Hadron Spectroscopy with Strangeness

Wednesday, 3 April 2024 - Friday, 5 April 2024

University of Glasgow

Book of Abstracts

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Session 2 / 2

Belle results on hyperon spectroscopy and future prospects at Belle II

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I will talk on recent results on hyperon spectroscopy from the Belle experiment. The results include $\Lambda(1670)$, $\Sigma(1435)$, $\Xi(1620/1690)$, and $\Omega(2012)$. I will also discuss future prospects of the Belle II experiment.

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Hyperon Spectroscopy at J-PARC

Author: Kiyoshi Tanida[None]

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I will talk on the results from recent experiments in J-PARC and discuss on future prospects on hyperon spectroscopy. The talk will cover:

- E31: $\Lambda(1405)$ by $d(K^-, NY\pi)$ reactions
- E42: H-dibaryon search in $^{12}C(K^-, K^+)$ reaction
- E72: Search for the new exotic hyperon $\Lambda(1665)$
- Some other experiments under planning

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Status and Plans at GSI/FAIR

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I plan to give an overview of GSI and FAIR, its science scope, the current status of the FAIR construction, the next steps and current developments.

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Discussion: An experimentalist's wishlist

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Discussion: A theorist's wishlist

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Welcome

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Baryon Spectroscopy at J-PARC

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It has been 15 years since J-PARC started operating. J-PARC is a research complex to cover particle, hadron, nuclear and condensed matter physics. At the Hadron Hall, intense pion and/or kaon beams up to 2 GeV/c enable us to study hypernucleus, exotic hadron and hyperon scattering. Recently the new beamline, names as the high-momentum beamline has been constructed to deliver primary protons up to 31 GeV/c. This opens us up to systematic research for Xi and charmed baryon spectroscopies with missing-mass technique. A multi-purpose spectrometer for spectroscopy experiments is now being constructed. I would like to present plans for spectroscopy experiments that will soon begin. If time permits, I will also talk about an upgrade plan for the experimental facility.

Session 6 / 9

Studies of exotic baryon structure via strangeness photoproduction at BGOOD

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The existence of exotic multi-quark states beyond the conventional valence three quark and quark-antiquark systems has been unambiguously confirmed in the heavy quark sectors. Such states could manifest as single colour bound objects, or evolve from meson-baryon and meson-meson interactions, creating molecular like systems and re-scattering effects near production thresholds. Equivalent structures may be evidenced in the light, *uds* sector. This is investigated with the BGOOD photoproduction experiment at ELSA. BGOOD accesses low momentum (low t) exchange kinematics, which is ideal to study spatially extended, molecular-like baryon structure which may manifest in reaction mechanisms.

Our published results in the strangeness sector suggest a dominant role of meson-baryon dynamics which has an equivalence to the P_C states in the charmed sector. Highlights include structure in $K^0\Sigma^0$ and $K^+(\Lambda(1405) \to \pi^0\Sigma^0)$ photoproduction at K^*Y thresholds and new data for forward $K^+\Sigma^0(1385)$ photoproduction.

Supported by DFG projects 388979758/405882627 and the European Union's Horizon 2020 programme, grant 824093.

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Correlation functions for the $N^*(1535)$ and the inverse problem: the role of the K Lambda, K Sigma and eta p coupled channels

Author: Eulogio Oset[None]

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I shall report on recent calculations of the correlation functions for the coupled channels K lambda, K Sigma, Eta N, using input from the chiral unitary approach. Then I will face the inverse problem, starting from these correlations and assuming present experimental errors in this type of correlation functions, I will show how one can learn about dynamics of the interaction of particles, scattering lengths and effective ranges, and the existence of a bound state, corresponding to the N*(1535), and very important, with which precision one can obtain these observables starting from the knowledge of the correlation functions with given errors. At present only the K Lambda correlation function is known, which we reproduce fairly well, and we show the need of measuring the correlation functions for the other channels in order to obtain reliable numbers for these observables.

Session 5 / 11

The pole nature of the $\Lambda(1405)$: A lattice QCD calculation

Authors: Amy Nicholson[1]; Andrew Hanlon[2]; André Walker-Loud[3]; Barbara Alexandra Cid Mora[None]; Ben Hörz[4]; Colin Morningstar[5]; Daniel Mohler[6]; Fernando Romero-López[7]; John Bulava[8]; Joseph Moscoso[1]; Sarah Skinner[5]

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This talk presents results of the first coupled-channel meson-baryon $\pi\Sigma - \bar{K}N$ computation from lattice QCD in the $\Lambda(1405)$ region. Correlation functions were calculated using a single ensemble with pion mass $m_\pi = 200$ MeV and kaon mass $m_{\mathrm{K}} = 487$ MeV, and included single- and multi-hadron operators. Once the finite-volume energy spectra were reliably extracted, the Lüscher method was employed to study scattering amplitudes. The final results exhibited two poles in the complex energy plane of the two-channel K-matrix for all parametrizations used. Their locations correspond to a virtual bound state below $\Sigma\pi$ threshold and a resonance pole below the $N\bar{K}$.

Session 9 / 12

Production of (strange) resonances

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I discus the importance of peripheral (photo)production in production of resonances.

Session 2 / 13

Results and future prospects from LHCb

Author: Mark Peter Whitehead[1]

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I will discuss contributions from LHCb to strange hadron spectroscopy to date, and try to motivate and discuss future expansions of such programmes with the LHCb upgrade and LHCb Upgrade II detectors. The enormous data samples expected will bring opportunities for further contributions that will be covered.

Session 5 / 14

The $\Xi(1820)$ resonance, one or two poles?

Authors: Chu Wen Xiao[None]; Eulogio Oset[1]; Raquel Molina Peralta[None]; Wei-Hong Liang[None]; Zhi-Feng Sun[None]

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We recall that the chiral unitary approach for the interaction of pseudoscalar mesons with the baryons of the decuplet predicts two states for the $\Xi(1820)$ resonance, one with a narrow width and the other one with a large width. We contrast this fact with the recent BESIII measurement of the $K^-\Lambda$ mass distribution in the $\psi(3686)$ decay to $K^-\Lambda\bar{\Xi}^+$, which demands a width much larger than the average of the PDG, and show how the consideration of the two $\Xi(1820)$ states provides a natural explanation to this apparent contradiction. We also propose a reaction to observe the two-pole structure.

Session 8 / 15

Strangeness spectroscopy with Photoproduction Experiments

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The spectrum of excited Σ and Λ states is sparse with only few additions from last decade. Recently, ideas are developed how to identify the missing states using polarized photons and polarized targets. Two differents experiments are currently investigating the measurement of polarization observables for hyperon photoproduction, the CBELSA/TAPS experiment at ELSA and the GlueX experiment at

Jefferson Lab.
In this talk, I will present recent plans to perform polarized measurements of hyperons at the GlueX experiment at Jefferson Lab. In addition, I will show the prospects of a newly planned experiment at the ELSA accelerator in Bonn, Germany.

Session 4 / 16

Constraining the $\pi\Sigma - \bar{K}N$ models with the $\pi\Sigma$ photoproduction data

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The measurements of $\pi\Sigma$ mass distributions in the $\gamma p \rightarrow K^+\pi\Sigma$ photoproduction reaction [1] probe the energy region of the $\Lambda(1405)$ resonance, just below the $\bar{K}N$ threshold, and provide new challenges for the theoretical models of $\pi\Sigma - \bar{K}N$ coupled channels interactions. Adopting the photoproduction model presented in [2, 3] and the chirally motivated Prague model for $\bar{K}N$ interactions [4] we performed a first time attempt on a combined fit of the K^-p low-energy data and the $\pi\Sigma$ photoproduction mass spectra, without fixing the meson-baryon rescattering amplitudes [5]. The achieved description of the photoproduction mass distributions represents a significant improvement when compared with the parameter free predictions made in [3] but remains inferior to a more comprehensive model presented in [6] that employs much larger set of adjustable parameters, some of them purely phenomenological. I will discuss our current results in view of further upgrades being made to the photoproduction kernel. Some deficiencies (or limitations) of the currently available experimental data used in our fits will be discussed as well.

[1] K. Moriya et al. (CLAS Collaboration), Phys. Rev. C 88 (2013) 045201.
[2] P.C. Bruns, arXiv:2012.11298 [nucl-th].
[3] P.C. Bruns, A. Cieplý, M. Mai, Phys. Rev. D 106 (2022) 074017.
[4] P.C. Bruns, A. Cieplý, Nucl. Phys. A 1019 (2022) 122378.
[5] A. Cieplý, P.C. Bruns, Nucl. Phys A 1043 (2024) 122819.
[6] S.X. Nakamura and D. Jido, PTEP 2014 (2014), 023D01; arXiv:1310.5768 [nucl-th].

Session 7 / 17

Strangeness Analyses with CLAS12 at Jefferson Lab

Author: Stuart Fegan[1]

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Commissioned in 2017, the CLAS12 spectrometer is the flagship detector system in Hall B at Jefferson Lab, replacing the previous spectrometer, CLAS, which operated from 1997 until 2012. CLAS12 enables large acceptance studies of electron-induced reactions using the now energy-doubled CEBAF electron beam, with access to quasi-real photoprodcution processes via the low-Q2 Forward Tagger. This talk will showcase the current status of strangeness analyses in CLAS12, with a focus on studies of S = -2, -3 baryons in exclusive photonuclear reactions, where CLAS12 data is expected to provide a significant increase in the available statistics for Ω^- and Ξ baryons.

Session 9 / 18

J– meson resonances in QCD

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Our theoretical and experimental understanding of the spectrum of meson resonances with $J^{PC} = (1,2,3)^{--}$ heavier than the $\phi(1020)$ is relatively weak. While there is strong evidence for fairly narrow isovector and isoscalar 3^{--} states, there are no good 2^{--} candidates, and the 1^{--} sector, where resonances may be broad and are expected to overlap, is rather confused. The corresponding excited kaon spectrum, which is also not as definitive as we would like, is mainly based upon the LASS dataset from the 1980s.

Associations of states in the isoscalar sector with particular flavor structure as 'ω' or 'ϕ' typically follow from assumptions based in OZI phenomenology, and it is not clear that these assumptions have been tested as throughly as they should be away from the lowest $\omega(782)$, $\phi(1020)$ states.

These observations motivate lattice QCD calculations of the J^{--} sector. To avoid the complication of explicit three-body decays, a first round of calculations have been performed at the SU(3) flavor point where the light quarks have the same mass as the strange quarks, considering both the octet case and the singlet case. I will show some results on the resonance content of QCD, explore some limited tests of OZI assumptions, and propose some plausible extrapolations to the physical light quark mass.

Session 3 / 19

Hadron spectroscopy from lattice QCD

Author: Christopher Thomas[1]

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I will provide an overview of some recent work on the spectroscopy and interactions of hadrons using first-principles lattice QCD calculations. Progress will be illustrated with a few examples of calculations of the masses and other properties of hadron resonances, including the coupling of a resonance to a photon, and scattering amplitudes. I will comment on the phenomenology suggested by the calculations, potential applications to other interesting channels and future prospects.

Session 2 / 20

Measurement of Hyperon Polarization at GlueX

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We have investigated the spin structure of photoproduced hyperon pairs for the first time. At Jefferson Lab, we have collected data on the reactions $\gamma p \to \overline{\Lambda}\Lambda p$ (with $\Lambda \to \pi^- p, \overline{\Lambda} \to \pi^+ \overline{p}$) from the threshold up to a beam photon energy of 11.4 GeV. Phenomenological models have been developed to identify the reaction mechanisms behind the production of $\Lambda\bar{\Lambda}$ and $p\bar{\Lambda}$ systems, based on their momentum and angular correlations. We will present differential cross-sections as well as preliminary measurements of hyperon polarization, along with a study on the spin correlation of the hyperon pairs from the GlueX Phase-I period. These findings are expected to enhance our understanding of the role of strangeness in the dynamics of photoproduced baryonic systems, especially for the

$p\bar{\Lambda}$ interaction that lacks guidelines from experimental data in the past. Furthermore, we will also discuss preliminary strangeonia investigations into the $K\pi$ mesonic system recoiling against Λ or Σ hyperons, which allows for the extraction of recoil polarization information to be incorporated into the amplitude analysis of kaon exchange in the GlueX polarized photon beam data.

Session 6 / **21**

Overview of Hyperon Physics in Photoproduction at GlueX

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The GlueX experiment in Hall D at Jefferson Lab has amassed high-statistics data on photoproduction processes. By leveraging the high-intensity linearly polarized photon beam the hyperon program at GlueX has made many contributions to this sector. With these results, contributions that advance the GlueX mission of understanding hadrons have been achieved through measurements of various important observables.

In recent years, contributions to the understanding of pseudoscalar meson and hyperon production in high energy t-channel photoproduction has been published through measurements of the beam asymmetry in $\gamma p \to K^+\Sigma^0$ \[1\] and Spin Density Matrix Elements (SDMEs) in $\Lambda(1520)$ \[2\]. Furthermore, important studies on the controversial nature of the $\Lambda(1405)$ have been presented \[3\] and ongoing studies of the "lineshape" of the resonance could shed light on its internal structure.

In the doubly strange sector, quark models and, more recently, lattice QCD calculations have predicted many more Ξ baryon states than have been experimentally observed. Moreover, the production mechanisms of these states are very poorly understood. By capitalizing on the narrow peaks, as compared to the broad and overlapping N^* states, characteristic of the lowest lying Ξ states, we can analyze the systematic aspects of the spectrum. In addition, we can measure the differential cross section and polarization observables to study the production mechanisms that produce these Ξ resonances.

I will present on the past and ongoing results and the future of the hyperon program at GlueX with a focus on the doubly strange sector.

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1. Phys. Rev. C 101, 065206
2. Phys. Rev. C 105, 035201
3. EPJ Web of Conferences 271, 07005

Session 10 / **22**

The KLong Facility in Hall D at Jefferson Lab

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The KLong Experiment in Jefferson Lab Hall D will use a secondary beam of neutral kaons and the GlueX experimental setup to perform strange hadron spectroscopy. By achieving a flux on the order of 1×10^4 K_L /sec, KLF will allow a broad range of measurements that improve the statistics of previous world data by several orders of magnitude.
The experiment will measure both differential cross sections and self-analysed polarisations of the produced Λ, Σ, Ξ and Ω hyperons spanning the mass range W = 1490 MeV to 2500 MeV. KLF data will significantly constrain partial wave analyses and reduce model-dependent uncertainties in the extraction of the properties and pole positions of the strange hyperon resonances, as well as establish the orbitally excited multiplets in the spectra of the Ξ and Ω hyperons. The proposed facility will also have a defining impact in the strange meson sector through measurements of the final state Kπ system up to 2 GeV invariant mass, allowing the determination of pole positions and widths of many resonances.
This talk will give an overview of the KLong Facility design, current status, and prospects for its impact in strangeness spectroscopy.

Session 4 / 23

New insights into the nature of the Λ(1380) and Λ(1405) resonances away from the SU(3) limit

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In the KbarN-piSigma coupled-channel system, two resonance states of the Lambda(1405) and Lambda(1380) states are considered to appear in the same physical Riemann sheets. To investigate the origin of these states, the detailed knowledge on the interaction is required. In this talk, we discuss the pole positions at the unphysical quark masses which can be accessed in the lattice QCD calculations. We consider the detailed interpolation of the chiral dynamics model between the SU(3) limit and the physical point. We find that these states have always two different poles for any SU(3) limit, one in singlet and the other in octet. We show that the accidental symmetry of the two octets due to the leading order Weinberg-Tomozawa term is broken by the next-to-leading order terms. Furthermore, the interchange of the two trajectories of the Λ(1380) and the Λ(1405) away from the SU(3) limit at next-to-leading order.

Session 1 / 26

Strange meson spectroscopy –from COMPASS to AMBER

Author: Stefan Wallner[1]

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While the excitation spectrum of light-meson, which are composed of up and down quarks, is already mapped out rather well, the strange-meson spectrum still holds many surprises that we need to discovered. At the COMPASS experiment at CERN, we study the spectrum of strange mesons using a negative kaon beam. The flagship channel is the decay to the $K^-\pi^-\pi^+$ final state, for which COMPASS has acquired the so-far world's largest data set. Based on this data set, we performed a partial-wave analysis in order to disentangle the produced mesons by their spin-parity quantum numbers and measure their masses and widths. In this talk, we will focus on recent results from this analysis including searches for a spin-exotic strange meson and we will give prospects for a high-precision measurement of the strange-meson spectrum at AMBER –a new QCD facility at CERN.

Session 1 / 27

Strangeonium at BESIII

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At BESIII, the lineshapes of e+e- ->phi eta', phi eta, KK, omega pi0, eta pipi, omega pipi are measured from 2.0 to 3.08 GeV, where resonant structures are observed in these processes. Multiple lineshapes of intermediate state are obtained by a partial wave analysis of e+e- ->K+ K- pi0 pi0, K+K- pi0 and the structures observed provide essential input to understand the nature of phi2170. These results provide important information for light flavor vector mesons i.e. excited rho, omega and phi, for energy regions above 2 GeV.