EXA 2014

International Conference on Exotic Atoms and Related Topics

September 14th – 19th, 2014

Stefan Meyer Institute for subatomic Physics
Austrian Academy of Sciences, Vienna, Austria

Scientific program

The EXA2014, the 5th edition of the EXA conference series, takes place in Vienna, Austria, from September 14th to 19th, 2014. It is organized by the Stefan-Meyer-Institute for Subatomic Physics (SMI) of the Austrian Academy of Sciences.

The scientific program comprises the following topics:

- Antihydrogen: CPT and gravity
- Leptonic atoms: QED and gravity
- Kaon-nucleon and kaon-nucleus interaction
- Low-energy QCD
- Hadron physics with antiprotons
- Future facilities and instrumentation

Invited speakers

G. Adkins
M. Bashkanov
V. Baru
S. Bass
M. Cargnelli
C. Carli
D. Cassidy
P. Crivelli
M. Diermaier
M. Diepold
L. Fabbietti
A. Filippi
E. Friedman
H. Fujioka
G. Gabrielse
A. Gal
S. Guellati
F. Herfurth
M. Hori
Y. Ichikawa
Y. Ikeda
K. Itahashi
M. Iwasaki
D. Jido
V. Korobov
P. Krizan
B. Lauss
Y. Litvinov
M. Lutz
J. Mares
J. Messchendorp
V. Metag
A. Miyazaki
P. Moskal
R. Münzer
D. Murtagh
L. Nemenov
D. Nicmorus
J. Nieves
M. Oka
S. Okada
P. Perez
K. Piscicchia
S. Sawada
K. Shimomura
C. Storry
J. Tasson
G. Testera
S. Ulmer
D. van der Werf
W. Weise
U. Wiedner
S. Wycech

International advisory committee

R. Alkofer
C. Amsler
S. Bertolucci
M. Doser
U. Dosselli
A. Gal
C. Guaraldo
R. Hayano
E. Hiyama
K. Jungmann
S. Karshenboim
A. Kostelecky
W. Marciano
J. Mares
J. Marton
N. Mavromatos
S. Nagamiya
K. Pachucki
S. Paul
G. Rosner
D. Schwalm
W. Weise
E. Widmann
U. Wiedner
J. Zmeskal

Local organizing committee

E. Widmann (Chair), J. Marton (Co-Chair), J. Zmeskal (Co-Chair), P. Bühler (Scientific Secretary), K. Suzuki, and J. Matejka (Secretary)

Conference website

http://www.oeaw.ac.at/smi/EXA/

Contents

1 Addresses and other information

Conference venue

The main venue of the conference, and location where the plenary sessions will take place is the

Theatersaal of the *(see map)*
Austrian Academy of Sciences
Sonnenfelsgaße 19
1010 Vienna

This is a few steps from the main building of the Academy

Austrian Academy of Sciences *(see map)*
Doktor-Ignaz-Seipel-Platz 2
1010 Vienna

Parallel sessions

On Wednesday afternoon, September 17th there are 2 parallel sessions (see the timetable)

Session I takes place in the Theatersaal.
Session II takes place in the Sitzungszimmer in the main building of the Academy.

Poster session

The poster session on Tuesday afternoon, September 16th takes place in the Aula of the main building of the Academy.

Reception

We invite all participants to a welcome drink on Sunday, September 14th from 18:00 – 20:00 in the

Restaurant VinziRast "mittendrin" *(see website)*
Währinger Straße 19
1090 Vienna

Conference dinner

We will have the conference dinner on Thursday, September 18th, from 19:30 on in the

Parkhotel Schönbrunn *(see website)*
Hietzinger Hauptstraße 10-14
1130 Vienna

Presentations

Material for oral presentations shall be uploaded by the speakers to the conference Indico website prior to the presentation (https://indico.gsi.de/conferenceOtherViews.py?confId=2604&view=nicecompact).

⇑TOC ⇑Time table

1.1 Lunch restaurants

There are many restaurants, snack bars, and other options to have lunch in a few minutes walking distance around the lecture hall (see map). A few are listed below.

Restaurants/Food

in within walking distance of the Lecture Hall

Places for a quick lunch near the ÖAW

Name, Address	Take Away	Eat In	Warm Food	Super-market
Anker, Wollzeile 30	**X**	**X**		
Ströck, Rotenturmstraße 6	**X**	**X**		
Akakiko, Rotenturmstraße 6	**X**	**X**	**X**	
Nordsee, Rotenturmstraße 4	**X**	**X**	**X**	
Pizza Bizi, Rotenturmstraße 4	**X**	**X**	**X**	
Levante, Wollzeile 19	**X**	**X**	**X**	
Merkur, Hoher Markt 12	**X**	**X**	**X**	**X**
Spar, Wollzeile 39	**X**			**X**
Billa, Biberstraße 15	**X**			**X**

Places for a relaxed lunch near the ÖAW

Name	Address
Café Engländer	Postgasse 2
Beim Czaak	Postgasse 15
Figlmüller	Bäckerstraße 6
Inigo Restaurant	Bäckerstraße 18
Gasthaus Pfudl	Bäckerstraße 22
Zwölf Apostelkeller	Sonnenfelsgasse 3

⇑TOC ⇑Time table

2 Time table

Please note that the blue labels in the time table are clickable links.

	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday
8:00 am		Registration Theatersaal				
8:30 am		Welcome		S. Guellati-Kélifa	G. Gabrielse	
9:00 am		M. Diepold	U. Wiedner	D.P. Van der Werf	M. Hori	M. Iwasaki
9:30 am		K. Shimomura	J. Nieves	S. Ulmer	V. Korobov	J. Mares
10:00 am		G. Adkins	M. Oka	D. Fitzakerley	B. Lauss	K. Piscicchia
10:30 am		Pause	Pause	Pause	Pause	Pause
11:00 am		D. Cassidy	M. Lutz	J. Tasson	D.J. Murtagh	S. Bass
11:30 am		P. Crivelli	J. Messchendorp	G. Testera	Y. Litvinov	V. Baru
12:00 am		A. Miyazaki	Y. Ikeda	P. Perez	M. Bashkanov	L. Nemenov
12:30 am		Break	P. Krizan	Break	A. Gal	S. Wycech
1:00 pm			Break		Break	End
1:30 pm				I: S. Sakai II: C. Pistillo I: W. Krzemien II: V. Yazkov		
2:00 pm		W. Weise		I: H. Nagahiro II: A. Dote	K. Itahashi	
2:30 pm		M. Cargnelli	D. Nicmorus	I: M. Zielinski II: D. Bakalov I: J. Hrtankova II: J. Wurtele	D. Jido	
3:00 pm		Y. Ichikawa	F. Herfurth	I: L. Venturelli II: B. Franke	P. Moskal	
3:30 pm		E. Friedman	C. Carli	Pause I: S. Ohnishi II: A. Wagner	Pause	
4:00 pm		Pause	Pause	I: R. Alkofer II: M. Mohanty	V. Metag	
4:30 pm		A. Filippi	S. Sawada	I: D. Gotta II: A. Voronin I: J. Revai II: A. Ivanonv	H. Fujioka	
5:00 pm		R. Münzer	S. Okada	I: – II: A. Olin	M. Diermaier	
5:30 pm		L. Fabbietti	Poster	Pause V. Flambaum	C. Storry	
6:00 pm	Reception and registration Restaurant VinziRast "mittendrin"			S. Brodsky		
6:30 pm						
7:00 pm						
7:30 pm					Conference dinner	
8:00 pm						

⇑TOC ⇑Time table

3 Session chairs

	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday
8:00 am		Registration Theatersaal				
8:30 am		Welcome		R. Hayano	C. Amsler	
9:00 am		E. Friedman	W. Weise			J. Marton
9:30 am						
10:00 am						
10:30 am		Pause	Pause	Pause	Pause	Pause
11:00 am		C. Guaraldo	A. Gal	D. Cassidy	J. Mares	V. Korobov
11:30 am						
12:00 am						
12:30 am		Break		Break		
1:00 pm			Break		Break	End
1:30 pm				I: V. Metag II: J. Marton		
2:00 pm		A. Dote			K. Suzuki	
2:30 pm			J. Zmeskal			
3:00 pm						
3:30 pm				Pause I: M. Oka II: S. Bass	Pause	
4:00 pm		Pause	Pause		E. Widmann	
4:30 pm		U. Wiedner	J. Zmeskal			
5:00 pm						
5:30 pm			Poster	Pause S. Wycech		
6:00 pm	Reception and registration Restaurant VinziRast "mittendrin"					
6:30 pm						
7:00 pm						
7:30 pm					Conference dinner	
8:00 pm						

⇑TOC ⇑Time table

4 Monday, September 15th

08:00 – 08:30
Registration

E. Widmann, 08:30 – 09:00
Welcome

M. Diepold, 09:00 – 09:30
Nuclear structure from laser spectroscopy of light muonic atoms and ions

M. Diepold(1)

(1) Max Planck Institut für Quantenoptik

On behalf of the CREMA collaboration

Abstract

Muonic atoms and ions are hydrogen-like systems that are formed when negative muons are stopped in ordinary matter, replacing all of the atom's electrons by a single muon. The muon's Bohr radius is 200 times smaller than the corresponding electronic Bohr radius in ordinary H-like ions due to the 200 times larger mass of the muon. This results in a increased sensitivity (200^3) to the finite charge and magnetic radius of the nucleus.

We have recently determined the proton charge radius by laser spectroscopy of the 2S-2P transition ("Lamb shift") in muonic hydrogen [1,2]. Our value of Rp=0.84087(39) fm is ten times more accurate, but 7 sigma discrepant from the world average, which is based on elastic electron-proton scattering and precision spectroscopy of electronic hydrogen. This so-called "proton radius puzzle" has sparked great interest in both atomic and nuclear physics [3]. Physics beyond the Standard Model has also been proposed to solve the problem.

To shed new light on this discrepancy, we have measured the Lamb shift in muonic deuterium and extracted a value of the charge radius of the deuteron. In addition, our most recent experiment [4] has succeeded to measure the Lamb shift in both the mu4He+ and mu3He+ ions, and will be able to provide a ten times more accurate value for the charge radii of the lightest helium isotopes.

References

[1] R. Pohl et al. (CREMA coll.), Nature 466, 213 (2010).
[2] A. Antognini et al. (CREMA coll.), Science 339, 417 (2013).
[3] R. Pohl et al., Ann. Rev. Nucl. Part. Sci 63 (2013) (review in advance).
[4] A. Antognini et al. (CREMA coll.), Can. J. Phys. 89, 47 (2011).

K. Shimomura, 09:30 – 10:00
Muonium at J-PARC: from fundamental to application

K. Shimomura(1)

(1) KEK

Abstract

In this contribution, we will present recent activities at J-PARC by using muonium from the fundamental physics to applied science, especially, on muonium hyperfine structure measurement, muon g-2 and ultra slow muon microscope.

1) Muonium hyperfine structure measurement

Muonium is the bound system of a positive muon and an electron. Among the various spectroscopic measurements, ground state hyperfine structure measurement under external magnetic field is rather attractive, since they provide the information of the internal consistency of QED and the most precise value of muon mass, which is important parameter for muon g-2 expereiment. The latest experiment at Los Alamos obtained the remarkable precision value (120ppb for magnetic moment). However, the main uncertainty came from the luck of statics. In this measurement, quasi DC muon beam was adopted. To overcome above statics limit, use of the intense pulsed muon beam obtained J-PARC MUSE H line is ideal.

2) Muon g-2 measurement with muonium ionization

One of the indications for New Physics (NP) up to now is in the muon anomalous magnetic moment (g-2); there is 3.3σ discrepancy between the SM prediction and measurement by the E821 experiment at BNL with an accuracy of 0.54 ppm. One of the other windows to NP is the muon electric dipole moment (EDM); having the CPT symmetry, the EDM violates CP, which is necessary for the baryon-antibaryon asymmetry while strongly suppressed in SM. The J-PARC muon g-2/EDM experiment aims to measure the muon g-2 and EDM with an accuracy of 0.1 ppm and a sensitivity of 10^{-21} e·cm, respectively, to cast light on NP. To achieve the world best accuracy, high intensity beam at J-PARC MUSE and novel technique of the ultra-cold muon beam, which are obtained thermal muonium ionization by intese laser systems. The ultra-cold beam enables muons to be stored and detected in the magnetic field with no electric focusing, resulting in no need to choose the magic momentum of 3.094 GeV/c used for decades and minimizing dimensions of the stored magnetic field and its systematics.

3) Ultra slow muon microscope with muonium ionization

The Ultra Slow Muon Microscope (USMM), under construction at the U-line of the Muon Facility in J-PARC/MLF, will be the first experimental instrumentation in the world possessing two novel muon sources with unique capabilities: an ultra slow muon beam for depth profiling from the surface to the interior of a material, across interfaces, with nanometer resolution near surface, and a muon microbeam for probing the interior of a material with a resolution of several micrometers at the stopping position. The new spatial imaging method, USMM, is developed for studies of local functional properties and their dynamical aspects near surface and buried interfaces which play key roles in materials and life sciences, such as electron and spin density of states, charge, spin transportation, defects and vacancies in catalytic reaction and so on.

G. Adkins, 10:00 – 10:30
Higher order corrections to the positronium hyperfine splitting

G. Adkins(1)

(1) Franklin and Marshall College

Abstract

The positronium ground state hyperfine splitting (hfs) has long been of interest as a high-precision test of our understanding of binding in QED. The positronium hfs is particularly sensitive to recoil effects (because the ratio of masses is one) and to virtual electron-positron annihilation, but positronium is insensitive to strong and weak interaction effects. Consequently, the comparison between theory and experiment for the positronium hfs, and more generally the positronium spectrum, tests different aspects of the theory compared to comparisons in other exotic atoms. For the past fifteen years there has been a persistent discrepancy between predicted and measured values of the positronium hfs of about four standard deviations (although a new experimental result is consistent with present theory). Recent experimental work at the University of Tokyo, the University of California Riverside, and related work at ETH Zurich is leading to new high-precision measurements, and the calculation of three-loop corrections has begun. The status of the positronium hfs problem and a discussion of recent progress will be the topic of my talk.

D. Cassidy, 11:00 – 11:30
Experiments with atomic and molecular positronium

D. Cassidy(1)

(1) UCL

Abstract

ositronium (or Ps) is a hydrogen-like metastable bound state between an electron and its antiparticle, the positron. This was first produced experimentally by Martin Deutsch in 1951 [1], and since that time Ps has been the subject of numerous experimental studies [2]. However, since antimatter is relatively hard to come by in the lab, and because Ps has a short lifetime against self-annihilation, it is difficult to produce large numbers Ps atoms at the same time, and so experimental work was restricted measurements using one atom at a time. This situation is now starting to change because of developments in positron trapping technology [3] that make it possible to generate intense bursts of positrons and thereby create a "gas" of positronium; this can easily be probed with pulsed lasers making spectroscopic measurements feasible. Moreover, if a high positron beam density is used the resulting Ps atoms may be able to interact with each other, allowing us to observe spin exchanging collisions, Ps-Ps scattering, and the formation of Ps2 molecules. In this talk I will give an overview of some recent experiments performed using a positron trap, including the formation of molecular positronium [4] and a spin polarized Ps gas [5], spectroscopy [6] and scattering [7] of confined Ps, some optical measurements of the Ps hyperfine interval [8] and the production of Rydberg states of Ps [9].

References

[1] Martin Deutsch "Evidence for the Formation of Positronium in Gases" Phys. Rev. 82, 455 (1951).

[2] A. Rich, "Recent experimental advances in positronium research" Rev. Mod. Phys. 53, 127 (1981).

[3] C.M. Surko and R.G. Greaves, "Emerging science and technology of antimatter plasmas and trap-based beams" Phys. Plasmas 11, 2333 (2004).

[4] D.B. Cassidy and A.P. Mills, Jr., "The production of molecular positronium" Nature (London) 449, 195 (2007).

[5] D. B. Cassidy, V. E. Meligne, and A. P. Mills, Jr., "Production of a Fully Spin-Polarized Ensemble of Positronium Atoms" Phys. Rev. Lett. 104, 173401 (2010).

[6] D. B. Cassidy, M. W. J. Bromley, L. C. Cota, T. H. Hisakado, H. W. K. Tom, and A. P. Mills, Jr., "Cavity Induced Shift and Narrowing of the Positronium Lyman-α Transition" Phys. Rev. Lett. 106

[7] D. B. Cassidy and A. P. Mills, Jr., "Enhanced Ps-Ps Interactions due to Quantum Confinement" Phys. Rev. Lett. 107, 213401 (2011).

[8] D. B. Cassidy, T. H. Hisakado, H. W. K. Tom, and A. P. Mills, Jr. "Positronium Hyperfine Interval Measured via Saturated Absorption Spectroscopy" Phys. Rev. Lett. 109, 073401 (2012).

[9] D. B. Cassidy, T. H. Hisakado, H. W. K. Tom, and A. P. Mills, Jr. Efficient Production of Rydberg Positronium" Phys. Rev. Lett. 108, 043401 (2012).

P. Crivelli, 11:30 – 12:00
Positronium 1S-2S spectroscopy

P. Crivelli(1)

(1) Institute for Particle Physics, ETH Zurich

Abstract

We report the status of our ongoing experiment at ETH Zurich (in collaboration with MPQ Garching and Marquette University) aiming to improve by a factor of 5 the current precision of the 1S-2S transition frequency of positronium. This will provide a stringent test of the QED calculations at the alpha2̌077m level. We will describe the details of the experimental setup and the first observation of the annihilations of Ps in the 2S state. We will also discuss the prospects of a further improvement of this measurement and of the 1S-2S transition interval of muonium.

A. Miyazaki, 12:00 – 12:30
First Spectroscopy of the Hyperfine Interval of Positronium Using MillimeterWaves

A. Miyazaki(1), T. Yamazaki (2), T. Suehara (3), T. Namba (2), S. Asai (2), T. Kobayashi (2), H. Saito (2), Y. Tatematsu (4), I. Ogawa (4), T. Idehara (4)

(1) CERN
(2) The University of Tokyo
(3) Kyushu University
(4) Fukui University

Abstract

We firstly performed the millimeter-wave spectroscopy of the ground-state positronium. The energy difference between ortho-positronium (o-Ps) and para-positronium (p-Ps), the hyperfine structure, is in the millimeter-wave range (203 GHz). Since the magnetic dipole transition from o-Ps to p-Ps is strongly suppressed due to their short lifetime, strong millimeter waves of over 20 kW are required to measure the Breit-Wigner resonance of the transition. This experiment has not yet been performed because previously there were no high-power millimeter-wave devices. We newly developed high-power and frequency-tunable millimeter-wave system composed of a gyrotron and a Fabry-Perot cavity, and directly measured the Breit-Wigner resonance of the transition from o-Ps to p-Ps. This is a breakthrough to use millimeter waves in spectroscopic measurements. Three parameters of this transition, the hyperfine structure, lifetime of p-Ps, and spontaneous transition rate are simultaneously determined through the measured Breit-Wigner resonance.

The hyperfine structure of positronium has been indirectly obtained via the Breit-Rabi formula and precise measurement of the Zeeman shifted levels in a static magnetic field of about 1 T. The indirectly measured value differs from QED calculations by 15 ppm (3.9 standard deviations). Some underestimated systematic uncertainties, such as a non-thermalized effect of positronium and non-uniformity of the magnetic field, are suspected. The direct measurement is free from systematic problems due to the static magnetic field. Although current accuracy of the direct measurement is about 700 ppm, it can be improved and used to examine the reported discrepancy in the indirect measurement.

W. Weise, 14:00 – 14:30
Topics in Low-Energy QCD with Strange Quarks

W. Weise(1)

(1) ECT* and Technical University of Munich, Munich

Abstract

Recent developments and phenomena related to low-energy antikaon interactions with baryonic systems are summarized. Expectations for kaonic deuterium and for the K-deuteron scattering length are outlined in view of planned experiments. Updated information is provided concerning the structure of the Lambda(1405). The quest for kaon condensation and the role of strangeness in dense baryonic matter is discussed with focus on the core of neutron stars.

⇑TOC ⇑Time table

M. Cargnelli, 14:30 – 15:00
X-ray spectroscopy of kaonic atoms at SIDDHARTA

M. Cargnelli(1)

(1) Austrian Academy of Sciences - Stefan Meyer Institute

SIDDHARTA COLLABORATION

Abstract

The X-ray measurements of kaonic atoms play an important role for understanding the low-energy QCD in the strangeness sector. The SIDDHARTA experiment studied the X-ray transitions of 4 light kaonic atoms (H, D, 3He and 4He) using the DAFNE electron-positron collider at LNF (Italy). The most precise values of the shift and width of the kaonic hydrogen 1s state were determined, which are now being used as fundamental information for the low-energy K-p interaction in theoretical studies. The yields of kaonic hydrogen K-series transitions and of the kaonic He3 and He4 L-series were measured, the upper limit of the X-ray yields of kaonic deuterium was determined, important for future K-d experiments. The shifts and widths of the kaonic 3He and 4He 2p states were analyzed, solving the 'kaonic helium puzzle' both for the shifts and widths. In this contribution, the experimental approach and the results of SIDDHARTA will be presented, and the plans of the new experiments of kaonic deuterium, will also discussed.

Y. Ichikawa, 15:00 – 15:30
Results of the J-PARC E27 experiment

Y. Ichikawa(1)

(1) Kyoto University)

Abstract

Recently, a study of kaonic nuclei have been actively conducted because they have a rich information, such as the sub-threshold Kbar-N interaction and the behavior of Λ(1405) in many body systems. While the existence of kaonic nuclei has been intensively studied both theoretically and experimentally, there is no conclusive result establishing its existence. Here, we have carried out a experiment as a first phase to search for a K^-pp bound state, which is considered the simplest kaonic nucleus, by using the $d(\pi^+, K^+)X$ reaction at 1.69 GeV/c (J-PARC E27 experiment). Since the production cross section of the K^-pp would not be so large in this reaction, coincidence of high-momentum ($>$ 250MeV/c) proton(s) in large emission angle (39^o-122^o) was required to enhance the signal to background ratio. We have obtained an inclusive $d(\pi^+, K^+)X$ spectrum in a wide missing-mass range from Λ, Σ to Λ(1405)/Σ(1385), in high statics and high energy resolution for the first time. A broad enhancement in the proton coincidence spectra are observed around the missing-mass of 2.27 GeV/c^2, which might be attributed to the K^-pp production. We will report the results both on inclusive and coincidence analyses.

⇑TOC ⇑Time table

E. Friedman, 15:30 – 16:00
Low-energy antinucleon-nucleus interaction revisited

E. Friedman(1)

(1) Racah Institute of Physics, the Hebrew University, Israel

Abstract

Experimental annihilation cross sections of antineutrons and antiprotons at very low energies are compared. On a proton target the cross sections vary smoothly up to 600 MeV/c and the differences are described fully by Coulomb focusing. Direct data comparisons for heavier targets are not possible due to lack of overlap between energies and targets. Interpolations with optical potentials that fit all the antiproton-nucleus data from atoms up to 600 MeV/c surprisingly reveal features of Coulomb scattering in the antineutron annihilation cross sections on nuclei. Additional measurements with antiprotons are outlined which will enable direct data-to-data comparisons.

A. Filippi, 16:30 – 17:00
The FINUDA Experiment: recent results

A. Filippi(1)

(1) INFN Torino

Abstract

Data on kaon induced reactions on nuclei are scarce and old, dating back to more than 40 years ago. They had been collected in bubble chamber experiments, filled with ^{4}He, hydrocarbon mixtures or Neon, or in emulsions, composed mainly by mixtures of elements heavier than Oxygen.

FINUDA could exploit the decay almost at rest of the $\phi(1020)$ mesons produced at the e^+e^- DAΦNE machine to study the interaction of low-energy kaons on several thin targets composed by *p*-shell nuclei, isotopically pure to a level better than 97%.

In parallel to hypernuclear spectroscopy and decay investigations, FINUDA deployed a wide program dedicated to the study of kaon absoption processes, by one or more nucleons, in reactions with the emission of Λ and $\Sigma^{\pm}$ (Y) hyperons. The apparatus, a magnetic spectrometer, allowed the recostruction of the hyperons and the identification of the other emitted charged tracks with a large efficiency and good momentum resolution.

The study of the kaon absorption reactions in nuclei is particularly complex as the recoiling nuclear system cannot be measured, and often, after the interaction, it is left in an unstable state. Therefore missing mass considerations can be helpful only in a fraction of cases. Dedicated analysis methods, based on models which reproduce by Monte Carlo simulations the elementary absorption reactions and following processes (hyperon conversions and/or final state interactions of nucleons and hyperons, hyperon decays), have been developed to pursue the most complete and precise description as possible of the experimental data.

Results on the interactions at rest of negative kaons on ^{6}Li, ^{7}Li, ^{9}Be, ^{13}C and ^{16}O have been obtained. They are of fundamental importance in the understanding of processes involving the dynamics of strange quarks in nuclei and can give valuable inputs in the attempt to model strange nuclear matter behavior at low energies.

In this talk a selection of the most recent results achieved by FINUDA in the study of YN pair production will be reported, with a description of the experimental methods for the data selection and the adopted analysis techniques.

R. Münzer, 17:00 – 17:30

Search for the kaonic bound state ppK- in $pp \to pK + \Lambda$

R. Münzer(1), L. Fabbietti(2), E. Epple(1)

(1) TUM

(2) GSI Helmholtzzentrum für Schwerionenforschung GmbH (GSI)

Abstract

The investigation of the kaon-nucleon interaction currently has been intensified in the last years due to new measuremnts of the Λ(1405) and indications on the existence of the $ppK-$ bound state. Such results are heavily discussed since they can lead to new knowledge about the Antikaon-Nucleon interaction. In the last years the reaction $pp \to pK + \Lambda$ has been measured at the GSI-Darmstadt with the FOPI and the HADES Spectrometer at beam energies of 3.1 GeV and 3.5 GeV, respectively. New analysis methods have been developed in our group to understand quantitatively all the processes contributing to the pKLambda final state and a statistics of around 1000 and 20000 exclusively measured events has been collected with the FOPI and the HADES spectrometer, respectively. At the FOPI experiment a set of around 1000 events and in the HADES experiment around 20000 events of these exclusive reaction $pp \to pK + \Lambda$ could be extracted. These reconstructed exclusive events were analyzed within the Bonn Gatchina Partial Wave Analysis framework, which provides a coherent solution including several resonant and non-resonant production channels. The results have shown, that the inclusion of interferences between different channels is an important effect, which has to be considered in the analysis. Based on the description of the Partial Wave Analysis an upper limit for the cross-section for the production of the $ppK-$ could be determined. In this talk the analysis method of the Partial Wave Analysis as well as the results for the contribution of different production channels and the upper limit for the $ppK-$ will be shown. Furthermore a strategy for a future analysis project based on the Partical Wave Analysis for different beam energies will be presented.

L. Fabbietti, 17:30 – 18:00
The Lambda1405 measured in p+p and K-induced reactions: recent results

L. Fabbietti(1)

(1) Physik Department, Technische Universität München

Abstract

The Lambda1405 cannot be described within any theoretical framework as a normal hadron composed of three quarks, but is considered as emerging naturally from the coupling of different meson-baryon states with strange content. Hence one can look at this resonance as a molecule, where the dominant contribution are an Antikaon-proton and pi-Sigma states. Chiral SU(3) provides quantitative predictions for the amplitudes and phases of the poles building the Lambda(1405) but finally many experimental data remain partially unexplained and not described by theory. Experimentally the production of the Lambda(1405) and its decay into a (Sigma-pi)^0 final state can be studied using different entrance channels and the extracted spectral function differs strongly from the latter. In particular in this talk, recent results published by the HADES collaboration from p+p collisions at 3.5 GeV and measured by the KLOE-AMADEUS collaboration in experiment with stopped kaons will be compared and discussed in the context of all the available information about the Lambda(1405). The puzzle remains undisclosed but new data are available.

5 Tuesday, September 16th

U. Wiedner, 09:00 – 09:30
Hadron Physics and the PANDA experiment at FAIR

U. Wiedner(1)

(1) University Bochum, Germany

Abstract

Hadron physics at moderate energies covers a broad physics spectrum, reaching from investigations of the nucleon structure, the spectroscopy of light-quark states to hadronic interactions. Different accelerator facilities, which provide electron and photon beams, proton and antiproton beams or high-energy lepton collisions, deliver complimentary information. This talk will highlight some exciting recent achievements and discuss them in the context of the planned PANDA experiment.

⇑TOC ⇑Time table

J. Nieves, 09:30 – 10:00
Hidden charm molecular states

J. Nieves(1)

(1) IFIC (CSIC-UV)

Abstract

Among the newly observed structures in the heavy-quarkonium mass region, some have been proposed to be hadronic molecules. We investigate the consequences of heavy-quark flavor symmetry on these heavy meson hadronic molecules. The symmetry allows us to predict new hadronic molecules on one hand, and test the hadronic molecular assumption of the observed structures on the other hand. We explore the consequences of the flavor symmetry assuming the X(3872) and Zb(10610) as an isoscalar DDbar* and isovector BBbar* hadronic molecule, respectively. A series of hadronic molecules composed of heavy mesons are predicted. In particular, there is an isoscalar 1++ BBar* bound state with a mass about 10580 MeV which may be searched for in the $Y(1S,2S)\pi+\pi-\pi 0$ mass distribution; the isovector charmonium partners of the Zb(10610) and the Zb(10650) are also predicted, which probably corresponds to the very recently observed Zc(3900) and Zc(4025) resonances by the BESIII Collaboration.

On the other hand, owing to heavy antiquark-diquark symmetry, the doubly heavy baryons have approximately the same light-quark structure as the heavy antimesons. As a consequence, the existence of a heavy meson-antimeson molecule implies the possibility of a partner composed of a heavy meson and a doubly heavy baryon. These states are of special interest since they can be considered to be triply heavy pentaquarks.

M. Oka, 10:00 – 10:30
New Aspects of Hadron Spectroscopy with Heavy Flavor

M. Oka(1)

(1) Tokyo Institute of Technology

Abstract

I will discuss recent developments in hadron spectroscopy, in particular, the hadrons with heavy quarks and their interactions. Hadrons with heavy quarks have new symmetry and dynamics from the QCD point of view. I stress the heavy quark spin symmetry in the spectrum of heavy mesons and baryons, and also the roles of light di-quarks in the heavy baryons.

⇑TOC ⇑Time table

M. Lutz, 11:00 – 11:30
On finite volume effects in the chiral extrapolation of baryon masses

M. Lutz(1)

(1) GSI

Abstract

We perform an analysis of the QCD lattice data on the baryon octet and decuplet masses based on the relativistic chiral Lagrangian. The baryon self energies are computed in a finite volume at next-to-next-to-next-to leading order (N^{3}LO), where the dependence on the physical meson and baryon masses is kept. The number of free parameters is reduced significantly down to 12 by relying on large-N_c sum rules. Altogether we describe accurately more than 220 data points from six different lattice groups, BMW, PACS-CS, HSC, LHPC, QCDSF-UKQCD and NPLQCD. Values for all counter terms relevant at N^{3}LO are predicted. In particular we extract a pion-nucleon sigma term of 39^{+2}_{-1} MeV and a strangeness sigma term of the nucleon of $\sigma_{sN} = 84^{+28}_{-4}$ MeV. The flavour SU(3) chiral limit of the baryon octet and decuplet masses is determined with (802 $\pm$ 4) MeV and (1103 $\pm$ 6) MeV. Detailed predictions for the baryon masses as currently evaluated by the ETM lattice QCD group are made

J. Messchendorp, 11:30 – 12:00
Charming physics using matter-antimatter annihilations

J. Messchendorp(1)

(1) KVI-CART/University of Groningen

Abstract

The strong interaction remains one of the most fascinating topic in modern subatomic physics. Quantum ChromoDynamics (QCD) is successfully reproducing the physics phenomena at distances much shorter than the size of the nucleon. Here, perturbation theory can be used yielding results of high precision and predictive power. However, at larger distance scales, however, perturbative methods cannot be applied anymore, although spectacular phenomena, such as the generation of hadron masses and quark confinement, occur. Studies using charmed hadrons and gluon-rich matter have the potential to connect the perturbative and the non-perturbative QCD region. The annihilation of matter with antimatter in the mass regime of charmonium is an ideal environment to discover new states or transitions that could reveal the secrets of the strong interaction. Hadronic and electromagnetic transitions between charmonium states and their decays have been measured with a world-record in precision at experiments exploiting electron-positron colliders such as BESIII in Beijing, China. Moreover, unconventional narrow charmonium-rich states have recently been discovered at various facilities in an energy regime above the open-charm threshold. Thereby, possibly a new era in charmonium spectroscopy is initiated. The PANDA experiment at the research facility FAIR near Darmstadt, Germany, will exploit the annihilation of cooled anti-protons with protons to perform charmonium spectroscopy with a decisive precision. I will present the most promising results that have recently been obtained in the field of charmonium spectroscopy with emphasis on BESIII together with the future perspectives of PANDA.

Y. Ikeda, 12:00 – 12:30

Lattice QCD survey of spectroscopy and hadron interactions

Y. Ikeda$^{(1)}$

$^{(1)}$ RIKEN, Nishina Center

Abstract

One of the interesting subjects in hadron spectroscopy is to look for the multiquark configurations. One of candidates is the H-dibaryon (udsuds), and the possibility of the bound H-dibaryon has been recently studied from lattice QCD. We also extend the HAL QCD method to define potential on the lattice between baryons to meson systems including charm quarks to search for the bound tetraquark Tcc (ud ěbarc ěbarc) and Tcs (ud ěbarc ěbarc). In the presentation, after reviewing the HAL QCD method, we report the results on the H-dibaryon, the tetraquark Tcc (ud ěbarc ěbarc) and Tcs (ud ěbarc ěbarc), where we have employed the relativistic heavy quark action to treat the charm quark dynamics with pion masses, m_{pi}=410, 570, 700 MeV.

P. Krizan, 12:30 – 13:00
Belle II and hadron spectroscopy

P. Krizan(1)

(1) Ljubljana University and J. Stefan Institute

Abstract

The two B factories, PEP-II with BaBar and KEKB with Belle, have been a real success story. Not only did they measure a large CP violation in B meson decays, constrained angles and sides of the unitary triangle, and studied numerous new phenomena, they also observed a long list of new hadrons, some of which do not seem to fit into the standard meson and baryon schemes. The next generation of B factories, a called Super B factory will search for departures from the Standard model. For this task, a 50 times larger data sample is needed, corresponding to an integrated luminosity of 50/ab. Needless to say that with such a large data sample there are many more topics to explore, including searches for new and exotic hadrons, and investigation of their properties.

D. Nicmorus, 14:30 – 15:00
Status of FAIR

D. Nicmorus(1)

(1) FAIR

Abstract

The new international accelerator facility FAIR under construction in Darmstadt aims at studying matter at atomic, nuclear, and hadronic levels. I will review different aspects of the current status of the Facility for Antiproton and Ion Research. I will present the focus of the experimental programmes at FAIR, with highlight on open questions addressed by developments in hadron physics, nuclear structure and compressed nuclear matter physics, plasma and atomic physics, as well as related applications.

⇑TOC ⇑Time table

F. Herfurth, 15:00 – 15:30
The CRYRING@ESR project

F. Herfurth(1)

(1) GSI, Darmstadt

Abstract

The CRYRING@ESR project is the early installation of the low-energy storage ring LSR, the Swedish in kind contribution to FAIR, which was proposed as the central decelerator ring for antiprotons at the FLAIR facility. Since the modularized start version of FAIR does not include the erection of the FLAIR building, it was proposed to install the CRYRING storage ring behind the existing experimental storage ring ESR already now. This opens the opportunity to endeavor part of the low energy atomic physics with heavy, highly charged ions as proposed by the SPARC collaboration but also experiments of nuclear physics background in the NUSTAR collaboration much sooner than foreseen in the FAIR general schedule. Furthermore, since the installation of the ring will be handled mostly by FAIR standards, it will be used to test major parts of the FAIR control system for the first time and well ahead of time before it is needed to run SIS100. An option for the future that is being evaluated right now is to feed back antiprotons from the production at FAIR into the existing ESR. This would make antiprotons available in CRYRING and hence enable an early realization of at least part of the low energy antiproton program at FAIR, proposed and advanced by the FLAIR collaboration.

C. Carli, 15:30 – 16:00
Status of the ELENA Project at the CERN AD

C. Carli(1), W. Bartmann (1), P. Belochitskii(1), H. Breuker (1), F. Butin (1), T. Eriksson (1), S. Maury (1), W. Oelert (2), S. Pasinelli (1), G. Tranquille (1)

(1) CERN
(2) Johannes Gutenberg Universität

Abstract

The CERN Antiproton Decelerator (AD) routinely delivers about 3E7 antiprotons every 100 s and with an energy of 5.3 MeV to experiments. The Extra Low Energy Antiproton ring (ELENA) is a small 30 m circumference synchrotron under construction to further decelerate antiprotons from the AD down to 100 keV, an unusually low energy for synchrotron, and to further cool them with an electron cooler. Controlled deceleration in a synchrotron equipped with an electron cooler to reduce emittances in all three planes will allow the existing AD experiments to increase substantially their antiproton capture efficiencies and render new experiments possible. The beam will be transported from ELENA to the experiments by an electrostatic transfer line, which is an elegant and cost effective solution at such low energies. The basic ELENA design including main performance limitations and expected beam characteristics and the project status including planning will be reported.

S. Sawada, 16:30 – 17:00
Status of the J-PARC facility

S. Sawada(1)

(1) KEK

Abstract

The Japan Proton Accelerator Research Complex, J-PARC, started its operation in 2008. The beam intensity from the accelerator has been improved a lot and active research activities have been carried out at the experimental facilities such as the Materials and Life Science Experimental Facility, the Neutrino Experimental Facility, and the Hadron Experimental Facility. In this talk, activities mainly at the Hadron Experimental Facility will be introduced as well as some prospects.

S. Okada, 17:00 – 17:30
High-resolution hadronic-atom x-ray spectroscopy with cryogenic detectors

S. Okada(1), D.A. Bennett(2), C. Curceanu (4), W.B. Doriese(2), J.W. Fowler, (2), T. Hashimoto(1), R. Hayano (3), M. Iliescu(4), S. Ishimoto (5), K. Itahashi (1), M. Iwasaki(1), J. Marton (6), G.C. O'Neil (2), H. Outa (1), M. Sato (1), D.R. Schmidt(2), D.S. Swetz (2), H. Tatsuno (3), J.N. Ullom (2), E. Widmann(6), S. Yamada (7), J. Zmeskal(6)

(1) RIKEN
(2) NIST
(3) University of Tokyo
(4) INFN-LNF
(5) KEK
(6) Stefan Meyer Institute
(7) Tokyo Metropolitan University

Abstract

High-resolution x-ray spectroscopy of hadronic atoms will be performed with a cryogenic x-ray detector system based on an array of superconducting transition-edge-sensor (TES) microcalorimeters [1]. The spectrometer offers unprecedented full-width-at-half-maximum energy resolutions of 2 - 3 eV at 6 keV, which is about two orders of magnitude better than that of conventional semiconductor detectors. The 240 pixel spectrometer array will have a large collecting area of about 20 mm^2 thanks to recent technological advances in multiplexed readout of TES multi-pixel arrays. This will open a new door to investigate hadron-nucleus strong interactions and will also improve the precision of charged-hadron mass values.

A hadronic atom is a Coulomb-bound system formed by a negatively charged hadron (e.g., pi$^-$, K$^-$, pbar, Sigma$^-$, Xi$^-$), electrons, and a nucleus. Effects of the strong interaction between the hadron and atomic nucleus are experimentally extracted from characteristic x-ray-emission spectroscopy of the most tightly bound energy levels that are the most perturbed by the strong force (e.g., [2-4] are recent measurements).

Many kaonic-atom experiments have collected data on a variety of targets [5]; however, the energy resolution of the conventional semiconductor spectrometers employed in these experiments is insufficient to see the small spectral effects due to the strong interaction. As a result, the depth of the K$^-$ - nucleus potential at zero energy remains unknown. This is closely related to the investigation of bound states of the kaon in the nucleus that is one of the hottest topics in strangeness nuclear physics now. Aiming at a breakthrough in this field, we are planning to perform ultra-high-resolution x-ray spectroscopy of kaonic atoms at J-PARC hadron beamline using arrays of TES microcalorimeters developed by NIST, which will be the first application of TESs to a hadronic atom experiment. Additionally, hadronic-atom x-ray spectroscopy has been used as a tool for measuring the charged hadron mass; we intend to improve the precision of the charged kaon mass measurement with TES spectrometers.

In this talk we will give an overview of this project and discuss the recent progress.

References

[1] C. Enss (ed.), Cryogenic Particle Detection, Topics in Applied Physics, vol. 99, Springer, 2005.

[2] S. Okada et al., Phys. Lett. B 653 (2007) 387-391.

[3] SIDDHARTA collaboration, Phys. Lett. B 697 (2011) 199-202.

[4] SIDDHARTA collaboration, Phys. Lett. B 704 (2011) 113-117.

[5] C.J. Batty, E. Friedman, A. Gal, Phys. Rep. 287 (1997) 385-445.

5.1 Poster session, 17:30 – 18:30

in alphabetic order

1. D. Bakalov, External-field shifts in precision spectroscopy of hydrogen molecular ions
2. D. Bakalov, Density shift and broadening of the transition lines in pionic helium
3. A. Bekbayev, Precision studies of the hydrogen molecular ion and its isotopologues
4. C. Berucci, Design and setup of a high resolution X-ray detector system for the kaonic deuterium experiment at J-PARC
5. M. Diepold, Radiative deexcitation of the metastable 2S-state in muonic hydrogen and deuterium
6. B. Franke, The Multipass Cavity of the μHe+ Lamb Shift Experiment
7. L. Nemenov, Interactions at proton momentum 24 and 450 GeV/c and experimental check the LowEnergy QCD precise predictions.
8. S. Okada, Development of room-temperature thermal-muonium-emitting material for ultra-slowmuon production
9. A. Pichler, Search for the violation of the Pauli Exclusion Principle with electrons
10. F. Pipper, Investigations on Prompt Gamma Imaging as Quality Assurance for Ion Therapy
11. C. Sauerzopf, Simulations for the measurement of the groundstate hyperfinestructure of antihydogen
12. C. Sauerzopf, A detector for in-beam measurements of the groundstate hyperfinestructure of antihydrogen
13. K. Tanaka, Measurement of muonium hyperfine splitting at J-PARC
14. Y.K. Tanaka, Analysis of eta’ mesic nucleus spectroscopy with 2.5 GeV proton beam at GSI
15. K. Tokesi, L-shell ionization cross sections by positrons
16. M. Ukai, Xi -atom X-ray measurement at J-PARC - a new direction of Hyperball project

⇑Poster ⇑TOC ⇑Time table

D. Bakalov
External-field shifts in precision spectroscopy of hydrogen molecular ions

D. Bakalov(1), S. Schiller(2), V.I. Korobov(3)

(1) Institute for Nuclear Research and Nuclear Energy, Bulgarian Academy of sciences, Sofia 1784, Bulgaria

(2) Institut fuer Experimentalphysik, Heinrich-Heine-Universitat Duesseldorf, D-40225 Duesseldorf, Germany

(3) Bogolyubov Laboratory of Theoretical Physics, Joint Institute for Nuclear Research, Dubna 141980

Abstract

High precision spectroscopy of trapped hydrogen molecular ions and their isotopomers opens room for new, improved-accuracy determination of fundamental constants such as the electron-to-proton and electron-to-deuteron mass ratio, the fine structure constant etc., and of their time variability. In order to understand the likely experimental uncertainties due to residual external magnetic and electric fields, we have evaluated the Zeeman and the static dipole and quadrupole Stark shift and the black-body shift of the transition frequencies between low-lying rovibrational states of the molecular ions HD+ and H2+. By using a generalized effective Hamiltonian we express the results of the numerical calculations by a few coefficients of the effective Hamiltonian for each ro-vibrational state. This then allows obtaining the systematic shift of the typically large number of individual hyperfine components of a rovibrational transition by angular momentum algebra. Our calculations allowed the identification of hyperfine components of rovibrational transitions with particularly low sensitivity to external field effects. Moreover, we have generated "composite frequencies", in which the overall Zeeman and Stark shifts are nulled. This permits, in principle, to reduce the experimental inaccuracy by 1-2 orders of magnitude.

D. Bakalov
Density shift and broadening of the transition lines in pionic helium

D. Bakalov(1)

(1) Institute for Nuclear Research and Nuclear Energy, Bulgarian Academy of Sciences

Abstract

We report on the theoretical estimates of the density shift and broadening of selected transition lines in pionic helium evaluated in the semiclassical approach, earlier successfully applied to the calculation of the density effects in antiprotonic helium spectroscopy, These results are expected to help reduce the uncertainty of the oncoming laser spectroscopy experiments with pionic helium.

A. Bekbayev
Precision studies of the hydrogen molecular ion and its isotopologues

A. Bekbayev(1), V. Korobov(2), D. Aznabayev(3)

(1) K.
(2) Joint Institute for Nuclear Research
(3) T

Abstract

We present systematic calculations of the leading order relativistic corrections including the hyperfine splitting (HFS) for a wide range of rotational and vibrational states of the HT+ molecular ion. We also calculate the DC and AC Stark effects for the molecular hydrogen ions H2+ and HD+ in the non-relativistic approximation. The influence of the DC Stark polarizability effect on the hyperfine substates of a ro-vibrational state is carefully analyzed. Our results enable the detailed evaluation of certain systematic shifts of the transition frequencies for the purpose of ultra-high-precision optical, microwave, or radio-frequency spectroscopy of the hydrogen molecular ions in a trap.

C. Berucci

Design and setup of a high resolution X-ray detector system for the kaonic deuterium experiment at J-PARC

C. Berucci(1), M. Cargnelli(1), J. Marton (1), E. Widmann (1), J. Zmeskal (1)

(1) Stefan Meyer Institute, Austrian Academy of Sciences, Vienna, Austria

Abstract

The study of the KbarN system at low energies play a key role for the understanding of the strong interaction between hadrons in the strangeness sector. Based on the development of new X-ray detectors and on the availability of the intense kaon beam line K1.8BR at J-PARC the kaonic deuterium experiment will provide the strong-interaction level shift and width of the kaonic deuterium 1s state. The measurements of the X-ray transitions to the 1s level in kaonic deuterium will allow, together with the available results from kaonic hydrogen, to extract the isospin-dependent antikaon-nucleon scattering lengths. I will present Monte Carlo simulation to optimize the kaonic deuterium experiment and I will give a overview of the setup.

M. Diepold

Radiative deexcitation of the metastable 2S-state in muonic hydrogen and deuterium

M. Diepold(1)

(1) Max Planck Institut für Quantenoptik

Abstract

Recently the CREMA collaboration (Charge Radius Experiment using Muonic Atoms) succeeded to measure the Lamb shift (2S-2P energy difference) in muonic hydrogen by means of laser spectroscopy, providing a ten times more accurate value for the charge radius of the proton [1,2].

This study analyzes the data sets taken with muonic hydrogen and muonic deuterium even further in order to investigate the deexcitation of the metastable 2S-state in both isotopes.

In this effort the population and lifetime of atoms undergoing collisional quenching to the 2P-state was measured. Additionally we observe radiative deexcitation of so called "long-lived" 2S-states in muonic deuterium that is interpreted as formation and successive decay of excited muonic molecules [3].

References

[1] R. Pohl et al. (CREMA coll.), Nature 466, 213 (2010)

[2] A. Antognini et al. (CREMA coll.), Science 339, 417 (2013).

[3] M. Diepold et al. (CREMA coll.), Phys. Rev. A 88, 042520 (2013)

B. Franke
The Multipass Cavity of the μHe+ Lamb Shift Experiment

B. Franke(1), J. Krauth(1)

(1) Max-Planck-Institute of Quantum Optics

Abstract

A multipass laser cavity is presented which can be used to illuminate an elongated volume from a transverse direction. The illuminated volume can have a several cmš large transverse cross section. Convenient access to the illuminated volume for other experimental components is granted at a large solid angle. The multipass cavity is very robust against misalignment, and no active stabilization is needed. The scheme is suitable e.g. for beam experiments, where the beam path must not be blocked by a laser mirror, or if the illuminated volume has to be very large. Measurements of the intensity distribution inside the multipass cavity are found to be in good agreement with the simulation. On this poster, the technical developments used to operate the cavity are presented, and an overview over possible applications is given: It was used for the muonic-hydrogen experiment in which 6μm laser light illuminated a volume of 7x25x176mm^3, consisting of mirrors that are only 12mm in height. Furthermore it may be suited for transverse cooling of a beam of atoms/molecules (using two of such cavities) or the creation of a "light curtain" illuminating a region of about 20x10cm^2 over a distance of 1cm or more along the beam axis.

L. Nemenov

Interactions at proton momentum 24 and 450 GeV/c and experimental check the LowEnergy QCD precise predictions.

L. Nemenov(1), O. Gorchakov(1), V. Yazkov(2)

(1) JINR, Dubna

(2) Skobeltsyn Institute of Nuclear Physics, Lomonosov Moscow State University

Abstract

The presented analysis shows that the atom production in the p-nuclear interactions is significantly increasing if the momentum of proton Pp will change from 24 up to 450 GeV/c. If we take into account the acceptance of the DIRAC setup at CERN then for Θ_{lab} = 4° and Pp=450 GeV/c the yields of pi+pi-, pi+K-, K+pi- and pi+pi- atoms per one proton-nuclear interaction are 17, 35 and 27 times more, respectively, than at Θ_{lab} = 5.7° and Pp=24 GeV/c. Taking into account the duty factor of the PS and SPS accelerators, the previous numbers will be increased of a factor 4.

The large yield of dimeson atoms at Pp=450 GeV/c allows significantly improve the precision of pi+K-, K+pi- atoms lifetime measurements, to study the long-lived pi+pi- atoms and to evaluate their Lamb shift value. In parallel it will be possible to increase the precision of the pi+pi- atoms lifetime measurement.

All these measurements allow to check the precise Low Energy QCD predictions for piK and pipi scattering length with high accuracy. The yields of K+K- and other atoms will be presented as well.

S. Okada

Development of room-temperature thermal-muonium-emitting material for ultra-slowmuon production

S. Okada(1), P. Bakule (2), G. Beer (3), Y. Fujiwara (4), K. Ishida, (1), M. Iwasaki (1), S. Kanda (4), H. Kawai (5), N. Kawamura (6), R. Kitamura (4), W. Lee (7), G. Marshall (8), Y. Matsuda (4), T. Mibe (6), Y. Miyake (6), S. Nishimura (4), Y. Oishi (1), A. Olin(3,8), N. Saito (6), K. Shimomura (6), P. Strasser (6), M. Tabata(5,9), D. Tomono(10), K. Ueno (6), E. Won (7), K. Yokoyama(11)

(1) RIKEN
(2) FZU
(3) UVic
(4) U. Tokyo
(5) Chiba Univ.
(6) KEK
(7) Korea Univ.
(8) TRIUMF
(9) JAXA
(10) Kyoto Univ.
(11) QMUL

Abstract

Ultra-slow muons, which are positive muons having an energy of a few eV, are useful tools for producing variable-energy muon beams with extraordinarily small energy spread by accelerating them through an electrostatic field. This technique has attracted attention for extending muSR studies to thin films, surfaces and interfaces, and nano-structures, which has not yet been achieved by the conventional muSR technique using surface muons. We will also apply this new technique to a measurement of the muon anomalous magnetic moment g-2 and electric dipole moment at J-PARC [1], which requires an intense muon beam having an extremely small transverse momentum. The ultra-slow muon production has been realized by laser ionization of thermal muonium atom (Mu) emitted from a tungsten foil heated to 2300 K [2]. On the other hand, it is known that silica powder is useful as a Mu-emitting material at room temperature [3]. We are investigating the possible use of silica aerogel, a material similar to silica powder, as a room-temperature self-standing Mu-emitting material. The room-temperature target has the following significant merits: 1) experimentally easy to handle (no significant heat), 2) smaller emittance of the ionized source (lower Mu energies), 3) smaller spatial spread and smaller Doppler broadening (thanks to lower Mu energy distribution) leading to a more efficient use of the available laser power.

In the TRIUMF S1249 experiment, Mu emission from silica aerogel into vacuum was observed [4]; and the recent measurement (Oct, 2013) yielded promising results with aerogels having a surface with sub-mm structures such as pores. For practical development, we are now preparing an ultra-slow muon beamline dedicated to the research and development of ultra-slow muon production with room-temperature targets at RIKEN-RAL port3.

In this presentation we introduce these studies with the preliminary results and a future plan of the

room-temperature target study at RIKEN-RAL ultra-slow muon beamline.

References
[1] T. Nagae (ed): Prog. Theor. Exp. Phys., Special issue 2 (2012).
[2] K. Nagamine et al., Phys. Rev. Lett. 74 (1995) 4811., P. Bakule et al., NIM B
[3] G. A. Beer et al., Phys. Rev. Lett. 57 (1986) 671.
[4] P. Bakule et al., Prog. Theor. Exp. Phys. (2013) 103C01.

A. Pichler
Search for the violation of the Pauli Exclusion Principle with electrons

A. Pichler(1), H. Shi(1), J. Marton(1)

(1) Stefan Meyer Institute, Austrian Academy of Sciences, Vienna, Austria

Abstract

Formulated by Wolfgang Pauli in 1925 [1], the Pauli Exclusion Principle (PEP) has been the foundation for our understanding of many fields of physics where systems of fermions are concerned. Since no simple explanation for the principle exists, it remains to be a postulate open to experimental tests, which are difficult as there is no well-established theory to predict a violation in a quantitative way. However, there have been high precision experiments searching for a possible PEP violation in the framework of Quantum Mechanics. In a pioneering experiment, Ramberg and Snow [2] supplied electric current to a Cu target, and searched for PEP violating atomic transitions of the "fresh" electrons from the current. The non-existence of the anomalous X-rays from such transitions then set the upper limit for a PEP violation. Following this method, the VIP (VIolation of Pauli Exclusion Principle) experiment improved the sensitivity due to high resolution X-ray detectors and background suppression in the Gran Sasso underground laboratory (LNGS). It obtained an upper limit at the level of 10^{-29} [3,4] for the probability that an external electron captured by a Cu atom can de-excite to the 1s state already occupied by two electrons. The experiment and the results will be presented. The preparation of the follow-up experiment VIP-2 planned at Gran Sasso [5], aiming to increase the sensitivity by two orders of magnitude, will also be shown.

This project is partly supported by the FWF project P25529-N20.

References

[1] W. Pauli, Z. Phys. 31, 765(1925);
[2] E. Ramberg and G.A. Snow, Phys. Lett. B238, 438441(1990);
[3] S. Bartalucci, et al: Phys. Lett. B641, 1822(2006);
[4] C. Curceanu, et al: AIP Conf. Proc. 1508, 136(2012); doi: 10.1063/1.4773125;
[5] J. Marton, et al: J. Phys.: Conf. Ser. 447, (2013)012070;

F. Pipper
Investigations on Prompt Gamma Imaging as Quality Assurance for Ion Therapy

F. Pipper(1), A. Pichler(1), D. Steinschaden(1), J. Zmeskal(1)

(1) Stefan Meyer Institute, Austrian Academy of Sciences, Vienna, Austria

Abstract

In situ methods of dose verification for ion therapy are still in development. A promising approach is the measurement of prompt gamma ray emission following nuclear reactions, which can be correlated to the Bragg peak. This technique is known as prompt gamma imaging (PGI).

An important topic for PGI is the ideal positioning of the detector due to low count rates. Recent simulations indicate a non-trivial angular distribution of prompt gamma intensities in certain ranges of emission energy. Knowledge of this distribution will improve not only statistics but also any response function used for reconstruction of the Bragg peak. Measurements with a slit collimated HPGe detector for various primary ion energies are in preparation.

C. Sauerzopf

Simulations for the measurement of the groundstate hyperfinestructure of antihydogen

C. Sauerzopf(1), S. van Gorp (2), B. Kolbinger (1), R. Lundmark (3), C. Malbrunot (4), Y. Nagata (2), B. Radics (2), M. Tajima (5), E. Widmann (1)

(1) Stefan Meyer Institute, Austrian Academy of Sciences, Vienna, Austria
(2) Atomic Physics Laboratory, RIKEN
(3) Chalmers University of Technology
(4) CERN
(5) Tokyo University

Abstract

Charge, Parity and Time (CPT) symmetry is the most fundamental theoretical concepts in particle physics. The ASACUSA-Hbar collaboration aims to test this property by measuring the hyperfine structure in ground state antihydrogen [1].

Due to the big challenge in producing a beam of antihydrogen [2] sophisticated simulations are needed. Especially tracking of antihydrogen atoms through magnetic fields, atomic processes like Stark effect and Zeemann splitting, microwave transitions in a cavity and antiproton annihilations are required. To achieve this the particle physics toolkit Geant 4 [3] is used as a basis for developing a modular easily usable framework for simulating the ASACUSA antihydrogen beamline, the detectors and the hyperfine transitions within the microwave cavity.

The presented work describes the current status of this simulation framework and gives an overview on the challenges that arise when introducing low energy processes and testing the antiproton annihilation codes within Geant 4.

References

[1] C. Malbrunot et. al., Hyperfine Interactions, February 2014, 1-6 (2014).
[2] N. Kuroda et. al., Nature Communications 5, 3089 (2014).
[3] J. Allison et. al., IEEE Transactions on Nuclear Science, 53 No. 1, 270-278 (2006)

C. Sauerzopf
A detector for in-beam measurements of the groundstate hyperfinestructure of antihydrogen

C. Sauerzopf(1), C. Berucci (1), N. Kuroda (2), C. Malbrunot(3), O. Massiczek(1), Y. Matsuda (2), Y. Nagata (4), H. Shi (1), M. Simon (1), E. Widmann (1), J. Zmeskal (1)

(1) Stefan Meyer Institute, Austrian Academy of Sciences, Vienna, Austria
(2) University of Tokyo
(3) CERN
(4) Atomic Physics Laboratory, RIKEN

Abstract

Producing a beam of antihydrogen, as published by the ASACUSA-Hbar collaboration[1], imposes some big experimental challenges that limit the production rate. Therefore a suitable detector needs to have very good suppression of background events.
The main sources of background are upstream annihilations of antiprotons within the cusp and cosmic particles penetration the detector. These background sources are addressed by surrounding a central detector with two hodoscope layers and the requirement to trigger only if the detector records a hit in both hodoscope layers and the central detector. Additionally basic vertex reconstruction to discriminate between different quantum states of the antihydrogen atoms after the spin selection sextupole is possible. This allows to use the same detector for initial beam and trap diagnosis as well as for the final measurement of the groundstate hyperfinestructure of antihydrogen [2].
This work displays the current state of the detector and trigger developments in preparation for the upcoming beamtime in Autumn 2014 at the CERN AD facility.

References

[1] N. Kuroda et. al., Nature Communications 5, 3089 (2014).
[2] C. Malbrunot et. al., Hyperfine Interactions, February 2014, 1-6 (2014).

K. Tanaka
Measurement of muonium hyperfine splitting at J-PARC

K. Tanaka(1), M. Aoki (4), Y. Fukao (2), Y. Higashi (1), T. Higuchi (1), H. Iinuma (2), Y. Ikedo (2), K. Ishida (3), M. Iwasaki (3), R. Kadono (2), O. Kamigaito (3), S. Kanda (1), D. Kawall (8), N. Kawamura (2), A. Koda (2), K. M. Kojima (2), K. Kubo (5), Y. Matsuda (1), T. Mibe (2), Y, Miyake (2), T. Mizutani (1), K. Nagamine (2), K. Nishiyama (2), T. Ogitsu (2), R. Okubo (2), N. Saito (2), K. Sasaki (2), K. Shimomura (2), P. Strasser (2), M. Sugano (2), M. Tajima (1), D. Tomono (6), H. A. Torii (1), E. Torikai (7), A. Toyoda (2), K. Ueno (2), Y. Ueno (1), A. Yamamoto (2), M. Yoshida (2)

(1) University of Tokyo
(2) KEK
(3) RIKEN
(4) Osaka University
(5) ICU
(6) Kyoto University
(7) University of Yamanashi
(8) University of Massachusetts

MU-HFS collaboration

Abstract

We are planning a measuremnt of the ground state hyperfine structure of muonium at J-PARC/MLF. Muonium is a hydrogen-like bound state only consist of leptons, and its HFS is a good probe for testing QED theory. The muon mass and magnetic moment which are fundamental constants of muon have been so far determined by the muonium HFS experiment at LAMPF. The high intensity beam soon to be available at J-PARC allows one order of magnitude more accurate determination of those constants, which also plays an important role in the new measurement of anomalous magnet monment. Muonium atoms are formed by electron capture reaction with Krypton gas. The microwave resonance is observed by measurement of positron asymmetry from muonium decay. We present the current status of apparatus development and simulation study.

Y.K. Tanaka
Analysis of eta' mesic nucleus spectroscopy with 2.5 GeV proton beam at GSI

Y.K. Tanaka(1), K.-T. Brinkmann(2), S. Friedrich (2), H. Fujioka (3), H. Geissel (4), E. Gutz (2), E. Haettner (4), R.S. Hayano(1), Y. Higashi (5), S. Hirenzaki (5), K. Itahashi (6), M. Iwasaki (6), D. Jido (7), N. Kurz (4), V. Metag (2), T. Nagae (3), H. Nagahiro (5), M. Nanova (2), T. Nishi (1), H. Outa (6), S. Pietri (4), A. Prochazka (4), K. Suzuki (8), T. Suzuki (1), Y.N. Watanabe (1), H. Weick (4), E. Widmann (8), J. Winfield (4), H. Yamakami(3)

(1) University of Tokyo
(2) Universität Giessen
(3) Kyoto University
(4) GSI
(5) Nara Women's University
(6) RIKEN
(7) Tokyo Metropolitan University
(8) SMI

Abstract

We are planning a missing-mass spectroscopy experiment of eta' mesic nuclei to study in-medium effect for the eta' meson. We will employ a 2.5 GeV proton beam from SIS18 (Heavy Ion Synchrotron at GSI, and use the 12C(p,d) reaction to create eta' mesic carbon nuclei. To obtain the missing-mass spectrum, the momenta of the ejectile deuterons will be measured by the FRS (Fragment Separator) used as a spectrometer. The first experiment will be performed at GSI in July-August 2014. In this contribution, we will report the details of the first experiment including very preliminary analysis and results.

K. Tokesi
L-shell ionization cross sections by positrons

K. Tokesi(1), T. Mukoyama (1), Y. Nagashima(2)

(1) Institute for Nuclear Research, Hungarian Academy of Sciences, H-4001 Debrecen, P.O. Box 51, Hungary
(2) Department of Physics Tokyo University of Science 1-3 Kagurazaka, Shinjuku Tokyo 162-8601, Japan

Abstract

Inner-shell ionization process by positron impact is of fundamental importance to understand the collision dynamics between anti-particle and atom. Extensive experimental and theoretical investigations have been reported. At high energies the inner-shell ionization cross sections by positrons are almost same as those by electrons. On the other hand, in the case of low-energy region large difference in cross sections between electrons and positrons is expected because of the Coulomb defection of the projectile due to the target nucleus and the exchange effect. In this work the L-shell ionization cross sections for Ag, In and Sn by positron impact were calculated with the binary-encounter approximation (BEA) and the classical trajectory Monte Carlo (CTMC) method. The BEA cross sections are obtained for four difference atomic models, i.e. the free-fall model, the non-relativistic and relativistic hydrogenic models, and the HFR model. The BEA cross sections and the CTMC results are compared with the measured values. The CTMC calculations are in good agreement with the experimental data. On the other hand, the BEA values with different velocity distributions are generally larger than the experimental results in the energy region higher than 15 keV, except for the case of the free-fall model at 30 keV.

M. Ukai
Xi -atom X-ray measurement at J-PARC - a new direction of Hyperball project

M. Ukai(1)

(1) Dept. of Phys. Tohoku Univ.

Abstract

Study of Xi-N interaction is important for unified understanding of baryon-baryon interaction.NN interaction has been well studied by plenty of scattering experiments, and Lambda N interaction by spectroscopy of hypernuclei. On the otherhand, we will investigate the Xi N interaction through a Xi- atomic X-ray measurement. Energy shifts and widths of Xi atomic X rays provide information on the Xi- nuclear potential near the nuclear surface. Combining systematic Xi X-ray data and Xi hypernuclear data (e.g. J-PARC E05) Xi N interaction can be studied. An intense K- beam 1.8 GeV, optimal momentum for Xi production, is now available at the J-PARC K1.8 beam line. Two Xi -atom experiments are planned at K1.8 (J-PARC E03, E07). They will be the first experiments to measure the Xi atomic X-rays. In both experiments, Xi hyperons are produced via the (K-,K+) reaction and X-rays from Xi atom are measured by Hyperball. Hyperball is a large acceptance germanium detector array, and it successfully observed hypernuclear gamma-rays. For each experiment, Hyperball is specifically configured. E07 searches double Lambda hypernuclei and measures Xi atomic X-ray. It employs combination of nuclear emulsion plates, Hyperball installed near the emulsion, and a magnetic spectrometer system. Xi hyperons are produced in a diamond target located upstream of the emulsion, some of which are trapped by a nucleus in the emulsion (Ag, Br ...). Xi producing events are tagged by the spectrometer, and Xi stopped events are selected by looking at an emulsion image where Xi is traced to be implanted using information from the counters. In this method, Xi-X-ray from for Ag and Br nuclei can be obtained with almost no background. On the other hand, E03 dedicated to measure the Xi X-ray, employs a nuclear target of a specific element in stead of emulsion. Xi hyperons are produced in the target and partly stop inside. Xi producing events are tagged by the spectrometer, while Xi non-stop events are rejected by a SSD detector installed at the downstream of the target. With this method, high statistics can be achieved. As a first step of E03, a Fe target will be used.

In this paper, these two experiments will be described. In particular, new Hyperball system dedicated to E07 experiment is introduced.

6 Wednesday, September 17th

S. Guellati-Kélifa, 08:30 – 09:00

Precise determination of the fine structure constant and test of quantumelectrodynamics

S. Guellati-Kélifa(1)

(1) Laboratoire Kastler Brossel

Abstract

In our experiment the fine structure constant is deduced from the measurement of the recoil velocity of an atom when it absorbs a photon. Such a measurement is performed by combining a Ramsey-Bordé atom interferometer with Bloch oscillations. We obtain a value of α with a relative uncertainty of 6.6×10^{-10}. Using this value of α, we obtain a theoretical value of the electron magnetic moment in agreement with the experimental measurement of Harvard's group. The comparison of these values provides the most stringent test of QED. Moreover, the uncertainty is small enough to verify for the first time the muonic and hadronic contributions to the electron magnetic moment.

In this talk we will discuss the latest developments of this experiment.

D.P. Van der Werf, 09:00 – 09:30
The ALPHA experiment: Status and Outlook

D.P. Van der Werf(1)

(1) Swansea

ALPHA collaboration http://alpha.web.cern.ch; C. Amole, M.D. Ashkezari,M. Baquero-Ruiz, W. Bertsche, P.D. Bowe, E. Butler, A. Capra, C.L. Cesar,M. Charlton, A. Deller, P.H. Donnan, S. Eriksson, J. Fajans, T. Friesen,M.C. Fujiwara, D.R. Gill, A. Gutierrez, J.S. Hangst, W.N. Hardy, M.E. Hayden,A.J. Humphries, C.A. Isaac, S. Jonsell, L. Kurchaninov, A. Little, N. Madsen,J.T.K. McKenna, S. Menary, S.C. Napoli, P. Nolan, K. Olchanski, A. Olin,P. Pusa, C. Ø. Rasmussen, F. Robicheaux, E. Sarid, C. R. Shields,D.M. Silveira, S. Stracka, C. So, R.I. Thompson, D.P. van der Werf,J.S. Wurtele.

Abstract

Since the first trapped antihydrogen in 2010 [1] and observing its long lifetime in the 0.5 K deep neutral atom trap [2], experiments have been performed on the anti-atom resulting in the observation of resonant transitions between the hyperfine states of the ground state [3], experimental limits on the ratio of the gravitational mass to the inertial mass of antimatter and an experimental limit on the charge of antihydrogen [5].

We will give an overview of the ALPHA experiment [6] and present some the results originating from recent experiments on trapped antihydrogen. Furthermore, a outline of a newly proposed antimatter gravity experiment will be given [7].

References

[1] G. B. Andresen et al. (ALPHA collaboration), Nature 468, 673 (2010).
[2] G. B. Andresen et al. (ALPHA collaboration), Nature Phys. 7, 558 (2011).
[3] C. Amole et al. (ALPHA collaboration), Nature 483, 439 (2012).
[4] C. Amole et al. (ALPHA collaboration), Nature Communications 4, 1785 (2013).
[5] C. Amole et al. (ALPHA collaboration), Nature Communications 5, 3955 (2014).
[6] C. Amole et al. (ALPHA collaboration), Nucl. Instr. and Meth. in Phys. Res. A 735 (2014) 319
[7] P. Hamilton et al., Phys. Rev. Lett. 112, 121102 (2014).

S. Ulmer, 09:30 – 10:00
First Direct High Precision Measurement of the Magnetic Moment of the Protonand Status of the BASE Experiment

S. Ulmer[1]

[1] RIKEN Advanced Science Institute

Abstract

One of the fundamental properties of the proton and the antiproton is the spin magnetic moment $_{p,p}$. So far, the most precise value of the proton magnetic moment was based on spectroscopy of a hydrogen maser in a magnetic field [1]. Theoretical corrections at the level of 17.7 ppm were required to extract ţp with a fractional precision of about 10ppb. Using a Penning trap with a superimposed magnetic inhomogeneity, the magnetic moment of the antiproton was measured with a fractional precision of 4.4ppm [2]. In our Penning trap experiments we aim at direct measurements of both values with fractional precisions at the ppb level, or better. The comparison of both values will provide a stringent test of CPT-invariance with baryons. Our measurements are based on the determination of a frequency ratio $\mu_p/\mu_N = \nu_L/\nu_c$, where μ_N is the nuclear magneton, and ν_L and ν_c the Larmor- and the cyclotron frequency, respectively. The cyclotron frequency is measured by image current detection, while the Larmor frequency is obtained by performing quantum jump spectroscopy in a magnetic inhomogeneity. This method has already been applied with great success in measurements of the electron/positron magnetic moments, however the (anti)proton magnetic moment is about 660 times smaller than that of the electron/position system which constitutes a significant challenge. To resolve proton spin quantum transitions a magnetic bottle of 300.000 T/m^2 is required [3]. This strong inhomogeneity limits experimental precision to the ppm level. Thus, we apply the so-called double Penning trap technique which separates the spin state analysis and the precision frequency measurement to two traps, an analysis trap and a precision trap, where the magnetic field is homogeneous. Recently we demonstrated this technique for the first time with a single proton [4] and based on this success we measured the proton magnetic moment for the first time directly[5]. Our first direct high-precision measurement of the proton magnetic moment is more than 760 times more precise than any direct measurement performed so far. The value is consistent with the currently accepted CODATA value, but 2.5 times more precise. To apply this method to the antiproton, we are currently constructing the BASE experiment at the antiproton decelerator of CERN. In the talk I will present our recent magnetic moment measurement and report on the status of both experiments.

References

[1] P.F. Winkler Phys. Rev. A 5, 83-114 (1972).
[2] J. DiSciacca et al., Phys. Rev. Lett. 110, 130801 (2013).
[3] S. Ulmer et al., Phys. Rev. Lett. 106, 253001 (2011).
[4] A. Mooser et al., Phys. Lett. B 723, 78 (2013).
[5] A. Mooser et al., Nature 509, 596 (2014).

D. Fitzakerley, 10:00 – 10:30
Antihydrogen production by two stage charge exchange

D. Fitzakerley(1), E. Hessels(1), C. Storry(1), M. George(1), M. Weel(1), G. Gabrielse(2), C. Hamley(2), N. Jones(2), E. Tardiff(2), A. Muellers(3), J. Walz(3), W. Oelert(3), D. Grzonka(4), M. Zielinski(5)

(1) York University
(2) Harvard University
(3) University of Mainz
(4) Forschungszentrum Jülich
(5) Krakow University

Abstract

Antihydrogen atoms are produced via laser controlled, two stage charge exchange in a cryogenic Penning trap. 5×10^6 antiprotons and 3×10^8 positrons are held in a nested well potential structure. Rydberg Cs atoms travel radially across the trap and through the positron plasma to produce Rydberg Positronium. The Ps* atoms are produced isotropically, with some atoms moving along the axis of the Penning trap and interacting with the cold antiprotons via a second charge exchange to form potentially very cold antihydrogen. Antihydrogen formation is detected by comparing the antiproton annihilation counts with the Cs excited to the Rydberg state to those obtained when the Cs remains in the ground state.

J. Tasson, 11:00 – 11:30
Gravity, CPT, and the Standard-Model Extension

J. Tasson(1)

(1) St. Olaf College

Abstract

Many gravitational phenomena have been well tested with macroscopic matter composed of neutrons, protons, and electrons, but much remains unexplored. Gravitational interactions with other types of matter such as antimatter, charged matter, and matter beyond the first generation remain nearly untested. The gravitational Standard-Model Extension (SME) provides a test framework for the analysis of both traditional matter tests, as well as tests with new types of matter. This talk will provide a review of Lorentz and CPT violation and SME-based proposals for gravitational tests with a focus on novel sensitivities that may be achieved with exotic atoms.

G. Testera, 11:30 – 12:00
AEgIS Status and Outlook

G. Testera(1)

(1) INFN

Abstract

The experiment AEgIS is currently taking data at AD. The experiment is aiming to form a cold antihydrogen beam to perform a direct measurement of the gravitational acceleration on antihydrogen and spectroscopic measurements. The goal, the preliminary achievements, the status and the perspectives of the experiment will be presented.

P. Perez, 12:00 – 12:30
The GBAR experiment

P. Perez(1)

(1) CEA-Saclay

Abstract

The GBAR project (Gravitational Behaviour of Antihydrogen at Rest) at CERN, will measure the free fall acceleration of ultracold neutral antihydrogen atoms in the terrestrial gravitational field. The experiment consists in preparing antihydrogen ions (one antiproton and two positrons) and sympathetically cool them with Be+ ions to a few 10 microK. The ultracold ions will then be photo-ionized just above threshold, and the free-fall time over a known distance measured. I will describe the project, the accuracy that can be reached by standard techniques, and discuss possible improvements using quantum reflection of antihydrogen on surfaces to use quantum methods of measurements.

V. Flambaum, 17:45 – 18:15
Effects of violation of the fundamental symmetries (P,T,Lorentz,CPT) and variation of the fundamental constants

V. Flambaum(1)

(1) University of New South Wales

Abstract

This abstract covers recent results on two different topics:

1. New results for variation of the fine structure constant alpha based on the quasar absorption spectra data indicate the variation of alpha in space. The spatial variation can explain fine tuning of the fundamental constants which allows humans (and any life) to appear. We appeared in the area of the Universe where the values of the fundamental constants are consistent with our existence. There is an agreement between the results obtained using different telescopes and different redshifts.

The astrophysical results may be used to predict the variation effects in laboratory experiments. The variation effects are strongly enhanced in highly charged ions.

2. Measurements and calculations of parity (P) violation in atoms and ions provide tests of the Standard model and limits on new physics. Atomic and molecular experiments can also be used to detect nuclear anapole moment - magnetic multipole which violates fundamental symmetries: parity (P) and charge conjugation (C). These measurements will give us the strength of parity violating nuclear forces and may provide new test of the Standard model. Measurements of time-reversal (T) violating interactions and electric dipole moments (EDM) in atomic and molecular experiments present a possibility to search for physics beyond the Standard model.

Violation of the fundamental symmetries (P,T (EDM), Lorents) may also be produced by the primordial axion condensate created after Big Bang, and by other hypothetical cosmic fields. Limits on these fields may be obtained from current and new proposed experiments.

S. Brodsky, 18:15 – 18:45

Atoms in Flight and the Remarkable Connections between Atomic and HadronicPhysics

S. Brodsky(1)

(1) SLAC National Accelerator Laboratory, Stanford University

Abstract

Atomic physics and hadron physics are both based on Yang Mills gauge theory; in fact, quantum electrodynamics can be regarded as the zero-color limit of quantum chromodynamics. I review a number of areas where the techniques of atomic physics provide important insight into the theory of hadrons in QCD. For example, the Dirac-Coulomb equation, which predicts the spectroscopy and structure of hydrogenic atoms, has an analog in hadron physics in the form of light-front relativistic equations of motion which give a remarkable first approximation to the spectroscopy, dynamics, and structure of light hadrons. The renormalization scale for the running coupling, which is unambiguously set in QED, leads to a method for setting the renormalization scale in QCD. The production of atoms in flight provides a method for computing the formation of hadrons at the amplitude level. Conversely, many techniques which have been developed for hadron physics, such as scaling laws, evolution equations, and light-front quantization have equal utility for atomic physics, especially in the relativistic domain. I also will present a new perspective for understanding the contributions to the cosmological constant from QED and QCD.

6.1 Parallel session I, 13:30 - 17:30

S. Sakai, 13:30 – 13:50

The eta’ optical potential in nuclear medium based on the eta’N interaction froma chiral effective model

S. Sakai(1), D. Jido(2)

(1) Kyoto University

(2) Tokyo Metropolitan University

Abstract

In this talk, we discuss the eta’ optical potential based on the eta’N two body interaction obtained from a chiral effective model. The eta’ mass reduction inside the nuclear medium is expected by the degeneracy of the pseudoscalar-singlet and octet mesons in the chiral restored phase in the chiral limit. The observation of the eta’-nucleus bound state is planned experimentally. Here, we estimate the eta’ optical potential using the eta’N interaction obtained from the linear sigma model. The eta’N interaction in the linear sigma model comes from the scalar meson exchange and UA(1) symmetry breaking effect, and it is found to be fairly strong attraction. This strongly attractive two body interaction leads to a deep and attractive optical potential. Moreover, the etaN transition is included in our calculation, so the eta’ optical potential have imaginary part. The imaginary part is relatively small compared to the real part in our estimation. Such a strongly attractive and the small absorptive optical potential gives narrow bound states in eta’ and nucleus systems.

W. Krzemien, 13:50 – 14:10
Search for the eta-mesic 4He with WASA-at-COSY

W. Krzemien(1), P. Moskal(1,2), M. Skurzok(1)

(1) M. Smoluchowski Institute of Physics, Jagiellonian University, 30-059 Cracow, Poland
(2) IKP, Forschungszentrum Jülich, D-52425 Jülich, Germany

Abstract

The eta-mesic nuclei in which the eta meson is bound with nucleus via strong interaction was postulated about 25 years ago, however till now there is no direct experimental confirmation of its existence. We search for an evidence of eta-mesic He with the WASA detector. An exclusive measurement of the excitation functions for the dd->3Heppi- and for the dd->3Henpi0->3Hengg reactions was performed at the Cooler Synchrotron COSY-Juelich with the WASA-at-COSY detection system. The outgoing N-pi pairs originate from the conversion of the eta meson on a nucleon inside the He nucleus. The data were collected in two dedicated experiments in 2008 and in 2010. The experimental method and the current status of the research will be presented.

H. Nagahiro, 14:10 – 14:30
Formation of eta-prime(958) mesic nuclei by (p,d) reaction

H. Nagahiro(1)

(1) Nara Women's University

Abstract

We show theoretical calculations for the formation spectra of eta'(958)-nucleus systems in the (p,d) reaction for the investigation of the in-medium modification of the eta' mass [1]. We conclude that one finds an evidence of possible attractive interaction between eta' and nucleus as peak structure. Spectroscopy of the (p,d) reaction can be performed experimentally at existing facilities, such as GSI [2].

References

[1] H.Nagahiro, et al., PRC 87 (2013) 045201.
[2] K.Itahashi, et al., PTP 128 (2012) 60.

M. Zielinski, 14:30 – 14:50
Study of the eta meson production with polarized proton beam

M. Zielinski(1), P. Moskal(1), I. Ozerianska(1)

(1) Jagiellonian University, Krakow, Poland

Abstract

The dynamics of η meson production and the interaction of η mesons with nucleons can be studied using the $\vec{p}p \to pp\eta$ reaction via measurements of the analyzing power A_y. Previous experiments measuring A_y suffer from low statistics [1,2,3] and large uncertainities, therefore further studies are desirable. To this end, we have performed a measurement of the $\vec{p}p \to pp\eta$ reaction using the large acceptance and φ symmetric WASA-at-COSY detector, for beam momenta of 2026 MeV/c and 2188 MeV/c. Protons ejectiles were registered in the forward part of the WASA detector, while the η meson decay products (e.g. $\eta \to \gamma\gamma$) were detected in the central Electromagnetic Calorimeter. The polarization for each beam momentum has been determined using pp elastic scattering. Furthermore, in order to control systematic effects caused by potential asymmetries in the detector setup, the spin of the proton beam has been flipped for every accelerator cycle.

Systematic studies have been performed calculating the degree of polarization, which is different for spin up and spin down modes. The results of these studies show that the polarization is sensitive to the x- and y-coordinate of the vertex position [4,5]. Moreover, it seems now possible to control the polarization determined from the $\vec{p}p \to pp$ reaction with a systematic error of about 1%.

In this talk we would like to present preliminary results of determination of the polarization for the $\vec{p}p \to pp$ reaction, and the status of the ongoing analysis of the $\vec{p}p \to pp\eta$ reaction.

References

[1] R. Czyzcykiewicz et al. Phys. Rev. Lett.98 (2007) 122003.
[2] F. Balestra et al. Phys. Rev. C 69 (2004) 064003.
[3] P. Winter et al. Eur. Phys. J. A 18 (2003) 355.
[4] M. Hodana, P. Moskal and I. Ozerianska, Acta Phys. Polon. B Suppl. 6 (2013) 1041.
[5] M. Hodana, P. Moskal, I. Ozerianska and M. Zielinski, Acta Phys. Polon. B 45 (2014) 697.

J. Hrtankova, 14:50 – 15:10
Interaction of antiproton with nuclei

J. Hrtankova$^{(1)}$, J. Mares$^{(1)}$

$^{(1)}$ Nuclear Physics Institute, Rez, Czech Republic

Abstract

This contribution reports on our recent, first fully self-consistent calculations of $\bar{p}$ bound states in selected nuclei, performed within the relativistic mean-field (RMF) model using optical $\bar{p}$-nucleus potential. Current interest in the $\bar{p}$-nucleus interaction is motivated by future activities at FAIR [1-3]. First, the G-parity motivated antiproton-meson coupling constants were employed and possible deviations from the G-parity values were taken into account by introducing a scaling factor [1]. Our calculations confirmed large polarization effects of the nuclear core caused by the presence of the antiproton and revealed significant effect of the $\bar{p}$ self-interaction which was not considered in previous RMF calculations.

Next, we applied a $\bar{p}$-nucleus potential consistent with $\bar{p}$-atomic data [4]. The imaginary part of the phenomenological optical potential was introduced to describe absorption of the $\bar{p}$ in the nuclear medium and all relevant decay channels were included. The reduction of the phase space for the annihilation products for deeply bound $\bar{p}$ states was taken into account while treating fully self-consistently energy and density dependencies of the corresponding suppression factors. As a result, the $\bar{p}$ absorption widths significantly decrease when the phase space suppression is considered.

References

[1] I.N. Mishustin et al., Phys. Rev. C 71 (2005) 035201.
[2] A.B. Larionov et al., Phys. Rev. C 78 (2008) 014604.
[3] T. Gaitanos, M. Kaskulov, H. Lenske, Phys. Lett. B 703 (2011) 193.
[4] E. Friedman, A. Gal, J. Mareš, Nucl. Phys. A 761 (2005) 283.

L. Venturelli, 15:10 – 15:30
First measurements of the antiproton-nucleus annihilation cross section at 130keV.

L. Venturelli(1), H. Aghai-khozani (2), D. Barna (3), M. Corradini (1), R. Hayano (3), M. Hori (2), T. Kobayashi (3), M. Leali (1), E. Lodi-Rizzini (1), V. Mascagna (1), M. Prest (4), A. Soter (2), K. Todoroki (3), E. Vallazza (5), N. Zurlo (1)

(1) Dipartimento di Ingegneria dell'Informazione, Universita' degli Studi di Brescia and INFN
(2) Max-Planck-Institut fur Quantenoptik, Hans-Kopfermann-Strasse 1, D-85748 Garching, Germany
(3) University of Tokyo, Japan
(4) Universita degli Studi dell'Insubria and INFN
(5) Instituto Nazionale di Fisica Nucleare

Abstract

The ASACUSA collaboration has a wide physics program mainly focused to test CPT invariance through the spectroscopy of antihydrogen and of antiprotonic helium. In addition, a part of the experimental program concerns the measurement the antiproton annihilation cross sections on different nuclei at very low energy which is of interest both for nuclear physics and for fundamental fosmology. As regards nuclear physics, the measurements in the sub-MeV region can contribute for example to determine the parameters of the potential models, to investige the excitation process of the nuclear matter and to search nuclear resonances. In addition the cross section data can be useful for the cosmological models which try to explain the absence of antimatter in the observable universe by assuming that antimatter is confined within particular regions. These "islands" of antimatter can overlap with matter and their evolution would strongly depend on the value of the annihilation cross sections.

Recently the first observation of in-flight antiproton-nucleus annihilation at 130 keV has been obtained with the ASACUSA detector [1] which demonstrates that the measurement of the cross section of the process is feasible at such extremely low energies. Here we present the results of the analysis of the data acquired with carbon, palladium and platinum targets and the evaluations of the cross sections for 130 keV antiprotons are reported.

References

[1] H. Aghai-Khozani et al., Eur. Phys. J. Plus 127 (2012) 125

S. Ohnishi, 15:50 – 16:10
Lambda(1405) resonance in K-d scattering reaction

S. Ohnishi(1,2), Y. Ikeda(2), T. Hyodo(3), E. Hiyama(2), W. Weise(4,5)

(1) Tokyo Inst. Tech.
(2) RIKEN
(3) YITP
(4) ECT*
(5) TU Munich

Abstract

We solve the $\bar{K}NN - \pi YN$ coupled-channels Alt-Grassberger-Sandhas equations and examine how the Λ(1405) resonance manifests itself in the $\pi\Sigma$ invariant mass distributions of $\bar{K}d- > \pi\Sigma N$ reactions. Two types of models for the two-body meson-baryon interactions are employed: an energy-independent and an energy-dependent version, both derived from the leading order chiral SU(3) Lagrangian but with different off-shell properties in the three-body $\bar{K}NN - \pi YN$ system.

R. Alkofer, 16:10 – 16:30
Electromagnetic baryon form factors in the Poincaré covariant Faddeev approach

R. Alkofer(1), G. Eichmann (2), H. Sanchis Alepuz (2), R. Williams(2)

(1) University Graz
(2) University Giessen

Abstract

Recent results for the Green's functions of Landau gauge QCD will be used to formulate a Poincaré-covariant Faddeev approach to baryons. The resulting three-body amplitudes for a given spin and parity describe the quark core of the respective baryons. In recent calculations the full three-body problem has been solved in a framework in which the interaction among quarks is reduced to a vector-vector interaction via a single dressed-gluon exchange (Rainbow-Ladder truncation). The formalism allows for the study of the baryon spectrum as well as their internal properties. In this talk I will focus on recent results for electromagnetic form factors for nucleons and spin-3/2 baryons. Their model independent features are assessed using two different models for the interaction. The results for charge radii and magnetic moments as a function of the quark current mass provide some indication what the pion cloud (missing in this calculation but present in nature) may contribute to baryonic properties.

D. Gotta, 16:30 – 16:50
Pionic hydrogen and friends

D. Gotta(1)

(1) Institut für Kernphysik, Forschungszentrum Jülich

Abstract

In the lightest exotic atoms 2̌013 muonic and pionic hydrogen and deuterium - physical and technical problems are manifold interrelated. In pionic hydrogen the ground-state level shift and broadening give access to the pion-nucleon scattering lengths, for which the pionic deuterium level shift provides a mandatory constraint. Moreover, the determination of the level broadening in deuterium is the most precise method to quantify pion threshold production in proton-proton reactions. However, collisional processes during the atomic de-excitation cascade considerably complicate analyses of the X-ray line shapes in order to extract the hadronic effects. Therefore, in addition the purely electromagnetic twin system muonic hydrogen was studied. Results of these experiments performed at PSI by using a high-resolution crystal spectrometer are discussed in the context of recent theoretical efforts within the approach of chiral perturbation theory and atomic cascade calculations.

J. Revai, 16:50 – 17:10
Three-body calculation of the 1s level shift in kaonic deuterium

J. Revai(1), P. Doleschall(1), N. Shevchenko(2)

(1) Wigner Research Centre for Physics of the H.A.S
(2) Nuclear Physics Institute of the ASCR

Abstract

For the first time a dynamically exact calculation was performed for a hadronic atom with more than two particles. The main difficulty in the description of these systems is the simultaneous correct treatment of the strong and Coulomb interactions. To solve this problem for three-body systems Z. Papp proposed a method (see e.g. [1]), based on the expansion of the 3 Faddeev components of the wave function on Coulomb-Sturmian basis. The discrete and complete set of these functions has the main advantage, that the matrix elements of the Coulomb Green's function can be calculated analytically. The method was successfully applied to nuclear few-body systems with repulsive Coulomb force and for purely atomic systems. However, the case of attractive Coulomb force combined with the strong interaction was not considered. With suitable modifications we used it to perform a dynamically exact calculation of the 1s level shift of kaonic deuterium. This first calculation was done with simple complex KbarN I=0 and I=1 interactions, reproducing the SIDDHARTA kaonic hydrogen 1s level shift (accurately) and the elastic $K^- p$ cross section (approximately). Calculations with more realistic KbarN interactions will follow. Apart from yielding a value for the 1s level shift, these calculations have the important advantage, that they provide a reliable control of the different commonly used approximations for obtaining a theoretical value of this quantity.

References

[1] Z. Papp, W. Plessas, Phys.Rev. C 54,50(1996)

6.2 Parallel session II, 13:30 - 17:30

C. Pistillo, 13:30 – 13:50
Emulsion detectors for the antihydrogen detection in AEgIS

C. Pistillo(1)

(1) University of Bern

Abstract

The AEgIS experiment at CERN aims to perform the first direct measurement of gravitational interaction between matter and antimatter by measuring the deviation of a cold antihydrogen beam in the Earth gravitational field. The design of the experiment has been recently updated to include emulsion films as position sensitive detector. The submicrometric position accuracy of emulsions leads indeed to a significant improvement of the experimental sensitivity. We present results of preliminary tests and discuss perspectives for the final measurement.

V. Yazkov, 13:50 – 14:10
First πK atom lifetime and πK scattering length measurements

V. Yazkov(1)

(1) Skobeltsyn Institute of Nuclear Physics, Lomonosov Moscow State University, Russia

Abstract

Theory, using Low Energy QCD, calculated with high precision the $\pi\pi$ and πK scattering length. Because these calculations are using the chiral symmetry that describe quarks, gluons, and the QCD vacuum property, the experimental check of these predictions is important. To check the theoretical calculations for the process including also s quarks we must measure the πK atom lifetime that is connected to the πK scattering lengths by a precise relation. The results of the search for hydrogen-like atoms consisting of $\pi^- K^+$ and $\pi^+ K-$ mesons are presented. Evidence for πK atoms production, using a 24 GeV/c protons beam from CERN PS interacting with a nickel target, is reported here. From the analysis of Coulomb final state interaction πK pairs was evaluated the number of produced πK atoms $N_A = 653 \pm 42$ together with the value of the πK pairs from atoms that breakup in the same target $N_a = 178 \pm 49$. Using these results the analysis yields to a first value for the πK atom lifetime of $t = 2.5^{+3.0}_{-1.8}$ fs and a first model-independent measurement of the S-wave isospin-odd πK scattering length $|a0 - | = 1/3|a_{1/2} - a_{3/2}| = 0.11^{+0.09}_{-0.04}$ $1/M_\pi$ (the I in a_I stands for isospin).

A. Dote, 14:10 – 14:30

Investigation of KbarNN resonances with a coupled-channel Complex ScalingMethod + Feshbach projection

A. Dote(1), T. Inoue(2), T. Myo(3)

(1) KEK Theory Center
(2) Nihon University, College of Bioresource Sciences
(3) Osaka Institute of Technology

Abstract

In strange nuclear physics and hadron physics, kaonic nuclei (nuclear system with anti-kaons (Kbar)) have been a hot topic since the formation of dense state are expected due to the strong KbarN attraction. To reveal the nature of kaonic nuclei, lots of efforts have been devoted to the study of a prototype system of kaonic nuclei, "K-pp". Especially, now is the very exciting time because new experimental results are being reported from two groups of J-PARC (E15 and E27).

We have started a study of kaonic nuclei with a coupled-channel Complex Scaling Method (ccCSM) which was proposed in our previous work [1]. This method can treat simultaneously coupled-channel problem and resonance problem which are important ingredients for the K-pp study. Recently, we have developed a handy method, so-called ccCSM+Feshbach method. The K-pp is actually a coupled-channel system of Kbar NN and pi YN. (Y=Lambda, Sigma hyperon) Such a coupled-channel problem can be well reduced to a single-channel problem of KbarNN by a tricky use of ccCSM to be realized the Feshbach projection completely.

Up to now, by a careful study with the ccCSM+Feshbach method using an energy-dependent potential based on chiral SU(3) theory [1], we have obtained results as follows: The K-pp is not so deeply bound with 30 MeV binding. The decay width depends on a parameter and ansatz for the treatment of energy dependence; 20 60 MeV. Analyzing the ccCSM wave function, we find that the mean distance of two nucleons in the K-pp is found to be 2.2 fm which is almost equal to the NN distance in normal nuclear matter.

So far, we have considered only the KbarNN with spin 0 and isospin 1/2. In the conference, we will report KbarNN resonances with other quantum numbers, such as spin 1 which may appear in the the J-PARC experiments. We hope to discuss on comparison of our result and the J-PARC experimental results. In addition, we will mention to the relativistic effect and the preliminary result of the full coupled-channel calculation, if possible.

References

[1] A. Dote, T. Inoue and T. Myo, Nucl. Phys. A912, 66 (2013).

D. Bakalov, 14:30 – 14:50

Toward the measurement of the hyperfine splitting in the ground state of muonichydrogen

D. Bakalov(1), A. Vacchi(2)

(1) Institute for Nuclear Research and Nuclear Energy, Bulgarian Academy of sciences, Sofia 1784, Bulgaria

(2) Istituto Nazionale di Fisica Nucleare, Sezione di Trieste, Via A. Valerio 2, 34127 Trieste, Italy

Abstract

We report on the recent advances in the project to measure the hyperfine splitting in the ground state of the muonic hydrogen atom and determine the proton Zemach radius with improved accuracy 2̌013 a project that is believed to face the proton size puzzle from an alternative point of view. Progress has been made in each of the fields that were initially considered as stumbling blocks. The project for the development of a tunable mid-infrared laser source with characteristics appropriate for this spectroscopy application is near to completion. The verification of the experimental method based on studying the time distribution of muon transfer events to heavier elements and the energy dependence of the transfer rate, is in progress at RIKEN- RAL facility, where the pulsed muon source has a sufficient intensity. The efficiency of the method and the expected accuracy have been re-analyzed by means of Monte Carlo simulations.

J. Wurtele, 14:50 – 15:10
Experimental Determination of a Bound on Antihydrogen Charge

J. Wurtele(1)

(1) UC Berkeley/LBNL

Alpha Collaboration (CERN, http://alpha.web.cern.ch)

Abstract

An unusual test of CPT and quantum anomaly cancellation has been performed [1] by the ALPHA Collaboration. A bound on the charge neutrality of antihydrogen has been determined [1] through a retrospective analysis of the dynamics of antihydrogen atoms as they are released from the ALPHA trap. The analysis studies the influence of electric fields on antihydrogen dynamics under different assumptions of putative charge. Extensive numerical modeling and knowledge of the position of actual antihydrogen annihilations on our silicon vertex detector yield a limit on antihydrogen charge of $Q = (-1.3 \pm 1.1 \pm .4) \times 10^{-8}$ e where e is the magnitude of the electron charge, and the errors are from statistical and systematic effects, respectively. Future experiments using a stochastic acceleration technique [2] have the potential to significantly improve the experimental precision reported here.

References

[1] C. Amole et al. (ALPHA collaboration) and A. E. Charman. An Experimental Limit on the Charge of Antihydrogen, Nature Communications, June 2014. http://dx.doi.org/10.1038/ncomms4955.
[2] M. Baquero-Ruiz, A. E. Charman, J. Fajans, A. Povilus, F. Robicheaux, J. S. Wurtele and A. I. Zhmoginov, Measuring the electric charge of antihydrogen by stochastic acceleration. http://arxiv.org/ab

B. Franke, 15:10 – 15:30
The Muonic Helium Lamb Shift Experiment

B. Franke(1), J. Krauth(1)

(1) Max-Planck-Institute of Quantum Optics

Abstract

Muonic atoms have an increased sensitivity on finite size effects of the nucleus due to the ≈200-fold mass of the muon compared to the electron. The Lamb shift experiment of the CREMA collaboration in muonic hydrogen [1] and deuterium allowed to determine the proton radius and other nuclear properties with an order of magnitude higher precision, compared to spectroscopic measurements of ordinary hydrogen. As a successor experiment, the determination of the Lamb shift in the muonic helium ions mu3He+ and mu4He+ [2] will be a contribution to solving the proton radius puzzle as well as the discrepancy in electronic isotope-shift measurements. On this poster, an overview of the achieved results of the CREMA collaboration is presented and set into the context of the discrepancies to other experimental findings. Recent results from the measurements on helium isotopes during spring/summer 2014 are included.

References

[1] R. Pohl et al. (CREMA coll.), Nature 466, 213 (2010)

[2] A. Antognini et al. (CREMA coll.), Can. J. Phys. 89, 47-57 (2011)

A. Wagner, 15:50 – 16:10

High-precision measurement of the electron mass and stringent tests of BS-QEDwith highly-charged ions

A. Wagner(1), F. Köhler(2), J. Hou (1), S. Sturm (1), G. Werth (3), W. Quint(2), K. Blaum(1)

(1) Max-Planck-Institut für Kernphysik

(2) GSI

(3) Johannes Gutenberg-Universität

Abstract

High-precision measurements of the gyromagnetic factor (g-factor) of the electron bound in highly-charged ions have provided the most stringent tests of bound-state Quantum electrodynamics (BS-QED) to date [1,2] as well as the most precise determination of the electron mass [3]. In our experiment, a single highly-charged ion is produced and stored in a triple-Penning trap system which is placed in a hermetically sealed vacuum chamber. Cryogenic temperatures enable an ultra-high vacuum and thus nearly unlimited storage times for the ion. The measurements are performed with a single ion, whose three eigenfrequencies are measured in the homogenous magnetic field of the Penning trap. By employing a self-developed phase-sensitive detection technique [4], the modified cyclotron frequency of the ion can be measured at very low energies. Simultaneously to the measurement of the eigenfrequencies, spin flips are induced by microwaves at the Larmor precession frequency. Successful spin flips are monitored with the continuous Stern-Gerlach effect. From several hundred measurements of the frequency ratio of Larmor to cyclotron frequency, a resonance curve is obtained from which the g-factor can be extracted with a fractional statistical uncertainty as low as 3-10-11.

References

[1] S. Sturm et al., Phys. Rev. Lett. 107, 023002 (2011)
[2] A. Wagner et al., Phys. Rev. Lett. 110, 033003 (2013)
[3] S. Sturm et al., Nature 506, 467 (2014)
[4] S. Sturm et al., Phys. Rev. Lett. 107, 143003 (2011)

M. Mohanty, 16:10 – 16:30
Atomic Parity Violation in single trapped Ba+ and Ra+ ions.

M. Mohanty(1), E. Dijck (1), M. Portela (1), N. Valappol (1), A.T. Grier (1), S. Hoekstra (1), K. Jungmann (1), C.j.G. Onderwater(1), R.G.E. Timmermans(1), L. Willmann (1), H.W. Wilschut (1)

(1) Van Swinderen Institute, FMNS, University of Groningen

Abstract

Atomic Parity Violation (APV) opens the path to improved determination of electroweak parameters. This can be done by measuring light shifts, which permit the mapping of weak interaction effects on the energy splitting of the magnetic substates in a single trapped Ra+ ion. A particular experimental requirement for a light shift measurement is the localization of the ion within a fraction of an optical wavelength in presence of two orthogonal light fields of known polarization.

Alkaline earth metal ions are well suited for such an experiment, because atomic structure calculations are possible to the required level of precision. The sensitivity of APV grows faster than the third power of the atomic number Z. Thus, the heaviest alkaline earth element Radium (Z=88) and the high precision of optical frequency metrology possible with single trapped ions are key ingredients for such a precision measurement.

The radium isotopes in such experiments are produced at the TRImP facility at the KVI, University of Groningen. We have measured the hyperfine structure of the 6d2D3/2 states and the isotope shift of the 6d 2D3/2 - 7p2P1/2 transition in 209-214 Ra+ isotopes. We present an improved lifetime measurements of the 5d2D5/2 state on a single trapped Ba+ ion. We will also present absolute frequency measurements of the 6s2S1/2- 6p2P1/2 and 5d2D3/2-6p2P1/2 transitions with an order of magnitude improved precision. The experiment progresses towards measuring light shifts in Ba+. This is a precursor experiment on the way to more precise determination of weak interaction parameters i.e. the Weinberg angle in a single trapped Ra+ ion.

A. Voronin, 16:30 – 16:50
Resonance spectroscopy of gravitational quantum states of antihydrogen

A. Voronin(1), V. Nesvizhevsky(2)

(1) Lebedev Physical Institute of the Russian Academy of Sciences, Moscow
(2) Institut Laue-Langevin, Grenoble

Abstract

Phenomena of quantum reflection enables existence of long-living quantum states of antihydrogen, bouncing above material surface in gravitational field of the Earth. The typical life-time of such states is of order of 0.1 s. Such states become a promising laboratory for studding gravitational properties of antimatter. We dicsuss methods of precision measuring energy level spacing based on inducing resonance transition between lowest gravitational states. Different sources of shift of resonance lines, including acStark shift are studdied. Accurate measuring of energy level spacing gives acces to the gravitational mass of antihydrogen. We demonstrate that statistical accuracy of determination of gravitational mass of antihydrogen with amounts of antiatoms available in planning experiments is of order of $10^{-}4$.

A. Ivanonv, 16:50 – 17:10
Effective gravitational potential induced by a static metric of spacetime

A. Ivanonv(1), M. Pitschmann(1)

(1) Technical University of Vienna, Vienna

Abstract

We analyse the non-relativistic approximation of the Dirac equation for slow fermions moving in spacetimes with a static metric, caused by the weak gravitational field of the Earth and a chameleon field, and derive the most general effective gravitational potential, induced by a static metric of spacetime. The derivation of the non-relativistic Hamilton operator of the Dirac equation is carried out by using a standard Foldy-Wouthuysen (SFW) transformation. We discuss the chameleon field as source of a torsion field and torsion-matter interactions.

A. Olin, 17:10 – 17:30

Observation of Hyperfine Transitions in Trapped Ground-State Antihydrogen

A. Olin(1)

(1) TRIUMF/University of Victoria

On behalf of the ALPHA collaboration http:alpha.web.cern.ch: C. Amole, M.D.Ashkezari, M. Baquero-Ruiz, W. Bertsche, P.D. Bowe, E. Butler, A. Capra, C.L.Cesar, M. Charlton, A. Deller, P.H. Donnan, S. Eriksson, J. Fajans, T. Friesen,M.C. Fujiwara, D.R. Gill, A. Gutierrez, J.S. Hangst, W.N. Hardy, M.E. Hayden,A.J. Humphries, C.A. Isaac, S. Jonsell, L. Kurchaninov, A. Little, N. Madsen,J.T.K. McKenna, S. Menary, S.C. Napoli, P. Nolan, K. Olchanski, A. Olin, P.Pusa, C.Ø. Rasmussen, F. Robicheaux, E. Sarid, C. R. Shields, D.M. Silveira, S.Stracka, C. So, R.I. Thompson, D.P. van der Werf, J.S. Wurtele.

Abstract

Cold antihydrogen promises a unique opportunity to study the properties of atomic antimatter, and via comparisons with its well-studied matter-counterpart, the possibility to test fundamental symmetries such as CPT invariance. We report the first observation of positron spin flip transitions between hyperfine levels of ground state antihydrogen () and the first experimental constraint on the zero-field hyperfine splitting of these atoms. The experiments involved atoms confined in a 0.5 Kelvin deep magnetic potential well, and provides compelling evidence that ground-state are held in the trap for long periods of time. Transitions between hyperfine levels are induced by injecting microwave radiation at appropriate frequencies. The resulting spin flip causes the to be expelled from the trap and the resulting antiproton annihilation is then observed. Remarkably, this experiment was performed with trapping rate of approximately 1 anti-atom/attempt. The observed results will be compared with expectations from simulations of trapped dynamics and independent in-situ electron cyclotron resonance measurements of magnetic and microwave field amplitudes. Prospects for experiments that will constrain the zero-field hyperfine splitting of the atom at the 10-6 level in our newly constructed apparatus will also be discussed.

7 Thursday, September 18th

G. Gabrielse, 08:30 – 09:00
The electric and magnetic dipole moment of the electron

G. Gabrielse(1)

(1) Harvard University

Abstract

M. Hori, 09:00 – 09:30
Laser spectroscopy of metastable antiprotonic and pionic helium atoms

M. Hori(1)

(1) Max-Planck Institute for Quantum Optics

Abstract

We describe recent results in laser spectroscopy of antiprotonic helium atoms carried out by the ASACUSA collaboration at CERN. We also briefly introduce an experiment which attempts to measure the resonance transitions of pionic helium atoms by laser spectroscopy for the first time.

V. Korobov, 09:30 – 10:00
Bound-state QED calculations for antiprotonic helium

V. Korobov(1)

(1) Joint Institute for Nuclear Research

Abstract

In our recent work [1] we have calculated the relativistic Bethe logarithm contribution at order ma^7 in the two Coulomb center approximation. These results then have been used for improved calculations of the transition energies for the hydrogen isotope molecular ions and antiprotonic helium atoms. The general formula for the one-loop self-energy contribution at the ma^7 order has been obtained in [2]. Including other theoretical contributions in a nonrecoil limit at order ma^7, such as one-loop vacuum polarization, the Wichman-Kroll contribution, the complete two-loop contribution, etc, and the leading term of the ma^8 order one gets transition energies for the ro-vibrational transitions of the pbar-He with the relative uncertainty of 4×10^{-11}. We show that our latest results make feasible determination of the electron-to-antiproton mass ratio mp/me using antiprotonic helium spectroscopy with a fractional precision 3.6×10^{-11}, while from the hydrogen molecular ions the electron-to-proton mass ratio may be determined with a relative uncertainty of 1.5×10^{-11}.

References

[1] V.I. Korobov, L. Hilico, and J.-Ph. Karr, Phys. Rev. A 87, 062506 (2013).

[2] V.I. Korobov, L. Hilico, and J.-Ph. Karr, Phys. Rev. Lett. 112, 103003 (2014); V.I. Korobov, L. Hilico, and J.-Ph. Karr, Phys. Rev. A 89, 032511 (2014).

B. Lauss, 10:00 – 10:30

Performance of the ultracold neutron source at PSI and the search for anelectric dipole moment of the neutron

B. Lauss(1)

On behalf of the PSI UCN Team and the nEDM collaboration

Abstract

Ultracold neutrons (UCN) can be stored in suitable vessels for hundreds of seconds and therefore serve as excellent probe for fundamental physics experiments, probing e.g. the properties of the neutron, gravity, extra forces, or other physics beyond the Standard Model scenarios. Such experiments have in common the need for high UCN intensities. At the Paul Scherrer Institute, Switzerland a new ultracold neutron source [1] was built. Based on superthermal UCN production in about 30 liters of solid deuterium at 5 K [2], UCN can be delivered to three beam ports in regular operation. Scientific proposals are now being invited. We will report on the characterization measurements, the achieved intensity improvements, and the experience gained in operating the UCN source. At the same time the experiment to search for a permanent electric dipole moment of the neutron (nEDM) [3] is being operated by an international collaboration. The present apparatus uses the setup which led to the best nEDM limit so far [4], but was afterwards substantially improved. Data-taking started in 2013. In parallel a new apparatus with two precession chambers is being developed aiming at another order of magnitude increase in sensitivity. We will report on the performance of our experiment, its status and give an outlook.

References

[1] B. Lauss, Hyperfine Interactions 211 (2012) 21-25.
[2] K. Kirch et al., Nuclear Physics News 20, 1 (2010) 17.
[3] C.A. Baker et al., Physics Procedia 17 (2011) 159-167.
[4] C.A. Baker et al., Physical Review Letters 97 (2006) 131801.

D.J. Murtagh, 11:00 – 11:30
ASACUSA Status and Outlook - Hbar

D.J. Murtagh(1), N. Kuroda(2), S. Ulmer(3), S. Van Gorp(1), Y. Nagata(1), K. Michishio(4), T. Mizutani(2), A. Mohri(1), H. Nagahama(2), M. Ohtsuka(2), S. Sakurai(5), H.A. Torii(2), H. Higaki(5), Y. Kanai(1), Y. Nagashima(4), Y. Matsuda(2), Y. Yamazaki(1)

(1) Atomic Physics Laboratory, RIKEN, Saitama 351-0198, Japan

(2) Institute of Physics, Graduate School of Arts and Sciences, University of Tokyo, Tokyo 153-8902, Japan

(3) Ulmer Initiative Research Unit, RIKEN, Saitama 351-0198, Japan

(4) Department of Physics, Tokyo University of Science, Tokyo 162-8601, Japan

(5) Graduate School of Advanced Sciences of Matter, Hiroshima University, Hiroshima 739-8530, Japan

Abstract

Antihydrogen is the simplest stable antimatter atomic system consisting of an antiproton and a positron. A source of antihydrogen amendable to precision spectroscopic investigation would provide a sensitive direct test of CPT symmetry. To achieve this, the ASACUSA-Cusp collaboration has developed an antihydrogen beam which will be used for Rabi-like in flight spectroscopy measurements. Antihydrogen is formed within an unique anti-Helmholtz configuration cusped magnetic field which allows spin dependent focusing and hence, produces a spin-polarized beam. During mixing of positrons and antiprotons, 80 antihydrogen atoms have been observed 2.7 m downstream of the production region where perturbing magnetic fields are negligible. The absolute count rate for atoms with principal quantum number less than 43 was 0.04/s (during a mixing cycle). This result is a significant step towards the physics goal of the ASACUSA-Cusp experiment, the precision spectroscopy of the ground-state hyperfine structure of antihydrogen.

References

[1] Kuroda, N. et al., A source of antihydrogen for in-flight hyperfine spectroscopy. Nature Communications 5 (2014) 3089.

Y. Litvinov, 11:30 – 12:00
Study of two-body beta decays of highly-charged ions

Y. Litvinov[1], F. Bosch[1]

[1] GSI, Darmstadt

Abstract

Periodic time modulations were found recently in the measurements of the two-body orbital electron capture (EC) decay of hydrogen-like 140Pr58+ and 142Pm60+ ions stored and cooled in the Experimental Storage Ring (ESR). The modulations in both investigated systems can be characterized by periods TP near to 7 s and amplitudes a of about 20% [1]. The observed phenomenon caused intensive discussions in the physics community on its possible explanation. Numerous suggestions were proposed. However, no consensus is presently reached and the effect remains still unexplained.

In the last years, a new Schottky detector has been developed [2], which allowed for an unambiguous determination of the EC decay-time of each individual stored and cooled parent ion, with a very high time accuracy of merely a few tens of milliseconds. The EC decay of H-like 142Pm60+ ions was re-investigated in the ESR by employing the previously used Schottky pick-up as well as this new detector [3]. The data recorded by both detectors confirmed that the exponential EC decay is modulated with a period TP =7.11(8) s (mean of both detectors), in full accordance with the modulation period TP = 7.10(25) s obtained for 142Pm60+ in the previous experiment. However, the mean modulation amplitude of both detectors of a = 12(2)%, although being statistically significant, is almost two times smaller than the one seen previously. Also the three-body β+ decays of H-like 142Pm60+ ions has been analyzed in the new experiment. No significant modulation period could be observed.

The nature of the modulated EC decays, if undoubtedly confirmed in future experiments, is still unclear and, since it might be related to physics beyond the Standard Model, it requires urgently additional experimental investigations and theoretical interpretation. In this presentation the present status of the experiment and future perspectives will be discussed in detail.

References

[1] Yu. A. Litvinov et al., Phys. Lett. B664 (2008) 162

[2] F. Nolden et al., Nucl. Instr. Meth. A6 5 9 (2011) 69

[3] P. Kienle et al., Phys. Lett. B726 (2013) 638

M. Bashkanov, 12:00 – 12:30
Dibaryons at COSY

M. Bashkanov(1)

(1) University of Tübingen

Supported by COSY-FFE (FZ Jülich).

Abstract

Despite their long painful history dibaryon searches (where dibaryon means a baryon number B = 2 state independently on the internal structure: genuine six-quark state/baryonic-molecule) have recently received new interest, in particular by the recognition that there are more complex quark configurations than just the familiar $q\bar{q}$ and qqq systems.

A resonance like structure recently observed in double-pionic fusion to deuteron, at $M = 2.38 GeV$ with $\Gamma = 70 MeV$ and $I(J^p) = 0(3^+)$ meanwhile proved to be the so-called ž01cinevitable dibaryonž01d d^*. To investigate its structure we have measured its decay branches into the $d\pi^0\pi^0$, $d\pi^+\pi^-$, $pp\pi^-\pi^0$, $pn\pi^0\pi^0$ and pn channels by pd and dp collisions in the quasi-free reaction mode, utilizing the WASA detector setup at COSY.

The pn decay channel was measured by use of polarized deuterons in inverse kinematics. These new np analyzing power data exhibit a pronounced resonance effect in their energy dependence. The SAID partial-wave analysis with inclusion of these data reveals a pole in the complex plane of the $^3D_3$ partial wave at $(2380 \pm 10) MeV - i(40 \pm 5) MeV$ in accordance with the d^* resonance hypothesis.

Further investigations on the internal structure of the d^* dibaryon, the SU(3) multiplet companions as well as the mirror partners are expected to be done in near future.

A. Gal, 12:30 – 13:00
$N\Delta$ and $\Delta\Delta$ dibaryons revisited

A. Gal(1)

(1) Hebrew University

Abstract

Three-body hadronic models with separable pairwise interactions are formulated and solved to calculate resonance masses and widths of $L = 0$ $N\Delta$ and $\Delta\Delta$ dibaryons using relativistic kinematics. For $N\Delta$, $I(J^P) = 1(2^+)$ and $2(1^+)$ resonances slightly below threshold are found by solving πNN Faddeev equations. For $\Delta\Delta$, several resonances below threshold are found by solving $\pi N\Delta$ Faddeev equations in which the $N\Delta$ interaction is dominated by the $1(2^+)$ and $2(1^+)$ resonating channels. The lowest $\Delta\Delta$ dibaryon resonances found are for $I(J^P) = 0(3^+)$ and $3(0^+)$, the former agreeing well both in mass and in width with the relatively narrow $\mathcal{D}_{03}(2370)$ resonance observed recently by the WASA@COSY Collaboration. Its spin-isospin symmetric partner $\mathcal{D}_{30}$ is predicted with mass around 2.4 GeV and width about 80 MeV.

K. Itahashi, 14:00 – 14:30
Precision measurement of deeply bound pionic Sn atoms in RIBF

K. Itahashi(1)

(1) RIKEN

Abstract

We report results from our recent precision measurement of pionic Sn atoms in RIBF. The presentation will include results from our pilot run in 2010 and our first production series of measurement in June 2014. We are presently preparing for a simultaneous measurement of 1s and 2s pionic states in 121Sn atom. The measurement is aiming at first measurement of 2s pionic state in Sn atom and will benefit in improving the systematic errors arising in the absolute energy scales. The results will improve the precision of the deduced quantities of chiral condensate at the normal nuclear density.

D. Jido, 14:30 – 15:00
eta’-nucleon interaction in chiral dynamics and eta’-nucleus bound systems

D. Jido(1)

(1) Tokyo Metropolitan University

Abstract

P. Moskal, 15:00 – 15:30
Experimental overview on the eta and eta' meson production

P. Moskal(1)

(1) Jagiellonian University

Abstract

During last decade large samples of data have been collected on the production of the ground-state mesons in collisions of proton or deuteron beam with hydrogen or deuterium target. These measurements have been performed in the vicinity of the kinematical threshold where only a few partial waves in both initial and final state are expected to contribute to the production process. This simplifies significantly the interpretation of the data, yet still appears to be challenging due to the few particle final state systems with a complex hadronic potential. We will review experiments and phenomenology of the near threshold production of the eta and eta-prime mesons in the proton-proton and proton-deuteron collisions.

V. Metag, 16:00 – 16:30
Determining the meson-nucleus potential - on the way to mesic states

V. Metag(1)

(1) II. Physikalisches Institut, Univ. Giessen

Abstract

Experimental approaches to determine the real and imaginary part of the meson-nucleus potential will be described. The experiments have been performed with the Crystal Barrel/TAPS detector at the electron accelerator ELSA (Bonn) and the Crystal Ball/TAPS detector at MAMI (Mainz). Measuring the transparency ratio as well as the excitation function and momentum distribution for photo production of ω- and η'- mesons, we find that for the η'-meson the imaginary part of the potential is smaller than the real part. In case of the ω-meson we observe the opposite. This makes the etaprime meson a good candidate for the search for meson-nucleus bound states while no resolved ω-mesic states can be expected. The results are discussed and compared to theoretical predictions. An outlook on future experiments is given.

H. Fujioka, 16:30 – 17:00
Spectroscopy of η' nuclear bound states at GSI and FAIR — verypreliminary results and future prospects

H. Fujioka[1]

[1] Kyoto University

Abstract

We have been working on a spectroscopy experiment searching for η'-nucleus bound states at GSI. The binding of an η' meson may arise from an attractive etaprime-nucleus interaction which leads to a mass reduction at finite density, as a result of partial restoration of chiral symmetry in association with the $U_A(1)$ anomaly.

The first experiment, GSI S-437, will take place in July and August, 2014. We will make use of the $^{12}C(p,d)$ reaction; the ejectile deuterons will be momentum-analyzed by the fragment separator (FRS). Furthermore, we will upgrade the experimental setup at Super-FRS in the FAIR era, so as to improve the sensitivity.

In this contribution, very preliminary results of the analysis of brand-new data will be reported. In addition, we will discuss future plans towards FAIR experiments.

M. Diermaier, 17:00 – 17:30
Hyperfine spectroscopy setup for antihydrogen and first results with a hydrogen beam

M. Diermaier(1), P. Caradonna(1), C. Klaushofer(1), C. Malbrunot (2), M. Oswald (1), C. Sauerzopf (1), M. Simon (1), M. Wolf (3), J. Zmeskal (1), E. Widmann(1)

(1) Stefan Meyer Institute, Austrian Academy of Sciences, Vienna, Austria
(2) CERN
(3) Stockholms Universitet

Abstract

The ASACUSA collaboration aims to measure the ground state hyperfine splitting of the antihydrogen atom, since this is a system where the CPT symmetry can be investigated with extremely high sensitivity. The principal idea is described in [1,2]. During the CERN LS1 shut down, antiprotons were not available. Therefore, a source of cold, polarized, and modulated atomic hydrogen has been constructed to enable comprehensive testing of the Rabi-like experimental setup consisting of a microwave spin flip cavity and superconducting sextupole magnet [3].
After shortly discussing the main components of the atomic hydrogen source and detector as well as the spectroscopy beamline I will present the latest experimental data, which allowed for a characterization of the focusing effect of the superconducting sextupole magnet and the resonance line shape of the spin flip cavity. Furthermore, a confirmation of the proposed measurement principle for the hyperfine splitting of antihydrogen was achieved by the determination of the ground state hyperfine splitting of atomic hydrogen with a precision on the 10 ppb level.

References

[1] E. Widmann et al., Hyperfine Interactions, 215, 1-8 (2013)
[2] N. Kuroda et al., Nature Communications, 2089, 5 (2014)
[3] C. Malbrunot et al., Hyperfine Interactions, (2014) DOI: 10.1007/s10751-014-1013-z

C. Storry, 17:30 – 18:00
A new simple atom for atomic physics: e+ bound to H- in atomic state, H-+ -

C. Storry(1)

(1) York University, Toronto, Canada

Abstract

8 Friday, September 19th

M. Iwasaki, 09:00 – 09:30
J-PARC experiments on kaon-nucleon/nucleusinteraction - overview

M. Iwasaki(1)

(1) RIKEN

Abstract

J. Mares, 09:30 – 10:00
K^- and η nuclei

J. Mares(1), A. Cieply(1), D. Gazda(1), E. Friedman(2), A. Gal(3)

(1) Nuclear Physics Institute, 250 68 Rez, Czech Republic
(2) Racah Institute of Physics, the Hebrew University
(3) Hebrew University, Jerusalem, Israel

Abstract

This contribution reports on our recent calculations of K^- and η quasi-bound states in nuclear systems using subthreshold energy dependent $\bar{K}N$ and ηN amplitudes [1-4].
Many-body K^- nuclear systems were calculated within a chirally motivated meson-baryon coupled-channel model due to Cieply and Smejkal [5]. Self-consistent evaluations yield K^- potential depths -ReV_K of order 100 MeV. Dynamical polarization effects and two-nucleon absorption modes are discussed. The widths of all K^- nuclear quasi-bound states are comparable or even larger than the corresponding binding energies, exceeding considerably the energy level spacing [2].
The strong energy dependence of the s-wave ηN scattering amplitude was included self consistently in η nuclear bound state calculations within several underlying ηN models. Binding energies and widths of η nuclear states were calculated for nuclei across the periodic table [3,4], including ^{2}5Mg for which some evidence was proposed in a COSY experiment [6].

References
[1] A. Cieply, E. Friedman, A. Gal, D. Gazda, J. Mares, Phys. Lett. B 702 (2011) 402; Phys. Rev. C 84 (2011) 045206.
[2] D. Gazda, J. Mares, Nucl. Phys. A 881 (2012) 159.
[3] E. Friedman, A. Gal, J. Mares, Phys. Lett. B 725 (2013) 334.
[4] A. Cieply, E. Freidman, A. Gal, J. Mares, Nucl. Phys. A 925 (2014) 126.
[5] A. Cieply, J. Smejkal, Nucl. Phys. A 881 (2012) 115.
[6] A. Budzanowski et al (COSY-GEM Collab.), Phys. Rev. C 79 (2009) 012201(R).

K. Piscicchia, 10:00 – 10:30
Investigation of the low-energy kaons hadronic interactions in light nuclei byAMADEUS

K. Piscicchia(1)

(1) LNF INFN CENTRO FERMI

Abstract

The AMADEUS experiment deals with the investigation of the low-energy kaon-nuclei hadronic interaction at the DAΦNE collider at LNF-INFN, which is fundamental to solve longstanding questions in the non-perturbative strangeness QCD sector. AMADEUS step 0 consisted in the analysis of 2004/2005 KLOE data, exploiting K^- absorptions in H, ^4He, ^9Be and ^{12}C, leading to the first invariant mass spectroscopy study with low momentum in-flight negative kaons. With AMADEUS step 1 a dedicated pure Carbon target was implemented in the central region of the KLOE detector, providing a high statistic sample of pure at-rest K^- nuclear interaction.

We will show the results obtained in the analysis of the $\Sigma^+\pi^-$ and $\Sigma^0\pi^0$ (pure isospin 0) channels, intended to shed light on the controversial nature of the $\Lambda(1405)$ state. The analysis of the $\Lambda\pi^-$ channel, from which the measurement of the module of the isospin 1, S-wave non resonant transition amplitude ca be extracted for the first time, will be presented. The search for kaonic nuclear clusters, and the investigation of single versus multi nucleon absorption in correlated Λp Λd and Λt pairs production will be shown.

S. Bass, 11:00 – 11:30
QCD symmetries in eta and etaprime mesic nuclei

S. Bass(1)

(1) Stefan Meyer Institute, Austrian Academy of Sciences, Vienna

Abstract

We discuss the role of QCD symmetries and confinement in understanding eta and etaprime mesic nuclei. Eta and etaprime bound states in nuclei are sensitive to the flavour-singlet component in the meson. The bigger the singlet component, the more attraction and the greater the binding. Recent results on the etaprime mass in nuclei from the CBELSA/TAPS collaboration are very similar to the prediction of the Quark Meson Coupling model. In the model eta-etaprime mixing induces a factor of two enhancement of the eta-nucleon scattering length relative to the prediction with a pure octet eta, with real part about 0.8 fm.

V. Baru, 11:30 – 12:00
Low-energy QCD, kaonic deuterium

V. Baru(1)

(1) Bochum

Abstract

An analysis of hadronic atoms data is known to be the best tool to extract information about hadronic scattering lengths [1,2]. In particular, the recent combined analysis of piH and piD data carried out within ChPT [2] resulted in a high accuracy extraction of the S-wave piN scattering lengths.

While the situation in kaonic systems is in general more complicated due to the presence of inelastic channels a combined analysis of KN and KD data has a big potential to pin down the KN scattering lengths. In this talk we discuss the status of the theory for KD scattering within low-energy EFT. A special emphasis is put on the role of recoil effects which appear as one of the main sources of the theory uncertainty in the calculation.

References

[1] J. Gasser, V. Lyubovitskij and A. Rusetsky, Phys. Rep. 456, 167 (2008)

[2] V. Baru, C.Hanhart, M.Hoferichter, B.Kubis, A.Nogga and D. Phillips, PLB 694, 473 (2011); NPA 872, 69 (2011)

L. Nemenov, 12:00 – 12:30
Search for Long-Lived States of pi+pi- atom

L. Nemenov(1)

(1) JINR Dubna

Abstract

The observation of long-lived (metastable) states of pi+pi- atoms (A2pi) opens the possibility to measure the energy difference between ns and np states and to determine the value of the combination 2a0 +a2 of S-wave pipi scattering lengths with isotope spins 0,2 in a model-independent way. This result, together with the A2pi lifetime measurement that provides the value |a0 -a2|, allows to get a0 and a2 separately using only pi+pi- atoms data.

In this experiment the proton beam with momentum 24 GeV/c interacts with a Be target with thickness 100mm and generates A2pi in short-lived ns states. Passing through the target a fraction of A2pi interacts with Be-atoms and get exited into long-lived 2p, 3p, 4p... states. From the Be target more than 6% of A2pi come out to the vacuum in the long-lived states. For the short lived A2pi, with Lorenz factor 20, the decay lengths of 2S, 3S and 4S are in the interval between 0.017 and 1.1mm, while the metastable atoms in the states 2P, 3P and 4P have the decay lengths between 5.7cm and 44cm.

After the Be target at a distance of 100mm, it was installed a Pt foil in which only long-lived atoms break up, generating pi+pi- pairs with small relative momentum Q in their c.m.s. In order to suppress the background from the pi+pi- generated in the Be target, a magnet with BL=0.023 Tm was installed between Pt foil and the target. At the exit of this magnet the pairs produced on the Be target have their Qy component increased of 12.7 MeV/c, while the pairs generated on Pt foil, have their Qy component increased only of 2.3MeV/c by the fringing magnetic field. In this report we present the results of the analysis which select pi+pi- pairs with small transverse component QT<1.5 MeV/c. The distribution in the longitudinal component QL of these pairs shows a peak around QL=0 MeV/c. The statistical significance of this peak is 5s and it could be explained by the long-lived pi+pi- atoms breaking in the Pt foil.

S. Wycech, 12:30 – 13:00
Baryonium, a common ground for atomic and high energy physics

S. Wycech[1]

[1] National Centre for Nuclear Studies

Abstract

Baryonium understood here as a nucleon-antinucleon quasi-bound state was searched for at CERN in the days of LEAR. Nothing has been found, but broad states or states close to the threshold were not excluded. A convincing detection requires selective experiments. Such experiments offering more than scattering or crude absorption have been performed in recent years. These are of two kinds

(a) decays J/Ψ -> proton, antiproton, meson (or photon) J/Ψ -> several π mesons [1]

(b) level widths in the lightest antiprotonic atoms 'cold capture' in some heavy antiprotonic atoms [2]

The selectivity in reactions (a) is due to definite initial state and CP invariance, the selectivity in reactions (b) may be obtained with fine structure resolution, so far available only in the H atom. Both decays (a) indicate existence of a broad S-wave, I= 0 structure which may be interpreted, at least on the basis of Paris N-N-bar potential, as a 50 MeV broad bound state denoted X(1835) by BES. Atomic X-ray experiments give some support for the effect of such state and indicate another 5 MeV wide P-wave quasi-bound state. Both these states find support in the Paris potential.
This talk will review the data and concentrate on a model for decays (a), its applicability to the search of baryonium in few-N systems and formation of J/Ψ in nuclei. There is a similarity in the search of baryonium with antiprotonic atoms and studies of $\Lambda(1405)$ in K mesic atoms. I will try to discuss relations and possibilities.

References

[1] J.Z.Bai for BES Collaboration. Phys.Rev.Lett. 91(2003) 02200, M. Ablikim for BES Collaboration, Phys.Rev.Lett. 95 (2005) 262001, J-P. Dedonder et al., Phys.Rev. C 80 (2009)0145207.
[2] A. Trzcinska et al, Nucl. Phys. A 692.

9 List of participants

in alphabetic order

G. Adkins	Franklin & Marshall College	gadkins@fandm.edu
H. Aghai-Khozani	Max-Planck-Institut fur Quantenoptik, Garching	h.aghai@cern.ch
R. Alkofer	University Graz	reinhard.alkofer@uni-graz.at
C. Amsler	Albert Einstein Center, University Bern	claude.amsler@cern.ch
D. Aznabayev	Al-Farabi Kazakh national university, faculty of physics and technics	buski_dn@mail.ru
D. Bakalov	Institute for Nuclear Research and Nuclear Energy, Bulgarian Academy of Sciences	dbakalov@inrne.bas.bg
V. Baru	Ruhr University Bochum	vbaruru@gmail.com
M. Bashkanov	University Tübingen	mikhail.bashkanov@uni-tuebingen.de
S. Bass	Stefan Meyer Institute, Vienna	steven.bass@cern.ch
A. Bekbayev	Al-Farabi Kazakh national university, faculty of physics and technics	bekbaev-askhat@mail.ru
M. Berger	Stefan Meyer Institute, Vienna	manfred.berger@oeaw.ac.at
C. Berucci	Stefan Meyer Institute, Vienna	carolina.berucci@oeaw.ac.at
S. Brodsky	SLAC National Accelerator Laboratory, Stanford University	sjbth@slac.stanford.edu
P. Bühler	Stefan Meyer Institute, Vienna	paul.buehler@oeaw.ac.at
M. Cargnelli	Stefan Meyer Institute, Vienna	michael.cargnelli@oeaw.ac.at
C. Carli	CERN	christian.carli@cern.ch
D. Cassidy	University College London	d.cassidy@ucl.ac.uk
P. Crivelli	Institute for Particle Physics, ETH Zürich	paolo.crivelli@cern.ch
C. Curceanu	INFN-LNF Frascati	catalina.curceanu@lnf.infn.it
M. Diepold	Max Planck Institut für Quantenoptik	marc.diepold@mpq.mpg.de
M. Diermaier	Stefan Meyer Institute, Vienna	martin.diermaier@oeaw.ac.at
A. Dote	KEK Theory Center	dote@post.kek.jp
L. Fabbietti	Technische Universität München	laura.fabbietti@ph.tum.de
A. Filippi	INFN Torino	filippi@to.infn.it
D. Fitzakerley	York University, Toronto, Canada	danfitz@yorku.ca
V. Flambaum	University of New South Wales	v.flambaum@unsw.edu.au
B. Franke	Max-Planck-Institute of Quantum Optics	beatrice.franke@mpq.mpg.de
E. Friedman	Racah Institute of Physics, the Hebrew University	elifried@cc.huji.ac.il
S. Friedreich	Institute for Particle Physics, ETH Zürich	susanne.friedreich@gmx.at
H. Fujioka	Kyoto University	fujioka@scphys.kyoto-u.ac.jp
G. Gabrielse	Harvard University	gabrielse@physics.harvard.edu
A. Gal	Hebrew University	avragal@savion.huji.ac.il

D. Gotta	Forschungszentrum Jülich	d.gotta@fz-juelich.de
C. Guaraldo	INFN-LNF Frascati	guaraldo@lnf.infn.it
S. Guellati-Khélifa	Laboratoire Kastler Brossel	saida.guellati@lkb.upmc.fr
R. Hayano	University Tokyo	hayano@phys.s.u-tokyo.ac.jp
F. Herfurth	GSI Helmholtzzentrum für Schwerionenforschung GmbH	f.herfurth@gsi.de
M. Hori	Max-Planck Institute for Quantum Optics	masaki.hori@mpq.mpg.de
J. Hrtankova	Nuclear Physics Institute	hrtankova@ujf.cas.cz
Y. Ichikawa	Kyoto University	yudai@scphys.kyoto-u.ac.jp
Y. Ikeda	RIKEN	yikeda@riken.jp
K. Itahashi	RIKEN	itahashi@riken.jp
A. Ivanov	Atominstitut, Technische Universitä Wien	ivanov@kph.tuwien.ac.at
M. Iwasaki	RIKEN	masa@riken.jp
D. Jido	Tokyo Metropolitan University	jido@tmu.ac.jp
G. Körner	NuPECC	sissy.koerner@tum.de
V. Korobov	Joint Institute for Nuclear Research	korobov@theor.jinr.ru
J. Krauth	Max-Planck-Institut für Quantenoptik	julian.krauth@mpq.mpg.de
P. Krizan	University of Ljubljana	peter.krizan@ijs.si
W. Krzemien	Jagiellonian University	wojciech.krzemien@if.uj.edu.pl
B. Lauss	Paul Scherrer Institute	bernhard.lauss@psi.ch
Y. Leifels	GSI Helmholtzzentrum für Schwerionenforschung GmbH	y.leifels@gsi.de
Y. Litvinov	GSI Helmholtzzentrum für Schwerionenforschung GmbH	y.litvinov@gsi.de
M. Lutz	GSI Helmholtzzentrum für Schwerionenforschung GmbH	m.lutz@gsi.de
J. Mares	Nuclear Physics Institute	mares@ujf.cas.cz
J. Marton	Stefan Meyer Institute, Vienna	johann.marton@oeaw.ac.at
J. Messchendorp	KVI-CART, University of Groningen	j.g.messchendorp@rug.nl
V. Metag	II. Physikalisches Institut, Universität Giessen	volker.metag@exp2.physik.uni-giessen.de
A. Miyazaki	CERN	akira.miyazaki@cern.ch
A. Mohanty	KVI-CART, University of Groningen	mohanty.amita18@gmail.com
P. Moskal	Jagiellonian University	p.moskal@uj.edu.pl
D. Murtagh	RIKEN	daniel.james.murtagh@cern.ch
R. Münzer	Technische Universität München	rmuenzer@ph.tum.de
H. Nagahiro	Nara Women's University	nagahiro@cc.nara-wu.ac.jp
L. Nemenov	Joint Institute for Nuclear Research, CERN	leonid.nemenov@cern.ch
H. Neufeld	University of Vienna	helmut.neufeld@univie.ac.at
D. Nicmorus	FAIR	diana.nicmorus@fair-center.eu
J. Nieves	IFIC, CSIC - University Valencia	jmnieves@ific.uv.es

H. Ohnishi	RIKEN/RCNP, Osaka University	h-ohnishi@riken.jp
S. Ohnishi	Tokyo Institute of Technology	s_ohnishi@riken.jp
S. Okada	RIKEN	sokada@riken.jp
M. Oka	Tokyo Institute of Technology	oka@th.phys.titech.ac.jp
A. Olin	TRIUMF, University of Victoria	olin@triumf.ca
P. Perez	CEA-Saclay	patrice.perez@cea.fr
A. Pichler	Stefan Meyer Institute, Vienna	florian.pipper@oeaw.ac.at
F. Pipper	Stefan Meyer Institute, Vienna	andreas.pichler@oeaw.ac.at
K. Piscicchia	INFN-LNF Rome, Centro Fermi	kristian.piscicchia@lnf.infn.it
C. Pistillo	University of Bern	ciro.pistillo@cern.ch
J. Revai	Wigner Research Centre for Physics, Hungarian Academy of Sciences	revai.janos@wigner.mta.hu
S. Sakai	Kyoto University	s.sakai@ruby.scphys.kyoto-u.ac.jp
C. Sauerzopf	Stefan Meyer Institute, Vienna	clemens.sauerzopf@oeaw.ac.at
S. Sawada	KEK	shinya.sawada@kek.jp
N. Shevchenko	Nuclear Physics Institute	shevchenko@ujf.cas.cz
K. Shimomura	KEK	ksimomu@post.kek.jp
K. Suzuki	Stefan Meyer Institute, Vienna	ken.suzuki@oeaw.ac.at
C. Storry	York University, Toronto, Canada	codys@yorku.ca
K. Tanaka	University of Tokyo	tanaka@kaduo.jp
Y. Tanaka	University of Tokyo	tanaka@nucl.phys.s.u-tokyo.ac.jp
J. Tasson	St. Olaf College	tasson1@stolaf.edu
G. Testera	INFN, Genova	testera@ge.infn.it
K. Tokesi	Institute for Nuclear Research, Hungarian Academy of Sciences	tokesi@atomki.mta.hu
M. Ukai	Department of Physics, Tohoku University	m-ukai@lambda.phys.tohoku.ac.jp
S. Ulmer	RIKEN, Advanced Science Institute	stefan.ulmer@cern.ch
D. Van der Werf	Physics Department, School of Science, Swansea University	d.p.van.der.werf@swansea.ac.uk
L. Venturelli	Universita' di Brescia and INFN	venturelli@bs.infn.it
A. Voronin	P.N. Lebedev Physical Institute	dr.a.voronin@gmail.com
A. Wagner	Max-Planck-Institut für Kernphysik	ankewag@uni-mainz.de
W. Weise	ECT*, Technische Universität München	weise@tum.de
E. Widmann	Stefan Meyer Institute, Vienna	eberhard.widmann@oeaw.ac.at
U. Wiedner	Ruhr University Bochum	wiedner@ep1.rub.de
J. Wurtele	University of California, Berkeley	wurtele@berkeley.edu
S. Wycech	National Centre for Nuclear Studies	wycech@fuw.edu.pl
V. Yazkov	Skobeltsyn Institute of Nuclear Physics, Lomonosov Moscow State University	valeri.yazkov@cern.ch
M. Zielinski	Jagiellonian University	m.zielinski@uj.edu.pl
J. Zmeskal	Stefan Meyer Institute, Vienna	johann.zmeskal@oeaw.ac.at