The first International African Symposium on Exotic Nuclei IASEN2013

Report of Contributions

Contribution ID: **0** Type: **Oral**

PreSPEC-AGATA nuclear structure studies using radioactive isotope beams

Monday, 2 December 2013 12:05 (25 minutes)

The new PreSPEC-AGATA project is aimed at nuclear structure and reaction studies using radioactive isotope beams. At the SIS/FRS facility at GSI exotic beams at relativistic energies were employed for Coulomb excitation and secondary fragmentation experiments. High-resolution gamma-ray spectroscopy is the main tool to investigate the shell evolution far off stability, proton-neutron interaction, symmetries and nuclear shapes. Compared to the former RISING set-up an advanced particle (LYCCA) and gamma-ray (AGATA) detection system are used. At the future FAIR facility, these tools will be employed by the High-resolution In-flight SPECtroscopy (HISPEC) project. The improvements in the experimental set-ups, together with the opportunities to be opened, are discussed. The latest experimental results from the campaign in 2012 will be presented.

Notes

on behalf of the PreSPEC-AGATA collaboration

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Presenter: Dr WOLLERSHEIM, Hans-Jürgen (GSI Helmholtzzentrum)

Session Classification: Structure Session II

Contribution ID: **1** Type: **Poster**

Elastic and inelastic scattering of 4He on 9Be: excited states and nucleon transfers

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Angular distributions of the 4He+Be elastic and inelastic scattering were measured at the energy Elab=63MeV, delivering by the K130 Cyclotron of the Jyväskylä University.
Angular dependences of the differential cross sections for the 4He(9Be,9Be*)4He, 4He(9Be,10Be)3He and 4He(9Be,10B)3H have been measured to get potential parameters.
Adding of second valence neutron or proton to the 9Be nucleus leads to the production of nuclei 10Be and 10B. As an example, differential cross sections versus angle for the ground states for 10Be and 10B are given in Figure. Results of the present experiment are shown by solid symbols and data from [1] are presented by the open symbols.

Fig. Differential cross sections of the ground states of 10Be and 10B.
These reactions were used as an effective method to study the both internal cluster structures and isobar analog states for 10Be and 10B, as members of Jp=0+, T=1 multiplet. Experimental angular distributions for ground and for a few first excited states were analyzed with the frame of the optical model and distorted-wave theory DWUCK5 [2].
An attempt to extract spectroscopic factors was performed.

1. M.N. Harakeh et al. Nucl. Phys. A344 (1980), p.14-40.
2. http://nrv.jinr.ru/

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Contribution ID: **3** Type: **Oral**

Local suppression of collectivity in the N=80 isotones at the Z=58 subshell closure

Thursday, 5 December 2013 15:15 (20 minutes)

Recent data on transition strengths, namely the hitherto unknown B(E2) values of radioactive Nd-140 and Sm-142 in the N=80 isotones, have suggested that the proton 1g7/2 subshell closure at Z=58 has an impact on the properties of low-lying collective states [1,2].
The unstable, neutron-rich nuclei Nd-140 and Sm-142 were investigated via projectile Coulomb excitation at the REX-ISOLDE facility at CERN with the high-purity Germanium detector array MINIBALL. The measurements demonstrate that the reduced collectivity of Ce-138 is a local effect possibly due to the Z=58 subshell closure and requests refined theoretical calculations. The latter predict a smoothly increasing trend [3,4].

[1] C. Bauer et al., submitted to Phys. Rev. C (2013)
[2] G. Rainovski et al., Phys. Rev. Lett. 96 (2006) 122501
[3] D. Bianco et al., Phys. Rev. C 85 (2012) 034332
[4] Ch. Stoyanov, private communication

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Session Classification: Nuclear Physics: Parallel Session I

Contribution ID: **4** Type: **Oral**

Isomers and enhanced stability of the heaviest elements

Thursday, 5 December 2013 10:00 (25 minutes)

Deformed, axially-symmetric nuclei in the trans-fermium region are known to exhibit high-K isomerism, because of the presence of high-Ω orbitals near both the proton and neutron Fermi surfaces. The properties of such isomers provide important information on the single-particle structures and on the role played by the pairing, and residual nucleon-nucleon interactions in the region. It is also believed that the existence of high-K states at relatively low excitation energies could lead to an enhanced stability of the super-heavy elements. However, the knowledge is very limited owing to the paucity of experimental data.

A number of experiments in Fm, No and Rf nuclei near the N=152 sub-shell closure, aimed at the discovery of isomeric states and elucidation of their properties, were carried out at Argonne using the Fragment Mass Analyzer.
Recently, a digital data acquisition system was deployed, which allowed comprehensive pulse-shape analysis of the recoil-decay pile-up events to be performed and identification of implant and decay events separated by decay times as short as hundreds of nanoseconds. Furthermore, this novel approach resulted in a much lower ∼50-keV threshold for conversion-electron events, associated with decays of isomeric states within the first 6 μs following implantation, independent from the energy threshold set in the digitizer firmware.
Data from those experiments will be presented and the results will be discussed in comparison with predictions from multi-quasiparticle blocking calculations that include empirical estimates for the configuration-dependent residual interactions.

This work was supported by the U.S. Department of Energy, Office of Nuclear Physics, under Contract No. DE-AC02-06CH11357.

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Session Classification: Super-Heavy Elements Session

Contribution ID: **5** Type: **Oral**

Investigations of shape conundra using Coulomb-excitation measurements at RIB facilities

Monday, 2 December 2013 12:30 (25 minutes)

The highly-efficient and segmented TIGRESS gamma-ray spectrometer at TRIUMF has been used to perform a reorientation-effect Coulomb-excitation study of the first 2+ state at 3.368 MeV in 10Be. This is the first Coulomb-excitation measurement that enables one to obtain information on diagonal matrix elements for such a high-lying first excited state from gamma-ray data. With the availability of accurate lifetime data, a value of -0.110(0.087) eb is determined for the diagonal matrix element, which assuming the rotor model, leads to a negative spectroscopic quadrupole moment. This negative value is in agreement with timely no-core shell-model calculations performed with the CD-Bonn 2000 two-nucleon potential and large shell-model spaces, and Green's function Monte Carlo predictions with two- plus three-nucleon potentials. This agreement outlines, however, a clear deficiency in our understanding of the spin-orbit interaction. Further reorientation-effect Coulomb-excitation measurements at iThemba LABS and the new RIB facility at CERN, HIE-ISOLDE, will also be discussed.

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Session Classification: Structure Session II

Contribution ID: **6** Type: **Oral**

The ALTO facility for the production of rare nuclei

Monday, 2 December 2013 09:55 (25 minutes)

The ALTO facility (Accélérateur Linéaire et Tandem d'Orsay) at Institut de Physique Nucléaire d'Orsay is ready for operation. The aim of this facility is to provide neutron rich isotope beams for both nuclear physics study (away from the valley of stability) and developments dedicated to next generation facilities such as SPIRAL2. The neutron rich isotopes are produced by photofission of 238U induced by the 50 MeV electrons from the linear accelerator. The isotopes coming out of the fission target effuse towards an ion source to form a beam that is analyzed through the on line separator PARRNe. Additional experimental beam lines have been constructed.A description of the facility as well as the physics program will be presented.

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Session Classification: Structure Session I

Contribution ID: **7** Type: **Poster**

Cluster decay of 208-238Th isotopes

Cluster decay is a kind of radioactivity in which the emitted nuclei are heavier than alpha particle but lighter than the binary fission fragments. This is one of the famous phenomena which have been predicted theoretically before to be confirmed experimentally. This is because this type of decay occurs in nuclei that decay primarily by alpha emission. The branching ratios relative to alpha decay is less than 10-10.
Since cluster decay is an intermediate process between alpha decay and fission, both alpha and fission-like approaches could be used to investigate cluster emission. In the present work, the cluster radioactivity of 208-238Th is studied by using a fission-like model taking interacting potential as the sum of coulomb and proximity potentials. The emission of the particle is considered as a quantum tunneling penetration of the potential barrier in the semi-classical WKB approximation. The released energy is deduced from the new table of atomic mass evaluation (AME12) and from the Finite Range Droplet Model. The obtained decay half-lives are compared with the few available experimental values and those of other models. The effect of the multipole deformation and orientation of nuclei on the half-life is discussed.

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Contribution ID: **8** Type: **Poster**

Neutrons transfers and fusion in reactions with halo nucleus 6He

The probabilities p of the external neutron transfer of 6He and 18O nuclei at different energies of the neutron separation ε, energies in a center of mass system E and collision impact parameter b were calculated via a numerical solution to the nonstation ary Schrödinger equations [1]. An analytical approximation of the probability was found and used to calculate the cross section for formation of the 198Au isotope in the 6He + 197Au reaction. The calculation results agree satisfactorily with the experimental data [2] for energies near the Coulomb barrier.

REFERENCES

1. Samarin, V.V. and Samarin, K.V., Bull. Russ. Acad. Sci. Phys., 2012, vol. 76, no. 7, p. 450.
2. Kulko, A.A., et al., J. Phys. G: Nucl. Part. Phys., 2007, vol. 34, p. 2297.

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Contribution ID: **9** Type: **Poster**

Collective modes of the dinuclear systems at low energy reactions in the vicinity of the coulomb barrier height

At low energy reactions in the vicinity of the coulomb barrier height colliding nuclei may have dynamical deformations. Vibrations of the surfaces of nuclei, occurring within the range of nuclear forces over the colliding time commensurate with the period of vibrations, cannot be independent. The energies of excited stationary vibrational states of a dinuclear system that correspond to deformations of nuclear surfaces along the axis connecting the centers of these nuclei and the wave functions for these states were calculated by solving of the multidimensional Schrodinger equation [1]. We would like to highlight the two most important properties of excited phonons. First, the spacings between di-nuclear vibrational levels depend on R; therefore, the excitation energies in the barrier region are in general different from respective excitation energies in isolated nuclei. Second, the curves representing vibration energies feature avoided-crossing segments within which excited vibrational states involve combinations of several modes and differ substantially from vibrations in isolated nuclei. A physical interpretation of the fine structure of the barrier distribution D(E) [2,3] was given on the basis of a system of effective potential barriers and the population of excited vibration and rotation states.

REFERENCES

1.V.V. Samarin, Phys. of Atom. Nucl., 72, 1682 (2009)
2. H. Timmers et al., Nucl. Phys. A 633, 421 (1998).
3. T. Rumin et al., Phys. Rev. C 61, 014605 (2000).

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Contribution ID: **10** Type: **Poster**

RBS and PIXE study of photocatalytic track-etched membranes

During the last decade extra attention has been placed on methods of reagent less water purification based on applications of advanced oxidation processes (AOPs). Especially when using photocatalytic materials both consolidated or in suspension. Composite membrane-photocatalyst systems aim to mineralize organic substances absorbed on the membrane surface during water filtration.
In this study track etched membranes (TMs) were modified by reactively sputtering a thin film of titanium dioxide (TiO2) over the TM surface. In order to protect the TM's surface against photocatalytic oxidation a protective layer of silver (Ag) was thermally evaporated over the TM surface pre-sputter.
After investigating the resulting composite TMs, it was established that the subsequent TiO2 films had crystal structures similar to that of brookite [210] and [111].
Based on the optical properties of the system the band gaps of the composite membranes were calculated to be 3.05 eV for TiO2-TMs and 2.76 eV for Ag-TiO2-TMs respectively, the improved band gap of the Ag-TiO2 owing to the electron doping effect of the added Ag to the semiconductor.
Under the influence of UV irradiation the composite TiO2 thin films gained "super-hydrophilic" properties. By studying the kinetics of change of the water contact angle under UV radiation, it was found that after an hour the contact angle decreases to 0° and the composite TM surface becomes completely hydrophilic.
The culmination of all this research regarding these multifunctional TMs resulted in their "low-absorptive", "low-fouling", "super-hydrophilic", "self-cleaning" surface property development. These composite TMs are a prospective material for future water treatment processes.
Taking into account the current high interest in creation of applied photocatalytic technology it was decided to investigate deeper into the structural properties of these composite photocatalytic layers by nuclear analytical methods.
The modified TM in this study underwent two very different sequential deposition processes. Through Proton Induced X-ray Emission (PIXE) it was confirmed that both layers were still present after sputtering as well as homogeneous. Due to PIXEs sensitivity to elemental presence it was possible to detect any trace elemental contamination, thereby refining the deposition process.
After extracting the composition profile from the Rutherford Backscattering (RBS) data and simulating those depth profiles in RUMP and SIMNRA, the elemental layer thickness could be determined from the number of atoms per unit area of the film. The RBS spectra indicated that the films were homogeneous along depth. However, an interesting phenomenon was discovered, namely, the formation of interfacial layers within the composite TMs.
Work is performed with partial support of the Ministry of Education and Science of the Russian Federation, the State contract No. 14.513.11.0063, in collaboration with Stellenbosch University, University of the Western Cape, NRF, JINR and iThemba Labs.

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Contribution ID: **11** Type: **Oral**

SHELS - Separator for Heavy ELement Spectroscopy. First results.

Thursday, 5 December 2013 15:35 (20 minutes)

In the past, various types of reactions and identification techniques were applied in the investigation of formation cross sections and decay properties of transuranium elements. The fusion - evaporation reactions with heavy targets, recoil - separation techniques and identification of nuclei by the parent – daughter generic coincidences with the known daughter-nuclei after implantation into position - sensitive detectors were the most successful tools for production and identification of the heaviest elements known presently. This technique may be further improved and presently it may be very promising for the identification of new elements, search for new isotopes and measurement of new decay data for the known nuclei.
Within the past 15 years, the recoil separator VASSILISSA [1] has been used for the investigations of evaporation residues (ERs) produced in heavy ion induced complete fusion reactions. In the course of the experimental work a bulk of data on ERs formation cross sections, synthesized in asymmetric reactions was collected.
With γ and β detector arrays, installed at the focal plane of the VASSILISSA separator, detailed spectroscopy of Fm – Lr isotopes was performed during last 5 years.
In the years 2004 – 2010 using the GABRIELA (Gamma Alpha Beta Recoil Invetsigations with the ELectromagnetic Analyser) set-up [2] the experiments aimed to the gamma and electron spectroscopy of the transfermium isotopes, formed at the complete fusion reactions with accelerated heavy ions were performed. Isotopes of No and Lr were studied. The experiments with high intensity 22Ne beam showed, that for slow evaporation residues rather high (~ 10 %) transmission efficiency need to be obtained. In this case for α – γ and α – β coincidences used in the study of the isotopes of 104 and 105 elements good statistics could be obtained during one month of the experiment.
Accumulated experience allowed us to perform ion optical calculations and to design the new experimental set up, which will collect the base and best parameters of the existing separators and complex detector systems used at the focal planes of these installations [3].
New experimental set up (SHELS, the velocity filter) on the basis of existing VASSILISSA separator was developed for synthesis and studies of the decay properties of heavy nuclei. In May - July 2013 first test experiments were performed. At the focal plane of the separator GABRIELA set up (α, β, γ detectors array) was installed.

[1] A. Yeremin et, al,. Phys. At. Nucl., 66 (2003) 1042 - 1052
[2] K. Hauschild et. al., Nucl. Instr. and Meth., A560 (2006) 388-394
[3] A. Yeremin et. al., Nucl. Instr. and Meth., B266 (2008) 4137-4142

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Presenter: Dr POPEKO, Andrey (Joint Institute for Nuclear Reserach)

Session Classification: Nuclear Physics: Parallel Session II

Contribution ID: **14** Type: **Oral**

Super-heavy element and other exotic nuclei research at LLNL

Thursday, 5 December 2013 09:35 (25 minutes)

The experimental nuclear physics group at LLNL is actively investigating exotic nuclei in a variety of regions of the chart of nuclides – from light nuclei to super heavy elements. The experimental nuclear physics effort at LLNL is centered on investigating nuclei at the extremes—in particular, extremes of spin, isospin, neutron richness, excitation energy, decay and detectability, mass, and stability. This talk will focus on recent heavy and super heavy element experiments including nuclear structure investigations of the heaviest nuclei. Other areas of research, including radioactive ion beam experiments, trapping experiments, nuclear decay spectroscopy experiments, and rare decay searches, will be discussed as time permits. Recent experimental results on studies of exotic nuclei by scientists at LLNL will be presented.

This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344.

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Session Classification: Super-Heavy Elements Session

Contribution ID: **15** Type: **Oral**

Roles of nuclear weak processes in stars

Friday, 6 December 2013 09:40 (25 minutes)

Roles of nuclear weak processes in nucleosynthesis in stars and star evoultions are discussed based on recent studies on nuclear structure of both stable and unstable nuclei.
New neutrino-nucleus reaction cross sections are evaluated by using new shell-model Hamiltonians, which have proper tensor interactions and explain well the shell evolutions (change of magic numbers) toward drip-lines and spin properties of nuclei [1,2,3]. Results on ^{12}C, ^{13}C, ^{56}Fe, ^{56}Ni and ^{40}Ar are presented, and applications to element synthesis by neutrino-processes in core-collapse supernova explosions are discussed [4,5,6,7]. Effects of ν oscillations are also duscussed [8].
Electron capture and β-decay rates in stellar environments with high densities and high temperatures are evaluated by shell-model calculations for sd-shell and pf-shell nuclei
We show that an improved evaluation of e-capture rates in Ni isotopes has been obtained [9] by a new Hamiltonian, GXPF1J, which can reproduce recent experimental data of GT strength in ^{56}Ni [10].
The rates for URCA nuclear pairs in sd-shell are evaluated with USDB [11]. They are shown to provide clearly the URCA densities for A=23 and 25 and cooling of core temperatures of stars with mass 8-10 $M_{\odot}$ [12].
Finally, β-decay rates for waiting-point nuclei with N =126 are evaluated by including both the Gamow-Teller and first-forbidden transitions [9]. Possible effects on r-process nucleosymthesis at A$\sim$195 are discussed.

[1] T. Suzuki, R. Fujimoto and T. Otsuka, Phys. Rev. C 67, 044302 (2003).
[2] T. Otsuka, T. Suzuki, R. Fujimoto, H. Grawe and Y. Akaishi, Phys. Rev. Lett. 95, 232502 (2005).
[3] T. Otsuka, T. Suzuki, H. Honma, Y. Utsuno, N. Tsunoda, K. Tsukiyama and M. Hjorth-Jensen, Phys. Rev. Lett. 104, 012501 (2010).
[4] T. Suzuki, S. Chiba, T. Yoshida, T. Kajino and T. Otsuka, Phys. Rev. C 74, 034307 (2006).
[5] T. Suzuki, A. B. Balantekin and T. Kajino, Phys. Rev. C 86, 015502 (2012).
[6] T. Suzuki, M. Honma, K. Higashiyama, T. Yoshida, T. Kajino, T. Otsuka, H. Umeda and K. Nomoto, Phys. Rev. C 79, 061603 (2009).
[7] T. Suzuki and M. Honma, Phys. Rev. C 87, 014607 (2013).
[8] T. Suzuki and T. Kajino, J. Phys. G: Nucl. Part. Phys. 40, 083101 (2013).
[9] T. Suzuki, M. Honma, H. Mao, T. Otsuka and T. Kajino, Phys. Rev. C 83, 044619 (2011).
[10] M. Sasano et al., Phys. Rev. Lett. 107, 202501 (2012).
[11] T. B. A. Brown and W. A. Richter, Phys. Rev. C 74, 034315 (2006); W. A. Richter, S. Mkhize and B. A. Brown, ibid. 78, 064302 (2008).
[12] H. Toki, T. Suzuk, K. Nomoto, S. Jones and R. Hirschi, Phys. Rev. C 88, 015806 (2013); S. Jones et al., Astrophys. J. 772, 150 (2913).
[13] T. Suzuki, T. Yoshida, T. Kajino and T. Otsuka, Phys. Rev. C 85, 015802 (2012).

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Session Classification: Astrophysics Session

Contribution ID: **16** Type: **Oral**

Study of nuclear clustering and cluster decay using the modern shell model approach

Thursday, 5 December 2013 15:55 (20 minutes)

Multi-particle correlations are important in nuclear clustering, alpha decays, multi-particle transfer reactions and in other aspects of nuclear dynamics. In this presentation we use the modern configuration-interaction approach to study these questions. Using algebraic models and some of the most advanced realistic shell model Hamiltonians, we explore the alpha spectroscopic factors for low-lying states, study the distribution of clustering strength, and discuss the structure of an effective 4-body operator describing the in-medium alpha dynamics in the multi-shell valence configuration space. Sensitivity of alpha clustering to the components of an effective Hamiltonian, which includes its collective and many-body components, will be discussed. We compare our results with the experimentally available data on alpha decay and cluster-transfer reactions.

Notes

Support from the U.S. Department of Energy under contract number DE-SC0009883 is acknowledged.

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Presenter: Dr VOLYA, Alexander (Florida State University)

Session Classification: Nuclear Physics: Parallel Session II

Contribution ID: **17** Type: **Oral**

Electron shell and alpha-decay

Monday, 2 December 2013 14:55 (25 minutes)

The influence of the electronic surrounding (the electron shell of an atom or an ion and the electron gas in solids) on the alpha-decay width is analyzed. Both decreasing of the penetrability of the potential barrier due to nonzero electron density in the internal (relatively to the outer turning point) area and the change of the outer boundary conditions on the resonance solution (reflection of the alpha-particle wave in the classically-allowed area) were taken into account. The latter effect is a consequence of the fact that the Coulomb parameter η of the asymptotic resonance wave function G(ρ) + iF(ρ) where G(ρ) and F(ρ) are irregular and regular Coulomb wave functions is determined by the potential acting between the alpha-particle and the residual system (a nucleus + electrons) and thus is not coincide with the alpha-nucleus Coulomb parameter η'. The Hartree-Fock-Dirac atomic wave function is used for the description of the density of the electron shell. The numerical integration of the radial Schrödinger equation was performed directly by means of the Runge-Kutta and (for the reliability of the solution which is frequently-oscillating in very long interval of variation of the argument ρ) by the Stoermer methods. Equivalent results are obtained by these two approaches. The relationship between the sub-barrier amplitude of the resonance wave function and the alpha-decay width Γ presented in [1] is used for evaluation of the effect.
The effect turns out to be not so great. As an example the relative difference between the alpha-decay widths of the bare nucleus of 232Th and the Th atom turns out to be equal to 1.0 percent. Our calculations demonstrate that the relativistic effect manifesting itself in the motion of the electrons of inner shells makes a significant contribution to the effect. The effect decreases slightly with increasing of the alpha-particle energy.

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1. S.G.Kadmensky, W.I.Furman // Alpha-decay and related nuclear reactions. M.: Energoatomizdat.
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Session Classification: Cluster Session

Contribution ID: **18** Type: **Poster**

Long-range plans with radioactive ion beams at Dubna

The new project of the in-flight fragment separator ACCULINNA-2 [1] at U-400M cyclotron in Flerov Laboratory of Nuclear Reaction, JINR is proposed as the third generation of the Dubna Radioactive Ions Beams complex, briefly DRIBs [2]. It is expected to be a more universal and powerful instrument in comparison with existing separator ACCULINNA [3]. The RIBs intensity should be increased by factor 15 (factor 6 - via angular acceptance and factor 2.5 – via more intensive primary beams of upgraded cyclotron), the beam quality greatly improved and the range of the accessible secondary radioactive beams broadened up to Z~20. The new separator will provide high intensity RIBs in the lowest and wide energy range attainable for in-flight separators, i.e. E ≈ 5÷50 MeV/nucleon. The prime objectives of ACCULINNA-2 are to provide good energy resolution and high efficiency for correlation measurements. Extensive research program which could be carried out at this facility as from 2015 and its operating principle are foreseen.

1. A.S. Fomichev et al., JINR Communication E13-2008-168, Dubna (2008)
2. http://159.93.28.88/flnr/dribs.html; http://159.93.28.88/dribs/publ.html
3. A.M. Rodin et al., Nucl. Instr. and Meth. B 204 (2003) 114-118; http://aculina.jinr.ru/

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Contribution ID: **19** Type: **Oral**

Coulomb breakup of 31Ne within the finite range DWBA

Coulomb breakup of nuclei away from the valley of stability have been one of the most successful probes to unravel their structure. However, it is only recently that one is venturing into medium mass nuclei like 23O and 31Ne. This is a very new and exciting development which has expanded the field of light exotic nuclei to the deformed medium mass region.
In this contribution we report an extension of the previously proposed [1, 2] theory of Coulomb breakup within the post-form finite range distorted wave Born approximation to include deformation of the projectile. The electromagnetic interaction between the fragments and the target nucleus is included to all orders and the breakup contributions from the entire non-resonant continuum corresponding to all the multipoles and the relative orbital angular momenta between the fragments are taken into account. Only the full ground state wave function of the deformation projectile, of any orbital angular momentum configuration, enters in this theory as input, thereby making it is free from the uncertainties associated with the multipole strength distributions that may exist in many of the other theories.

We shall present the one neutron removal cross section and other reaction observables in the Coulomb breakup of 31Ne on heavy targets at 234 MeV/nucleon beam energy and we will also compare our results with the recent experimental data [3]. The effect of deformation on various reaction observables will be studied.

References

[1] R. Chatterjee, P. Banerjee and R. Shyam, Nucl. Phys. A 675, 477 (2000).
[2] R. Chatterjee, R. Shyam, K. Tsushima, A. W. Thomas, Nucl. Phys. A 913, 116 (2013).
[3] T. Nakamura et al., Phys. Rev. Lett. 103, 262501 (2009).

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Contribution ID: **20** Type: **Poster**

Interpretation and prediction of nuclear experimental results by the data-containing codes

One of the trends in modeling of rare isotopes production is the creation and the development of codes which, on the one hand, realize various standard theoretical approaches of the reactions producing exotic nuclei and, on the other hand, contains a large bulk of nuclear data. This development follows the direction of higher capability of the programs and, in addition, makes these codes user-friendly step by step.
Typical examples of such codes namely EMPIRE and TALYS are discussed. The results of the calculations of the reaction cross sections and isomeric ratios are presented for illustration.
It is shown that in the most cases the programs are capable to describe a complete set of reaction data and thus the results of the calculations may be considered as a reasonable predictions of yields of rare nuclides.

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Contribution ID: **21** Type: **Poster**

Octupole excitation in uranium isotopes

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The nuclei 230U and 232U have been studied using the AFRODITE array together with a recoil detector. A comprehensive set of in-band E2 transitions were observed in the lowest lying negative-parity band of 232U while two new E2 transitions were observed for 230U. These allowed ratios to be extracted and compared with systematics in the actinide region. The values are similar to those of their Th and Ra isotones. Therefore these results contradict the tetrahedral prediction in the actinide region.

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Contribution ID: **22** Type: **Poster**

Two-neutron-transfer to 178Yb and population of 178m2Hf via incomplete fusion

The DIAMANT light-charged-particle detector from ATOMKI has been coupled with the AFRODITE gamma-ray spectrometer at iThemba LABS in a collaboration enabled by a bilateral agreement between the governments of South Africa and Hungary. This has facilitated the study of incomplete fusion reactions in the bombardment of a Ytterbium-176 target with a beam of 50 MeV Lithium-7 ions. The beam was generated as a collaborative effort between ion source experts at iThemba LABS and the Flerov Laboratory for Nuclear Reactions (FLNR) of the Joint Institute for Nuclear Reactions (JINR), Dubna under an ongoing intergovernmental agreement, enabling a Tri-Partite Alliance to be formed between experimentalists from the respective institutions in the three countries.

Particle-Identification (PID) spectra from DIAMANT generated from the ATOMKI custom-built VXI electronics clearly show the detection of protons, tritons and alpha particles, which, when gated on, allowed the selection of gamma-ray coincidences detected with AFRODITE when the respective complementary Helium-6, Helium-4 (α) and triton fragments fused with the target.

Analysis of the charged-particle-selected gamma-ray coincidence data enabled the identification of Hafnium-180 in the proton-gated Eγ-Eγ correlation matrix, as well as Hafnium-178, including the band based on the T1/2=31a K⊠ = 16+ four-quasiparticle state. Hafnium-178 is also evident in the triton-gated matrix, which suggests that this nucleus is populated via two incomplete fusion channels, this one in which the fused fragment is Helium-4, and the other in which a Helium-6 neutron-rich fragment fuses with the Ytterbium-176 target.

The relative contribution from the (7Li,p4n) fusion evaporation channel is at present unclear, but there is other evidence for Helium-6-induced reactions in the population of neutron-rich Ytterbium-178 whereby two neutrons have been transferred to the target. The ground-state band of Ytterbium-178 can be clearly observed in both the proton-gated and alpha-gated matrices, which is consistent with the 176Yb(7Li, αp)178Yb reaction. The deuteron yield is comparatively weak which has hampered the unambiguous confirmation of the 176Yb(7Li, αd)177Yb reaction, though analysis is still in progress.

The comparatively strong population of Hafnium-178 via the two reaction channels discussed above has allowed the population ratio Iγ(proton-gated)/ Iγ(triton-gated) of the ground-state, two-quasiparticle K^pi = 8- and 4-quasparticle K^pi = 14- and K^pi = 16+ bands to be extracted as function of spin . There is evidence for a marked increase in relative population of the K^pi = 16+ band when compared to the other lower-spin band structures.

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Contribution ID: **23** Type: **Oral**

Dilute excited states in light nuclei

Thursday, 5 December 2013 16:15 (20 minutes)

The results of measuring the radii of some excited states of light nuclei are presented. A method based on the analysis the diffraction patterns of the cross-section (Modified diffraction model MDM) was proposed. We studied the inelastic α-scattering on 9Be, 11B, 12C and 13C with the excitation of some excited states whose structure recently attracted a lot of attention from different theoretical investigations. The evidence that the famous Hoyle state (0+, 7.65 MeV) in 12C has the enhanced dimensions and is the head of a rotational band (besides the band based on the ground state) was obtained. The radius of the second 2+ member state (E*= 9.8 or 9.6 MeV) occurred to be similar to that of the Hoyle state (~3.0 fm). A 4+ state was identified at E* = 13.75 MeV. The radii of the 8.86 MeV, 1/2- state in 13C and 8.56 MeV, 3/2- state in 11B occurred to be close to that of the Hoyle state and these states can be considered as analogues of the latter. Comparison of the data with the predictions of such theoretical models as alpha condensation (AC) and antisymmetrized molecular dynamics (AMD) has been done. Though some of the predictions of AC (e.g., the probability of the L = 0 component of alpha clusters in the Hoyle state) are close to the experiment most of the data disagree with them and one may speak only about rudimentary manifestation of the condensate effects.
A neutron halo was observed in the excited 3.09 MeV, 1/2+ state of 13C and in the 1.68 MeV, 1/2+ state of 9Be. The data obtained from the inelastic scattering were confirmed by the analysis of the asymptotic normalization coefficients extracted from the 12C(d,p)13C reaction.

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Session Classification: Nuclear Physics: Parallel Session I

Contribution ID: **24** Type: **Oral**

Spectroscopy of very heavy elements at and beyond the limits

Thursday, 5 December 2013 10:25 (25 minutes)

Limits for spectroscopy of heavy elements were pushed down to 10 nb level with tagged prompt spectroscopy of 246Fm. The developments done within this collaboration to enable this experiment opened the way for prompt gamma-ray spectroscopy of Super Heavy Elements (SHE). In parallel we developed synthesis of a new isotopic MIVOC compound at IPHC Strasbourg that was successfully accelerated in the cyclotron of Jyväskylä University (JYFL, Finland) and has been prepared also for GANIL Caen (France) and FLNR Dubna (Russia).
Availability of intense 50Ti beam permitted to step in the SHE region with the first prompt detailed gamma spectroscopy of 256Rf (Z=104) using the state-of-the-art gamma-ray spectroscopic techniques with the association of JUROGAM II, RITU and GREAT at the University of Jyväskylä. Ground states rotational structure observed for the first time in these two nuclei will be presented and compared to those of selected neighboring nuclei. The kinematic and dynamic moments of inertia deduced form these data will be discussed.
Focal-plane spectroscopy revealed in Very Heavy Elements (VHE) interesting high-K structures, providing anchor points for contemporary nuclear models in this mass region. A dedicated part of this contribution will shed light on recent result in high-K structures in this mass region. Their sensitivity to the underlying single-particle content is a useful tool to provide strong experimental anchor points for nuclear models in this mass region.
Focal plane spectroscopy has also the strong advantages to permit delayed alpha, gamma and electron coincidences and to have lower cross-section detection limit. The future Super Spectrometer Separator S3, developed in the SPIRAL2 framework, is built to take the best advantages of the high selecting power of a two stages recoil separation system associated to the high beam intensities that will be made available by the new linear accelerator LINAC. After a presentation of the SIRIUS focal plane detection system developed for S3, perspectives for future spectroscopic studies of VHE and SHE will be discussed in a last part of the presentation.

Notes

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Session Classification: Super-Heavy Elements Session

Contribution ID: **25** Type: **Oral**

Two-nucleon transfer reactions and implications for studies of unstable nuclei

Wednesday, 4 December 2013 10:25 (25 minutes)

Two-nucleon transfer, such as (p,t) and (p,3He) reactions on stable nuclei, was studied extensively in the past, thereby successfully revealing crucial properties of stable nuclei. For unstable target systems this type of reaction also promises to be especially useful. However, a theoretical description of the reaction in terms of the distorted-wave Born approximation suffers from several problems. A disconcerting problem is the issue of direct, simultaneous transfer in competition with sequential transfer. At best, the existing understanding in terms of two opposing viewpoints could be described as controversial. Clearly, conclusions drawn from studies in which the reaction mechanism is not adequately understood should be treated with caution.

Current knowledge regarding two-nucleon pickup will be reviewed, and new experimental studies, which hold promise of clarifying the nature of the reaction mechanism, will be discussed.

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Session Classification: Reaction Session

Contribution ID: **26** Type: **Poster**

Population of strongly deformed nuclear states within cluster approach

Using the cluster model, the population of the yrast superdeformed states of ^{152}Dy nucleus treated as dinuclear configuration is described. The excitation functions for the production of the superdeformed states in the different asymmetric and almost symmetric reactions are calculated and analyzed. The dependencies of the relative intensities of $E2$-transitions between the rotational states of superdeformed band of ^{152}Dy on de-excitation channels, charge asymmetry of the entrance channel, and beam energy are established. The calculated results are compared with the available experimental data. Using the same appoach, we analyze the possible formation and experimental observation of hyperdeformed states in the entrance channel of heavy ion reactions.

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Contribution ID: **27** Type: **Oral**

Neutron knockout on beams of Sn-106,108 and Cd-106

Wednesday, 4 December 2013 10:00 (25 minutes)

Characterizing the nature of single-particle states outside of double shell closures is essential to a fundamental understanding of nuclear structure. This is especially true for those doubly magic nuclei that lie far from stability and where the shell closures influence nucleosynthetic pathways. The region around Sn-100 is one of the most important due to the proximity of the N=Z=50 magic numbers, the proton-drip line, and the end of the rp-process. However, owing to the low production rates, there is a lack of spectroscopic information and no firm spin-parity assignment for isotopes close to Sn-100. Neutron knockout reaction experiments on beams of Sn-106,108 and Cd-106 have been performed at the NSCL. By measuring gamma rays in CAESAR and momentum distributions from reaction residues in the S800, the spin-parity of ground state and first excited state for Sn-105,107 have been found, constituting the first measurement of the spin-parity for odd-mass tin isotopes lighter than Sn-109. The results also show a high degree of mixing in the ground states of the isotopes Sn-106,108 between the d5/2 and g7/2 single particle-states and they are compared to reaction calculations. For the Cd-106 beam single-,double-, and triple-neutron knockout reactions have been observed. For Cd-105 the spin-parity is already known, therefore, the measurement of the momentum distributions of the ground and first excited states of this residue is an important validation of the technique used for the light tin isotopes.

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Session Classification: Reaction Session

Contribution ID: **28** Type: **Oral**

Status of the FLNR DRIBs Project

Monday, 2 December 2013 10:20 (25 minutes)

The goal of the DRIBs project is to provide more possibilities for the effective study of the properties of heavy and light exotic nuclei at the Flerov Laboratory of Nuclear Reactions. In the course of the project, physical tasks will be shared among three specialized accelerators.
The realization of project DRIBs provides for:
 creation of a Superheavy Element Factory,
 modernization of the existing cyclotrons U400 and U400M,
 creation of new generation experimental set-ups.
The DRIBs project should be realized at simultaneous implementation of the SHE research program of the FLNR.
The Superheavy Element Factory will be based on the high-current (A≤ 100, E ≤ 10 MeV•A, I ≤ 10 pμA) universal DC-280 cyclotron. This accelerator is constructed in a new experimental hall equipped according to radiation safety class II. At the SHE Factory, the synthesis and study of properties of superheavy elements, a search for new reactions for the SHE synthesis, and the study of the chemical properties of new elements will be performed. The construction and assembly of the cyclotron magnet have begun.
The U400 cyclotron is used as a stand-alone accelerator for the synthesis and study of nuclear and chemical properties of superheavy elements and as a post-accelerator for the production of exotic nuclei beams. The modernization of the accelerator and its experimental hall is scheduled for 2016–2017. Subsequently, the accelerator will be used for the study of fusion-fission, quasi-fission and multi-nucleon transfer reactions, nuclear spectroscopy of heaviest isotopes, and exotic nuclei structure and reactions.
The modernization of the U400M cyclotron is almost completed. It will operate in stand-alone mode and as a driver accelerator for the study and production of light exotic nuclei.
New experimental set-ups are under development.

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Session Classification: Structure Session I

Contribution ID: **29** Type: **Oral**

GALS – setup for production and study of heavy neutron rich nuclei

Thursday, 5 December 2013 15:15 (20 minutes)

Unexplored area of heavy neutron rich nuclei is very important for nuclear physics investigations and, in particular, for the understanding of astrophysical nucleosynthesis. In this region is the closed neutron shell N=126 located which is the last "waiting point" in the r-process .The half-lives and other characteristics of these nuclei are extremely important for this process and scenario of supernovae explosions. Study of the structural properties of nuclei along the neutron shell N = 126 could also contribute to the present discussion of the quenching of shell gaps in nuclei with large neutron excess.
During the last several years a combined method of separation has been intensively studied and developed based on stopping nuclei in gas and subsequent resonance laser ionization of them. This method was used up to now for separation and study of light exotic nuclei and fission fragments. Such techniques allows one to extract nuclei with a given atomic number, while a separation of the single ionized isotopes over their masses can be done rather easily by a magnetic field.
A new setup, based on these principles and devoted to synthesis and study of new heavy nuclei formed in low energy multi-nucleon transfer reactions is under stage of realization at Flerov lab. JINR. A creation and a launch of this facility will open a new field of research in low-energy heavy-ion physics, and new horizons in the study of unexplored "north-east" area of the nuclear map.

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Session Classification: Nuclear Physics: Parallel Session II

Contribution ID: **30** Type: **Oral**

Beta-decay spectroscopy of N=82 nuclei and the path of the r-process:

Monday, 2 December 2013 16:40 (25 minutes)

The shell structure at N = 82 plays a crucial role for the rapid neutron capture (r-) process. For example, it determines the shape of the large A~130 peak in the solar system abundance pattern and affects the timescale of the r-process as well as the amount of neutrons later available for induced fission. However, below Z = 50 the evolution of the N = 82 gap is still unknown and, therefore, the predictions of neutron separation energies, half-lives, and neutron capture cross sections are uncertain making the location and duration of the r-process still an open question.
Clearly, more experimental data are needed to provide r-process calculations and nuclear models with experimental inputs.
To address this problem we have performed a decay-spectroscopy experiment at the Radioactive Ion Beam Factory (RIBF, RIKEN) in the neutron-rich region below 132Sn. The recent beam development of RIBF, along with the installation of the EURICA γ-ray detector have made this region accessible to decay-spectroscopy experiments.
The nuclei of interest were produced by fission of a 345A MeV 238 U primary beam colliding with a 9Be target. Beam purification was provided by the BigRIPS fragment Separator. The fragments of interest were unambiguously identified and their following β decays were recorded by the WAS3ABi silicon stopper in conjunction with the EURICA germanium array. Implantations were correlated with their subsequent decays on an event-by-event basis allowing for the measurement of half-lives, β-delayed γ rays, and γ rays from implanted microsecond isomers. In particular, about 30 new half-lives have been measured, including the r-process waiting point 128Pd.
In this contribution we will present the experiment and the preliminary results of the data analysis.
The astrophysical implications of these results will also be discussed.

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Session Classification: Rare Processes & Decays

Contribution ID: **31** Type: **Poster**

Strong absorption model for break-up threshold anomaly

The fusion of weakly bound nuclei, both stable and radioactive, has been the subject of renewed interest both in theory and experiment. In the recent years with the advent of acceleration techniques, it has become possible to produce variable in energy, relatively intense beams of weakly bound nuclei in a wide range of N and Z. The use of secondary beams of radioactive nuclei considerably widens the possibilities to investigate the properties of atomic nuclei and nuclear reactions. The difference between tightly bound and weakly bound projectiles in energy-dependent behavior of the optical potential has drawn much attention. In the past, several important characteristics have been utilized to study the difference between tightly bound and weakly bound projectiles. In the present work, a strong absorption model (SAM) has been proposed, to explain the experimental results for different systems with stable and weakly bound nuclei. This model is based on the idea that the nuclei have relatively sharp edges and that any contact between two colliding nuclei inevitably leads to the removal of flux from the elastic channel through the occurrence of inelastic scattering and other reaction channels. The strong absorbing radius that comes from this SAM is an important characteristic to explain reactions with various projectile systems. Bigger the value of strong absorbing radius, smaller will be the Coulomb force range that relate to the Coulomb barrier. This can be used to explain the phenomena of break-up threshold anomaly (BTA).

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Contribution ID: **32** Type: **Oral**

The subtleties of pairing and collective structures in deformed nuclei

Thursday, 5 December 2013 14:10 (25 minutes)

It is well known that simple monopole pairing is a pretty crude approximation. It can account for the observations that the ground states of all even-even nuclei have spin-parity 01+ and that there is a pairing gap above the ground state in deformed nuclei before particle-hole (p-h) configurations can be excited. As an approximation it is best for proton and neutron mid-shell nuclei where the available single particle Nilsson wavefunctions have large overlaps. However at the beginning of regions of deformation, where high-K orbitals can be bought to the Fermi surface from a lower shell, simple monopole pairing is inadequate in describing the physics of the observed data. This is because the overlap of the wavefunctions is small for low-K deformation driving prolate orbitals and high-K oblate orbitals extruded from a lower shell. This was initially pointed out by Griffin, Jackson and Volkov [1] and used to account for the back-bending frequencies of bands based on high-K orbitals by Jerry Garrett [2].
More recently, with a considerable increase in the quantity and quality of experimental data available, configuration dependent pairing has been used to account for the properties of low-lying first excited 02+ states in N=88 and 90 nuclei at the onset of deformation in the rare earths [3,4]. The properties of 02+ states in these and other nuclei at the start of regions of deformation and the effects blocking of pairing leading a decrease in the back-bending critical frequencies in odd nuclei will be presented.
[1] R. E. Griffin, A. D. Jackson and A. B. Volkov, Phys. Lett. 36B, 281 (1971).
[2] J D Garrett et al., Phys. Lett. B118, 297 (1982).
[3] J F Sharpey-Schafer et al, Eu. Phys. J. A47, 5 (2011).
[4] J F Sharpey-Schafer et al, Eu. Phys. J. A47, 6 (2011).

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Session Classification: Nuclear Physics

Contribution ID: **33** Type: **Oral**

Emission Mössbauer spectroscopy of Mn/Fe implanted III-nitrides

Thursday, 5 December 2013 11:45 (25 minutes)

III-Nitrides doped with 3d metals have attracted much attention since the theoretical prediction that Mn-doped GaN is a potential dilute magnetic semiconductors with high Curie temperatures (Tc ≥ 300 K), resulting from carrier mediated magnetic interactions due to itinerant holes coupling with localized dopant spins. Several reports have shown these materials to exhibit different forms of magnetism, the origin of which is still under debate.
We have undertaken emission 57Fe Mössbauer spectroscopy measurements on GaN, AlN and InN films after implantation of radioactive 57Mn+ ions at ISOLDE/CERN. The samples were held at temperatures between 105−726 K in an implantation chamber and implanted with 57Mn fluences up to 10^12 ions/cm^2. Spectra were collected at gamma emission angles of 0 degrees and 60 degrees relative to the sample's c-axis.
The spectra obtained for GaN and AlN reveal magnetic structure in the 'wings' of the spectra which were analysed using a semi-empirical relaxation model utilizing two Blume-Tjon (BT) sextets. The observed magnetic effect may be explained by a slow spin-lattice relaxation due to paramagnetic substitutional Fe³⁺ weakly coupled to the lattice. The observed spin-relaxation rate closely follows a <i>T</i>² temperature dependence, characteristic of a Raman process. On the other hand, the spectra for InN did not reveal any presence of magnetic features; this could be explained by the absence of high spin Fe³⁺.
The central region of the spectra for all samples showed angular dependence and was initially fitted with two quadrupole split doublets assigned to Fe atoms on substitutional III sublattice (Fe_S) and the majority of Fe located on or near substitutional sites associated with vacancy type defects (Fe_C). In addition, a third quadrupole split doublet (Fe_D) was required to give good fits. The absence of anisotropy on (Fe_D) suggest that this component is due to Fe atoms in isolated amorphous zones.
The annealing behaviour and variation of hyperfine parameters for the fitted spectral components in these materials will be presented.

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Session Classification: Applications Session II

Contribution ID: **34** Type: **Oral**

An overview of emission 57Fe Mössbauer spectroscopy investigations in metal oxides

Wednesday, 4 December 2013 11:45 (25 minutes)

Oxides, in particular ZnO doped with 3d-metal impurities has been of scientific interest since the suggestion that it could be a magnetic semiconductor with applications in spintronics [1]. 57Fe Mössbauer spectroscopy is a powerful method to determine the properties of the probe atoms, giving simultaneously information on the charge/spin state, site symmetry and on magnetic interactions. In this presentation, we report on emission 57Fe Mössbauer spectroscopy measurements following implantation of dilute 57Mn+ ions (<5×1012 cm-2) at ISOLDE/CERN in ZnO, α-Al2O3 and MgO single crystal samples held at temperatures between 77-800 K in an implantation chamber.

The spectra obtained for these materials are characterized by a magnetic structure on the wings of the spectra with the central region dominated by implanted ions occupying a combination of different lattice sites either due to interstitial Fe, substitutional Fe or probe atoms in amorphous surroundings due to the implantation damage. The magnetic hyperfine pattern of the spectra in each oxide is assigned to Fe3 + ions in a paramagnetic state with unusually long relaxation times observable at the highest measured temperatures [2]. This report will focus on a comparison of the derived hyperfine parameters, assigned charge states, extracted spin-lattice relaxation rates and observed annealing stages obtained for these materials. The results obtained from this study will be also compared with data obtained from 57Co and 57Fe implantations.

References

[1] Dietl et al., Science, 287 (2000) 1019
[2] Gunnlaugsson et al., Appl. Phys. Lett., 97 (2010) 142501

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Session Classification: Applications Session I

Contribution ID: **38** Type: **Oral**

Spin and parity dependent level densities in exotic calcium isotopes

Thursday, 5 December 2013 15:35 (20 minutes)

Level densities are fundamental quantities in the description of many-body systems. Besides their importance as a basic nuclear structure property, it is well known that, through the statistical model of nuclear reactions, level densities have a strong impact on the results of calculations of other nuclear physics observables. This is particularly so for thermonuclear rates in nucleosynthesis models, in fission and fusion reactor design, and for the derivation of γ−strength functions from the decay of highly excited nuclei. Experimental information on level densities is largely confined to low excitation energies, where knowledge of the excited states is rather complete, and just above the particle emission thresholds, where resonance spacings can be determined from capture reactions. Theoretical model calculations exist for all ranges of nuclei from the highland of stability up to the most exotic nuclei. Nevertheless, there are no experimental data to corroborate these calculations. With the advent of Radioactive Ion Beams of different intensities, many opportunities will be provided in elucidating this important property experimentally. A long range of exotic calcium isotopes level densities will be investigated.

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Session Classification: Nuclear Physics: Parallel Session I

Contribution ID: **39** Type: **Oral**

Investigation into the effects of deformation on proton emission rates via lifetime measurments

Thursday, 5 December 2013 16:35 (20 minutes)

Proton emission rates are highly sensitive to nuclear deformation but in all known cases the deformation has never been experimentally determined. Currently, tunnelling calculations have to rely on theoretical estimates of quadrupole deformation, a key input parameter, due to the lack of experimentally determined values. In order to address this logical weakness, A new plunger device, DPUNS, has been designed and built at the University of Manchester to measure the lifetimes of unbound states in exotic nuclei approaching the proton drip-line. The measurement of excited-state lifetimes above proton-decaying states yields information on the reduced transition probabilities which in turn can be used, albeit in a model dependent way, to ascertain the degree of deformation in the nuclear system.

The DPUNS device is designed to work in both vacuum and gas environments but will primarily be used in conjunction with the gas filled separator RITU at the University of Jyv¨askyl¨a. Combining DPUNS with JUROGAMII, RITU and the GREAT spectrometer allows the accurate measurement of excited-state lifetimes in exotic nuclei identified via charged-particle tagging.

The presentation will focus on the measurement of excited state lifetimes in the proton-emitting nucleus 151Lu (70 μb) and the impact the results have had on state-of-the-art calculations. Spectroscopic information gained from the observation of isomeric proton decays in this nucleus will also be discussed.

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Presenter: Dr TAYLOR, M J (Schuster Laboratory, University of Manchester, Manchester, UK)

Session Classification: Nuclear Physics: Parallel Session II

Contribution ID: **41** Type: **Poster**

Study of the interaction of 6,7Li with the 28Si nucleus at low energies

This paper presents the results of a joint analysis of the experimental Data: angular distributions (AD) of elastic scattering and reactions total cross sections (σR) of the Interaction of 6,7Li ions with 28Si nuclei at (7.5 – 32) MeV energies. Calculations were carried out in the framework of the deformed optical potential (OP) using SPI-GENOA program.
Calculated values of σR on 28Si reproduce well the experimental trend of a slight decrease with increasing energy of projectile 6,7Li in the energy range E = 15 – 55 MeV/A. In the sub-barrier region for 6,7Li trend sharp decrease of σR with decreasing E-values in the range of 10 MeV/A to sub-barrier energies. However, due to lack of measured data σR at near-barrier energies difficult to estimate how occur they change depending on the energy E and the mechanism of this phenomenon. Therefore, is very relevant – getting experimental σR for reactions (6,7Li + 28Si) at low energies.
We obtained the linear dependence of the OP parameters of energy 6,7Li:
for 6Li+28Si: V=123.4764+0.890165●E; aV=0.73358+0.004429●E; WS=0.37432+0.15244●E; aS=0.73415+0.00451●E; WD=12.4971+0.123044●E; aD=0.84399+0,000850●E.
for 7Li+28Si: V=104.227+2.6557●E; aV=0.6199+0.01741●E; WS=4.5639−0.2121●E; aS=0,41197+0,031086●E; WD=10.482+0.3303●E; aD=0.8123+0.004●E ,
where the values of V, WS, WD and energy E are expressed in MeV, and the diffuseness aV, aS, aD in fm.
Comparison and analysis of the data shows: for (7Li + 28Si) – experimental σR not measured at energies above 30 MeV/A, and for (6Li + 28Si) – at energies above 55 MeV/A. From comparative analysis of trends of experimental σR found: for (6,7Li + 28Si) with increasing energy in the range from 10 to 30 MeV/A are as follows: for 7Li – experimental σR virtually unchanged (stable with σR ≈ 1600 mb), and for 6Li – with increasing energy experimental σR gradually decreased from 1650 mb to 1350 mb.
Note that there are no experimental data of direct measurements of the reactions total cross sections at energies from Coulomb barrier (Bc) to 10 MeV/A – for 6Li, and 15 MeV/A – for 7Li.
This work was supported by the Ministry of Education and Science of the Republic of Kazakhstan in the framework of the Project grant funding (2012–2014 years, grant 378 from 04.02.2013).

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Contribution ID: **44** Type: **Poster**

Clusters, halos and S-factors in fermionic molecular dynamics

Thursday, 5 December 2013 16:15 (20 minutes)

Light nuclei are studied within the Fermionic Molecular Dynamics model. An effective interaction based on the Argonne V18 interaction is used for all nuclei. Short-range central and tensor correlations are treated explicitly using a unitary correlation operator. The evolution of cluster structures and halos with increasing neutron or proton number or excitation energy is discussed. The astrophysical S-factor is calculated for 3He(alpha,gamma)7Be radiative capture reaction in a fully microscopic fashion. Other applications are the Hoyle type states in 12C above the 3 alpha threshold or the two proton halo state in 17Ne.

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Session Classification: Nuclear Physics: Parallel Session II

Contribution ID: **45** Type: **Poster**

A New Interpretation of Cluster Radioactivity Mechanism

The discovery of nuclear molecules [1], double nuclear system and deep inelastic transfer reactions [2, 3] allow a new interpretation to be proposed for the cluster formation mechanism.
It is assumed that nuclei of elements heavier than lead are capable of spontaneously condensing valence nucleons (nucleons above 208Pb) to nuclei of lights elements – clusters. This process results in formation of an asymmetric nuclear molecule, in which both nuclei are in the ground state and interact with each other through the nucleus-nucleus potential. The cluster is formed by successive transfer of valence nucleons to the α-particle, which is formed with a high probability in the surface of the initial nucleus, and further on the light nuclei increasing in mass. Cluster formation is an exoergic process. However, the energy release in this process-Q is below the exit Coulomb barrier and cluster emission (decay of the nuclear molecule) proceeds as a quantum-mechanical process of penetration through the potential barrier.
Realism of the proposed concept of the cluster formation mechanism can be evaluated by considering cluster radioactivity of quite heavy nuclei like 251,252Cf. Within the adiabatic approach [4] to the mechanism of cluster radioactivity the cluster to emit by these nuclei can be the 48Ca nuclei with experimentally measurable half-life. More than twenty years have passed since these adiabatic calculations but so far nobody in the world has observed cluster radioactivity in the 251,252Cf nuclei. Within the proposed approach, emission of the 48Ca cluster from 251,252Cf nuclei is impossible because the process of nucleon transfer from heavy nucleus to the light nucleus will continue after the formation of 48Ca, ending in spontaneous fission of the initial nucleus.

References

[1] E.Almgvist, D.A.Bromley and J.A.Kuehner Phys. Rev. Lett. 1960. V.4. P. 515.

[2] V.V.Volkov Phys.Reports. 1978. V.44. P.93-157.

[3] W.V.Schroder, J.R.Huizenga Treatise on Heavy-Ion Science. Ed. D.A.Bromley. N.Y.; London. 1984. V.2, P.115.

[4] W.Greiner, M.Ivascu, D.N.Poenaru and A.Sandulescu. Treatise on Heavy-Ion Science. Ed. D.A.Bromley. N.Y.; London. 1989. V.8, p.640-722.

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Contribution ID: **46** Type: **Oral**

Production of p-nuclides in photonuclear reactions

Friday, 6 December 2013 12:10 (25 minutes)

A number of naturally present nuclei from 74Se to 196Hg lie far from the stellar s- and r-process' trajectories and their abundances can not be explained by nucleosynthesis in neutron capture reactions. These nuclei are known as p-nuclei and photonuclear reactions are believed to be one of the channels of their production [1]. Existing calculation models can not accurately describe p-nuclei abundances and the lack of experimental measurements on these nuclei is a major limiting factor [2].

Measurements of yields of photonuclear reactions in which the 102Pd, 112,114Sn, 106,108Cd, and 92,94Mo nuclei are produced have been performed at the Skobeltsyn Institute of Nuclear Physics of the Moscow State University in the bremsstrahlung energy range of up to 55 MeV using the activation technique. Experimental results are compared with Hauser-Feshbach statistical model calculations and a significant disagreement is found.

Additional studies with photon energy range from reaction threshold to 10 MeV are currently being performed.

[1] M. Arnould and S. Goriely, Physics Reports 384, 1 (2003).
[2] I. Dillmann et al., Phys. Rev. C 81, 015801 (2010).

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Presenter: Dr STOPANI, Konstantin (Moscow State University, Skobeltsyn Institute of Nuclear Physics)

Session Classification: Resonances Session

Contribution ID: **47** Type: **Oral**

Observation of light shape isomers in the multi-body decay of 252Cf (sf)

Thursday, 5 December 2013 15:55 (20 minutes)

In our previous pablications devoted to the collinear cluster tri-parttition of the low excited nuclei [1, 2] we have discussed the role of scattering medium in the registration of the CCT products. Briefly, even if initially two CCT partners fly in the same direction perfectly collinearly they get some angular divergence after passing the scattering medium on the flight pass due to the multiple scattering. Thanks to such effect they can be registered independently in the "stop" mosaic detector. Actually even thin backing of the radioactive source provides the observable effect. In order to increase it additional absorber (Ti foil) was introduced just after the source at the distance of approximately 1mm. We observe essential mass deficit in the total mass of the fission fragments detected in coincidence with Ti ions knocked out from the foil. It could be expected if the scattered fragment looks like a di-nuclear system destroying due to inelastic scattering on the Ti nucleus. A mean flight time between the Cf source and the foil does not exceed 0.1 ns. It can be regarded as a low limit for the life time of the di-nuclear system (shape-isomer). Possible link of the effect under study and gamma-isomers recently observed in [3] is discussed.

References

1. Yu. V. Pyatkov et al., Eur. Phys. J. A 45 (2010) 29.
2. Yu. V. Pyatkov et al., Eur. Phys. J. A 48 (2012) 94.
3. D. Kameda et al., Phys. Rev. C 86 (2012) 054319.

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Presenter: Prof. PYATKOV, Yuri (JINR, MEPhI)

Session Classification: Nuclear Physics: Parallel Session I

Contribution ID: **48** Type: **Oral**

Exploring exotic nuclei within the MCAS framework

Wednesday, 4 December 2013 09:35 (25 minutes)

The study of exotic nuclei, especially near and beyond the drip lines, is becoming increasingly important with the advent of new facilities, which seek to explore the nuclear landscape well beyond the valley of stability. Theoretical efforts have increased in order to develop realistic models and determine (predict) properties, given that many of the nuclei of relevance may still be inaccessible experimentally. Its direct application to nuclear astrophysics makes this aspect crucial. This talk will describe one method of description of exotic nuclei, that coming from the collective model aspects of the Multi-Channel Algebraic Scattering (MCAS) theory, which has had great success in describing spectra of exotic nuclei. Comparisons with the shell model will be made where possible. Future prospects will be discussed.

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Presenter: Prof. KARATAGLIDIS, Steven (University of Johannesburg)

Session Classification: Reaction Session

Contribution ID: **52** Type: **Oral**

Complete electric and magnetic dipole response of nuclei from zero degree inelastic proton scattering

Friday, 6 December 2013 11:10 (35 minutes)

At RCNP Osaka, Japan, and iThemba LABS, South Africa, new facilities allowing for inelastic proton scattering at energies of a few hundred MeV per nucleon under extreme forward angles including zero degree have been developed. Some highlights of the physics addressed with these systems are presented. For example, they facilitate the measurement of the complete E1 strength from low excitation energies across the GDR and thus the dipole polarizability, which in turn provides information on the neutron skin thickness and parameters of the symmetry energy of neutron matter. Also, the complete spin-M1 resonance in heavy nuclei can be extracted for the first time. Finally, the high energy resolution of the data permits the determination of characteristic scales of the GDR fine structure related to the dominant decay mechanisms, and of level densities in the energy region of the GDR.

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Presenter: Prof. VON NEUMANN-COSEL, Peter (Institut fuer Kernphysik, Technische Universitaet Darmstadt)

Session Classification: Resonances Session

Contribution ID: **53** Type: **Oral**

The role of the atomic nucleus in testing fundamental symmetries: Can we moderate wavefunction related uncertainties?

Monday, 2 December 2013 15:40 (35 minutes)

In this talk I shall focus on some experiments that use the atomic nucleus as a probe to search for and place bounds on interactions that arise from physics beyond the Standard Model. One key aspect in such tests that has been under scrutiny in recent times is the contribution of nuclear structure. While nuclear structure can provide an enhancement of the effects arising from exotic interactions (such as CP violating EDMs), they can also wash out other rare effects, making our understanding of structure-related corrections crucial for such experimental probes. I shall present some experimental results that have recently provided demanding tests of theoretical calculations in a particular mass region and show the repercussions of these investigations in other light nuclei.

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Presenter: Prof. TRIAMBAK, Smarajit (University of Western Cape)

Session Classification: Rare Processes & Decays

Contribution ID: **54** Type: **Oral**

Using LaBr3 detectors for precision lifetimes measurements of excited states of 'interesting' nuclei

Thursday, 5 December 2013 12:10 (25 minutes)

Precision measurements of electromagnetic transition rates provide accurate inputs
into nuclear data evaluations and are also used to test and validate predictions of state of the art nuclear structure models. Measurements of transition rates can be used to ascertain or rule out multipolarity assignments for the measured EM decay, thereby providing spins and parity (difference) information for states between which the EM transition takes place. We report on a variety of precision measurements of electromagnetic transition rates between excited nuclear states using coincidence 'fast-timing' gamma-ray spectroscopy with cerium-doped lanthanum-tribromide (LaBr3(Ce)) detectors. Examples of recent precision measurements using a combined LaBr3-HpGe array based at the tandem van de Graaff accelerator, Bucharest, Romania will be presented addressing nuclear structure issues around the N=20 [1], N=82 [2] using stable-beam induced fusion-evaporation reactions; and the evolution of nuclear deformation around in neutron-rich Hf, W, Os nuclei using 7Li induced light-ion transfer reactions and following beta-decay [3]. The presentation will also discuss the ongoing development of a new multi-detector LaBr3 array for future studies of exotic nuclei produced at the upcoming Facility for Anti-Proton and Ion Research (FAIR) [4] as part of the NUSTAR–DESPEC project and the pre-NUSTAR implementations of detectors from this array to study electromagnetic transition rates in neutron-rich fission fragments at ILL-Grenoble, France and RIBF at RIKEN, Japan.

This work is supported by grants from the Engineering and Physical Sciences Research Council (EPSRC-UK) and the Science and Technology Facilities Council (STFC-UK).

[1] P.J.R.Mason et al., Phys. Rev. C 85, 064303 (2012)
[2] T. Alharbi et al., Phys. Rev. C87, 014323 (2013)
[3] P.J.R.Mason et al., AIP Conf. Procs. 1491, 93 (2012); in press, Phys. Rev. C
[4] P.H. Regan App. Rad. Isotopes 70, 1125 (2012)

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Presenter: Prof. REGAN, Patrick (University of Surrey & The National Physical Laboratory, UK)

Session Classification: Applications Session II

Contribution ID: **55** Type: **Oral**

The Facility for Rare Isotope Beams

Tuesday, 3 December 2013 10:10 (35 minutes)

The next generation radioactive beam facility in the U.S. is the Facility for Rare Isotope Beams (FRIB) which is currently being established at Michigan State University. FRIB is based on a 200 MeV/u 400kW superconducting linear accelerator. Initial capabilities include fragmentation of fast heavy-ion beams combined with gas stopping and reacceleration. The science program of FRIB will cover discoveries about the properties of rare isotopes in order to better understand the physics of nuclei, nuclear astrophysics, fundamental interactions, and applications for society. The final design of the conventional facilities—the tunnel and support buildings—is complete and the final design of the technical systems—accelerator and experimental equipment—is underway and anticipated to be complete in 2014. The present status and future scientific discovery potential of FRIB will be discussed.

FRIB is supported by the U.S. Department of Energy Office of Science under Cooperative Agreement DE-SC0000661.

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Presenter: Prof. THOENNESSEN, Michael (Michigan State University)

Session Classification: Facilities I

Contribution ID: **56** Type: **Oral**

The K600 High Energy-Resolution Zero-Degree Facility at iThemba LABS

Monday, 2 December 2013 14:30 (25 minutes)

The investigation of medium-energy hadronic scattering and reactions at zero degrees
has the advantage of being very selective to excitations with low angular momentum transfer. This simplifies analysis of the many contributions to the spectra due to the complex nature of the nuclear interaction. The addition of coincident particle and gamma detection further enhances the selectivity of such a facility.
This talk will provide an overview of the high energy-resolution K600 zero-degree facility at iThemba LABS. Recent results and future developments of the facility will be discussed.

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Presenter: Dr NEVELING, Retief (iThemba LABS)

Session Classification: Cluster Session

Contribution ID: **57** Type: **Oral**

Emission channeling with short-lived isotopes (EC-SLI) at CERN's ISOLDE facility

Wednesday, 4 December 2013 12:10 (25 minutes)

Emission channeling (EC) relies on implanting single crystals with radioactive probe atoms that decay by the emission of charged particles such as alpha, beta- or beta+ particles or conversion electrons, which, on their way out of the crystal, experience channeling or blocking effects along crystallographic axes and planes. The resulting anisotropic particle emission yield from the crystal depends in a characteristic way on the lattice sites occupied by the emitter atoms and is recorded with the aid of position sensitive detectors. In comparison to conventional lattice location techniques by means of ion beam channeling, e.g. Rutherford Backscattering/Channeling (RBS/C), the main benefits of emission channeling are a roughly four orders of magnitude higher efficiency and the ability to easily study also elements lighter than the host atoms. These facts allow performing detailed lattice location studies with very good statistical accuracy at low fluences of implanted probe atoms, usually as a function of implantation or annealing temperature of the very same sample, which is not feasible by other methods.

In this contribution we will give an overview on the current program for lattice location studies at CERN's ISOLDE on-line isotope separator facility, where the EC-SLI (Emission Channeling with Short-Lived Isotopes) collaboration maintains an on-line setup for this type of experiments. Besides some general features of the technique, recent results will be presented on the lattice location of Mg and Be acceptors in nitride semiconductors using the short-lived probes 27Mg(t1/2=9.45 min) and 11Be(13.8 s), as well as the transition metal probes 56Mn (2.6 h), 59Fe (45 d), 61Co (1.6 h) and 65Ni (2.5 h) in Si and in dilute magnetic semiconductors.

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Presenter: Dr WAHL, Ulrich (IST/ITN, Instituto Superior Tecnico, Universidade de Lisboa)

Session Classification: Applications Session I

Contribution ID: **58** Type: **Oral**

Hyperfine interactions in condensed matter research

Wednesday, 4 December 2013 11:10 (35 minutes)

The hyperfine interactions between the magnetic dipole and electric quadrupole moments of probe nuclei embedded in condensed matter have been utilized for many years to infer information either on the properties of the probe nuclei or of the matrix in which they are located [1]. These hyperfine interactions have led to development of interrogation techniques which allow the study of effects at the atomic level. Mössbauer Spectroscopy methodology has undergone significant development over the recent past, together with different approaches to populate the Mössbauer probe nuclei, as more complex systems have been investigated.

Following a brief review of the principles of application of nuclear moments in materials research, examples will be given of applications in 12B ⊠-NMR and 19F-Time dependent perturbed angular distribution (TDPAD) measurements, and of Mossbauer spectroscopy (MS) utilizing conversion electron Mössbauer spectroscopy (CEMS), MS following Coulomb excitation and emission MS following implantation of radioactive pre-cursors.
The strengths (and shortcomings) of the different approaches will be discussed.

This contribution will set the scene for a more detailed presentation on eMS measurements undertaken at ISOLDE/CERN.

[1] G. Schatz and A. Weidinger, Nuclear Condensed Matter Physics (Wiley, 1995)

Primary author: Prof. BHARUTH-RAM, Krishanlal (University of KwaZulu-Natal)

Presenter: Prof. BHARUTH-RAM, Krishanlal (University of KwaZulu-Natal)

Session Classification: Applications Session I

Contribution ID: **59** Type: **Oral**

Investigating the photon strength function to discrete levels

Friday, 6 December 2013 11:45 (25 minutes)

Over the last decade several measurements in light- and medium-mass nuclei have reported an enhanced ability for the absorption and emission of gamma radiation (photon strength function PSF) at low energies. The impact of this effect may have profound implications on neutron capture reaction rates which are not only responsible for the formation of elements heavier than iron in stellar and supernova environments [1] but are also of central importance for advanced fuel cycles in nuclear reactors [2]. The results were received with significant skepticism by the community mainly due to the lack of any known mechanism responsible for such an effect but also because another established experimental technique failed to confirm the measurement.
Now, a new experimental method which is free of model input and systematic uncertainties has been developed to determine the PSF. It is designed to study statistical feeding from the quasi-continuum (below the particle separation energies) to individual low-lying discrete levels. A key aspect to successfully study gamma decay from the region of high-level density is the detection and extraction of correlated high-resolution particle-gamma-gamma events which is accomplished using an array of Clover HPGe detectors and large area segmented silicon detectors. The excitation energy of the residual nucleus produced in the reaction is inferred from the detected proton energies in the silicon detectors. Gating on gamma-transitions originating from low-lying discrete levels specifies the states fed by statistical gamma-rays. Any particle-gamma-gamma event satisfying these and additional energy sum requirements ensures a clean and unambiguous determination of the initial and final states of the observed gamma rays. With these constraints the statistical feeding to discrete levels is extracted on an event-by-event basis.
In this talk I will review our experimental technique to extract information on the gamma-ray decay from the quasi-continuum and present results for 95Mo [3]. Furthermore, I will discuss ongoing experimental efforts to explore the properties of statistical spectra at stable and radioactive beam facilities.

[1] M. Arnould, S. Goriely and K. Takahashi, Physics Reports 450, 97213 (2007).
[2] M.B. Chadwick et al., Data Nuclear Data Sheets 112, 2887 (2011).
[3] M. Wiedeking et al., Phys. Rev. Lett. 108, 162503 (2012).

Primary author: Dr WIEDEKING, Mathis (iThemba LABS)

Presenter: Dr WIEDEKING, Mathis (iThemba LABS)

Session Classification: Resonances Session

Contribution ID: **60** Type: **Oral**

Studies of light exotic nuclei at ACCULINNA/ACCULINNA-2 facilities

Monday, 2 December 2013 17:05 (25 minutes)

ACCULINNA is in-flight fragment separator based on U-400M cyclotron at Flerov Laboratory of Nuclear Reactions (FLNR, JINR, Dubna, Russia). In the recent years there was a successful line of research at FLNR dealing with light dripline systems. Novel results were obtained for such isotopes as 5H [1,2,3], 7H [4], 8He [5], 9He [6], 10He [5,7], 6Be [8], and 26S [9]. The major results of these studies are presented and discussed both from experimental and theoretical points of view. In theoretical discussion we focus on continuum properties (including continuum properties of three-body systems), studies of specific correlations, and practicalities of connection between theory and experiment.

The important part of scientific plans for FLNR for the nearest 5-7 years include development of DRIBS-3 initiative (Dubna Radioactive Ion BeamS). In the framework of this initiative the ACCULINNA facility is currently being replaced with much more powerful ACCULINNA-2 fragment separator (commissioning planned in 2015). The ACCULINNA is planned to be gradually converted to applied activities (biology and material research). We discuss the characteristics and scientific objectives of the now build ACCULINNA-2 fragment separator and formulate the general scientific program for the first years of operation.

References:
[1] A.A. Korsheninnikov et al., Phys. Rev. Lett. 87 (2001) 092501.
[2] M.S. Golovkov et al., Phys. Lett. B 566 (2003) 70.
[3] M.S. Golovkov et al., Phys. Rev. Lett. 93 (2004) 262501.
[4] M.S. Golovkov et al., Phys. Lett. B 588 (2004) 163.
[5] M.S. Golovkov et al., Phys. Lett. B 672 (2009) 22.
[6] M.S. Golovkov et al., Phys. Rev. C 76 (2007) 021605(R).
[7] S.I. Sidorchuk et al., Phys. Rev. Lett. 108 (2012) 202502
[8] A.S. Fomichev et al., Phys. Lett. B 708 (2012) 6.
[9] A.S. Fomichev et al., Int. J. Mod. Phys. E 20 (2011) 1491.

Notes

L.V. Grigorenko for ACCULINNA collaboration

Primary author: Dr GRIGORENKO, Leonid (FLNR, JINR)

Presenter: Dr GRIGORENKO, Leonid (FLNR, JINR)

Session Classification: Rare Processes & Decays

Contribution ID: **61** Type: **Oral**

Radioactive ion beams for nuclear astrophysics at Texas A&M University

Tuesday, 3 December 2013 13:50 (35 minutes)

We have developed indirect techniques to determine reaction rates at stellar energies for radioactive nuclei that are important in stellar evolution. The work to date has focused on measurements that are relevant for (p,gamma) reactions. The techniques that we have developed include determinations of Asymptotic Normalization Coefficients from transfer reactions to fix direct capture reaction rates and measurements of beta-delayed proton decay to determine resonances near the proton threshold.

Most of the work done at TAMU has used secondary radioactive beams that have been produced in-flight with stable beams from our K500 superconducting cyclotron, and then separated from other reaction products by our recoil mass spectrometer MARS. This technique leads to secondary beams that have a rather broad energy and angular acceptance. Thus the experiments that can be carried out with them are limited.

A facility upgrade began at the TAMU Cyclotron Institute in January, 2005, that will soon allow us to produce accelerated radioactive beams. The radioactive ion beams will be produced by accelerating, in our K500 superconducting cyclotron, radioactive ions that will be produced by intense particle beams from our K150 cyclotron. This will lead to ion beams with very small energy spread and low emittance. The re-accelerated beams will then be used to extend our indirect measurements for nuclear astrophysics to heavier radioactive nuclei.

In the presentation, I will first describe the recent work that we have been doing related to nuclear astrophysics. I will then give an overview of the upgrade project along with projections for accelerated secondary beams that will be produced following the upgrade. Finally I will discuss how we plan to use the accelerated beams to extend our determinations of (p,gamma) reaction rates for nuclei that participate in the rapid proton capture (rp-)process.

Primary author: Dr TRIBBLE, Robert (Texas A&M University)

Presenter: Dr TRIBBLE, Robert (Texas A&M University)

Session Classification: Facilities III

Contribution ID: **62** Type: **Oral**

GANIL/SPIRAL 2 – status and future

Tuesday, 3 December 2013 11:05 (35 minutes)

Recent results related to study of nuclei far from stability obtained at the GANIL facility [1] will be presented. A short-term scientific program of the current facility and, in particular, the AGATA campaign at GANIL will be discussed.
A first phase of the SPIRAL 2 facility [1], an ambitious extension of the GANIL accelerator complex, will be accomplished in 2014. In the frame of this project, a new superconducting linear accelerator delivering high intensity, up to 40 MeV, light (proton, deuteron, 3-4He) beams as well as a large variety of heavy-ion beams with mass over charge ratio equal to 3 and energy up to 14.5 MeV/nucl. is in the final stage of construction. In the future SPIRAL2 Phase 2, using a dedicated graphite converter and the 5 mA deuteron beam, a neutron-induced fission rate is expected to approach 1014 fissions/s for high-density UCx target. The versatility of the SPIRAL 2 driver accelerator will also allow using fusion-evaporation, deep-inelastic or transfer reactions in order to produce very high intensity Rare Isotope Beams and exotic targets. The energies of accelerated RIB will reach up to 7-8 MeV/nucl. for fission fragments and 20 MeV/nucl. for neutron-deficient nuclei.
An ambitious scientific program at GANIL/SPIRAL2 impose a use of the most efficient and innovative detection systems as the upgraded magnetic spectrometer VAMOS, the 4π gamma-arrays EXOGAM2 and AGATA as well as charged particle detectors like MAYA, MUST 2 and TIARA. Several new concepts of the detection systems (ACTAR, FAZIA, PARIS) and a new separator/spectrometer S3 located in dedicated experimental hall are currently under construction. A dedicated new experimental hall called DESIR will be used for experiments with low-energy RIB provided by SPIRAL1, S3 and SPIRAL2 ISOL target-ion source system.
It will be shown that developments of high intensity stable and radioactive ion beams at GANIL cyclotrons, SPIRAL1 and new SPIRAL2 facility as well as important upgrade of existing detection systems will open new opportunities in experimental nuclear physics and its applications. A status of the construction of the SPIRAL2 facility and future operation modes of the GANIL/SPIRAL2 complex as a multi-user facility will be shortly presented.

[1] http://pro.ganil-spiral2.eu/

Primary author: Dr LEWITOWICZ, Marek (GANIL)

Presenter: Dr LEWITOWICZ, Marek (GANIL)

Session Classification: Facilities II

Contribution ID: **63** Type: **Oral**

Perspectives of physics of exotic nuclei beyond the shell evolution

Monday, 2 December 2013 09:20 (35 minutes)

The shell evolution due to nuclear forces can be seen in many places on the nuclear chart, and the tensor and three-body forces play particularly important and characteristic roles. The recent experimental discovery of
N=34 magic number in 54Ca at RIBF of RIKEN Nishina Center is a good example. I will overview the shell evolution. This shell evolution implies changes as functions of N and/or Z. I point out that this is Type I
Shell Evolution, and there is Type II Shell Evolution occurring due to particular changes of configurations within the same nucleus. The tensor force shows very interesting and visible effects. Shape coexistence appears within narrow energy range in some cases. I will discuss basic and general features of this new mechanism affecting the structure of exotic nuclei, as well as concrete examples taken from recent studies on exotic Ni isotopes.

Notes

Thank you very much for assigning this talk to a plenary session. I hope to discuss future of the physics of exotic nuclei.

Primary author: Prof. OTSUKA, Takaharu (Department of Physics, University of Tokyo)

Presenter: Prof. OTSUKA, Takaharu (Department of Physics, University of Tokyo)

Session Classification: Structure Session I

Contribution ID: **64** Type: **Oral**

Highlights from TRIUMF's Rare Isotope Program

Wednesday, 4 December 2013 09:00 (35 minutes)

TRIUMF's high power ISOL facility ISAC features world leading experiments that address current topics in nuclear structure, nuclear astrophysics, fundamental symmetries, and material science. This talk will provide an overview of the current facility and its capabilities, recent developments in terms of beam delivery and experimental capabilities, as well as recent highlights of the scientific program. Also a update on the status of the Advanced Rare Isotope Laboratory (ARIEL) will be given, which is currently under construction at TRIUMF and which will vastly expand the scope of the research program.

Primary author: Prof. KRUECKEN, Reiner (TRIUMF)

Presenter: Prof. KRUECKEN, Reiner (TRIUMF)

Session Classification: Reaction Session

Contribution ID: **65** Type: **Oral**

Molecular structures and clustering effects in reactions induced by light nuclei

Monday, 2 December 2013 13:55 (35 minutes)

A great deal of research work has been performed in the field of alpha clustering since the pioneering discovery, by Bromley and his collaborators half a century ago, of molecular resonances in the excitation functions for 12C+12C scattering [1]. Our knowledge of this field of nuclear molecular physics has increased considerably [2] and nuclear clustering remains one of the most fruitful domains of nuclear physics [3-7], facing some of the greatest challenges and opportunities in the years ahead.

The question whether quasi-molecular resonances always represent true cluster states in the compound systems, or whether they may also simply reflect scattering states in the ion-ion potential is still unresolved [1-3]. In many cases, these resonant structures have been associated with strongly-deformed shapes and with clustering phenomena, predicted from the Nilsson-Strutinsky approach, the cranked alpha-cluster model, or other mean-field calculations (see for instance last chapter of [4] and references therein). Of particular interest is the relationship between superdeformation (SD) and nuclear molecules, since nuclear shapes with major-to-minor axis ratios of 2:1 have the typical ellipsoidal elongation (with quadrupole deformation parameter beta ~0.6) for light nuclei. Furthermore, the structure of possible octupole-unstable 3:1 nuclear shapes (with beta ~1.0) - hyperdeformation (HD) - for actinide nuclei has also been widely discussed in terms of clustering phenomena. Typical examples of the possible link between quasi-molecular bands and extremely deformed (SD/HD)shapes have been widely discussed in the literature for N=Z nuclei such as 28Si [8], 32S [9], 36Ar [10-12], 40Ca [13] and 48Cr [14,15].

Large quadrupole deformations and alpha-clustering in light N = Z nuclei are known to be general phenomena at low excitation energy. For high angular momenta and higher excitation energies, very elongated shapes are expected to occur in alpha-like nuclei for A(CN)= 20-60. In fact, highly deformed shapes and SD rotational bands have been recently discovered in several such N = Z nuclei, in particular, 36Ar using gamma-ray spectroscopy techniques [16,17]. Extremely deformed rotational bands in 36Ar are observed as quasi-molecular bands in both 12C+24Mg and 16O+20Ne reactions [10-12,17], and their related ternary clusterizations are also predicted theoretically [13,17].

[1] K.A. Erb and D.A. Bromley, "Treatise on Heavy Ion Science, Vol. 3, p. 201, Ed. Plenum, New York (1985).
[2] W. Greiner, J.-Y. Park, and W. Scheid, "Nuclear Molecules", Ed. World Scientific (1995).
[3] W. von Oertzen, M. Freer, and Y. Kanada-En'yo, Phys. Rep. 432(2006)43.
[4] M. Freer, Rep. Prog. Phys. 70(2007)2149.
[5] "Clusters in Nuclei" Vol.1, Lecture Notes in Physics 818, C. Beck (ed.) Springer-Verlag Berlin-Heidelberg, 2010.
[6] "in Nuclei", Vol.2, Lecture Notes in Physics 848, C. Beck (ed.) Springer-Verlag Berlin-Heidelberg, 2012.
[7] "Clusters in Nuclei", Vol.3, Lecture Notes in Physics 875, C. Beck (ed.) Springer-Verlag Berlin-Heidelberg, 2013.
[8] Y. Taniguchi et al., Phys. Rev. C 80(2009)044316.
[9] M. Kimura and H. Horiuchi, Phys. Rev. C 69(2004)051304.
[10] C. Beck et al., AIP Conf. Proc. 1098(2008)207.
[11] W. Sciani et al., Phys. Rev. C 80(2009)034319.
[12] J. Cseh {et al., Phys. Rev. C 80(2009)034320.

[13] Y. Kanada-En'yo and M. Kimura, Phys. Rev. C 72(2005)064322.
[14] M.-D. Salsac et al., Nucl. Phys. A 801(2008)1.
[15] E. Vardaci et al., Journal of Phys.: Conferences Series 436(2013)012054.
[16] C.E. Svensson et al., Phys. Rev. Lett. 85(2000)2693.
[17] C. Beck, Journal of Phys.: Conferences Series 436(2013012014).

Primary author: Dr BECK, Christian (IPHC & Universite de Strasbourg)

Presenter: Dr BECK, Christian (IPHC & Universite de Strasbourg)

Session Classification: Cluster Session

Contribution ID: **66** Type: **Oral**

The NUSTAR project at GSI and FAIR

Thursday, 5 December 2013 09:00 (35 minutes)

NUSTAR comprises the current nuclear structure, astrophysics and reactions programme at GSI and its proposed continuation and extension at FAIR. NUSTAR relies on the availability of exotic rare isotope beams produced by fragmentation reactions and fission of relativistic heavy ions. The fragment separator FRS and a versatile set of instruments, including gamma arrays, particle spectrometers and a storage ring enable unique experiments at GSI. The Super-FRS at the FAIR facility will provide several orders of magnitude stronger beams, providing access to the extremes of nuclear stability. To exploit these opportunities novel experimental set-ups are in preparation. R&D efforts result already now in improved detectors and enables the NUSTAR collaboration to steadily enhance the sensitivity and selectivity limit of their experiments. Current NUSTAR physics highlights as well as development projects and activities will be discussed.

Primary author: Dr GERL, Juergen (GSI)

Presenter: Dr GERL, Juergen (GSI)

Session Classification: Super-Heavy Elements Session

Contribution ID: **67** Type: **Oral**

Nuclear input with relevance for supernova dynamics and nucleosynthesis

Friday, 6 December 2013 09:05 (35 minutes)

Modern many-body models, like various versions of the interacting shell model, have allowed to decisively improve the description of weak-interaction processes like electron captures and neutrino-induced reactions on nuclei under supernova conditions. The talk will describe these advances, compare the model predictions with relevant experimental data and show their impact on the supernova dynamics as well as on explosive nucleosynthesis processes; i.e. the nu-p process and the r-process in the neutrino-driven wind scenario.

Primary author: Prof. LANGANKE, Karlheinz (GSI Darmstadt)

Presenter: Prof. LANGANKE, Karlheinz (GSI Darmstadt)

Session Classification: Astrophysics Session

Track Classification: Nuclear Astrophysics

Contribution ID: **122** Type: **Poster**

Superheavy nuclei: which regions of the nuclear map are accessible in the near future?

During last decade the heaviest elements with Z=113-118 were discovered in Dubna in fusion reactions of 48Ca beam with appropriate actinide targets. The 48Ca program of synthesis of new elements is over as no heavier target than Californium is available. However 48Ca-based fusion reactions may be still used, in particular, for exploring new lands on the nuclear map. The perspectives of discovering new elements heavier than Z=118 as well as of synthesis of new isotopes of super-heavy (SH) nuclei are discussed in this talk. In particular, we found for the first time a narrow pathway leading to the centre of the island of stability of SH nuclei owing to possible beta+-decay of SH nuclei. The conclusions are based on the recent calculations of decay properties of heavy and SH nuclei with respect to alpha-decay, beta-decay and spontaneous fission.

Primary author: KARPOV, Alexander (Flerov Laboratory of Nuclear Reactions, Joint Institute for Nuclear Research,)

Presenter: KARPOV, Alexander (Flerov Laboratory of Nuclear Reactions, Joint Institute for Nuclear Research,)

Contribution ID: **123** Type: **Oral**

Status and perspectives of double beta decay searches

Monday, 2 December 2013 16:15 (25 minutes)

Double beta decay is an extremely rare nuclear decay process characterised by
a change in the atomic number Z by two units while leaving the mass number A constant. Basically it can occur in two modes, with the emission of two electrons and two anti-neutrinos or the emission of two electrons only. While the rst mode is expected within the current Standard Model of Particle Physics, the neutrino-less double beta decay of nuclei is not allowed and thus its potential observation is of outstanding importance for neutrino physics and physics beyond the Standard Model. It can only occur if a neutrino is its own antiparticle and if it is massive. Especially for the first property double beta decay is considered as gold-plated process. However, due to the known smallness of the neutrino mass, the process is very rare and requires special low radioactive background environments.
After a general introduction into double beta decay and its role in neutrino physics, the seminar focusses on the current experimental searches and results and their implications for particle physics. An outlook towards future projects and the involved challenges is given, including a discussion on nuclear matrix elements and possible supporting experimental activities.

Primary author: Dr ZUBER, Kai (TU Dresden)

Presenter: Dr ZUBER, Kai (TU Dresden)

Session Classification: Rare Processes & Decays

Contribution ID: **124** Type: **Oral**

Fusion study of 194Pt with 6Li at around barrier energies

Friday, 6 December 2013 10:05 (25 minutes)

An activation experiment has been performed at the IFIN-HH Tandem accelerator (Bucharest) for obtaining information about the behaviour of fusion cross section at below barrier energies. The acquisition system was based on TNT digitizers and should face heavy loads at the beginning of the measurements. Special algorithms have been developed to account for the dead time and they will be described. The dead time problems made the data analysis more tedious than expected. Preliminary results at the barrier agree with conventional model calculations.

Primary author: Prof. BORCEA, Catalin (IFIN-HH Bucharest)

Presenter: Prof. BORCEA, Catalin (IFIN-HH Bucharest)

Session Classification: Astrophysics Session

Contribution ID: **125** Type: **Oral**

Nuclear structure: from stable to unstable nuclei

Monday, 2 December 2013 10:45 (25 minutes)

It is shown that many properties of the nuclear collective excitations in stable and unstable nuclei can be described within a microscopic approach based on the density functional method. The pseudospin symmetry in the structure of the very heavy nuclei
is discussed.

Primary author: Prof. VORONOV, Victor (Bogoliubov Laboratory of Theoretical Physics, Joint Institute for Nuclear Research)

Presenter: Prof. VORONOV, Victor (Bogoliubov Laboratory of Theoretical Physics, Joint Institute for Nuclear Research)

Session Classification: Structure Session I

Contribution ID: **126** Type: **Poster**

High-resolution magnetic analyser MAVR for the study of momentum distributions of weakly-bound nuclei

A project of the high-resolution magnetic analyzer MAVR is proposed. The analyzer will comprise new magnetic optical and detecting systems for separation and identification of reaction products in a wide range of masses (5−150) and charges (1−60).
The magnetic optical system consists of the MSP−144 magnet and a doublet of quadrupole lenses. This will allow the solid angle of the spectrometer to be increased by an order of magnitude up to 30 msr. The magnetic analyzer will have a high momentum resolution (10−4) and high focal-plane dispersion (1.9 m). It will allow products of nuclear reactions at energies up to 30 MeV/nucleon to be detected with the charge resolution ~1/60. Implementation of the project is divided into two stages: conversion of the magnetic analyzer proper and construction of the nuclear reaction products identification system.
The MULTI detecting system is being developed for the MAVR magnetic analyzer to allow detection of nuclear reaction products and their identification by charge Q, atomic number Z, and mass A with a high absolute accuracy. The identification will be performed by measuring the energy loss (ΔE), time of flight (TOF), and total kinetic energy (TKE) of reaction products. The particle trajectories in the analyser will also be determined using the drift chamber developed jointly with GANIL.
These characteristics the best fit for study the momentum distribution of weakly bound nuclei. The momentum distributions were measured with the magnetic spectrometer MSP-144. It has been shown that the distribution width practically does not depend on the target. Its small value, sigma ~28 MeV/c, confirms the presence of a halo in 6He. The measurements with the 6Li beam were performed at the U400M accelerator at 18 and 46 MeV/A. A value of sigma ~50 MeV/c, intermediate between that for 6He and ordinary stable nuclei, was obtained for the width of the momentum distribution of the 4He fragments.

Primary author: Dr MASLOV, V. A. (Joint Institute for Nuclear Research, Dubna)

Co-authors: VOSKOBOINIK, E. I. (JINR Dubna); KOLESOV, I. V. (JINR Dubna); OSIPOV, N. F. (JINR Dubna); SKOBELEV, N. K. (JINR Dubna); LUKYANOV, S.M. (JINR Dubna); KAZACHA, V. I. (JINR Dubna); MELNIKOV, V. N. (JINR Dubna); PENIONZHKEVICH, Yu. E. (JINR Dubna); SOBOLEV, Yu. Gv (JINR Dubna)

Presenter: Dr MASLOV, V. A. (Joint Institute for Nuclear Research, Dubna)

Contribution ID: **127** Type: **Oral**

Radioactive ion beams at ISOLDE: applications to semiconductor physics

Thursday, 5 December 2013 11:10 (35 minutes)

Progress in semiconductor technology requires a thorough understanding and control of defects responsible for the properties of semiconducting materials, both of intrinsic defects, such as vacancies, self-interstitials, or anti-sites, and of extrinsic defects, such as dopants and impurity atoms. Depending on the material and the structural size used in a device, the electrical and optical properties can be significantly altered by a defect which is present at a concentration as low as 10**12 cm-3.
Radioactive atoms have been used in solid state physics and in material science for many decades. Besides their classical application as tracer for diffusion studies, nuclear techniques such as Mossbauer spectroscopy, perturbed γγ angular correlation (PAC), β-NMR, and emission channelling (EC) have used nuclear properties (via hyperfine interactions or emitted particles) to gain microscopic information on the structural and dynamical properties defects in solids [1]. The availability of many different radioactive isotopes as a clean ion beam at facilities like ISOLDE/CERN [2] has triggered an era involving methods sensitive for the structural, optical and electronic properties of defects in solids, especially in the field of semiconductor physics [3,4].
Like stable isotopes, radioactive isotopes used as dopants influence the electronic and optical properties of semiconductors according to their chemical nature. Experimental and theoretical tools are needed for identifying the properties of defects, the diffusion mechanisms being responsible for the mobility of defects and the strengths of the mutual interactions between dopant atoms and intrinsic as well as extrinsic defects. Spectroscopic techniques like deep level transient spectroscopy (DLTS) and photo-luminescence (PL) gain a new quality by using radioactive isotopes. Due to the radioactive decay the chemical origin of an observed electronic and optical behaviour of a specific defect or dopant can be unambiguously identified.
This contribution will highlight a few examples to illustrate the potential of radioactive isotopes for solving various problems connected to defects in semiconductor physics.
The financial support by the BMBF under contract 05K13TSA is gratefully acknowledged.

[1] G. Schatz and A. Weidinger, Nuclear Condensed Matter Physics (Wiley, Chichester, 1995).

[2] http://isolde.cern.ch/

[3] Th. Wichert and M. Deicher, Nuclear Physics A 693, 327 (2001).

[4] M. Deicher, G. Weyer, Th. Wichert, and the ISOLDE Collaboration, Hyperfine Interactions 151/152, 105 (2003).

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Session Classification: Applications Session II

Contribution ID: **128** Type: **Oral**

International FAIR - challenges and chances in modern physics and technologies

Tuesday, 3 December 2013 15:20 (35 minutes)

The Facility for Antiproton and Ion Research in Europe, FAIR, will provide worldwide unique accelerator and experimental facilities offering to scientists from the whole world an abundance of outstanding research opportunities, broader in scope than any other contemporary large-scale facility worldwide. Indeed, it is the largest basic research project on the roadmap of the European Strategy Forum of Research Infrastructures (ESFRI), and it is cornerstone of the European Research Area.
More than 2500 scientists will push the frontiers of our knowledge in hadron, nuclear, atomic and applied physics far ahead, with important implications also for other fields in science such as cosmology, astro- and particle physics, and technology.
This presentation outlines the current status of the FAIR project and the strategy of its realization based on the acquired funding.
Also the research program of FAIR with emphasis on particular physics issues of all four "scientific pillars" of the project will be presented.

Reference: www.fair-center.eu

Primary authors: Dr SHARKOV, Boris (FAIR GmbH, Darmstadt); Dr WEISSBACH, Florian (FAIR GmbH, Darmstadt)

Presenter: Dr WEISSBACH, Florian (FAIR GmbH, Darmstadt)

Session Classification: Facilities IV

Contribution ID: **130** Type: **Oral**

Exploring nuclear structure by binary reactions with stable and radioactive nuclear beams

Tuesday, 3 December 2013 14:25 (35 minutes)

The study of neutron-rich nuclei with unusually large neutron/proton ratio is challenging the conventional description of the structure of nuclei. Almost a decade of investigation has established that when moving from the region of β-stability to the drip line, the shell structure undergoes important modifications with the possible disappearance of the usual shell gaps and the emergence of new magic numbers. This behaviour has been attributed to the dynamic effects of the nucleon-nucleon interaction, its density dependence, linked to the reduction of the spin-orbit contribution for more diffuse systems, and the influence of the proton-neutron interaction and of its higher order term, the tensor force. Recently also three-nucleon forces have been invoked in order to justify the stabilization of the nuclear shells. Unexpected shell erosions have been found all over the nuclear chart, together with the appearance of low lying intruder states in supposedly semi-magic nuclei, giving rise to the so-called islands of inversion. One example is the Ni isotopic chain (Z=28) which covers two doubly-closed shells with neutron numbers N=28 and 50 therefore providing an almost unique testing ground for investigating the evolution of the shell structure in neutron rich nuclei.

Binary reactions such as Coulomb excitation, deep-inelastic and multi-nucleon transfer reactions are a powerful tool to populate yrast and non yrast states in neutron-rich nuclei using stable or radioactive nuclear beams, particularly in combination with high resolution gamma-ray detector arrays. Data from the AGATA experimental campaigns together with selected examples from high and low resolution gamma ray spectroscopy detectors will be presented. The status of the SPES radioactive nuclear beams project at LNL will also be illustrated.

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Session Classification: Facilities III

Contribution ID: **131** Type: **Oral**

RIKEN RI beam factory, Japanese flagship for nuclear Science

Tuesday, 3 December 2013 12:15 (35 minutes)

RIKEN Radio Isotope Beam Factory (RIBF) presently provides the most intense RI beam in the world. We outline the 80-year history of accelerator developments in RIKEN to reach the present facility, and the physics scope of RIBF is discussed, based on the recent results. The research strategy of Japanese nuclear physics is also introduced in connection with the world trend of upcoming nuclear physics facilities.

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Session Classification: Facilities II

Contribution ID: **132** Type: **Oral**

The ISOLDE facility at CERN: production, study and application of exotic isotopes.

Tuesday, 3 December 2013 11:40 (35 minutes)

The ISOLDE facility is the longest running experiment at CERN. It is also the last fully dedicated to nuclear physics and its applications. In the 45 years since it first produced radioactive beams, it has pioneered the production of radioisotopes using the ISOL technique producing ever-more exotic beams. Now, in 2013, more than 1000 radioisotopes from 70 elements can be produced and this has inspired a rich and extremely varied experimental programme. Although 50% of the experimental programme is still dedicated to pure nuclear physics, applications constitute an important and growing aspect of the activity at ISOLDE.
The applied programme at ISOLDE is in itself extremely varied spanning materials physics, biophysics and medicine. These latter two have been the subject of considerable growth in the past few years. In particular the development of an innovative beta-NMR system, which will allow the study of spectroscopically "blind" but vitally important elements such as Cu and Zn in biological systems, has been tested and is being prepared for full operation in 2014. Research in medical physics has been bolstered by the announcement that from 2016, ISOLDE will produce exotic isotopes to investigate novel aspects of imaging and therapy. This new facility – MEDICIS (Medical Isotopes collected at Isolde) – has recently commenced construction and is a collaboration between ISOLDE/CERN and numerous hospitals around Switzerland.
This talk will give an overview of the ISOLDE facility, in particular with reference to the production and purification of radioactive beams. Then, a detailed overview of some of the recent highlights from the nuclear physics programme, with particular attention to the applications mentioned above will be presented.

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Session Classification: Facilities II

Contribution ID: **133** Type: **Oral**

Exotic nuclei in astrophysics

Friday, 6 December 2013 10:30 (5 minutes)

Recently the scientific society marked several anniversaries, connected with discoveries which have played significant role in the development of astrophysical investigations. The year 2009 was chosen by the United Nations and UNESCO to be the year of astronomy. This was inspired by the 400th anniversary of Galileo Galilei's discovery of the telescope, giving the start of regular studies in the field of astronomy. An important contribution to the development not only of the physics of the micro-world, but also to the understanding of the processes occurring in the Universe, was the discovery done 100 years ago by E. Rutherford of the atomic nucleus. Since then the investigations in the fields of elementary particles and atomic nuclei have helped to understand many processes in the micro- world. Exactly 80 years ago K. Yanski used a radio-telescope for the first time in order to accept signals from cosmic objects and at present this part of physics is the most efficient method for studying the properties of the Universe. And finally, the launching into space on 12 April 1961 (50 years ago) of the first Sputnik with a human being on board - the Soviet cosmonaut Yuri Gagarin - marked the beginning of the investigation of the Universe with the direct participation of man. All these achievements considerably extended our ideas about the Universe.
The author of the present work has tried to present some problems of the evolution of the Universe, the nucleosynthesis and cosmochronology from the point of view of nuclear physics and elementary particles, in particular using the latest results, obtained with radioactive nuclear beams. Comparison is made between the processes taking place in the Universe and the mechanism of formation and decay of nuclei, as well as with their interaction at different energies. Examples are given to show the possibilities of nuclear methods to study cosmic objects and the properties of the Universe. The results of studying nuclear reactions, induced by radioactive ion beams, make it possible to analyse in a different way the nucleosynthesis scenario in the region of the lightest elements.

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Presenter: Prof. PENIONZHKEVICH, Yuri (JINR)

Session Classification: Astrophysics Session

Contribution ID: **134** Type: **Oral**

0+ excited states in nuclei: critical signatures of structure

Monday, 2 December 2013 11:30 (35 minutes)

All even-even nuclei possess excited 0+ states. Often, they are poorly characterized because they can be difficult to populate. However, the identification of 0+ states and the characterization of their properties is critical to the elucidation of the structure of all even-even nuclei. Examples at both closed and open shells will be selected to illustrate this aspect of nuclear structure exploration. Particular emphasis will be placed on nuclei with seniority dominated structure and nuclei exhibiting shape coexistence.

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Presenter: WOOD, John L. (Georgia Tech)

Session Classification: Structure Session II

Contribution ID: **135** Type: **Oral**

The SPES project at the Legnaro National Laboratories: status and perspectives

Thursday, 5 December 2013 13:35 (35 minutes)

The SPES radioactive ion beam facility is presently under construction at the Legnaro National Laboratories. The aim of the project is to provide high intensity and high-quality beams of neutron-rich nuclei to perform forefront research in nuclear structure, reaction dynamics and interdisciplinary fields like medical, biological and material sciences. SPES is a second generation ISOL radioactive ion beam facility. It represents an intermediate step toward the future generation European ISOL facility EURISOL. The SPES project is part of the INFN Road Map for the Nuclear Physics and is strongly supported by the national laboratories for nuclear research LNL (Legnaro) and LNS (Catania). It is based on the ISOL method with a proton beam impinging on a UCx Direct Target sustaining a maximum power of 8 kW. The primary proton beam is delivered by a commercial Cyclotron accelerator with an energy of about 70 MeV and a beam current of about 200 ⊠A. Neutron-rich radioactive ions will be produced by Uranium fission at an expected fission rate in the target of the order of 1013 fissions per second. The exotic isotopes will be re-accelerated by the ALPI superconducting LINAC at energies of 10 AMeV and higher, for masses in the region of A=130 amu, with an expected rate on the secondary target of 108 pps.

Primary authors: Dr DE ANGELIS, Giacomo (INFN, Laboratori Nazionali di Legnaro); Dr PRETE, Gianfranco (INFN, Laboratori Nazionali di Legnaro)

Presenter: Dr DE ANGELIS, Giacomo (INFN, Laboratori Nazionali di Legnaro)

Session Classification: Nuclear Physics

Contribution ID: **136** Type: **Oral**

A Rare-Ion facility at iThemba LABS

Tuesday, 3 December 2013 09:35 (35 minutes)

iThemba LABS, based around the Separated Sector Cyclotron (SSC), is already the premier nuclear particle accelerator laboratory in Africa and indeed in the Southern Hemisphere. It proposes to address two of the "Grand Challenges" identified by the Dept. of Science & Technology, – i.e. Energy Security and Space Sciences – by building a rare-ion beam facility to bring South Africa to a position of international leadership in the fields of nuclear physics and material sciences.

Internationally, interest in nuclear physics is focusing on the study of the so-called 'terra incognita' – the unknown part of the table of nuclides – which includes the unstable 'neutron-rich' nuclei that cannot be produced using beams of stable atoms. This region holds the key to our understanding of nuclear forces and the origin of the elements of which the Universe is composed. Neutron-rich nuclei can only be created and studied in the laboratory by using beams of artificially produced radioactive-ion beams from an accelerator such as a cyclotron. Because the radioactive-ions in these beams are difficult to produce, and do not occur naturally, they are called "rare-ions". Rare-ions are also of particular use in the development of advanced materials. Measurements of the decay of the probe ion give direct evidence on the site of the implanted ion, on the nature of the site, and on diffusion characteristics of the dopant ions.

iThemba LABS proposes a staged development of a rare-ion beam facility:

1. The first stage would see the addition of a high-current, 70-MeV compact H-minus cyclotron to iThemba LABS. This cyclotron would take over the production of radioisotopes, 24 hours a day, thus releasing the existing SSC to be dedicated to physics research – mainly pure and applied nuclear physics – and to neutron radiotherapy. The capacity for physics training would be more than doubled and the links with international collaborations would be considerably strengthened owing to the increased availability of beam time, currently restricted to weekends only. (Proton therapy is assumed to be transferred to the proposed iThemba Particle Therapy Centre, a private-public partnership which is currently under consideration by the Minister.)
2. The second stage would see the production of radioactive-ion beams, bringing nuclear and materials research and training in South Africa to the international forefront. Since two H–minus ion beams can be extracted simultaneously from the proposed new 70-MeV cyclotron, one of these will be used to produce radioactive ions via the Isotope-Separation-On-Line (ISOL) method. These ions will then be formed into a beam which can then be cooled, mass-analysed, charge-bred and post-accelerated by two of the existing cyclotrons (the SPC1 injector and the SSC) for use in nuclear physics experiments.

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Session Classification: Facilities I

Contribution ID: **137** Type: **Oral**

Study of isoscalar giant resonances in exotic nuclei by means of inverse reactions

Thursday, 5 December 2013 14:35 (20 minutes)

For the MAYA and EXL collaborations

Isoscalar giant resonances in exotic nuclei can be studied using inelastic alpha scattering in inverse kinematics. In particular, the compression modes, i.e. isoscalar giant monopole (ISGMR) and dipole (ISGDR) resonances are very interesting because they can furnish information on the different terms of the nuclear incompressibility, especially if measured in long isotopic chains including nuclei far from the valley of stability. As beams of exotic nuclei have relatively low intensities thick targets have to be used in order to get a reasonable yield. However, this leads to degradation of the energy resolution and stops low-energy recoil particles. Two good alternatives exist. The first method is to use an active target, such as MAYA, which is a time-projection chamber and therefore can be used for detection of low-energy recoil particles. Furthermore, its thickness can be increased by increasing the length of the detection volume or the gas pressure without severe loss of energy resolution. The second method is to use a storage ring for storing the exotic nuclei, which then interact with target nuclei from a gas-jet target. Here, the luminosity and hence the yield are increased because the exotic nuclei circulate in the ring at a frequency of around 106 turns/s. Low-energy recoil particles traverse the gas-jet with little loss of energy and can be detected in solid-state detectors.

Pioneering experiments with both methods have been performed for inelastic scattering of secondary 56Ni beam off helium nuclei, which occurs inside the detector volume in the case of MAYA and with the gas jet in the case of the experimental storage ring (ESR) at GSI. In the case of MAYA experiment, the tracks of the recoil alpha particles have been measured in the detector volume yielding their scattering angles, ranges and therefore energies. Using forward-angle Si/CsI telescopes, the decay protons and alpha particles from the giant resonance region in 56Ni, have also been measured in coincidence with recoil alpha particles in MAYA. Results from both experiments will be presented.

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Presenter: Dr HARAKEH, Muhsin (KVI)

Session Classification: Nuclear Physics

Contribution ID: **138** Type: **Oral**

Nuclear science and applications with next generation of high-power lasers and brilliant low-energy gamma beams at ELI-NP

Tuesday, 3 December 2013 15:55 (35 minutes)

The development of high power lasers and the combination of such novel devices with accelerator technology has enlarged the science reach of many research fields, in particular High energy, Nuclear and Astrophysics as well as societal applications in Material Science, Nuclear Energy and Medicine.
The European Strategic Forum for Research Infrastructures (ESFRI) has selected a proposal based on these new premises called "ELI" for Extreme Light Infrastructure. ELI will be built as a network of three complementary pillars at the frontier of laser technologies. The ELI-NP pillar (NP for Nuclear Physics) is under construction near Bucharest (Romania) and will develop a scientific program using two 10 PW class lasers and a Back Compton Scattering High Brilliance and Intense Low Energy Gamma Beam , a marriage of Laser and Accelerator technology at the frontier of knowledge. In the present paper, the technical description of the facility, the present status of the project as well as the science, applications and future perspectives will be discussed.

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Presenter: GALES, Sydney (ELI-NP)

Session Classification: Facilities IV

Contribution ID: **139** Type: **Oral**

Effect of electron screening in alpha decay

Thursday, 5 December 2013 16:35 (20 minutes)

The effect of the electron screening on the alpha decay rate of typical nuclei is considered. To this end, the adiabatical approach is exploited, which consecutively takes into account the adiabaticity of the motion of the alpha particle through the shells [1]. The effect is found to be of the order of one tenth to one hundredth of a percent for the considered representative nuclei. The method can be applied to description of nuclear reactions of synthesis, which take place in stellar plasma or at laboratory. The effect is expected to be much stronger in the nuclear reactions at small energies, ~ 30 keV and lower.

TABLE I. Results for the relative change in half-periods in bare nuclides (last column).

Nuclide Q (MeV) T1/2 Y (%)
144Nd 1.905 2.29 × 1015 yr 0.24
214Rn 9.208 0.27 µs 0.02
226Ra 4.871 1600 yr 0.23
252Cf 6.217 2.645 yr 0.28
241Es 8.320 9 s 0.12
294118 11.81 0.89 ms 0.27

[1] F. F. Karpeshin, Phys. Rev. 2013, C87, 054319.

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Session Classification: Nuclear Physics: Parallel Session I