

ISOLDE Workshop and Users meeting 2009

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Book of Abstracts

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Session1 / 0**Transfer reactions with T-REX****Author:** Kathrin Wimmer¹**Co-authors:** Reiner Kruecken¹; Roman Gernhaeuser¹; The IS454, IS470 and T-REX collaborations²; Thorsten Kroell³; Vinzenz Bildstein¹¹ *Physik Department E12, Technische Universitaet Muenchen*² *CERN*³ *Institut fuer Kernphysik, Technische Universitaet Darmstadt*

The “Island of inversion” is a region in the nuclear chart around the neutron rich N=20 isotopes of Ne, Na and Mg, where intruder fp-orbitals favoring deformed shapes compete with the normal spherical sd configurations.

Transfer reactions yield important spectroscopic information, i.e. spin and parity assignments as well as spectroscopic factors, complementary to the information obtained in Coulomb excitation. Since the transferred nucleon can occupy excited states, the properties of these states can be studied as well. In order to study transfer reactions in inverse kinematics at REX-ISOLDE with MINIBALL a new setup T-REX was built covering a large solid angle for the detection of light charged particles. In the first experiment the nucleus ³¹Mg which is right on the edge of the “Island of inversion” was studied via the d(³⁰Mg, ³¹Mg)p reaction.

An alternative view on the change in structure when crossing the border of the island can be obtained from the study of excited 0+ states. The nearly spherical ground state of ³⁰Mg has as analogue an excited spherical 0+ state in ³²Mg whose ground state is deformed. The coexisting excited 0+ state in ³²Mg has not been observed so far. Theoretical predictions for the excitation energy of this state range from 1.5 to 3 MeV. We populated states in ³²Mg by a (t,p) two-neutron transfer reaction in inverse kinematics with a ³⁰Mg beam at 1.83 MeV/u from REX-ISOLDE impinging on a tritium-loaded Ti target which has been used at REX-ISOLDE for the first time.

Results from these experiments as well as future plans for transfer reactions at REX-ISOLDE will be presented.

This work is supported by BMBF 06MT238 and 06MT9156, EURONS (contract No. RII3-CT-2004-506065) and the DFG Cluster of Excellence “Origin and Structure of the Universe” (www.universe-cluster.de).

Session 10: Solid State Physics II and Nuclear Structure III / 1**Recent highlights from JYFL****Author:** Rauno Julin¹¹ *Department of Physics, University of Jyväskylä***Corresponding Author:** rauno.julin@jyu.fi

Light- and heavy ion beams from the K=130 cyclotron are used to produce nuclei far from stability at the Accelerator Laboratory of the Department of Physics of the University of Jyväskylä (JYFL), Finland. Novel instruments at the target and focal-plane areas of a gas-filled recoil separator for in-beam tagging measurements are available for probing structures of very neutron deficient and very heavy nuclei. Bunched and cooled radioactive beams from the IGISOL system are available for studies of nuclear ground-state properties by employing Penning traps and laser systems.

Recent results from measurements at these two facilities are presented. Future plans will also be introduced.

Session 3 / 2

The possibility for a rare beam trapping facility in IsraelAuthor: Michael Hass¹¹ Weizmann Institute of Science

Corresponding Author: michael.hass@weizmann.ac.il

The standard model of particle physics has proved to provide a good description of almost all known particle physics processes. Despite its successes, however, the standard model is known to be incomplete, e.g. in that the standard model parameters are arbitrary and derived from experiment rather than a priori.

Experiments to test for physics beyond the standard model are being developed to probe the ultra-high energy regime, which probes directly the new physics processes. A second class of experiments searches for the effects of new physics at lower energies by performing precise measurement of observables which are calculable from the standard model and attributing any variation to new physics. Recent years have seen a plethora of such experimental proposals which make use of existing accelerator facilities (e.g., the JLab Qweak and PREx proposals) as well as experiments which borrow techniques from Atomic, Molecular, and Optical (AMO) physics. Among the latter we may note Atomic Parity Violation (APV) experiments, neutrinoless double beta-decay searched, as well as measurements of correlation coefficients in the decay of radioactive atoms.

In this talk I will discuss the plans of performing such high precision searches at the WI, using a high-flux d+t neutron generator to produce ⁶He and ⁸Li by (alpha, n) reactions. This in turn will lead to experiments at the upcoming 40 MeV, 2 mA, proton and deuteron SARAF accelerator in Israel. The SARAF accelerator will provide record yields of light radioactive beams (such as ⁸Li and ⁶He), of O(10¹²) atoms/sec. The talk will address the present R&D efforts toward this goal and discuss possible collaborations with ongoing RNB trapping programs. Of particular emphasis is the use for such measurements of an electrostatic trap, that offers numerous advantages over other possibilities.

Session 6: Nuclear Structure II / 3

Beyond mean-field approach to shape coexistence phenomena in the A= 60-90 regionAuthor: Alexandrina Petrovici¹¹ National Institute of Physics and Nuclear Engineering (IFIN-HH)-

The investigation of shape coexistence phenomena dominating the structure of A= 60 - 90 nuclei requires the framework of beyond mean-field approaches. We use the {it complex} Excited Vampir variational approach to describe self-consistently the properties of proton-rich nuclei in this mass region. We study dynamical aspects of exotic nuclear structure using realistic effective interactions and rather large model spaces.

Large scale beyond mean-field calculations accounting the properties of experimentally accessible nuclei allow to predict characteristics that are beyond the experimental reach. Recent interesting results include the anomalous behaviour of Coulomb energy differences (CED) for the mass A=70 compared with CED evolution for A \simeq 80 nuclei, predictions concerning shape isomers and the influence of their Gamow-Teller β decay on the half-life of the waiting point nuclei in the X-ray bursts environment,

and the importance of the model space within a self-consistent large scale calculation of the Gamow-Teller strengths.

Summary:

We present a self-consistent variational treatment of coexistence phenomena dominating the structure and dynamics of proton rich nuclei in the $A=60-90$ mass region within the {it complex} Excited Vampir approach.

Shape coexistence and mixing, isospin mixing, competition between neutron-proton and like-nucleon pairing correlations are responsible for exotic phenomena in medium mass nuclei near the $N=Z$ line. The self-consistent treatment of exotic structure and decay dominated by their interplay is still an open problem.

Results include: Coulomb energy differences for pairs of analog nuclei with $A=70, 82, 86$ up to medium spins, predictions on the influence of possible shape isomers in ^{68}Se on the half-life in the X-ray bursts environment, discussion on the 'quenching' issue within a beyond mean-field approach.

Session 8: Spectroscopy / 4

Progress and future outlook for the CRIS project at ISOLDE

Author: Kieran Flanagan¹

Co-authors: Bradley Cheal¹; Dave Forest²; Garry Tungate²; Gerda Neyens³; Jonathan Billowes¹; Klaus Wendt⁴; Mark Bissell³; Masaki Hori⁵; Paul Campbell¹; Pieter Vingerhoets³; Ryugo Hayano⁶; Takumi Kobayashi⁶; Thomas Procter¹; Wannes Vanderheijden³

¹ *The University of Manchester*

² *The University of Birmingham*

³ *K.U. Leuven*

⁴ *The University of Mainz*

⁵ *Max-Planck-Institut für Quantenoptik*

⁶ *The University of Tokyo*

Corresponding Author: kieran.flanagan@cern.ch

The new Collinear Resonant Ionization Spectroscopy (CRIS) experiment aims to study the rarest isotopes produced at ISOLDE by using a combination of two techniques: resonant ionization spectroscopy (RIS) and collinear laser spectroscopy. The initial proposal will study the rare Francium isotopes. On the neutron-deficient side the role of the deformed $(\pi s_{1/2-1})_{1/2+}$ intruder state will be investigated, while on the neutron-rich side we will study the ground state properties of the short lived isotopes that lie on the boundary of the region of reflection symmetry breaking. This project also offers the possibility of producing ultra-clean isomeric beams, which can be studied independently of the ground state or other isobars. The installation of the new CRIS experimental line and laser laboratories has been ongoing throughout 2009. The initial construction and vacuum testing stages have been successfully completed. A novel laser setup is being developed, which aims to provide a compact and versatile method of performing laser spectroscopy. This talk will discuss the initial physics case and the current progress of the CRIS experiment as we prepare for the first on-line run in 2010.

Session1 / 6

Breakup study of neutron-drip line nuclei at RIBF

Author: Takashi Nakamura¹

¹ *Tokyo Institute of Technology*

Corresponding Author: nakamura@phys.titech.ac.jp

Recent experimental results on Coulomb and nuclear breakup for neutron drip-line nuclei at the newly commissioned RIBF at RIKEN are presented. Coulomb breakup reaction is a useful tool to probe halo structure since the cross section is enhanced due to the large E1 transitions at low excitation energies (soft E1 excitation) for halo nuclei. We have measured inclusive Coulomb breakup cross sections for the one-neutron halo candidate ^{31}Ne and two-neutron halo candidate ^{22}C at about 230-240 MeV/nucleon. These secondary beams were obtained using an intense ^{48}Ca beam at 345 MeV/nucleon at RIBF. In this experiment, we indeed observed the large Coulomb breakup cross sections over 0.5b for both nuclei, which can only be explained by the existence of halo structure in these nuclei. For ^{31}Ne we discuss the structure in terms of properties in the island of inversion as well. In this talk, we also report on the on-going project of SAMURAI/NEBULA, where kinematically complete measurements of breakup reactions for halo/skin nuclei are planned in the near future.

Session 10: Solid State Physics II and Nuclear Structure III / 7

In-source Laser Photoionization Spectroscopy of $^{191}\text{-}^{218}\text{Po}$ Isotopes at ISOLDE

Author: Maxim Seliverstov¹

¹ *K.U. Leuven, Instituut voor Kern-en Stralingsfysica*

Corresponding Author: maxim.seliverstov@cern.ch

Shape coexistence at low excitation energy in nuclei is a phenomenon for which interest has been continuously growing on both the experimental and theoretical fronts. The region around the neutron mid-shell $N = 104$ and closed proton shell $Z = 82$ is especially prolific. The platinum isotope ($Z = 78$) ground states show a transition from the weakly deformed oblate shape at $A < 176$ and $A > 188$ to a strongly prolate configuration for $176 < A < 188$ with shape coexistence in the mass region of the transition between the two groups of deformation. Similarly the mercury isotopes ($Z = 80$) around $N = 104$ show shape coexistence and shape transition and, for the lightest isotopes ($N < 106$), a large odd-even staggering in the charge radii as well as a large shift between the ground state and the isomer charge radii. More recently, the mean squared charge radii of the neutron-deficient $^{182}\text{-}^{190}\text{Pb}$ isotopes have been studied at ISOLDE under experiment IS407 using the in-source laser photoionization spectroscopy.

The polonium isotopes ($Z = 84$) are required to understand the transition across the proton shell closure of $Z = 82$. Although extensive studies have been performed on the neutron-deficient isotopes the measurement of the charge radii was limited to the longest lived isotopes $^{200,202,204}\text{-}^{210}\text{Po}$. The recent α -, β - and γ -spectroscopy studies on neutron-deficient polonium isotopes down to $A = 190$ have highlighted ground state shape coexistence. Those observations should be reflected on the charge radii similarly as in the case of mercury.

Charge radii and electromagnetic moments of the Po isotopes ($^{191, 192, 193, 193m, 194, 195, 195m, 196, 197, 197m, 198, 199, 199m, 200, 201, 201m, 202, 203, 204, 206, 207, 208, 209, 210, 211, 216, 218}$) have been measured at ISOLDE by simultaneous atomic- and nuclear-spectroscopy (in-source laser photoionization spectroscopy) in a framework of IS 456. According to the preliminary analysis of the experimental data the evolution of the even- A isotopes shows a departure from the trend beyond $A = 198$.

Session 6: Nuclear Structure II / 8

Coulomb excitation of neutron-deficient mercury isotopes

Authors: Andrew Petts¹; Nick Bree²

¹ *Oliver Lodge Laboratory - University of Liverpool*

² *Inst. voor Kern- en Stralingsfysica - Katholieke Universiteit Leuven*

Corresponding Author: nick.bree@cern.ch

Since a clear shape dissimilarity in the ground state of light odd-mass mercury isotopes was observed by means of isotope shift measurements [1], shape coexistence in this mass region has been an intensively studied phenomenon by means of in-beam spectroscopy and decay spectroscopy. For light even-mass mercury isotopes, it has been advocated that a prolate band at low excitation energy is coexisting with an oblate ground state band [2,3]. Coulomb excitation at safe energies serves as a vigorous technique to investigate the magnitude of transitions between low-lying states, revealing information on the mixing of the different bands. Pure beams of ^{182,184,186,188}Hg were delivered to a stable Cd target placed in the middle of the MINIBALL gamma spectrometer to induce Coulomb excitation. The obtained beam intensities were sufficient for the population of low-lying, low-spin states and the detection of the subsequent gamma decay. Observed deexcitation rates enable the transitional quadrupole matrix elements connecting different states to be extracted. Also the sign of the diagonal matrix element of the first excited 2+ state, containing the information about the nuclear quadrupole deformation, will be presented.

[1] J. Bonn et al., Phys. Lett. B38 (1972) 308

[2] W. Nazarewicz, Phys. Lett. B305 (1993) 195

[3] R. Julin et al., J. Phys. G 27 (2001) R109

Summary:

We report on a Coulomb excitation experiment at 'safe' energies on the even-even neutron-deficient ^{182,184,186,188}Hg isotopes at the REX-ISOLDE radioactive beam facility. Observed deexcitation rates enable the transitional quadrupole matrix elements connecting different states to be extracted. Also the sign of the diagonal matrix element of the first excited 2+ state, containing the information about the nuclear quadrupole deformation, will be presented.

Session 9: Solid State Physics I / 9

First results from emission channeling lattice location experiments of ²⁷Mg in nitride semiconductors

Author: Ulrich Wahl¹

Co-authors: Guilherme Correia ¹; Ligia Amorim ¹; Manuel Ribeiro da Silva ²; Norberto Catarino ¹; Pereira Lino ³; Stefan Decoster ¹

¹ *Instituto Tecnológico e Nuclear ITN*

² *Centro de Física Nuclear da Universidade de Lisboa*

³ *Universidade do Porto*

Corresponding Author: ulrich.wahl@cern.ch

During the SiC-W RILIS Mg run in September 2009 we managed to do first on-line emission channeling lattice location experiments using ²⁷Mg (9.46 min) implanted into GaN and AlN. The room-temperature as-implanted beta- emission channeling patterns showed that the large majority of ion implanted Mg is incorporated on Ga or Al sites. While the detailed analysis of this experiment by means of fitting the experimental patterns to the results of simulations for ²⁷Mg on different lattice sites remains to be done, simple visual inspection of the experimental data gave no indication for large fractions of Mg on interstitial sites.

The biggest problem to be overcome was the ~1.5 nA stable ²⁷Al contamination that was present at mass 27 in this type of target (and also in similar UC2 targets). However, the ²⁷Al contamination could be significantly reduced by running the target and line at very low temperatures (estimated target temperature 1000-1200°C). For that purpose the target and line heating currents were decreased to 220 A and 250 A, respectively, which reduced the ²⁷Al current to 2-4 pA, with around 0.3 pA of

27Mg left. In radioactive equilibrium this 27Mg current results in around 1500 Hz count rate in the position-sensitive emission channeling detector, enough to carry out on-line measurements during implantation but not sufficient to perform proper thermal sample annealing (a typical annealing sequence lasts ~20 min before the measurement can start). In order to deal with this situation better next year, the Si pad detector will be equipped with an aluminated mylar foil window, allowing to operate the detector while the sample is at elevated temperatures and thus allowing to directly measure a higher implantation temperatures.

Session 9: Solid State Physics I / 10

Uncovering new diffusion phenomena in compound semiconductors

Author: Thomas Wichert¹

Co-authors: Frank Wagner¹; Herbert Wolf¹; Janko Cieslak¹; Jörg Kronenberg¹; Karl Johnston¹; Manfred Deicher¹

¹ *Technische Physik, Universität des Saarlandes*

Corresponding Author: manfred.deicher@tech-phys.uni-sb.de

It has been shown that the presence of an external Cd pressure effects the formation of so-called uphill diffusion profiles in CdTe around 800 K. This surprising diffusion behavior has meanwhile been demonstrated for the elements Ag, Cu, Au, and Na in radiotracer experiments using suited isotopes delivered by ISOLDE [1,2,3]. It has also turned out that uphill diffusion can also be initialized, but at significantly lower temperatures, by different metal layers evaporated onto the surface implanted with the respective radiotracer. Besides for the group I dopants mentioned above, also for 61Co an unusual diffusion behavior is observed at diffusion temperatures up to 850 K, which converts to normal diffusion at a temperature of 900 K.

The diffusion of impurities like Ag in CdTe performed by annealing at 828 K under Cd pressure leads to symmetrically and peak-shaped depth profiles with respect to the center of a 800 μm thick crystal. The formation of such a profile requires that Ag atoms have diffused from regions of low concentration to regions of higher concentration, what is contrary to what is usually expected in diffusion experiments. Simulations of the diffusion profiles, which reproduce the experimental data in a quantitative way by taking into account the charge state and drift of the different defects, yield the following information: The dopant atoms are dominantly present as positively charged interstitials. They convert the initially Cd-vacancy rich, p-type material, into n-type material. As a consequence, the dopant profile maps the position of the Fermi level across the depth of the crystal, reflects at the same time the profile of the intrinsic defects, and the positions of the steep gradients of the concentration profile correspond to the positions of pn junctions in the semiconductor [4,5].

Recent experiments show if a thin metal layer is evaporated onto the implanted surface before the diffusion step uphill diffusion is observed as well: Thus, at a diffusion temperatures of 550 K (30 min) the presence of a Cu layer (20 nm) effects that the implanted Ag atoms are moved in a quantitative way to the backside of a 700 μm thick CdTe crystal if the crystal used has initially Te excess. In contrast, this effect is not visible if the evaporated metal layer is absent. Uphill diffusion of Ag is also observed if Cu is replaced by layers consisting of Au, Ni or Al.

It seems to be a general finding that uphill diffusion in CdTe is observable under the condition that the crystal lattice exhibits Te excess and a source generating interstitial Cd defects is provided during the diffusion process. Such a source of the interstitial Cd defects can either be formed by an external Cd vapor or by a Cd layer formed at the interface between the CdTe crystal and an evaporated metallic layer that extracts the Te atoms. Thus, the quantitative differences observed for the different metal layers might be related to a different efficiency in extracting Te atoms at the interface out of the CdTe lattice.

[1] H. Wolf, F. Wagner, Th. Wichert and ISOLDE Collaboration, Phys. Rev. Lett. 94 (2005) 125901

[2] H. Wolf, F. Wagner, T Wichert, Defect and Diffusion Forum 237-240 (2005) 491.

[3] H. Wolf, F. Wagner, J. Kronenberg, Th. Wichert, and ISOLDE collaboration, Defect and Diffusion Forum 289-292 (2009) 587.

[4] H. Wolf, F. Wagner, Th. Wichert, R. Grill and E. Belas, J. Electr. Mat. 35 (2006) 1350

[5] H. Wolf, F. Wagner, J. Kronenberg, Th. Wichert, R. Grill, E. Belas, and The ISOLDE collaboration, Diffusion Fundamentals 8 (2008) 3.1-3.8.

Session 8: Spectroscopy / 11

Biological applications of Perturbed Angular Correlations of γ -rays spectroscopy

Author: Monika Stachura¹

¹ *University of Copenhagen, Faculty of Life Sciences*

Corresponding Author: monika.kinga.stachura@cern.ch

Perturbed Angular Correlation of γ -rays (PAC) spectroscopy is a technique routinely used in solid state physics. However, it has also proved to be a method that allows for studies of biological systems, such as local structure at metal ion binding sites, dynamics of protein folding or protein-protein interactions.

In the present work we have selected some of the biological applications that we find particularly interesting. We will show how, with the use of PAC and NMR spectroscopy, we can monitor the time scale of dynamics at the metal ion binding site. Furthermore, we will present data on heavy metal ions binding to proteins and finally, we will illustrate some interesting examples of in vivo studies.

Session 10: Solid State Physics II and Nuclear Structure III / 12

Electronic Structure of Isolated Guest Atoms

Author: Wolf Dietrich Zeitz¹

Co-author: Karl Johnston²

¹ *Helmholtz-Zentrum Berlin für Materialien und Energie GmbH*

² *ISOLDE/CERN*

Corresponding Author: karl.johnston@cern.ch

Taking advantage of its unique supply of radioactive isotopes, groups of experimentalists apply nuclear techniques to investigate the properties of solids, surfaces, and soft matter at ISOLDE. The methods of choice are Moessbauer, perturbed angular correlation, and nuclear magnetic resonance spectroscopies. In addition to existing facilities, a set-up for the beta-NMR-technique has been transferred to ISOLDE which will expand the range of available isotopes by using tilted foils for polarising post-accelerated radioactive ion beams.

With the advent of powerful computer codes, the interpretation of the experimental results has been based on unifying principles. For example, the magnetic hyperfine fields and the electric field gradients of Cd guest atoms on ferromagnetic nickel, which have been measured by the "ASPIC" group, can be related to the partial wave scattering of electrons on the impurity potentials. For elements in particular, magnetic fields are dominated by a polarisation in the local s-band, while field gradients are derived from an asymmetry in the population of p-sublevels.

In the wake of extended simulations similar electronic configurations have been identified in break junctions, at steps of incomplete surface layers, in local confinements, and in the environment of impurities in crystals. This combined information is expected to promote understanding of electronic behaviour in such different fields as catalysis, electronic transport through gaps and interfaces and reflections at differently shaped quantum barriers.

Session 4: Technical Progress / 14**Isotopic fingerprints of gold-containing luminescence centers in ^{28}Si** **Author:** Karl Johnston¹**Co-authors:** Martin Henry²; Mike Steger³; Mike Thewalt³¹ *Universitaet des Saarlandes*² *School of Physical Sciences, Dublin City University, Ireland*³ *aDepartment of Physics, Simon Fraser University, Burnaby BC V5A 1S6, Canada***Corresponding Author:** karl.johnston@cern.ch

A consequence of a project to grow enriched material for a re-definition of the kilogram, optical spectroscopy on the resulting crystals has revealed many unexpected properties of supposedly well-known (and certainly well-studied) optical centres in Silicon.

It has been shown that a dramatic reduction in linewidth of many deep luminescence centers in highly enriched ^{28}Si can lead to the observation of isotopic fingerprints, revealing not only that a specific element is involved in the defect complex, but also the number of atoms of that element. This work has challenged the accepted picture of many of the most familiar optical centres in Si. A re-interpretation of existing data in terms of a family of four-atom complexes has been proposed for systems comprising Cu, Ag, Au and Li.

Obtaining the isotopic fingerprint of Au is problematic, since only ^{197}Au is stable, but we have now used the relatively long-lived ^{195}Au to reveal the presence, and the number, of Au atoms in several of these centres. We find a series of four-atom centres containing one Au plus Cu and/or Li. Surprisingly, the Au isotopic fingerprint also reveals a series of five-atom centres containing a single Au plus Cu and/or Li. Further evidence for the ubiquity of these four- and five-atom defects is provided by two previously observed Pt-related centres, with luminescence at 884 meV and 777 meV, which are present in these samples due to the decay of ^{195}Au to ^{195}Pt . In addition to Pt, these systems are found to contain three and four Cu atoms, respectively.

Session 7: Fundamental Studies / 15**Spectral properties and scattering in chaotic billiards and nuclei*****Author:** Achim Richter¹¹ *Institut fuer Kernphysik, TU Darmstadt, D-64289 Darmstadt, Germany and ECT*, Villa Tambosi, I-38100 Villazano(Trento), Italy***Corresponding Author:** richter@ikp.tu-darmstadt.de

Sufficiently flat microwave resonators ("microwave billiards") are well suited to study the quantum mechanical behavior of classically chaotic systems because of the formal equivalence of the respective wave equations, i.e. the Helmholtz and the Schroedinger equation. Using a superconducting 2-dimensional chaotic billiard ("stadium") as an example, it is shown that its spectral properties display universal features which are also evident in real mesoscopic systems of different scales, i.e. hadrons, nuclei, atoms, molecules and clusters. Furthermore, since such microwave resonators can be viewed as open quantum systems, measurements of the reflected and transmitted amplitudes provide generic information on chaotic quantum scattering like observed in compound nucleus reactions. This process is discussed for time reversal invariant and non-invariant systems.

Session 4: Technical Progress / 16**Latest news from REX: the 2009 campaign, new beams and technical developments****Author:** Didier Voulot¹¹ CERN**Corresponding Author:** didier.voulot@cern.ch

During 2009, REX has accelerated new particle types, and promising results have been obtained for the charge breeding of very heavy neutron-rich ion beams. These will be reported, as well as experience from the 2009 measurement campaign; results from the first tests with diamond detectors used as beam diagnostics; and the development work on a tilted foil set-up for the production of polarized beams. Major consolidation works are underway on both the linac and low-energy region of REX (for cooling, shielding and the control system), which will also be presented.

Session 10: Solid State Physics II and Nuclear Structure III / 17**Spectroscopy of the neutron-deficient ²⁰⁰Po isotope by Coulomb excitation, using REX-ISOLDE, RILIS and the Ge MINIBALL array****Authors:** Beyhan Bastin¹; Nele Kesteloot²; Nick Bree²**Co-authors:** - The ISOLDE target group³; - The MINIBALL collaboration³; - The REX-ISOLDE collaboration³; - The RILIS team³¹ Katholieke Universiteit Leuven-GANIL² Katholieke Universiteit Leuven³ -**Corresponding Author:** beyhan.bastin@cern.ch

In the region around the Z=82 shell closure with neutron number around midshell between N=82 and N=126, shape coexistence occurs at low excitation energy. This phenomenon is well-established in the neutron-deficient polonium isotopes as evidenced by low-lying rotational like bands intruding in the low-energy structure.

Proton-pair excitations across the magic Z=82 along with the strong proton-neutron interaction in the vicinity of the neutron midshell are considered as the driving mechanism for shape coexistence in this region. The strong perturbation of the energy-level systematics in the very light polonium isotopes is also interpreted as arising from the interaction between the regular and intruder structures.

While the onset of the deformation in the light Po isotopes is reasonably well established experimentally, questions remain concerning the sign of deformation and the magnitude of the mixing between different configurations. Furthermore, controversy is present with respect to the transition from the vibrational-like character of the heavier Po isotopes to the structure driven by shape coexistence as observed in the lighter Po isotopes.

In September 2009, the spectroscopy of the even-mass neutron-deficient ²⁰⁰Po key nucleus was performed using post-accelerated (up to 2.85 MeV/u) radioactive polonium beam from REX-ISOLDE (CERN) followed by Coulomb excitation in a 'safe' energy domain. The gamma rays were detected by the germanium MINIBALL detector array.

In the presentation, preliminary spectra and results will be presented. The differential cross section extraction will allow us to deduce both the transition and diagonal matrix elements for this nucleus. In the future, combined with the spectroscopy of ¹⁹⁸Po and ²⁰²Po using the same technique, the

obtained reduced transition matrix elements will be compared to beyond mean field models and will serve as important bench marks to test of the model and interactions used.

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NMR/ON measurement of magnetic moments of high-spin K-isomers in Hf isotopes.

Author: Lara Risegari¹

Co-authors: A. Deo ²; C. Bingham ³; Carole Gaulard ¹; Gary Simpson ⁴; Georges Audi ¹; Jirina R. Stone ⁵; K. Nishimura ⁶; Nick J. Stone ⁷; P.M. Walker ²; S. Muto ⁸; S. Ohya ⁹; T. Ohtsubo ⁹; Ulli Koester ¹⁰; W.B. Walters ¹¹

¹ *Centre de Spectrométrie Nucléaire et de Spectrométrie de Masse (CSNSM)-91405 Orsay Campus, France*

² *Department of Physics, University of Surrey, GU2 7XH Guildford, UK*

³ *Department of Physics and Astronomy, University of Tennessee, Knoxville, TN37996, USA*

⁴ *Laboratoire de Physique Subatomique et de Cosmologie (LPSC), 38026 Grenoble Cedex, France*

⁵ *Department of Physics, University of Oxford, OX1 3PU Oxford, UK ; Department of Physics and Astronomy, University of Tennessee, Knoxville, TN37996, USA ; Department of Chemistry and Biochemistry, University of Maryland, College Park, MD20742, USA*

⁶ *Faculty of Engineering, Toyama University, Toyama 930, Japan*

⁷ *Department of Physics, University of Oxford, OX1 3PU Oxford, UK and Department of Physics and Astronomy, University of Tennessee, Knoxville, TN37996, USA*

⁸ *Neutron Science Laboratory, KEK, 305-0801 Tsukuba, Japan*

⁹ *Department of Physics, Niigata University, Niigata, Japan*

¹⁰ *Institut Laue Langevin, F-38042 Grenoble Cedex 9, France and ISOLDE, CERN, CH-1211 Geneva 23, Switzerland*

¹¹ *Department of Chemistry and Biochemistry, University of Maryland, College Park, MD20742, USA*

In a recent experiment at the NICOLE on-line nuclear orientation facility, gamma ray anisotropy and nuclear magnetic resonance measurements were made on Hf isomeric states. A Hf³ beam was used to implant separated Hf isotopes into a magnetized pure nickel foil cooled to temperatures down to ~10 millikelvin.

A new NMR/ON resonance was observed in the 8- 180mHf isomer. Angular distribution was measured for many gamma-ray transitions in the decay of this isomer and the decay of isomeric states in 177Hf.

Data analysis is in progress and preliminary results will be reported.

Session 2 / 20

Laser spectroscopy of gallium isotopes using ISCOOL

Author: Bradley Cheal¹

Co-authors: Christopher Geppert ²; David Forest ³; Deyan Yordanov ⁴; Ernesto Mane ¹; Frances Charlwood ¹; Garry Tungate ³; Gerda Neyens ⁵; Henry Stroke ⁶; Iain Moore ⁷; Jon Billowes ¹; Juha Aysto ⁷; Kieran Flanagan ⁸; Klaus Blaum ⁴; Magda Kowalska ⁹; Mark Bissell ⁵; Pieter Vingerhoets ⁵; Rainer Neugart ¹⁰

¹ *The University of Manchester, UK*

² *GSI, Germany*

³ *The University of Birmingham, UK*

⁴ *Heidelberg, Germany*

⁵ *KU Leuven, Belgium*

⁶ *New York University, USA*

⁷ *University of Jyväskylä, Finland*

⁸ *KU Leuven, Belgium; IPN. Orsay, France; The University of Manchester, UK*

⁹ *Physics Department, CERN*

¹⁰ *Mainz, Germany*

Corresponding Author: bradley.cheal@cern.ch

Laser spectroscopy has been performed on isotopes of gallium at ISOLDE. This work reports the first use of ISCOOL (a gas-filled linear Paul trap) for new laser spectroscopic experiments. Ground state nuclear spin values, magnetic dipole moments, electric quadrupole moments and mean-square charge radii have been extracted for isotope masses in the range $A = 67 - 82$. An inversion of ground state spin is observed between ^{79}Ga ($I = 3/2$) and ^{81}Ga ($I = 5/2$), and an anomalous spin of $I = 1/2$ for ^{73}Ga .

Session 8: Spectroscopy / 21

The ISOLTRAP tape station system

Author: Magdalena Kowalska¹

Co-authors: - ISOLTRAP²; Sarah Naimi³

¹ *CERN*

² *Collaboration*

³ *CSNSM*

Corresponding Author: kowalska@cern.ch

Penning traps are ideal tools not only for high-precision mass measurements, but also for isobaric and even isomeric beam purification. A system for beta- and gamma- spectroscopy installed behind the trap can be used for both assisting mass measurements and performing decay spectroscopy on pure samples in regions where contamination hampers standard measurements.

Installing such a system at ISOLTRAP is very challenging due to a limited space, vacuum requirements, and the need to reaccelerate the ions to kV energies. In spite of these obstacles, first tests have been performed successfully. In we present the layout of the system, the results of the commissioning beamtime, and future prospects.

Session 1 / 22

Coulomb excitation of neutron-rich $^{29,30}\text{Na}$ nuclei with MINIBALL at REX-ISOLDE: Mapping the borders of the island of inversion

Author: Michael Seidlitz¹

Co-authors: A. Blazhev²; B. Bastin³; B. Bruyneel²; B. Siebeck²; D. DiJulio⁴; D. Voulot⁵; F. Wenander⁵; J. Cederkäll⁴; J. Diriken³; J. Taprogge²; J. Van de Walle⁵; K. Wimmer⁶; K. Wrzosek⁷; L. Gaffney⁸; M. Huyse³; M. Scheck⁸; N. Bree³; N. Kesteloot³; N. Warr²; P. Butler⁸; P. Delahaye⁵; P. Reiter²; P. Van Duppen³; P.J. Woods⁹; R. Gernhäuser⁶; R. Krücken⁶; R. Lutter⁶; T. Davinson⁹; T. Kröll¹⁰

¹ *Institut für Kernphysik, Universität zu Köln*

² *Institut für Kernphysik, Universität zu Köln, Germany*

³ *IKS, Katholieke Universiteit Leuven, Belgium*

⁴ *Lund University, Sweden*

⁵ *ISOLDE, CERN, Switzerland*

⁶ *Technische Universität München, Germany*

⁷ *University of Warsaw, Poland*

⁸ *University of Liverpool, United Kingdom*

⁹ *University of Edinburgh, United Kingdom*

¹⁰ *IKP, Technical University Darmstadt, Germany*

For the ^{28,29,30}Na isotopes a gradual transition from the usual filling of the neutron levels into the region with low lying 2p-2h cross shell configurations, the so-called island of inversion, is described by theory [1,2]. Detailed theoretical predictions for the transition strength are awaiting experimental verification in all three Na nuclei. Collective properties of excited states of ^{29,30}Na were subject of a recent Coulomb excitation experiment at REX-ISOLDE employing radioactive ^{29,30}Na beams with a final energy of 2.85 MeV/u. De-excitation γ -rays were detected by the MINIBALL γ -spectrometer in coincidence with scattered particles in a CD-shaped segmented Si-detector. The recently determined $B(E2)$ value [3] for the $5/2^+$ level in ²⁹Na at 72 keV could be confirmed. A preliminary $B(E2) \uparrow = 350(65) e^2 \text{fm}^4$ value for the $2^+ \rightarrow 3^+$ transition in ³⁰Na is of similar strength like the $0^+ \rightarrow 2^+$ transition strength in the neighboring ³²Mg. The new data show clearly an increase in collectivity for the neutron rich Na case, indicating a deformed intruder dominated ground state configuration.

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Session 2 / 23

Magnetic and quadrupole moments of Cu isotopes with collinear laser spectroscopy

Author: Pieter Vingerhoets¹

¹ *Instituut voor Kern- en Stralingsfysica, K.U.Leuven, Celestijnenlaan 200D B-3001 Leuven, Belgium.*

In this presentation we report on the measurement of the magnetic and quadrupole moments of the Cu isotopes with collinear laser spectroscopy at the Collaps beamline, along with the extraction of the mean square charge radii of the Cu isotope chain.

The Cu isotopes have only one proton outside the magic $Z=28$ shell, and have therefore attracted a lot of nuclear research interest in the past decade. The obtained results from three experiments at the Collaps beamline are presented, the last of which employed the recently installed RFQ beamcooler. Important results such as the spin of ⁷⁵Cu, the onset of deformation beyond the $N=40$ subshell gap and the trend of the magnetic moments along the isotope chain will be discussed. The moments extracted from these measurements are compared with theoretical calculations and clearly present a challenge for the current theoretical models in this region of the nuclear chart.

Session 5: HIE ISOLDE / 24

Status of the ISOLDE Target Area Upgrade

Author: Richard Catherall¹

¹ *CERN*

Corresponding Author: richard.catherall@cern.ch

The Design Study of the target area within the context of the HIE-ISOLDE project has been given a lower priority with respect to the upgrade of REX-ISOLDE to 10MeV/u. Nevertheless, first steps, considered as a pre-requisite to the upgrade of the ISOLDE target area, have been initiated. This includes radiation protection issues, Frontend modifications and remote handling. This talk will give a brief overview of the progress being made in these areas.

Session 4: Technical Progress / 25

The New ISOLDE Frontends

Author: Stefano Marzari¹

¹ CERN

A new design of Frontend has been developed at ISOLDE in view of replacing the existing and aging Frontends. Whilst maintaining compatibility with the present target design, new improvements and modifications have been incorporated into Frontend #6 and #7. These include simplified mechanics, a ceramic high voltage insulator, metallic joints, re-design of the beam optics, a rigid chassis and an auto-centering coupling table. The Frontend #6 has been tested and will be installed in February 2010. Frontend #7 is currently under construction and will be installed one year later. This talk will outline the improvements of the new Frontends and will touch on the renovation of the controls and HT transfer tube modifications also foreseen during the coming shutdown period.

Session 2 / 26

Coulomb Excitation of 94,96Kr at ISOLDE: Shape changes and deformation of neutron-rich Krypton Isotopes

Author: Dennis Muecher¹

¹ Institute for Nuclear Physics, University of Cologne

Corresponding Author: muecher@ikp.uni-koeln.de

Recently the energy of the first 2+ state in the N=60 96Kr nucleus was determined to be 241 keV. This was the first experimental observation of an excited state in this highly exotic nucleus. The 2+1 state in 94Kr is located at 665.5 keV, i.e. E(2+1) drops by more than 400 keV at N=60. This lowering of the 2+1 energy indicates a sharp shape transition behavior which is somewhat similar to that discovered in the Sr and Zr isotopic chains at N=60. The sudden decrease of E(2+1) from N=58 to N=60 does not fully agree with the more gradual change of deformation deduced from laser spectroscopy measurements of mean square charge radii. It is thus of considerable interest to characterize the nuclear shape evolution in the most neutron-rich Kr isotopes looking at transition matrix elements. We therefore have performed Coulomb Excitation experiments in inverse kinematics on 94,96Kr at ISOLDE (IS 485) using the MINIBALL gamma-ray spectrometer. We will show first results of this challenging experiment.

Session 9: Solid State Physics I / 27

Local Probe Studies in multiferroic AgCrO2

Authors: Armandina Lima Lopes¹; Gonalo Oliveira¹; Joo Guilherme Correia²; Joo Pedro Araujo³; Tania Mendona³; Vitor Amaral⁴

¹ *Centro de Fısica Nuclear, Universidade de Lisboa*

² *Instituto Tecnologico e Nuclear, Sacavem*

³ *Instituto de Nanociencia e Nanotecnologia, Universidade do Porto*

⁴ *Departamento de Fısica e CICECO, Universidade de Aveiro*

Corresponding Author: armandina.lima.lopes@cern.ch

The search for new systems that exhibit simultaneous ferroelectric and ferromagnetic orders have recently motivated Physic and Materials Science scientific communities to a meticulous research, that beyond searching the simultaneous electric and magnetic orders also have as an objective the maximization of its coupling. These materials offer the possibility to manipulate electrically the magnetic degrees freedom or vice-versa [1-2].

Recently, AgCrO₂ delafossite has been reported as another multiferroic material [3]. Also, a correlation between the electric dipoles and the magnetic structure of this system has been claimed.

In such compounds local distortions have a fundamental influence in the ferroelectric and ferromagnetic proprieties. Thus, for understanding the mechanism inherent to the macroscopic proprieties local probe studies, for acquiring information about the electronic structure, are of the most importance. Therefore, a Perturbed Angular Correlation (PAC) study was carried out in the AgCrO₂ system. For that purpose high purity samples were synthesized by solid-state reaction. Macroscopic characterization via structural, morphological, magnetic and electric analysis has been performed. The PAC studies have been performed from 800 K to 11K, with special focuses in the vicinity of the magnetic phase transition temperature. The results show the coexistence of two distinct local environments. The nature of these two Ag surroundings will be discussed.

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Session 3 / 28

Ion production needs for beta beams

Author: Elena wildner¹

¹ *CERN*

Corresponding Author: elena.wildner@cern.ch

Ion production needs for beta beams

“Neutrino properties are interesting probes to physics beyond the Standard Model. High quality neutrino beams of pure electron (anti-)neutrinos can be produced by accelerating beams of beta radioactive ions (beta beams) and let them decay in long straight sections in a race track shaped storage ring. Two ion species are needed, one producing neutrinos and the other anti-neutrinos. The reactions should have similar Q-values and the ions should have similar magnetic rigidities to be able to be accelerated in the same accelerator. A suitable scenario, using the CERN accelerator complex, has been studied within the EURISOL program, using ⁶He and ¹⁸Ne. The production of these isotopes, specific to this application, is crucial for the efficiency of this setup. For the time being there is a significant shortfall of ¹⁸Ne. The production of ¹⁸Ne would need specific research. Recent encouraging experiments at ISOLDE show that sufficient quantities of ⁶He can be obtained.

Alternative ions, ⁸B and ⁸Li, could also be good candidates for beta beams. ⁸Li could probably be produced by similar techniques as ⁶He, but ⁸B could probably not be produced by ISOL technology. Studies of the production of ⁸Li and ⁸B are ongoing in the EUROnu design studies within the European framework program (FP7) and could conceivably benefit from studies at ISOLDE.

In this presentation we explain the needs for these radioactive ions to give beta beams useful for neutrino physics after acceleration and storage in the CERN accelerator complex proposed in the EURISOL design study.”

Session 3 / 30

Target and Ion Source Development : (n,X) reaction for ^6He neutrino beams tested at ISOLDE

Author: Thierry Stora¹

Co-author: etam noah²

¹ CERN

² *ess and cern*

Corresponding Author: thierry.stora@cern.ch

We report here results obtained this year on the production of Beams by (n,X) reactions with the ISOLDE neutron converter. The converter is traditionally used to produce n-rich fission fragments in UCx targets.

We present here data on $^9\text{Be}(n,\alpha)^6\text{He}$ obtained with a new BeO target coupled to the VADIS ion source. Record ^6He intensities were indeed obtained. Information on the neutron spectrum were collected, and future options for optimization will be discussed, together with other possible beams based on this scheme.

This work was done in a framework of a large collaboration between GANIL, SOREQ-Weissman Inst. and CERN, as part of the 100kW Target task of EURISOL-DS.

Remaining and new beam developments (TISD) requested by INTC are discussed and prioritized in the Group for Upgrade of ISOLDE.

Session 9: Solid State Physics I / 31

Paramagnetism of Fe defects in ZnO

Author: Haraldur Gunnlaugsson¹

Co-authors: D. Naidoo²; G. Langouche³; G. Weyer¹; H. Masenda²; H. P. Gíslason⁴; K. Bharuth-Ram⁵; K. Johnston⁶; M. Fanciulli⁷; R. Mantovan⁸; R. Sielemann⁹; S. Ólafsson⁴; T Mølholt⁴; Y. Kobahashi¹⁰; Y. Yoshida¹¹

¹ Department of Physics and Astronomy, Aarhus University, Ny Munkegade 120, DK-8000 Århus C, Denmark

² School of Physics, University of the Witwatersrand, WITS 2050, South Africa

³ Instituut voor Kern-en Stralingsfysika, University of Leuven, B-3001 Leuven, Belgium

⁴ Science Institute, University of Iceland, Dunhaga 3, IS-107 Reykjavík, Iceland

⁵ School of Pure Physics, University of KwaZulu-Natal, Durban 4041, South Africa

⁶ EP Division, CERN, CH-1211 Geneva 23, Switzerland

⁷ Dipartimento di Scienza dei Materiali, Università di Milano Bicocca, Milano, Italy

⁸ Laboratorio Nazionale MDM CNR-INFN, 20041 Agrate Brianza (MI), Italy

⁹ Hahn-Meitner Institute, D-14109 Berlin, Germany

¹⁰ The Institute of Physical and Chemical Research (RIKEN), Wako, Saitama 351-0198, Japan

¹¹ Shizuoka Institute of Science and Technology, Shizuoka 437-8555, Japan

Corresponding Author: hpg@phys.au.dk

Semiconductors, which are ferromagnetic at room temperature, are strived after as potential multifunctional materials. For ZnO, room temperature ferromagnetism has been achieved by doping with 3d transition metals making potential dilute magnetic semiconductors. However, contradicting results have been obtained and neither the conditions for, nor the origin of the magnetism are as yet understood. Recent theoretical and experimental work have suggested the important role of lattice defects, while other authors have suggested unintentional precipitation, to be the source of the magnetism.

We have performed online ^{57}Fe Mössbauer spectroscopy following implantation of ^{57}Mn ($T_{1/2} = 1.5$ min.). Mössbauer spectroscopy is a powerful tool giving information on the valence state of the Fe, site symmetry and magnetic interactions on an atomic scale.

The Mössbauer spectra obtained after implantation into ZnO show magnetic sextets originating from iron in the ferric state. The formation kinetics of the ferric iron is shown to suggest formation of FeZn-O-VZn defects upon implantation. Measurements in external magnetic field show that these sextets are due to slow paramagnetic relaxations.

Session 7: Fundamental Studies / 32

Status of the WITCH experiment

Author: Marcus Beck¹

Co-authors: A. Herlert²; Ch. Weinheimer¹; E. Traykov³; F. Wauters³; F. Wenander²; J. Mader¹; M. Breitenfeld³; M. Tandecki³; N. Geeraert³; N. Severijns³; P. Delahaye²; P. Friedag¹; S. van Gorp³; V. Kozlov⁴

¹ *WWU Münster*

² *ISOLDE/CERN*

³ *K.U. Leuven*

⁴ *KIT Karlsruhe*

The WITCH experiment measures the energy spectrum of the recoil ions after nuclear beta decay. The radioactive ions are stored in Penning traps where they decay. The recoil spectrum is measured with a retardation spectrometer of MAC-E type. From the shape of the recoil spectrum the beta-neutrino angular correlation will be determined, with the goal to search for exotic interactions beyond the electroweak Standard Model.

A first recoil energy spectrum with low statistics has been measured with WITCH in 2006. In 2008 and 2009 the experimental set-up has been improved significantly. During this time also investigations of systematic effects progressed. A beamtime to test the improvements of the set-up is in progress. The status of the experiment and of the investigations of systematic effects will be presented.

Session 3 / 33

A Plan for building a Heavy Ion Accelerator in Korea

Author: Seung-Woo Hong¹

¹ *Sungkyunkwan University*

Corresponding Author: swhong@skku.ac.kr

In 2009 the Korean government announced a plan to construct a Heavy Ion Accelerator facility in Korea. A plan to construct a Heavy Ion Accelerator to produce rare isotope beams is underway. The

construction of this facility will be one of few mega-projects for basic science research facility in Korea. This facility tentatively referred to as KoRIA (Korea Rare Isotope Accelerator) is planned as a multipurpose research facility for nuclear, atomic, material, and bio-medical sciences. The present status of the planning will be presented.

Session 2 / 34

Nuclear structure oddities from ISOLTRAP mass measurements

Author: Sarah Naimi¹

Co-author: ISOLTRAP Collaboration the ²

¹ *Centre de Spectrometrie Nucleaire et de Spectrometrie de Masse (CSNSM)*

² *Heidelberg-Greifswald-CERN-Mainz-GSI-Orsay*

The results of two recent ISOLTRAP experiments are discussed in this contribution.

(1) Sudden offset of deformation around $N=60$
(or, Reformation of Kr isotopes around $N=60$)

Whereas canonical nuclear structure decrees a sub-shell closure at $N=56$, neutron-rich Zr and Sr istopes are known to exhibit sudden and intense deformation instead. This deformation, visible from a deep dent in the mass surface, is interpreted as a nuclear quantum phase transition. It is of interest to determine the conditions where this phase transition (or deformation) begins but also where it ends.

Microscopic mass predictions in the mean-field framework (HFB-17) tells us that Kr will be strongly deformed as well. However, first mass measurements of $^{96,97}\text{Kr}$, using the Penning-trap spectrometer ISOLTRAP, show this not to be the case.

(2) All quiet on the western $N=40$ front
(or, Magic-number migration in Mn isotopes)

The many attempts of establishing a shell closure at $N=40$ have resulted in admitting that the effect depends on whether $Z=28$ or not. New mass measurements of Mn ($Z=25$) from ISOLTRAP confirm this observation.

In fact, the strong effect at $N=35$ visible from previous measurements is shown to completely disappear. However, a new effect, though more subtle, does appear in the case of $N=34$, perhaps indicating the manifestation of a new magic number.

Session 8: Spectroscopy / 36

Fast timing studies at ISOLDE: highlights and perspectives

Author: Luis M Fraile¹

¹ *UCM*

Corresponding Author: luis.fraile@cern.ch

The measurement of absolute nuclear transition probabilities is a very sensitive tool to study the structure of the atomic nucleus. Direct access to transition rates can be achieved via the lifetime of nuclear levels de-populated in radioactive decay. The Advanced Time-Delayed (ATD) method, or

Fast timing, is a well-established technique to measure lifetimes ranging from 5 ps to 50 ns with count-rates as low as 5 decays per second [1]. The method provides insight into the structure of the nuclear levels in a complementary manner to other experimental techniques such as Coulomb excitation or collinear laser spectroscopy. Experiments over the last few years have exploited the potential of the technique in beta-decay spectroscopy and have explored its application to high-spin reactions and microsecond isomer studies [2].

The presentation will overview results obtained at ISOLDE, with physics cases spanning over the mass range $A = 30 - 230$. The technical advances leading to an enhanced sensitivity of the ATD method such as new scintillator crystals [3] will be underlined and future opportunities will be discussed.

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[3] M. Moszynski et al., IEEE Trans. Nucl. Science 55 (2008) vol. 3

Session1 / 38

Nuclear charge radii of magnesium isotopes by laser spectroscopy with combined fluorescence and beta-decay detection

Author: Joerg Kraemer¹

Co-authors: Andreas Krieger¹; Bastian Sieber¹; Christopher Geppert¹; Deyan T. Yordanov²; Gerda Neyens³; Kim Kreim²; Klaus Blaum²; Maarten Depuydt³; Magdalena Kowalska⁴; Mark L. Bissell³; Michael Hammen¹; Pieter Vingerhoets⁵; Rainer Neugart¹; Rodolfo M. Sanchez⁶; Wilfried Nörtershäuser¹

¹ University Mainz, Germany

² MPI-K Heidelberg, Germany

³ KU Leuven, Belgium

⁴ ISOLDE CERN, Switzerland

⁵ KU Leuven, Belgium

⁶ GSI Darmstadt, Germany

Corresponding Author: j.kraemer@gsi.de

The nuclear charge radius is a critical probe for testing nuclear models and detecting anomalies in the nuclear structure. The isotopic chain of magnesium exhibits intruder configurations with the pf shell being populated before the sd shell is complete. In this “island of inversion” the nuclear charge radii would indicate this structural change, expected to happen in the step from 30Mg to 31Mg, and in such a way answer the question if deformation is the driving force behind this phenomenon.

The experimental property providing the charge radius is the isotope shift, i.e. the shift in frequency of an atomic transition in different isotopes. The magnesium isotope shifts were measured by collinear laser spectroscopy making use of the versatility of this technique. For the exotic even-odd neutron rich magnesium isotopes 29,31Mg we used optical pumping to polarize the nucleus and detected the asymmetry in the beta decay after implantation in a MgO host crystal. It is the first time that beta-asymmetry measurements are applied for isotope-shift measurements, which became possible only after a thorough understanding and simulation of the observed line shapes. The equivalence of optical and beta detection was investigated on the basis of 29Mg, which was accessible with both methods. 27Mg and the even-even isotopes, 24,26,28,30,32Mg were measured with conventional fluorescence detection. Photon-ion coincidence provided a critical improvement of the signal-to-noise ratio for the measurement of the very exotic isotope 32Mg.

The results of the measurements on 24-32Mg will be presented the charge radii that can be extracted from the isotope shifts and compare them with the trends predicted on the basis of models and experimental information.

Frontend #6 test results

Author: Tim Giles¹

¹ *CERN*

Corresponding Author: tim.giles@cern.ch

In this talk I will present the features and optics of the new generation of Isolde frontends. A test stand for frontend #6 has been built and beam has been extracted from a target equipped with a standard Isolde ion source. I will show calculated tunes adapted for the GPS and HRS separators, and compare them with emittance measurements made on the test stand.

Session 7: Fundamental Studies / 41

Oscillations of lepton number, double electron capture and atomic mass difference

Author: Fedor Simkovic¹

Co-author: Mikhail Krivoruchenko ²

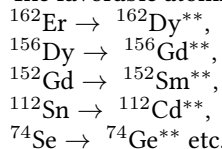
¹ *Comenius University*

² *ITEP Moscow*

Corresponding Author: simkovic@fmph.uniba.sk

Oscillations of two neutral atoms, which proceed with the violation of lepton number, is proposed. One of the neutral atoms is stable, the other one represents a quasistationary state subjected to electromagnetic deexcitation. The underlying mechanism is a transitions of two protons and two bound electrons to two neutrons $p + p + e_b^- + e_b^- \leftrightarrow n + n$. A phenomenological analysis of the oscillations plus deexcitations of atoms point out on a resonant enhancement of the neutrinoless double electron capture ($0\nu ECEC$) decay rate, that has a Breit-Wigner form. A resonant enhancement of the $0\nu ECEC$ -decay takes place when the atomic masses tend to be degenerate. Qualitative estimates show that in searches for lepton number violation oscillations of atoms might be a possible alternative to the conventional mechanism of the neutrinoless double β decay process with emission of two electrons.

The favorable atomic systems appear to be



There is a request for measurement of atomic mass differences with a precision of order of 10 eV.

Session 5: HIE ISOLDE / 42

HIE-ISOLDE: A look to the Physics

Author: Maria J. G. Borge¹

¹ *Inst.de Estructura de la Materia*

Corresponding Author: maria.garcia.borge@cern.ch

The provision of high-intensity accelerated radioactive beams (RIB) is currently of high priority for the nuclear physics community World wide.

ISOLDE has nowadays a vast variety of species produced, more than 1000 nuclei from almost 70 elements, the largest number by far of the existing ISOL-facilities. A key feature of the accelerated RIB at ISOLDE, REX-ISOLDE, is that essentially all isotopes produced can be charge bred and accelerated further up to 3 MeV/u. The present energy range limits the experimental program to Coulomb excitation of light and intermediate mass nuclei and to transfer reaction for the lightest species.

The ISOLDE facility has been expanded several times in order to continue being a reference facility. Improvement of beam quality, increase in intensity and availability of new radioactive beams will boost decay experiments as well as the study of ground state properties as, for instance, Penning trap mass measurements that continuously refine our understanding of the nuclear mass surface. An energy upgrade will make all produce nuclei available for reactions up to and above the Coulomb barrier opening new avenues from the physics point of view. The enlarged dynamic energy range up to 10 MeV/u, will allow the optimization in each case with respect to cross section and reaction channel open.

The availability of high quality and versatile RIB at ISOLDE, in particular the well-defined variable energy beams will facilitate measurement of single particle and collective structure in exotic nuclei. In this talk examples of these studies will be presented.

Session 10: Solid State Physics II and Nuclear Structure III / 43

Further investigations of a defect-complex in III-nitride ternary semiconductors

Author: P. Kessler¹

Co-authors: J.G. Correira²; K Johnston³; K. Lorenz²; R. Vianden⁴

¹ *Helmholtz-Inst. f. Strahl.- u. Kernp-Univ. Bonn, Physikalisches I*

² *Instituto Tecnológico e Nuclear, Estrada Nacional 10, P-2686-953 Sacavém, Portugal*

³ *Technische Physik, Universität des Saarlands, Building E2.6, P.O. Box 151150, 66041 Saarbrücken, Germany*

⁴ *Helmholtz Institut für Strahlen und Kernphysik, University of Bonn, Nussallee 14-16, 53115 Bonn, Germany*

Corresponding Author: patrick.kessler@cern.ch

Earlier PAC measurements with ¹¹¹In in GaN and AlN show a defect complex of the implanted In and a nitrogen vacancy (VN) which is stable up to high temperatures. This could give insights in the not well understood luminescence mechanism.

To gain more information about this complex we compared ¹¹¹In(¹¹¹Cd) with ¹¹¹mCd(¹¹¹Cd) measurements to check the possible influence of after effects that can occur after the decay of the parent nucleus ¹¹¹In via electron capture. This leaves a hole in the electron shell of the probe atom.

Furthermore the different relative charges of the incorporated probe atoms can be studied; ¹¹¹In being neutral and ¹¹⁷Cd(¹¹⁷In), ¹¹¹mCd(¹¹¹Cd) forming acceptors.

We present the results from our last two implantations at ISOLDE and compare them with previous measurements. ¹¹⁷Cd and ¹¹¹mCd were implanted in 3µm thin films of GaN and AlN on sapphire substrate. After thorough annealing we performed temperature dependent PAC measurements.

Session 4: Technical Progress / 44

IMPROVEMENT in RILIS SELECTIVITY and SPECTRAL RESOLUTION by the use of TIME-OF-FLIGHT TECHNIQUE

Author: Viacheslav Mishin¹

¹ *Institut for Spectroscopy RAS*

Corresponding Author: mishin@isan.troitsk.ru

Although the selectivity of resonance ionization laser ion sources is high, nevertheless, it does not sufficiently large to carrying out many crucial experiments with radioactive isotopes particularly in studies of isotopes located very far from the valley of element stability.

This report discusses the improved selectivity of the RILIS made possible by in-source time-of-flight ion compression. Brief description of the principle and some preliminary experimental results are presented. In off-line experiments Tm ion peaks of 5 μ s duration were observed using the time-of-flight assemble, ionizer and free field region, of 60 mm length and the voltage drop across the ionizer of 15 V. In case of Sn the ion peak width of 1 μ s can be obtained at the voltage drop across the ionizer of 45 V. By this is meant that the selectivity of Sn production can be as much as 100 employing the ISOLDE – RILIS with TOF ion bunch compression and the ion bunch gating technique.

Also this report discusses a possibility in principle carrying out the sub-Doppler laser spectroscopy using the RILIS and the time-of-flight technique.

Session 7: Fundamental Studies / 45

PROTON-RICH IONS DECAYING BY EC: A SYNERGY BETWEEN NUCLEAR AND NEUTRINO PHYSICS

Author: Berta Rubio Barroso¹

Co-authors: Alejandro Algora¹; Esther Estevez Aguado²; José Bernabeu¹

¹ *Instituto de Física Corpuscular (IFIC)-CSIC/Universitat de València-U*

² *Instituto de Física Corpuscular (IFIC)-Universitat de València-U*

Corresponding Author: berta.rubio@cern.ch

M. E. Estevez Aguado, A. Algora, J. Bernabeu, and B. Rubio
(IFIC, CSIC-Uni. Valencia, Spain)

Abstract: Neutrino oscillation studies have demonstrated that neutrinos have a mass and they mix. Next facilities will need pure, in flavour, and intense beams for very long-baseline experiments with massive detectors. The ultimate goal is the discovery and measurement of CP violation in the lepton sector. The CP-odd terms in the oscillation probability have different energy dependence with respect to the CP-even terms. Boosted ions decaying by electron capture with half-lives of the order of sec. offer the virtue of providing a forward monochromatic neutrino beam with appropriate properties for a beta-beam facility. These proton-rich isotopes are of high interest for nuclear physics studies too.

We have recently performed systematic study of candidate nuclei for the construction of a monochromatic neutrino beam facility in the proton rich rare earth region. In this contribution we show the results of the experimental study of the beta decay of two possible candidate nuclei (¹⁵²Yb and ¹⁵⁰Er) using the Total Absorption Gamma Spectroscopy (TAGS) technique at GSI. A comparison of these results with earlier high resolution measurements will be discussed as well as possible new measurements at Isolde.

Session 3 / 46

Towards building a Radionuclide Bank from proton irradiated Hg and Pb-Bi targets

Author: Susanta Lahiri¹

Co-author: Moumita Maiti¹

¹ *Saha Institute of Nuclear Physics*

Corresponding Author: susanta.lahiri@saha.ac.in

The proposed EURISOL facility is expected to be the world's largest ISOL facility to produce a large variety of high intensity radioactive ion beam in near future. Unlike the existing ISOL facilities, mercury or lead-bismuth target will be exploited simultaneously as neutron converter and coolant in the EURISOL facility. A large number of radionuclides will be produced as a result of a few GeV proton induced spallation reactions on these targets. Long term proton irradiation will introduce enough activity in the mercury assembly, which needs to be separated time to time in order to recycle the mercury. Though the size of separable activity is small compared to the total volume of mercury, but it will be enough for building "radionuclide bank" for several applications, like, industry, medicine, basic science, etc.

This "radionuclide bank" will be of use only if each constituent is separated with high radiochemical and radioisotopical purity. At the same time, the quantification of each of the radionuclide is also important. With this aim, we would like to develop different radiochemical methodologies for separation of different radionuclides from the irradiated mercury and lead-bismuth target. The off line experiments will be carried out at the radiochemistry laboratory of Saha Institute of Nuclear Physics (SINP), Kolkata, India. SINP radiochemistry laboratory is equipped with various α and γ detectors including Compton shielding.

Apart from clinically or industrially important short-lived radionuclides, emphasis will be given to search exotic long-lived radionuclides of astrophysical importance which may be formed in the minuscule amount in the mercury/lead-bismuth target as result of very high intensity proton beam. The ICPOES and ICPMS (both available in SINP-radiochemistry laboratory) will be useful to search these long-lived radionuclides rather than radiation detectors.

Summary:

Proposal for development of radiochemical methods for separation of different radionuclides from Hg/Pb-Bi target

Session 2 / 47

Precision mass measurements with ISOLTRAP - Past, present, and future

Author: Alexander Herlert¹

¹ *CERN*

Corresponding Author: alexander.herlert@cern.ch

The ISOLTRAP Penning trap mass spectrometer has contributed many precise and accurate ground state masses, e.g., for the investigation of nuclear structure, the determination of charge radii, or the study of nucleosynthesis pathways, just to name a few applications. With ISOLTRAP also new techniques were introduced which allow one to make better measurements or to reach more and more exotic nuclei. An overview of the present ISOLTRAP mass database is given including the

recent results from 2009. Furthermore, future physics cases are discussed and new technical developments, for example the installation of an electrostatic mass separator for better suppression of contamination.

Session 6: Nuclear Structure II / 48

Highlights from the ISAC Science Program

Author: Greg Hackman¹

¹ TRIUMF

Corresponding Author: hackman@triumf.ca

At TRIUMF-ISAC, high-power isotope separation on-line (ISOL), surface and resonant ionization, and linear heavy-ion accelerator technology provide radioactive beams of high intensity and low emittance. ISAC is complemented by a suite experimental facilities for research in nuclear astrophysics, nuclear structure, fundamental interactions and symmetries, and condensed matter research. This talk will review selected recent results from the ISAC science programs, such as: nuclear structure of lithium and beryllium isotopes; high-precision lifetime and branching ratio measurements in ²⁶Al and ¹⁹Ne; near-threshold states in A=20-30 nuclei and their contributions to astrophysical processes; and, interface effects in niobium films. A recently-submitted proposal to upgrade and extend the ISAC facility will be reviewed.

Session 6: Nuclear Structure II / 49

Coulomb excitation in the neutron deficient Sn and Cd isotopes

Author: Joakim Cederkall¹

¹ University of Lund

Corresponding Author: joakim.cederkall@cern.ch

Recent experiments at REX-ISOLDE as well as at fragmentation facilities, such as GSI and MSU, show an increased collectivity in the first 2+ state of the light Sn isotopes as compared to predictions from large scale shell model calculations. In this presentation we'll review some of the results and discuss recent measurements for the light Cd isotopes in view of a potential need for a renormalization of the neutron effective charge in the vicinity of ¹⁰⁰Sn.

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Introduction

Session 5: HIE ISOLDE / 51

HIE-ISOLDE: Status Report of the Project and Highlights

Author: Yacine Kadi¹

¹ CERN

Corresponding Author: yacine.kadi@cern.ch

The research with radioactive beams has strengthened the link between technical developments and physics output. The study of radioactive beams allows us to follow the evolution of nuclear structure over extended regions in the nuclear chart. ISOLDE has nowadays a vast variety of species produced, more than 1000 nuclei from almost 70 elements, the largest number by far of the existing ISOL-facilities. A key feature of the REX-ISOLDE complex is that essentially all isotopes produced can be charge bred and accelerated further up to 3 MeV/u. The present energy range limits the experimental program to Coulomb excitation of light and intermediate mass nuclei and to transfer reaction for the lightest species.

The ISOLDE facility has been expanded several times in order to continue being a reference facility. Improvement of beam quality, increase in intensity and availability of new radioactive beams will boost decay experiments as well as the study of ground state properties as, for instance, Penning trap mass measurements that continuously refine our understanding of the nuclear mass surface. An energy upgrade will make all produce nuclei available for reactions up to and above the Coulomb barrier opening new avenues from the physics point of view. The enlarged dynamic range, first to 5.5 MeV/u and in a later stage to 10 MeV/u, will allow the optimization in each case with respect to cross section and reaction channel opening.

A major upgrade of the present facility, High Intensity and Energy ISOLDE (HIE-ISOLDE), is now proposed to fully exploit the latest developments and significantly increase the ISOLDE scope. The HIE-ISOLDE project proposes a staged upgrade in three main categories: beam intensity, beam energy and beam quality. In this talk the present status of the project, and the future plans will be presented.

Session 5: HIE ISOLDE / 52

HIE-LINAC: accelerator status and a proposal for the experimental lines.

Author: Matteo Pasini¹

¹ CERN

Corresponding Author: matteo.pasini@cern.ch

The HIE-LINAC R&D phase has started in 2008 with the prototyping of the “high” beta SC QWR cavity and detailed beam dynamics studies. We report here on the latest achievement in term of the cavity prototyping, the results of the beam optics studies and a proposal for the beams lines for the future experimental facilities.

Session 4: Technical Progress / 53

ISOLDE RILIS: upgrade and development report.

Author: Valentin Fedosseev¹

¹ CERN

Corresponding Author: valentin.fedosseev@cern.ch

At ISOLDE RILIS the resonance ionization of isotopes is provided by high pulse rate dye lasers. Until 2008 the dye lasers were pumped by copper vapor lasers built a long time ago in Russia. Following

a plan for upgrade of the laser setup, two new 100W Nd:YAG lasers have been installed at RILIS. Operation of RILIS with the new pump lasers resulted in a noticeable improvement in the production of ion beams. In particular, the beam stability increased and higher yields have been observed. Some previously used ionization schemes are not reproducible with the Nd:YAG laser. For Mn this was addressed using the auxiliary LARIS installation by the development of a new ionization scheme which has been successfully applied for on-line experiments. Details of this and the future steps in the RILIS upgrade will be presented.