

W. Weise

Technische Universität München, Germany

Antikaon Interactions with Nucleons and Nuclei

A review is given on the present situation concerning the theory of antikaon-nucleon interactions based on chiral SU(3) dynamics.

The importance of high-precision threshold data and of measurements of Pi-Sigma mass spectra is emphasized.

Results for the K-pp system from Faddeev and variational calculations are analyzed in comparison. Extrapolations to larger Kbar-nuclear systems are discussed.

Extraction of the KN subthreshold amplitudes from K-mesic atoms

S. Wycech

Soltan Institute for Nuclear Studies, Warsaw

The K mesic atoms offer a chance to look directly into subthreshold K^-N scattering amplitudes. This region is of interest as there are conflicting models of the $\Lambda(1405)$ resonance and the related amplitudes. In K atoms the meson interacts with bound nucleons and the energy in the K^-N system is negative as a result of binding and K^-N recoil energies. Most of the atomic data involve heavy nuclei. These are not useful for the purpose since many nucleons participate and nuclear effects are sizable. Light nuclei are convenient as the nucleon binding energies in ^1H , ^2H , ^3H , ^3He and ^4He span the 0- 20 MeV region in a quasi-continuous way. With systematic experiments one can extract the K^-N scattering amplitudes below the K^-N threshold down to about - 35 MeV. At this moment such a program may be fulfilled only for $K^1\text{H}$ [1] and $K^4\text{He}$ [2].

Results will be presented, as well as technicalities which involve a method of ref.[3] for hydrogen, and a summation of the multiple scattering series for He.

Similar program has been fulfilled with light antiprotonic atoms. It indicates existence of sub-threshold quasi-bound states which find additional evidence in other experiments [4].

[1] [1] G.Beer et al Phys.Rev.Lett 94,212302(2009)

[2] S. Okada et al.Phys Lett. B653, 387 (2007)

[3]T.E.O.Ericson, B. Loiseau and S.Wycech, Phys.Lett. B594(2004)76

[4] B. El-Bennich et al.Phys.Rev. C79 054001(2009) and arXiv:0904.2163 [nucl-th]

Recent results on K^- absorption at rest on few nucleon systems with FINUDA.

Stefano Piano
INFN Sezione di Trieste
FINUDA Collaboration

Abstract:

The FINUDA studies of kaon absorption at rest on light nuclei (A) were carried out by examining $\Lambda - p(d, t)$ correlations [1] [2] [3]. Regardless of A , the $\Lambda - p(d, t)$ pairs are found to be preferentially emitted in opposite directions.

The observation of a nearly constant rate of back-to-back $\Lambda - p(d, t)$ pairs suggests that the absorption of K^- at rest in nuclei may proceed through the formation of intermediate bound states, commonly known now as Bound Kaonic Nuclear states (BKN).

The experimental study of the existence of such states is based on the features of the $\Lambda p(d, t)$ invariant mass distributions, which allow the structure of bound $[K^- NN(NNN, NNNN)]$ systems in nuclei to be determined. Such clusters were identified, and their masses (binding energies), decay widths and yields are reported.

The experimental results will be compared with the most recent theoretical findings and the role of final state interactions of Λ and $p(d, t)$ particles with the residual nucleus A' discussed.

PACS:21.45.-v, 21.80.+a, 25.80.Nv

References

- [1] FINUDA Collaboration, M. Agnello *et al.*, Phys. Rev. Lett. **94** (2005), 212303
- [2] FINUDA Collaboration, M. Agnello *et al.*, Phys. Lett. **B654** (2007), 80
FINUDA Collaboration, M. Agnello *et al.*, Eur. Phys. J. **A33** (2007), 283
- [3] FINUDA Collaboration, M. Agnello *et al.*, Phys. Lett. **B669** (2008), 229

Structure of K^-pp and single-pole nature of $\Lambda(1405)$

Y. Akaishi^{1,2}, T. Yamazaki^{1,3}

¹ *RIKEN Nishina Center, Wako, Saitama 351-0198, Japan*

² *College of Science and Technology, Nihon University, Funabashi, Chiba 274-8501, Japan*

³ *Department of Physics, University of Tokyo, Tokyo 113-0033, Japan*

In recent years we have predicted and investigated few-body deeply bound kaonic states [1,2], starting from the Ansatz that the $\Lambda(1405)$ is a K^-p quasi-bound state. The structure of the most basic one, K^-pp , reveals a molecular feature, namely, the K^- in $\Lambda(1405)$ as an “atomic center” plays a key role in producing strong covalent bonding with the other proton [3]. Thus, we pointed out that strongly bound \bar{K} nuclear systems are formed by “super-strong” nuclear force due to migrating real boson, \bar{K} .

Some theoretical background of our $\Lambda(1405)$ Ansatz of single-pole nature will be presented in contrast of the “double-pole” picture of so-called $\Lambda(1405)$ based on chiral SU(3) dynamics [4]. The evidence for two-pole structure of $\Lambda(1405)$ [5] is logically impossible to stand, since one of the poles cannot produce any peak-structure in experimental data. It is virtually important to distinguish the Λ^* mass, $1405 \text{ MeV}/c^2$ or $1420 \text{ MeV}/c^2$. A bubble-chamber data of $\Sigma\pi$ invariant-mass spectrum from stopped K^- on ${}^4\text{He}$ supports the 1405 Ansatz [6]. An experiment of stopped K^- on D [7] would provide a decisive datum for the mass discrimination [8].

References

- [1] Y. Akaishi and T. Yamazaki, Phys. Rev. C **65** (2002) 044005.
- [2] T. Yamazaki and Y. Akaishi, Phys. Lett. B **535** (2002) 70.
- [3] T. Yamazaki and Y. Akaishi, Proc. Jpn. Acad. B **83** (2007) 144; Phys. Rev. C **76** (2007) 045201.
- [4] T. Hyodo and W. Weise, Phys. Rev. C **77** (2008) 035204.
- [5] V.K. Magas, E. Oset and A. Ramos, Phys. Rev. Lett. **95** (2005) 052301.
- [6] J. Esmaili, Y. Akaishi and T. Yamazaki, arXiv: 0906.0505v1 [nucl-th].
- [7] T. Suzuki et al., this Workshop.
- [8] J. Esmaili, Y. Akaishi and T. Yamazaki, arXiv: 0909.2573v1 [nucl-th].

Many facets of the kaonic atoms ‘puzzle’

E. Friedman

Racah Institute of Physics, The Hebrew University, Jerusalem 91904, Israel

Global analyses of kaonic atoms data across the periodic table yield a deep real part of the K^- -nucleus potential of $\simeq 180$ MeV (attractive). Very similar depths are found in analyses of the $^{12}\text{C}(K^-,N)$ reaction near 1 GeV/c. Such depths can support strongly bound antikaon-nucleus states. In contrast a variety of $\bar{K}N$ interaction models predict shallow potentials of less than half of the above values. A critical review of this ‘puzzle’ is presented with the help of detailed comparisons with the \bar{p} -nucleus potential, which is derived from \bar{p} atoms and from \bar{p} scattering by nuclei up to 0.6 GeV/c.

T. Ishiwatari

SMI, Vienna

Kaonic helium-4 X-ray measurement in SIDDHARTA

Abstract:

The kaonic helium-4 $3d \rightarrow 2p$ X-ray transition was measured in a gaseous target, where Compton scattering in helium is negligible. The X-rays were detected with large-area Silicon Drift Detectors (SDDs) using the timing information of the K^+K^- pairs produced by ϕ decays at the DAFNE e^+e^- collider. A new value of the strong interaction shift of the kaonic ${}^4\text{He}$ $2p$ state was determined to be 0 ± 6 (stat) ± 2 (syst) eV, which confirms the recently obtained result by the KEK-PS E570 experiment. A resolution of the long-standing kaonic helium puzzle provided by the E570 experiment is now firmly confirmed by the present work.

M. Sato

Univ. Tokyo, Japan

Precision spectroscopy of kaonic helium-3 X rays at J-PARC

We will measure X rays from kaonic helium-3 atoms, which have not been measured before, at the J-PARC hadron facility to derive crucial information on the KN strong interaction at low energy (J-PARC E17).

A novel X ray detector, Silicon Drift Detector (SDD), will be used to achieve a few eV precision to determine the X ray energy.

At present, the preparation of the experiment is intensively in progress. In this contribution, the present status of the E17 experiment will be overviewed.

O. Vazquez Doce

LNF-INFN, Frasacti (Italy)

Study of the K- hadronic interactions in the KLOE data.

The AMADEUS collaboration is investigating the hadronic interactions of K- in the KLOE setup in the collected data from previous KLOE runs [1].

The KLOE drift chamber [2] is composed mainly by helium, and a Monte Carlo study [3] shows how 0.1% of the K- flying through the chamber should be stopped in the gas, giving an unique scenario to study the developed hadronic interactions in such an "active target".

Results of the analysis of a sample of the 2005 KLOE data (corresponding to an integrated luminosity of 1.1 fb⁻¹) are presented based on the search of correlations of neutral and charged particles with detected Lambda(1115) hyperons. The analysis of the Lambda-p, Lambda-d, and a invariant mass spectra for the Sigma⁰-pi⁰ gave first class results which will be presented, and have shown the capabilities in performing nuclear physics measurements with the KLOE detector.

The number and the quality of the signal opens the door for studies of many hadronic physics hot topic items, proving KLOE to be a powerful instrument for performing very interesting physics in the strange nuclear and hadronic physics sectors.

References:

[1] O. Vazquez Doce, presentation on 37th LNF Scientific Committee, <http://www.lnf.infn.it/committee/> (2008).

[2] M. Adinolfi et al., Nucl. Instr. Meth. A 488, 51-73 (2002)

[3] M. Cargnelli, C. Petrascu, O. Vazquez Doce and KLOE K-charged group, KLOE memo 337 (2007).

RIKEN J-PARC Center and its physics objective

M. Iwasaki, H. Ohnishi, F. Sakuma, A. Tsukada and S. Yokkaichi

RIKEN Nishina Center for Accelerator-Based Science, Saitama 351-0198, Japan,

E-mail address of the corresponding author [masa@riken.jp]

There are number of proposals and letter of intents to J-PARC PAC from RIKEN, aiming at the study of the origin of matter, namely research to understand the nature of quark-antiquark chiral-condensation, and its partial restoration in a nuclear matter. Very recently, based on this situation, RIKEN Nishina Center for Accelerator Based Science (RNC) is proposing institutional-based contribution to the physics program at Hadron-Hall utilizing slow extracted beam from J-PARC main ring. Tentatively, we call this project as “RIKEN J-PARC Center (RJC)”, and are trying to establish under the governance of RNC based on the cooperation with KEK, JAEA and J-PARC. The RJC project is to boost and promote those experimental programs as one of the missions of RNC. Obviously, the proposals and LOIs are the collaborative works with many other international institutions and willing to extend the collaboration, so the RJC should be realized based on the international discussions such as ECT*.

In the paper, we wish to describe the overview and perspective of the RJC at present, and discuss several experimental programs such as,

- 1) $p + A \rightarrow (e^+ + e^-) + X$ reaction, to study the partial modification of the in-medium ϕ -meson mass,
- 2) $\bar{p} + A \rightarrow \phi + X$ reaction, to study the possibility of the ϕ -meson bound state, and the “mass-shift potential”, and
- 3) $\bar{p} + A \rightarrow (K^+ + K^0) + \bar{K} + X$ reaction, to study the possibility of double- \bar{K} nuclear bound state.

These experiments are in variety of status, which might be realized even before the realization of the RJC project, nevertheless, we believe that the institutional-based contribution to J-PARC is vitally important. Further discussions and suggestions for the project are expected.

Laura Fabbietti

Technische Universität München, Germany

Future Experiments employing pion beams at GSI

High intensity pion beams, as currently available at GSI, can be used to study the behavior of big variety of particles with strangeness content.

The production of the $\Lambda(1405)$ in the $\pi^- + p \rightarrow \Lambda(1405) + K^0$ reaction is particularly interesting to investigate possible differences respect to photon, kaon and proton induced reactions and achieve a complete picture.

On the other hand, the ϕ production on several targets can deliver an useful tool to study the in-medium properties of this meson.

We are currently planning measurements with a pion beam using the FOPI spectrometer together with a novel GEM-TPC detector to be used as a vertex tracker.

Parallel to that, we are developing a pion beam tracking system to be implemented in the HADES spectrometer, where the highest intensity for pion beam are expected.

We present the first feasibility studies for these two projects, the status of the hardware development and discuss the physics goal we are currently aiming to.

Carlo Guaraldo

LNf-INFN, Frascati ,Italy

HadronPhysics2 and beyond

An overview of the running HadronPhysics2 project is given. The role of the HadronPhysics projects in the Framework Programmes of EU is discussed. The overall strategy of the Commission to optimize the remaining budget for Integrating Activities in FP7 is shown. An indication is offered for the next Call of FP7 and, then, beyond FP7.

Johann. Marton

SMI, Vienna, Austria

LEANNIS – a liaison between theory and experiment in antikaon physics

The low-energy regime of the strong interactions antikaon-nucleon and antikaon–nucleus represents a fascinating field with (hyperon) resonances of still unclear nature.

High precision x-ray measurements of the strong interaction induced energy shift and width in kaonic atoms (like experiment SIDDHARTA at LNF and experiment E17 at J-PARC) and new dedicated experiments on reactions involving antikaons will open the way to study the strong force at low energy with unprecedented accuracy. Especially interesting are searches for nuclear systems involving strangeness and bound by the strong force (KNCs, kaonic nuclear clusters). At present this topic is in lively discussion since indications for their existence were found. Furthermore, the search for KNCs is conducted in new experiments. The international scientific network LEANNIS in Hadronphysics2 within the European Framework Program FP7 will bring together experimentalists and theorists to perform joint work on the antikaon interaction with nucleons and nuclei. This talk will give an overview on the objectives of LEANNIS and research activities in this challenging field.

P. Kienle

Excellence Cluster Universe, Technische Universität München

Double Antikaon Production in Nuclei by Stopped Antiproton Annihilation

This talk is based on a Letter of Intent submitted in June 2009 to J-PARC by M. Iwasaki, P. Kienle, H. Onishi, F. Sakuma, and J. Zmeskal. We propose to search for double strangeness production by antiproton annihilation at rest on ^3He nuclei. The proposed experiment will provide significant information on double strangeness production and double strange nuclear cluster states.

**The AMADEUS project – precision studies of
the low-energy antikaon nucleon interaction**

Johann Zmeskal

for the AMADEUS collaboration

Stefan Meyer Institute for Subatomic Physics, Vienna, Austria

A new experiment, called AMADEUS, is planned at Laboratori Nazionali di Frascati, which will make use of the KLOE detector at DAΦNE and the upgrade of the DAΦNE machine, with an improvement in luminosity by a factor of about ten as compared to previous KLOE and DEAR beam times.

The dedicated built-in inner detector and target system will be described as well as the goal of AMADEUS to search for the existence or non-existence of antikaon-mediated deeply bound nuclear systems by an “exclusive” measurement. These measurements enable us in addition to study the dynamic of low-energy antikaon – nucleon/nuclei interaction, with important impact in the understanding of spontaneous chiral symmetry breaking in the framework of low-energy QCD.

T. Yamazaki

Univ. Tokyo, Japan

Where is the K^{Λ} -p quasi-bound state located, strongly bound or weakly bound ? Experimental discrimination between $\Lambda(1405)$ and $\Lambda(1420)$

T. Suzuki

Univ. Tokyo, Japan

The investigation of $\Lambda(1405)$ state in the stopped K- reactions on deuterium

O. Hartmann

GSI, Germany

Search for a $[K^*-pp]$ bound state with FOPI - Status of the Experiment

The FOPI collaboration has proposed in 2007 the investigation of the reaction $p+p \rightarrow K^+ + X \rightarrow K^+ + \Lambda + p$ in order to search for a possible bound state $X \equiv K^*pp$. The experiment has been carried out in august/september this year at the SIS accelerator at the GSI Darmstadt using the FOPI detector. For this experiment, the FOPI detector has been newly equipped with a liquid hydrogen target, a start detector/veto detector system, and a Lambda trigger built out of two layers of silicon strip detectors. The presentation will contain the present status of the experimental performance and the analysis.

As an outlook, a planned experiment to study further the K^* production and propagation in nuclear matter using the secondary pion beam at GSI-SIS will be discussed.