ using the G-matrix effective Ξ-N interaction derived from HAL QCD potential and Nijmegen meson-exchange potential ESC. In this talk, we will mainly discuss the binding energy of the Ξ^- particle by comparing it with the recent observed data.

Talk title: Neutrinoless Double Beta Decay
Presenter: Fedor Šimkovic

The recent progress in the theoretical description of the 0nbb-decay is shortly reviewed. The most favored mechanisms of this process are addressed and analyzed, particularly those associated with light and heavy neutrino masses and non-standard neutrino interactions. The present-day results of the calculation of double-beta decay nuclear matrix elements are discussed. A connection between the $2\nu\beta\beta$-decay and $0\nu\beta\beta$-decay matrix elements is analyzed. An impact of the quenching of the axial-vector coupling constant on double-beta decay processes is addressed, and a novel approach to determine the quenched value of g_A is presented.

Talk title: $^{3}_{\Lambda}H$ and $nn\Lambda$ measurements at Jefferson Lab
Presenter: Toshiyuki Gogami

Missing mass spectroscopy with the (e,e'K+) reaction can provide precise spectroscopic data of Lambda hypernuclei. In the talk, two experiments at JLab will be introduced. One is the nn-Lambda search experiment which was performed in 2018 with a tritium target (JLab E12-17-003). The other is a future program in which the Lambda binding energy of hypertriton is planned to be measured with the total uncertainty of about 60 keV (JLab E12-19-002).

Talk title: A new way to derive effective interactions under energy density functional theories
Presenter: Chieh-Jen Yang

We propose a novel idea to construct an effective interaction which is adaptive to the enlargement of model space specified at each order after renormalization. The enlargement of model space is carried out through particle-hole excitation. We use concepts from effective field theory to guide the construction of interactions. Results up to next-to-leading order for infinity nuclear matter and selected closed shell nuclei (^{4}He, ^{16}O and ^{40}Ca) are presented.

Talk title: Structure of $^{48}_{\Lambda}$K and estimates of $(e, e'K^+)$ production cross sections
Presenter: Atsushi Umeya

Abstract to be added.

Talk title: $K^+\Sigma^-$ photoproduction within the isobar model
Presenter: Dalibor Skoupil

We utilise the isobar model to investigate the $K^+\Sigma^-$ photoproduction off a

neutron in the resonance region. Except for the Born terms, we include high-spin (spin-3/2 and spin-5/2) nucleon resonances in the consistent formalism together with a few Δ and kaon resonances to achieve an acceptable agreement with data. Interestingly, we reveal that no hyperon resonances are needed to achieve a reasonable description of data. On the other hand the $N(1720)3/2^+$ resonance was found to be very important for correct description of data. The free parameters of the model were fitted to experimental data from the LEPS and CLAS Collaborations on differential cross sections and photon beam asymmetry. The novel feature of the fitting procedure is the use of a regularization method, the Least Absolute Shrinkage Selection Operator, and information criteria in order to select the best fit.

Talk title: Parameter selection in an isobar model for $K^+\Sigma^-$ photoproduction
Presenter: Dimitrios Petrellis

Newly acquired data on the $K^+\Sigma^-$ photoproduction off a neutron are analyzed by means of an isobar model. Due to the large number of free parameters of the model the fitting to the experimental data becomes problematic. In order to overcome this, we apply a regularization technique from statistical regression analysis combined with criteria from information theory.