The African Nuclear Physics Conference 2023 (ANPC2023)

Report of Contributions

Contribution ID: **263** Type: **Invited Talk**

Study of internal structures of 9,10Be and 10B in scattering of 2H and 6Li from 9Be

Thursday, 30 November 2023 11:30 (25 minutes)

Angular distributions for the 9Be(d,d)9Be, 9Be(d,p)10Be, 9Be(d,t)8Be, and 9Be(d,4He)7Li channels were measured [1]. Experimental angular distributions were described within the optical model, the coupled channel approach, and the distorted wave Born approximation. The spectroscopic factors for the systems 9Be =alpha+ 5He and 7Li = d + 5He are close to unity, which confirms the contribution of the considered cluster configurations to the structure of ground states. The analysis shows that the contribution of the compound nucleus mechanism is negligible. In the (d, 4He) channel, the deuteron transfer provides only a small contribution, whereas a relatively large contribution of 5He transfer was found.
The results of recent experiment on studying nucleon and cluster transfer processes in the reactions of the 6Li (68 MeV) ions with the 9Be target nuclei are reported. The angular distributions for the reaction channels 9Be(6Li,4He)11Bg.s., and
9Be(6Li,10B)5Heg.s. have been measured. To describe the possible contributions of
sequential transfer of nucleon and alpha clusters, as direct transfer of the 5He cluster, the Coupled Reaction Channel method (FRESCO)[2] is used. The spectroscopic
amplitudes are obtained for the configurations of (9Be+d) and (6Li+5He) in the 11B
nucleus and (6Li+4He) in the 10B nucleus. The results indicate a strong correlation
between a neutron and an , leading to the formation of the 5He-cluster in the transfer processes.
Figure shows the experimental differential cross sections for cluster transfer in the reaction channel 9Be(6Li,4He)11Bg.s. (circles) compared with the results of calculations (curves). In the case of 5He transfer, the following mechanisms were taken into account: simultaneous transfer (5He) and sequential transfer (n+4He and 4He+n). The probability of the sequential transfer (alpha-n or n-alpha) is much lower than that for the process of the simultaneous transfer of 5He over the entire range of angles.
[1] S. Lukyanov et al ., J.Phys.(London) G41, 035102 (2014).
[2] http://nrv.jinr.ru

Attendance Type

Primary authors: LUKYANOV, Sergey (FLNR); Dr AZHIBEKO, Aidos

Co-author: Dr MENDIBAYEV, Kayrat

Presenter: LUKYANOV, Sergey (FLNR)

Session Classification: Session 6

Track Classification: Invited Talks

Contribution ID: **264** Type: **Invited Talk**

The Theoretical Description of Nuclear Fission

Saturday, 2 December 2023 16:05 (25 minutes)

Sylvester Agbemava1, Eric Flynn1,2, Daniel Lay1,2, Kyle Godbey1, Witold Nazarewicz1,2

1FRIB Laboratory, Michigan State University, East Lansing, Michigan 48824, USA.
2Department of Physics and Astronomy, Michigan State University, East Lansing, Michigan 48824, USA.

Fission is a fundamental nuclear decay that plays an important role in many areas of science. Recently, significant progress has been made in the microscopic modeling of the dynamics of spontaneous and induced fission based on nuclear density functional theory (DFT) [1]. The nuclear fission process is a dramatic example of large-amplitude collective motion in which the nucleus undergoes a series of shape changes before splitting into distinct fragments. Because of the complexity of this process, our understanding is still not complete.
The simulation of independent and cumulative yields requires knowledge of the initial conditions of the fragments immediately after scission. We take a closer look at the microscopic description of nuclear fission within the framework of nuclear density functional theory, combining the multidimensional minimization of the collective action for fission with a statistical approach rooted in a microcanonical ensemble to track the relevant fission paths from the ground-state configuration up to scission [2, 3, 4].

This work was supported by the U.S. Department of Energy under Award No. DOE-DE-NA0002847 (NNSA, the Stewardship Science Academic Alliances program), DESC0013365 (Office of Science), and DE-SC0018083 (Office of Science, NUCLEI SciDAC-4 Collaboration)

[1] M. Bender et al., J. Phys. G 47, 113002 (2020).
[2] J. Sadhukhan, W. Nazarewicz, and N. Schunck, Phys. Rev C 93, 011304(R) (2016)
[3] N Schunck, LM Robledo - Reports on Progress in Physics, 2016
[4] N Schunck, D Duke, H Carr, A Knoll Phys Rev C 90, 054305 (2014

Attendance Type

In-person

Primary author: AGBEMAVA, Sylvester (FRIB/MSU)

Presenter: AGBEMAVA, Sylvester (FRIB/MSU)

Session Classification: Session 12

Track Classification: Invited Talks

Contribution ID: **265** Type: **Oral**

Emergence of triaxiality in 74Se from electric monopole transition strengths

Thursday, 30 November 2023 12:10 (15 minutes)

The 2+2 state in non-doubly-magic, even-even nuclei is commonly interpreted as due to a collective excitation. In the vibrational and rotational limits, this state originates from vibrations around the ground-state shape. Even though these basic paradigms are known to represent only a first-order approximation of the nuclear structure, they are still used for classifying isotopes throughout the chart of the nuclides and as a basis for more complex theoretical approaches. Nevertheless, since the appearance of low-energy nuclear vibrations has been debated in the recent literature, the possible vibrational interpretation of the 2+2
state also needs to be carefully reanalysed.
Monopole transitions (E0) are an ideal tool to investigate nuclear structure because they are related to the radial distribution of the electric charge inside the nucleus. Therefore, monopole transition strengths ρ2(E0) are sensitive to changes in the shape of the nuclear states. In particular, this observable is zero if the shape of the two involved states is the same and/or if there is no configuration mixing between their wavefunctions. Noteworthy,
the ρ2(E0) value between the first two 2+ states is zero in both the vibrational and axially-symmetric rotational limits. A surprising result has been recently obtained in the Ni isotopic chain, where large ρ2(E0; 2+2 ⟶ 2+1) values have been measured. Apart from simple models, a more sophisticated method based on the shell model was also applied to explain these large ρ2(E0) values, unsuccessfully.
Selenium isotopes are thought to be collective in their low-lying structure. Which kind of collectivity, however, is still a matter of debate. A nearly spherical-vibrational scenario was suggested for 74Se in a recent β-decay study. The anomalous low energy of the 0+2 state, which is a member of the two-phonon multiplet in this case, was explained as due to the mixing between the 0+2 state and the intruder, strongly-deformed 03 state. While this interpretation explains several observables in 74Se, others are not reproduced. If this picture is correct, the ρ2(E0; 2 +2 ⟶ 2 1) value should be negligible and the ρ (E0; 0 3 ⟶ 0 2) value should be large. Noteworthy, former studies identified the 0+2 state as another shape-coexisting state, and the 2+ state as the band-head of a γ-band.
Given the most recent suggestions regarding the appearance of multiple-shape coexistence in the neighbouring Ni isotopes, and the emerging role of triaxiality in the nearby 76 Se and the close Ge and Zn isotopes, further investigation in 74Se is required.
This contribution presents new experimental results regarding internal conversion coefficients and monopole transition strengths in 74Se. A large ρ2(E0; 2 +
2 ⟶ 2 1) value has been measured, with a magnitude comparable to those in the close Ni isotopes, while the ρ2(E0; 0 +3 ⟶ 0 2) value has been deduced to be small. Also, for the first time microscopic Beyond-Mean-Field (BMF) calculations for 74 Se will be present, and the role of triaxiality in this isotope discussed.

Attendance Type

In-person

Primary author: MARCHINI, Naomi (University of Florence - INFN Florence section)

Presenter: MARCHINI, Naomi (University of Florence - INFN Florence section)

Session Classification: Session 6

Track Classification: Nuclear Structure, Reactions and Dynamics

Contribution ID: **267** Type: **Invited Talk**

Recent progresses and perspective of RI Beam Factory

Thursday, 30 November 2023 11:05 (25 minutes)

The RI Beam Factory (RIBF) is a third-generation in-flight facility, designed and optimized for the RI beam production by uranium fission. High intensity beams available over a wide region of the nuclear chart by the BigRIPS separator, together with the three spectrometers, namely ZeroDegree, Samurai and SHARAQ/OEDO each having a specific advantage, make a powerful platform for reaction studies with fast RI beams. New initiatives aimed at advancing reaction studies at the RIBF have been taken in the last few years. One is that the energy-degrading RI beamline OEDO has been launched. Energy-degraded RI beams from OEDO provide various reaction opportunities down to the energy regime of about 10 MeV/u, far lower than the nominal secondary beam energies of the RIBF from 200 to 300 MeV/u. Another initiative is the HiCARI campaign at ZeroDegree, which introduced tracking-type germanium detectors, for the first time, for in-beam gamma-ray spectroscopy at the RIBF.
These initiatives not only provide fruitful scientific outcomes in terms of shell evolution or nucleosynthesis, but also lay a foundation for in-beam reaction studies toward the RIBF facility upgrade envisioned in near future, where the uranium beam intensity presently at about100 pnA will increase to 2,000 pnA.
In this talk, I will overview recent progresses at the RIBF and perspective with the RIBF facility upgrade.

Attendance Type

Remote

Primary author: SUZUKI, Daisuke (RIKEN Nishina Center)

Presenter: SUZUKI, Daisuke (RIKEN Nishina Center)

Session Classification: Session 6

Track Classification: Invited Talks

Contribution ID: **268** Type: **Oral**

Measurement of the 27Al(p,α)24Mg fusion reaction at astrophysical energies via the Trojan Horse Method.

Friday, 1 December 2023 14:50 (15 minutes)

The abundance of ^{26}Al carries a special role in astrophysics, since it probes active nucleosynthesis in the Milky Way and constrains the Galactic core-collapse supernovae rate. It is estimated through the detection of the 1809~keV γ-line of the daughter ^{26}Mg and from the superabundance of ^{26}Mg in comparison with the most abundant Mg isotope (A=24) in meteorites. For this reason, high precision is necessary not only in the investigation of ^{26}Al nucleosynthesis process but also in the investigation of the stable ^{27}Al and ^{24}Mg [1,2].
Moreover, these nuclei enter the so-called MgAl cycle playing an important role in the production of Al and Mg [3]. Recently, high-resolution stellar surveys have shown that the Mg-Al anticorrelation in red-giant stars in globular clusters may hide the existence of multiple stellar populations, and that the relative abundances of Mg isotopes may not be correlated with Al.

The common thread running through these astrophysical scenarios is the $^{27}\mathrm{Al}(p,\alpha)^{24}\mathrm{Mg}$ fusion reaction, which is the main ^{27}Al destruction channel and directly correlates its abundance with the ^{24}Mg one. Since available spectroscopic data and tabulated reaction rates show large uncertainties owing to the vanishingly small cross section at astrophysical energies, we have applied the Trojan Horse Method (THM) to the three-body quasi-free reaction $d(^{27}\mathrm{Al},\alpha^{24}\mathrm{Mg})n$. This has allowed us to perform high precision spectroscopy on the compound nucleus ^{28}Si, from which we extracted important information on the $^{27}\mathrm{Al}(p,\alpha)^{24}\mathrm{Mg}$ fusion cross section in the energy region of interest for astrophysics, not accessible to direct measurements.
All details can be found in refs.[4,5].
In particular, the indirect measurement made it possible to assess the contribution of the 84~keV resonance and to lower upper limits on the strength of nearby resonances.

About the impact of the measurement, in this work we have evaluated the effect of the THM recommended rate on intermediate-mass asymptotic giant branch stars experiencing hot bottom burning. Here, a sizeable increase in surface aluminum abundance is observed at the lowest masses due to the modification on the fusion cross section, while ^{24}Mg is essentially unaffected by the change we determined.

[1] S. Palmerini et al., Monthly Notices of the Royal Astronomical Society 467, 1193 (2017).

[2] C. Iliadis et al., The Astrophysical Journal Supplement 193, 23 (2011).

[3] C. Iliadis et al., Nuclear Physics A 841, 3 (2010).

[4] M. La Cognata et al., The Astrophysical Journal 941, 96 (2022).

[5] M. La Cognata et al., Physics Letters B 826, 136917 (2022).

Attendance Type

Primary author: LA COGNATA, Marco (INFN-LNS)

Presenter: LA COGNATA, Marco (INFN-LNS)

Session Classification: Session 9

Track Classification: Nuclear Astrophysics

Contribution ID: **269** Type: **Oral**

On the need of new measurements to understand neutron capture nucleosynthesis

Friday, 1 December 2023 15:20 (15 minutes)

Neutron capture nucleosynthesis via s-, r- and i-process are responsible for the production of elements heavier than Fe in the Universe.
Nucleosynthesis predictions can be affected by both the free parameters of the astrophysical models, which do not allow to accurately reproduce the neutron densities in stellar environments, and the uncertainties of the nuclear physics quantities employed in calculations. The isotopic composition of stellar dust (SiC presolar grains in particular) provides strong constraints to nucleosynthesis models and hints to the need for new measurements of weak interaction (beta decays and electron captures) rates in ionized plasmas as well as of neutron-capture cross sections of unstable nuclei and/or isomers. We will focus our discussion in the regions near N = 50 and N = 82, showing as the predictions for Sr isotopic distribution can be modified by the assumptions done for the 85Kr (ground and isomeric state) half-life and neutron capture cross section as well as the production of Ba isotopes can be deeply affected by the decay rates of Cs isotopes (new theoretical estimation for A=134-135 half-lives in plasma condition will be presented).

Attendance Type

Remote

Primary author: PALMERINI, Sara (University of Perugia and INFN Perugia)

Presenter: PALMERINI, Sara (University of Perugia and INFN Perugia)

Session Classification: Session 9

Track Classification: Nuclear Astrophysics

Contribution ID: **270** Type: **Invited Talk**

Nuclear physics as a tool to understand neutron stars and QCD phase transitions

Neutron stars are the most mysterious objects in the universe, with a radius of the order of 10 km and masses that can reach two solar masses. In 2017, a gravitational wave was detected (GW170817) and its source was identified as the merger of two neutron stars. Later on, a mass-gap object (either a neutron star or a black hole) was identified in the GW190814 event. To understand neutron stars, an appropriate equation of state that satisfies bulk nuclear matter properties has to be used and gravitational wave detections have provided some extra constraints to determine it. Moreover, the NICER telescope, launched in 2017, has also started (in 2021) to send information that helps us determine the radius of these compact objects.
On the other hand, the analysis of the QCD phase diagram points to a deconfined quark phase standing exactly at the region related to neutron stars, i.e., high densities and low temperatures, which opens the possibility that neutron stars can be different classes of compact objects: hadronic stars, hybrid stars with hadrons and quarks and even strange stars satisfying the Bodmer-Witten conjecture.
I will show that, using different models that describe hadronic and quark matter that massive hybrid stars can be obtained and, for certain model choices, quark cores corresponding to more than 80% of both, its total mass and radius, are possible. Moreover, all classes of compact objects mentioned above can explain the mass-gap object in the GW190814 event.

Attendance Type

Remote

Primary author: MENEZES, Debora (UFSC)

Presenter: MENEZES, Debora (UFSC)

Track Classification: Invited Talks

Contribution ID: **271** Type: **Oral**

Octupole correlations in 118Xe; A fresh look via lifetime measurement

The Xe nuclei with mass A < 120 are perfectly placed to study the octupole correlations phenomena. For these nuclei, the presence of octupole driving h11/2 and d5/2 orbitals near the Fermi surface make them suitable to exhibit octupole correlation. Other than Xe nuclei such octupole correlations have also been reported in several other isotopes of Cs and Ba having N < 70. In previous high spin gamma ray spectroscopy measurements in 118Xe nuclei though the octupole correlations have been reported in Refs. but in almost all the cases a precise data on parity assignments and the quadrupole moment of the bands involved were missing. Also, in cases where the octupole correlations has been discussed in relation to the observed inter-band transitions, 1022 keV (7− ⟶ 6+), 846 keV (9− ⟶ 8+), 726 keV (11− ⟶ 10+) and 924 keV (8− ⟶ 8+) in 118Xe, the quoted B(E1) values have errors in the range from 4% to 28%. One of the important source of uncertainty in these E1 values is the quadrupole moment of the bands involved apart from the observed low intensity of these transitions. In the present work, the 118Xe nucleus was reinvestigated with the aim: 1) to update the level scheme with inclusion of more γ transition in the non-yrast bands (if any), 2) to confirm the suggested parities of various excited bands with polarisation measurements and 3) to get a precise value of the quadrupole moment of the bands involved in octupole correlations by lifetime measurement of excited states. We have also performed the triaxial projected shell model (TPSM) calculations to investigate the observed band structures further.
High spin states in 118Xe have been populated via 93Nb (28Si, xpyn) 118Xe fusion-evaporation reaction at a beam energy of 115 MeV provided by the 15 UD pelletron accelerator facility at the Inter University Accelerator Center, New Delhi. In the experiment, several new γ-transitions have been found and are placed appropriately in the level scheme. Theoretical study using the triaxial projected shell model (TPSM) approach suggests that the first band-crossing is due to the alignment of two neutrons, and a parallel band tracking the yrast configuration is the γ-band built on the two-quasiparticle state. Enhanced E1 transition rates have been obtained between opposite parity bands, involving νh11/2 and νd5/2 orbitals having Δj = Δl = 3, indicates the presence of octupole correlation in this nucleus. More details of the analysis and the physics outcomes will be discussed during the presentation.

Attendance Type

In-person

Primary author: CHAMOLI, S.K. (Department of Physics & Astrophysics, University of Delhi)

Presenter: CHAMOLI, S.K. (Department of Physics & Astrophysics, University of Delhi)

Track Classification: Nuclear Structure, Reactions and Dynamics

Contribution ID: **272** Type: **Oral**

HiCANS neutron sources – The HBS project for a new class of accelerator based neutron sources

Saturday, 2 December 2023 14:40 (15 minutes)

Accelerator driven neutron sources with high brilliance neutron provision present an attractive alternative to classical neutron sources of fission reactors and spallation sources to provide scientist with neutrons to probe and analyze the structure and dynamics of matter. With the advent of high current proton accelerator systems, a novel class of such neutron facilities can be established termed High-Current Accelerator-driven Neutron Sources (HiCANS). Basic features of HBS are a high current proton accelerator, a compact neutron production and moderator unit and an optimized neutron transport system to provide thermal and cold neutrons with high brilliance and a full suite of high performing epithermal, thermal and cold neutron instruments.
The Jülich Centre for Neutron Science is leading a project to develop, design and demonstrate such a novel accelerator driven High-Brilliance neutron Sources (HBS). The project aims at construction of a scalable neutron source for a user facility with open access and service according to the various and changing demand of its communities. Embedded within an international collaboration with partners from Germany, Europe and Japan the Jülich HBS project offers best flexible solutions to the scientific and industrial users. The overall conceptual design as well as the technical design of HBS as blueprint of a HiCANS facility was published in a series of recent reports.
The current status of the project, progress and next steps regarding accelerator, target, moderators and beam delivery, milestones and its impact on the vision for future neutron landscape will be presented.

Attendance Type

Remote

Primary author: GUTBERLET, Thomas (Forschungszentrum Jülich GmbH)

Co-authors: RÜCKER, Ulrich (Forschungszentrum Jülich GmbH); MAUERHOFER, Eric (Forschungszentrum Jülich GmbH); ZAKALEK, Paul (Forschungszentrum Jülich GmbH); VOIGT, Jörg (Forschungszentrum Jülich GmbH); BAGGEMANN, Johannes (Forschungszentrum Jülich GmbH); LI, Jingjing (Forschungszentrum Jülich GmbH); LIEUTENANT, Klaus (Forschungszentrum Jülich GmbH); SCHWAB, Alexander (Forschungszentrum Jülich GmbH); DING, Qi (Forschungszentrum Jülich GmbH); SCHMIDT, Norberto (Forschungszentrum Jülich GmbH); EISENHUT, Sebastian (Technical University Dresden); BRÜCKEL, Thomas (Forschungszentrum Jülich GmbH); HANSLIK, Romuald (Forschungszentrum Jülich GmbH); BESSLER, Yannick (Forschungszentrum Jülich GmbH); FELDEN, Olaf (Forschungszentrum Jülich GmbH); LEHRACH, Andreas (Forschungszentrum Jülich GmbH); GEBEL, Ralf (Forschungszentrum Jülich GmbH); MEUSEL, Oliver (Goethe University Frankfurt); PODLECH, Holger (Goethe University Frankfurt)

Presenter: GUTBERLET, Thomas (Forschungszentrum Jülich GmbH)

Session Classification: Session 11

Track Classification: New Facilities and Instrumentation

Contribution ID: **273** Type: **Oral**

Enhancing Range Verification Techniques in Proton Therapy through a Hybrid Compton Camera

Wednesday, 29 November 2023 16:45 (15 minutes)

The UCT POLARIS system, a solid-state CZT detector designed for prompt gamma-ray imaging, has shown promise in improving range verification techniques in proton therapy. Nevertheless, limitations in timing resolution and energy range currently restrict its full clinical applicability. In this project, we present a novel approach to address these limitations by integrating the POLARIS detector with a fast-timing 2" x 2" $LaBr_3$(Ce) detector, creating a hybrid Compton camera. While the $LaBr_3$(Ce) detectors offer exceptional timing and energy resolution, along with an extended maximum energy range, the POLARIS detectors exhibit high position sensitivity and excellent energy resolution. To assess the feasibility of this hybrid setup, we conducted source measurements and a pulse-selected 66 MeV proton beam experiment at iThemba LABS.

Accurate tracking of double scatter gamma ray events from the POLARIS detector into the $LaBr_3$(Ce) detector is crucial, making effective background reduction essential to minimize unphysical events. Leveraging the onboard electronics of the POLARIS detector, we can selectively identify single scatter events within the CZT crystals. Additionally, to further reduce background, we employ a cyclotron beam radiofrequency time of flight analysis on the fast time data of the $LaBr_3$(Ce) detector. This analysis enables the identification and selection of gamma-ray events resulting from interactions between the proton beam and the target. By integrating these data reduction techniques and ensuring meticulous time synchronization of the two detector data acquisition systems, we aim to achieve precise tracking of gamma rays across both detectors.

The development of this Compton camera holds potential in enhancing range verification techniques, ultimately paving the way for the advancement of a clinical prompt gamma-ray imaging system. Through this approach, we anticipate strides in the field of proton therapy, offering improved accuracy and efficacy in treatment planning and delivery.

Attendance Type

In-person

Primary authors: JONES, Pete (iThemba LABS); PELLEGRI, Luna (University of the Witwatersrand and iThemba LABS); PETERSON, Steve (University of Cape Town)

Session Classification: Session 4

Track Classification: Applied Nuclear Physics

Contribution ID: **274** Type: **Invited Talk**

Cyclotron-Production of Innovative Radionuclides: Direct Activation and ISOL Technique Experience at INFN-LNL

Thursday, 30 November 2023 14:00 (25 minutes)

Introduction
The cyclotron-based production of radionuclides for medicine is one of the research activities carried out in the framework of the SPES (Selective Production of Exotic Species) project at the Legnaro National Laboratories of the National Institute for Nuclear Physics (INFN-LNL). The heart of SPES is the 70 MeV proton-cyclotron with a dual-beam extraction, installed in 2015 in a new building equipped with ancillary laboratories currently under completion.

Description of the Work or Project
The SPES project aims at the construction of an advanced ISOL (Isotope Separation On-Line) facility for the production of re-accelerated exotic ion beams for nuclear physics studies. The double-beam extraction of the cyclotron also allows to perform multidisciplinary activities, such as radionuclides production for medical applications and neutron-based research. This work will mainly present the activities carried out in the unit "Radionuclides for medicine and applied physics", showing the major results obtained with the interdisciplinary projects LARAMED (LAboratory of RAdionuclides for MEDicine) [Esposito et al.] and ISOLPHARM [Andrighetto et al.]. LARAMED is based on the direct-activation method, and it includes the proton-based production of 99mTc, 67Cu, 52/51Mn, 47Sc and recently Tb-isotopes, from the nuclear cross section measurements to the preclinical studies. ISOLPHARM uses the ISOL technique for the development and the production of radioisotopes with high-specific activity, such as 111Ag, going beyond the state-of-art in the field.

Conclusions
Thanks to a consolidated network of collaborations with national and international facilities, including the PRISMAP European consortium and several Italian universities and hospitals, the ongoing research activities on radionuclides production and their perspectives at the INFN-LNL will be presented at the African Nuclear Physics Conference (ANPC2023).

References

J. Esposito et al. (2019), LARAMED: a LAboratory for Radioisotopes of MEDical interest, Molecules 24(1), 20, https://doi.org/10.3390/molecules24010020
A. Andrighetto et al., ISOLPHARM website, https://isolpharm.pd.infn.it/web/

Attendance Type

Remote

Primary author: PUPILLO, Gaia (Istituto Nazionale di Fisica Nucleare, Laboratori Nazionali di Legnaro)

Co-authors: BALLAN, Michele (INFN-LNL); Dr ANDRIGHETTO, Alberto (INFN-LNL); Prof. BOSCHI, Alessandra (University of Ferrara); Dr CISTERNINO, Sara (INFN-LNL); Dr CORRADETTI, Stefano (INFN-LNL); Ms DE DOMINICIS, Lucia (INFN-LNL); Dr ESPOSITO, Juan (INFN-LNL); Dr MANZO-

LARO, Mattia (INFN-LNL); Dr MARTINI, Petra (University of Ferrara); Dr MOU, Liliana (INFN-LNL); Dr SCARPA, Daniele (INFN-LNL)

Presenter: BALLAN, Michele (INFN-LNL)

Session Classification: Session 7

Track Classification: Invited Talks

Contribution ID: **275** Type: **Oral**

Isoscalar giant monopole resonance in 24Mg and 28Si: Effect of coupling between the isoscalar monopole and quadrupole strength

Sunday, 3 December 2023 09:35 (15 minutes)

Background: In highly deformed nuclei, there is a noticeable coupling of the Isoscalar Giant Monopole Resonance (ISGMR) and the $K = 0$ component of the Isoscalar Giant Quadrupole Resonance (ISGQR), which results in a double peak structure of the isoscalar monopole (IS0) strength (a narrow low-energy deformation-induced peak and a main broad ISGMR part). The energy of the narrow low-lying IS0 peak is sensitive to both the incompressibility modulus K_∞ and the coupling between IS0 and isoscalar quadrupole (IS2) strength.

Objective: This study aims to investigate the two-peaked structure of the ISGMR in the prolate ^{24}Mg and oblate ^{28}Si nuclei and identify among a variety of energy density functionals based on Skyrme parameterisations the one which best describes the experimental data. This will allow for conclusions regarding the nuclear incompressibility. Because of the strong IS0/IS2 coupling, the deformation splitting of the ISGQR will also be analysed.

Methods: The ISGMR was excited in ^{24}Mg and ^{28}Si using α-particle inelastic scattering measurements acquired with an $E_\alpha = 196$ MeV beam at scattering angles $\theta_{\text{Lab}} = 0°$ and $4°$. The K600 magnetic spectrometer at iThemba LABS was used to detect and momentum analyse the inelastically scattered α particles. An experimental energy resolution of ≈ 70 keV (FWHM) was attained, revealing fine structure in the excitation-energy region of the ISGMR. The IS0 strength distributions in the nuclei studied were obtained with the Difference-of-Spectrum (DoS) technique. The theoretical comparison is based on the quasiparticle random-phase approximation (QRPA) with a representative set of Skyrme forces.

Results: IS0 strength distributions for ^{24}Mg and ^{28}Si are extracted and compared to previously published results from experiments with a lower energy resolution. With some exceptions, a reasonable agreement is obtained. The IS0 strength is found to be separated into a narrow structure at about $13 - 14$ MeV in ^{24}Mg, $17 - 19$ MeV in ^{28}Si and a broad structure at $19 - 26$ MeV in both nuclei. The data are compared with QRPA results. The results of the calculated characteristics of IS0 states demonstrate the strong IS0/IS2 coupling in strongly prolate ^{24}Mg and oblate ^{28}Si. The narrow IS0 peaks are shown to arise due to the deformation-induced IS0/IS2 coupling and strong collective effects. The cluster features of the narrow IS0 peak at 13.87 MeV in ^{24}Mg are also discussed. The best description of the IS0 data is obtained using the Skyrme force SkP$^\delta$ with an associated low nuclear incompressibility $K_\infty = 202$ MeV allowing for both the energy of the peak and integral IS0 strength in ^{24}Mg and ^{28}Si to be reproduced. The features of the ISGQR in these nuclei are also investigated. An anomalous deformation splitting of the ISGQR in oblate ^{28}Si is found. The observed structure of ISGQR in ^{24}Mg is described.

Conclusions: The ISGMR and ISGQR in light deformed nuclei are coupled and thus need to be described simultaneously. Only such a description is relevant and consistent. The deformation-induced narrow IS0 peaks can serve as an additional sensitive measure of the nuclear incompressibility.

Attendance Type

In-person

Primary author: BAHINI, Armand (iThemba LABS)

Co-authors: Prof. NESTERENKO, Valentin (Joint Institute for Nuclear Research (Dubna, Russia)); USMAN, Iyabo (University of the Witwatersrand); VON NEUMANN-COSEL, Peter (Institut fuer Kernphysik, Technische Universitaet Darmstadt); NEVELING, Retief (iThemba LABS); CARTER, John (School of Physics, Wits University)

Presenter: BAHINI, Armand (iThemba LABS)

Session Classification: Session 13

Track Classification: Nuclear Structure, Reactions and Dynamics

Contribution ID: **276** Type: **Oral**

Multiplicity of Scision Neutrons from Density Functional Scission Dynamics

The time evolution of the nuclear density of the fissioning system ^{240}Pu during the scission process is obtained from the time-dependent superfluid local-density approximation (TDSLDA) to the density functional theory.
A nuclear energy density functional based on the Skyrme force Skm* is used.
The duration of the scission process Δt as well as the neck radius (r_{min}) of the 'just-before scission' configuration and the minimum separation (d_{min}) of the inner surfaces of the fragments in the 'immediately-after scission' configuration were extracted in order to calculate the multiplicity of the scission neutrons (ν_{sc}) using a phenomenological dynamical scission model (DSM).
We find that ν_{sc}=1.347, i.e. half of the prompt fission neutrons measured in the reaction $^{239}Pu(n_{th}, f)$ are released at scission.
After scission, the fragments are left excited and with some extra deformation energy (mainly the heavy one). In this way we can account for the evaporation of the other half and for the emission of γ-rays.

Attendance Type

In-person

Primary author: Prof. CARJAN , Nicolae ("Horia Hulubei" National Institute for Physics and Nuclear Engineering)

Presenter: Prof. CARJAN , Nicolae ("Horia Hulubei" National Institute for Physics and Nuclear Engineering)

Track Classification: Nuclear Structure, Reactions and Dynamics

Contribution ID: **277** Type: **Oral**

Evolution of the neutron 1d spin-orbit splitting in ^{35}S and ^{39}Ca

Wednesday, 29 November 2023 10:55 (15 minutes)

Nuclei along N=20 provide an excellent region to investigate the change in nuclear structure and interactions. From their evolution from the doubly magic nucleus ^{40}Ca through to the Z=16 and Z=14 nuclei ^{36}S and ^{34}Si, respectively, to ^{32}Mg with a deformed $2p - 2h$ intruder ground state [1]. The mechanism responsible for the change in shell structure is not well understood and is suspected to be a subtle combination of the different components of the nuclear force namely the central, spin-orbit (SO), and tensor parts. A significant reduction of the neutron $d_{5/2}$ and $d_{3/2}$ spin-orbit splitting between ^{40}Ca and ^{36}S, as protons are removed from the $d_{3/2}$ orbital, would be indicative of the proton-neutron tensor force. By comparing the neutron $d_{5/2}$ hole strength between these nuclei, the strength of the tensor force is probed in an unprecedented manner. The centroids of the hole states in ^{35}S have been inferred from a ^{36}S(p,d)^{35}S experiment performed at iThemba LABS. A ^{36}S(p,d)^{35}S reaction is a useful tool to probe the neutron spin-orbit splitting in ^{36}S, provided a reliable ^{36}S target is available. This was achieved by specifically developing a new target system at iThemba LABS which allows for a cost-effective ^{36}S target without heavy contaminants. This novel target encapsulates sulfur between two Mylar foils and has been shown to be an effective way to produce targets with a significant amount of material (0.5-1 mg/cm^2). Using this moving ^{36}S target with 66 MeV incident protons states in ^{35}S were measured with the K600 magnetic spectrometer at iThemba LABS. States up to 20 MeV were observed\, identifying the neutron single-particle strength below and above the Fermi surface using the detection of the deuterons at the focal plane of the K600 spectrometer with an energy resolution of approximately 30 keV [2]. The results from the ^{36}S(p,d)^{35}S experiment were compared to the ^{40}Ca(p,d)^{39}Ca study by Matoba *et al.* [3]. The results show an increase of the neutron $1d_{5/2}$ - $1d_{3/2}$ SO splitting between ^{35}S and ^{39}Ca by 0.411 MeV. This is contrary to the universal trend of SO splitting with increasing mass number which would predict a decrease of ~0.450 MeV. This deviation is highly indicative of the effect of tensor forces. At present, the tensor force is not implemented in the vast majority of the available mean field and relativistic mean field calculations, whereby the amplitude of the SO splitting is solely attributed to the spin-orbit force. This study provides an unambiguous result indicating the role of the tensor force. It is shown that the strength of the tensor force is, however, lower than predicted by the shell model and ab-initio theory.

[1] O. Sorlin and M.-G. Porquet, Prog in Particle and Nuclear
Physics 61,602 (2008), ISSN 0146-6410
[2] R. Neveling, H. Fujita,*et. al* NIM in Physics Research Section A: Accelerators, Spectrometers, Detectors, and Associated Equipment 654, 29 (2011), ISSN 0168-9002
[3] M. Matoba, *et. al* Phys. Rev. C 48, 95 (1993).

This work is supported by the National Research Foundation of South
Africa grant 118846.

Attendance Type

In-person

Primary authors: JONGILE, Sandile (iThemba LABS); NEVELING, Retief (iThemba LABS); WIEDEKING, M. (iThemba LABS); SORLIN, olivier (GANIL); LEMASSON, Antoine (GANIL); PAPKA, Paul (Stellenbosch University); ADSLEY, Philip (iThemba LABS/Wits); PELLEGRI, Luna (University of the Witwatersrand and iThemba LABS); SMIT, Ricky (iThemba LABS); DONALDSON, Lindsay (iThemba Laboratory for Accelerator Based Sciences); EBRAN, Jean-Paul (CEA); MTHEMBU, Sinegugu (iThemba LABS); JONES, Pete (iThemba LABS); KHUMALO, thuthukile (iThemba LABS); JIVAN, Harshna (University of the Witwatersrand); AVAA, Abraham (iThemba/Wits); KENFACK JIOTSA, Doris Carole (PhD Student); Dr NEMULODI, Fhumulani (iThemba LABS); Mr MALATJI, Kgashane (iThemba LABS, Stellenbosch University); Mr NETSHIYA, Adivhaho (iThemba LABS, WITS); Dr YUAN, Cenxi (sun yat sen university); Dr KEELEY , Nicholas; Dr NOWACKI , Frederic; Dr SOMA, Vittorio (IRFU, CEA, Université Paris-Saclay, 91191, Gif-sur-Yvette, F); Dr DUGUET, Thomas (IRFU, CEA, Université Paris-Saclay, 91191, Gif-sur-Yvette, France); AZAIEZ, Faical (CNRS/IPNO); MACCHIAVELLI, Augusto (Lawrence Berkeley National Laboratory)

Presenter: JONGILE, Sandile (iThemba LABS)

Session Classification: Session 1

Track Classification: Nuclear Structure, Reactions and Dynamics

Contribution ID: **278** Type: **Oral**

Distant mirror nuclei studied with -1n and -2n knockout reactions

Thursday, 30 November 2023 12:40 (15 minutes)

Isospin symmetry – the neutron-proton exchange symmetry rooted in the concepts of charge symmetry and charge independence of the nuclear force – is one of the key concepts in nuclear physics. It results in beautiful and simple symmetries in the otherwise complex behaviour of nuclei, and examination of how those symmetries are broken can, in turn, shed light on the properties of the interactions concerned. To perform thorough investigations of the physics of isospin requires detailed spectroscopy of proton-rich nuclei – i.e. detailed level schemes and transitions strengths. Knockout reactions from relativistic radioactive beams is proving to be an extremely powerful approach – especially when combined with gamma-ray arrays with tracking capability such as GRETINA at the NSCL facility, results from which are presented here.

Two completely new level schemes of proton-rich, $T_z = -\frac{3}{2}$, nuclei ^{47}Mn and ^{45}Cr, have been produced [1] using one-neutron knockout for ^{47}Mn and two-neutron knockout for ^{45}Cr. In both cases, comprehensive new schemes were established, with confidence given to the final spin/parity assignments using the now well-established "mirrored knockout approach" [2,3] coupled to theoretical predictions of -1n and -2n exclusive cross sections. These results demonstrate the power of using the knockout approach for establishing complex level schemes in exotic nuclei.

Two theoretical models have been employed to analyse the resulting mirror energy differences (MED) – a large-scale fp-shell-model analysis, allowing for excitations from the $d_{3/2}$ level, and a new DFT-based model based on the No Core Configuration Interaction Model [4]. This new DFT approach, first applied in [5], which uses a non-truncated model space, presents an alternative method of MED analysis, which can be applied in well-deformed systems with complex configurations. The latest results and model analysis will be presented.

The analysis of ^{47}Mn, and its mirror nucleus ^{47}Ti (populated by the analogue -1p reaction), has also allowed for measurements of the lifetimes of the two $J^\pi = \frac{7}{2}^-$ analogue first-excited states. This has enabled an unusually high-precision comparison of analogue *B(M1)* transition strengths in a pair of mirror nuclei and the extraction of isoscalar and isovector transition strengths. The dependence of analogue *M1* transition strengths on T_z has been compared with the predictions from isospin formalism, and the latest results will be presented.

[1] S. Uthayakumaar et al., Phys. Rev. C 106, 024327 (2022)
[2] R.Yajzey et al., Phys. Lett. B. 823, 136757 (2021)
[3] S. A. Milne et al., Phys. Rev. C. 93, 024318 (2016).
[4] P. Bączyk and W. Satula, Phys. Rev C. 103, 054320 (2021).
[5] R.Llewellyn, et al., Phys. Lett. B. 811, 135873 (2020).
[6] S. Uthayakumaar et al., to be published (2023)

Attendance Type

In-person

Primary author: BENTLEY, Michael (University of York)

Co-author: Dr UTHAYAKUMAAR, Sivahami (Facility for Rare Isotope Beams)

Presenter: BENTLEY, Michael (University of York)

Session Classification: Session 6

Track Classification: Nuclear Structure, Reactions and Dynamics

Contribution ID: **279** Type: **Oral**

Development of a novel self-calibration technique for γ-ray energy-tracking arrays

Saturday, 2 December 2023 14:25 (15 minutes)

The development of γ-ray energy-tracking arrays using highly segmented High Purity Germanium (HPGe) detectors is currently the technological frontier of high-resolution gamma-ray spectroscopy in modern nuclear physics [1]. The tracking capability of such arrays strongly depends on the performance of the Pulse Shape Analysis (PSA), which uses the position-dependent response of the detector signals to determine the γ-ray interaction positions within the detector volume. The PSA algorithm is performed by comparing the measured signal pulse shape to expected pulse shapes associated with different interaction positions – i.e. the "signal basis". Therefore, producing a reliable signal basis is one of the key points for PSA.

A novel method to generate a reliable signal basis in a notably simple experimental way was proposed in [2], and this presentation reports on the testing and implementation of this method. In this method, a γ-ray source illuminates the full array and the Compton scattering data is obtained. Starting with the assumption of a segment-sized position resolution for every interaction point and using an iterative minimization procedure based on the tracking of Compton scattering events, it is possible to converge to the real positions after several iterations, which is the so-called "self-calibration" approach. Heil *et al.* [2] demonstrated the feasibility of the approach using a simulation, applied a simplified geometry for a generic array and without considering electronic pulses.

This presentation reports the new development of the self-calibration technique with a realistic geometry for the AGATA array with pulse-shape signals, and the first implementation of the approach using experimental source data with AGATA at the Legnaro National Laboratory. To demonstrate the performance of this technique, it is first applied to a simulation data obtained using the interaction points produced by the AGATA Geant4 simulation package combined with a calculated pulse shape signal basis generated by the AGATA Detector Library (ADL)[3]. The signal basis produced by the self-calibration method is compared with the initial ADL basis to show the validity of the method. This method was then applied to signals from real γ-ray source calibration data to generate, for the first time, an experimental in-situ signal basis for AGATA. This experimental self-calibrated basis is compared with the currently-used calculated ADL basis. PSA using both signal bases have been attempted and the comparison looks very encouraging for the new approach. Further development of the self-calibration technique is proposed and improvements to the experimental basis generated by the self-calibration technique are foreseen in the near future.

[1] A. Korichi, T. Lauritsen, Eur. Phys. J. A 55, 121 (2019).
[2] S. Heil, S. Paschalis, M. Petri, Eur. Phys. J. A 54, 172 (2018).
[3] B. Bruyneel, B. Birkenbach, P. Reiter, Eur. Phys. J. A 52, 70 (2016).

Attendance Type

In-person

Primary author: BENTLEY, Michael (University of York)

Co-authors: Dr CHEN, Sidong (University of York); Dr PASCHALIS, Stefanos (University of York); Dr PETRI, Marina (University of York)

Presenter: BENTLEY, Michael (University of York)

Session Classification: Session 11

Track Classification: New Facilities and Instrumentation

Contribution ID: **280** Type: **Oral**

Testing indirect experimental methods for constraining the 193,194Ir(n,γ) cross sections

Wednesday, 29 November 2023 15:05 (15 minutes)

Abstract

As much as nucleosynthesis or element formation is concerned, almost all the nuclei heavier than iron have been made in part by the slow neutron capture and the rapid neutron capture processes (≈ 50% each), respectively known as the s- and r- processes [1].
The neutron capture reactions 192Ir(n,γ)193Ir and 193Ir(n,γ)194Ir are indirectly studied by analysing data obtained from the Oslo Cyclotron Laboratory (OCL). These data will allow for the study of 193,194 Ir iso- topes, from the 192Os(α,tγ) and 192Os(α,dγ) reactions, respectively. The 193Ir(n,γ)194Ir cross sections which will be constrained by our measurement will provide a comparison to existing (n,γ) measurement data [2].
In addition, the 192Ir(n,γ)193Ir reaction is a branching point in the s-process making it very interesting, but it is challenging to measure the (n,γ) cross section directly since 192 Ir is unstable. Therefore the OCL data may provide very valuable information on the 192Ir(n,γ)193Ir cross section by indirectly constraining it with the experimental nuclear level density (NLD) and γ-strength function (γSF).
An array of Sodium Iodine (NaI)Tl detectors, called CACTUS, detected γ-rays and the silicon particle telescope array, called SiRi, was used to detect charged particles in coincidence. The NLDs and γSFs are being extracted below the neutron separation energy, Sn, using the Oslo Method [3]. Furthermore, the NLDs and γSFs will be used as inputs in the open-source code called TALYS to calculate cross-sections of 193,194 Ir. I will provide preliminary results of the measured NLDs and γSFs from the 192Os(α,dγ)194Ir reaction which will be used as inputs in the code TALYS to calculate cross-sections of 193,194Ir.

[1] Arnould, M., Goriely, S., and Takahashi, K. (2007). Physics Reports, 450(4-6), 97-213.
[2] Zerkin, V. V., and Pritychenko, B. (2018). The experimental nuclear reaction data (EXFOR) 888, 31-43.
[3] Schiller, A., Bergholt, L., Guttormsen, M., Melby, E., Rekstad, J., and Siem, S. (2000). Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equip- ment, 447(3), 498-511.

This work is based on the research supported by the National Research Foundation of South Africa (Grant Number:PMDS22070734847) and SAINTS Prestigious Doctoral Scholarship.

Attendance Type

In-person

Primary authors: Prof. LARSEN, An-Cecilie (University of Oslo); Prof. WIEDEKING, Mathis (University of the Witwatersrand and iThemba LABS); MAGAGULA, Sebenzile Pretty Engelinah (University of the Witwatersrand and iThemba Labs)

Presenter: MAGAGULA, Sebenzile Pretty Engelinah (University of the Witwatersrand and iThemba Labs)

Session Classification: Session 3

Track Classification: Nuclear Structure, Reactions and Dynamics

Contribution ID: **281** Type: **Workshop**

Alpha knockout reaction from light to heavy nuclei

Saturday, 2 December 2023 09:00 (25 minutes)

The proton-induced α knockout reaction, $(p, p\alpha)$, is a powerful probe of the α formation in the nucleus [1]. We have shown that a modern theoretical calculation of the α amplitude in the ^{20}Ne ground state combined with the $(p, p\alpha)$ reaction calculation by the distorted wave impulse approximation can quantitatively reproduce the existing experimental data [2]. On the other hand, quantitative reproductions of the α knockout cross section from ^{24}Mg, ^{28}Si, ^{32}S, ^{40}Ca, ^{48}Ti, etc., are still theoretically challenging. Stimulated by the α knockout reaction experiment from Sn(tin) isotopes [3], the universality of the α formation throughout the nuclear chart is also an interesting question. In this contribution, from a reaction theory point of view, I will review the recent progress in the α formation phenomena studied by the $(p, p\alpha)$ reaction and our recent achievement which showed a possibility that the α knockout reaction may be a good probe for the α formation on the surface of the α decay nuclei [4].

[1] T. A. Carey, P. G. Roos, N. S. Chant, A. Nadasen, and H. L. Chen, Phys. Rev. C 29, 1273 (1984).
[2] K. Yoshida, Y. Chiba, M. Kimura, Y. Taniguchi, Y. Kanada-En'yo, and K. Ogata, Phys. Rev. C 100, 044601 (2019).
[3] J. Tanaka et al., Science 371, 260 (2021).
[4] K. Yoshida and J. Tanaka, Phys. Rev. C 106, 014621 (2022).

Attendance Type

Remote

Primary author: YOSHIDA, Kazuki (Japan Atomic Energy Agency)

Presenter: YOSHIDA, Kazuki (Japan Atomic Energy Agency)

Session Classification: Workshop Session C

Track Classification: Workshop Talks

Contribution ID: **282** Type: **Invited Talk**

Theoretical approaches describing low-lying dipole states

Thursday, 30 November 2023 16:05 (25 minutes)

The presence of the low-lying dipole states on stable and unstable nuclei with neutron excess - known as Pygmy Dipole Resonances (PDR) - is well established in theoretical and experimental studies. The isospin mixed nature of the PDR allows to study the excitation with isovector and isoscalar probes.
The theoretical approaches devoted to investigate this new mode extend from the macroscopic collective models to the microscopic mean-field theories; all of them reproducing the isospin mixing feature.
Detailed investigation on the reaction mechanisms are in order when isoscalar probes are used. Cross section calculations - based on detailed structure descriptions - are calculated within semi-classical Coupled Channel equations with particular attention to the construction of the nuclear potential and radial form factors with the microscopic transition densities.
A short review will be presented on both structure and dynamic approaches paying attention to some of the few questions that remain to be clarified.

Attendance Type

In-person

Primary author: LANZA, Edoardo G.

Presenter: LANZA, Edoardo G.

Session Classification: Session 5

Track Classification: Invited Talks

Contribution ID: **283** Type: **Oral**

Probing Hyperdeformation in α-like nuclei with light charged particles

Comparative analyses of evaporative light particle energy and angular distributions within the Statistical Model (SM) framework indicate nuclear deformations at high spin significantly larger than those predicted by the Rotating Liquid Drop Model. Examples of light N=Z systems showing this behaviour are the 56Ni, 44Ti and 40Ca nuclei.
The clustering might be an important structural feature. On this basis the cranked cluster model was developed and the calculations suggested the presence of quasistable deformed cluster configurations at high angular momenta and excitation energies in 48Cr and 36Ar nuclei [1].
Following this view, we have undertaken the study of nuclear deformations of the 48Cr and 36Ar compound nuclei via the emission of charged particles [2,3].
Light charged particles were measured with the 8πLP detector array and a wide set of exclusive observables have been extracted and compared with SM simulations performed with the code LILITA_N21 [4].
The results of this analyses and the future investigation exploiting the advanced performances offered by the Time-of-flight spectrometer TOSCA [5] will be discussed.

[1] W. D. M. Rae and A. C. Merchant, Phys. Lett. B 279, 207 (1992).
[2] A. Di Nitto, E. Vardaci, et al., Phys. Rev. C 93, 044602 (2016).
[3] A. Di Nitto, E. Vardaci, et al., Phys. Rev. C 107, 024615 (2023).
[4] F. Davide, A. Di Nitto, E. Vardaci, and G. La Rana. Nucl. Instrum. Meth. A 1025,166178, (2022).
[5] E. Vardaci et al., in preparation.

Attendance Type

Remote

Primary authors: DI NITTO, Antonio (INFN NA and University of Naples); Prof. VARDACI, Emanuele (Dipartimento di Fisica, Università degli Studi di Napoli “Federico II”, Italy and Istituto Nazionale di Fisica Nucleare, Sezione di Napoli, 80126 Napoli, Italy); Prof. LA RANA, Giovanni (Dipartimento di Fisica, Università degli Studi di Napoli “Federico II”, Italy and Istituto Nazionale di Fisica Nucleare, Sezione di Napoli, 80126 Napoli, Italy); Dr ASHADUZZAMAN, Md (Dipartimento di Fisica, Università degli Studi di Napoli “Federico II”, Italy and Istituto Nazionale di Fisica Nucleare, Sezione di Napoli, 80126 Napoli, Italy); Dr BANERJEE, T. (Dipartimento di Fisica, Università degli Studi di Napoli “Federico II”, Italy and Istituto Nazionale di Fisica Nucleare, Sezione di Napoli, 80126 Napoli, Italy); Ms SETARO, P.A. (Dipartimento di Fisica, Università degli Studi di Napoli “Federico II”, Italy and Istituto Nazionale di Fisica Nucleare, Sezione di Napoli, 80126 Napoli, Italy); Mr ALIFANO, G. (Dipartimento di Fisica, Università degli Studi di Napoli “Federico II”, Italy and Istituto Nazionale di Fisica Nucleare, Sezione di Napoli, 80126 Napoli, Italy)

Presenter: DI NITTO, Antonio (INFN NA and University of Naples)

Track Classification: Nuclear Structure, Reactions and Dynamics

Contribution ID: **284** Type: **Invited Talk**

Exotic nuclei for Physics (AGATA), Astrophysics (Helios), and Applications (ClimOcean)

Saturday, 2 December 2023 11:40 (25 minutes)

Nuclear physics research is at the dawn of a new era. After the Big Bang and billions years of evolution, the universe has provided us around 2000 nuclei. Based on the information from these nuclei, nuclear theory has been established in order to understand the structure of the nucleus. The steady progress over the past twenty years in the development of high intensity stable beams and of beams of radioactive isotopes has allowed to vastly expand the objectives of experimental nuclear research. It is also becoming possible to study in the laboratory a range of nuclear reactions that take place in exploding stars providing crucial information to understand how the chemical elements that we find on Earth were formed. With more than 2000 nuclei produced artificially and around 6000 expected to be produced in the facilities in operation or under construction in China, Europe, Japan and US, the conventional nuclear theory meet serious challenges. For example, the disappearance and appearance of the magic number is presently leading to the re-examination of the shell model and also of the path of the nucleosynthesis in Universe. To achieve this ambitious goal one needs to study the characteristics of unstable (radioactive) nuclei through their decays and the various nuclear interactions. Such unstable nuclei have also a wide range of applications (medicine, climate changes etc.).
In this presentation I will discuss recent results of the AGATA experimental campaign presently ongoing at LNL, together with the future program at the SPES ISOL radioactive ion beam facility including nuclear astrophysics with solenoidal spectrometers (we have recently performed experiments at the ISS (Isolde) and HELIOS (ANL)) and applications focused on monitoring the adaptation of marine species to climate changes (IFIC – Valencia (E) and LNL- UniPD (I)).

Attendance Type

In-person

Primary author: DE ANGELIS, Giacomo (INFN LNL)

Presenter: DE ANGELIS, Giacomo (INFN LNL)

Session Classification: Session 10

Track Classification: Invited Talks

Contribution ID: **285** Type: **Invited Talk**

Neutron-proton pairing in the self-conjugate nuclei of the f-shell through two-nucleon transfer reactions

Sunday, 3 December 2023 08:55 (25 minutes)

Neutron-proton pairing is the only pairing that can occur in the T=0 and the T=1 isospin channels. T=1 particle-like pairing (n-n or p-p) has been extensively studied unlike T=0 neutron-proton pairing. The over-binding of N=Z nuclei could be one of its manifestation.
Neutron-proton pairing can be studied by spectroscopy as in ref.[1].We have here studied it through transfer reactions in order to get more insight into the relative intensities of the two aforementioned channels. Indeed, the cross-section of np pair transfer is expected to be enhanced if the number of pairs contributing to the populated channel is important. The observable of interest is the ratio of the two-nucleon transfer cross-sections to the lowest 0+ and 1+ states.
Neutron-proton pairing is predicted to be more important in N=Z nuclei with high J orbitals so that the best nuclei would belong to the g9/2 shell [2]. However, considering the beam intensities in this region, we have focussed on fp-shell nuclei.
Measurements of the two-nucleon transfer reaction (p,3He) were performed at GANIL with three radioactive beams produced by fragmentation and purified by the LISE spectrometer: 56Ni, 52Fe, 48Cr. The set-ups were based on the coupling of the MUST2 Silicon array for charged particle detection with the EXOGAM gamma-ray array and a zero-degree detection (ZDD) for the last experiment.
The two first measurements with 52Fe (N=Z=26) beam, which is a partially occupied 0f7/2 shell nucleus and 56Ni (N=Z=28) beam, which has a fully occupied 0f7/2 shell allowed us to study np pairing according to shell occupancy [2]. The last measurement with 48Cr beam will allow to study the interplay between np pairing and deformation.
I will present the cross-sections measured in both channels (T=0 and T=1) and discuss the consequence for each pairing channel. The aforementioned ratio of cross-sections and the angular distribution for the ground state of 54Co will be compared with DWBA calculations. Preliminary results for 48Cr(p,3He) will also be presented.

[1] B. Cederwall et al, Nature 469 (2011) 469.
[2] B. Le Crom, M. Assié et al, Phys. Lett. B 829 (2022) 137057.

Attendance Type

Remote

Primary author: ASSIÉ, Marlène (IJCLab)

Presenter: ASSIÉ, Marlène (IJCLab)

Session Classification: Session 13

Track Classification: Invited Talks

Contribution ID: **286** Type: **Invited Talk**

Compact detectors for high energy neutron spectrometry

Sunday, 3 December 2023 11:00 (25 minutes)

There continues to be a growing need for new compact neutron spectrometers, driven mainly by the requirements for dosimetry in hadron therapy, aircraft, spacecraft, future extra-terrestrial bases, and around high energy accelerator facilities. For dosimetry in the upper atmosphere and in space, neutrons in the energy range exceeding 100 MeV need to be measured. Since neutrons are seldom present without gamma rays, any useful detector is required to be able to discriminate between the two radiation types.

Three technological developments have reinvigorated the deployment of hydrocarbon-based detectors in non-laboratory environments. The advent of solid ("plastic") polyvinyltoluene-based detectors, which exhibit pulse shape discrimination (PSD) capabilities, remove many practical challenges and hazards associated with traditional liquid scintillators. Furthermore, the emergence of the small form-factor and low voltage silicon photomultiplier (SiPM) facilitates the design of compact devices, and digital data acquisition and processing systems allows PSD and spectrometry to be implemented in dynamically optimised software or firmware.

Neutron spectrometry outside of accelerator facilities is realised through unfolding, where the energy spectrum is deconvolved from the measured light output spectrum using a set of mono-energetic detector response functions. For neutron energies below 20 MeV, a detector response matrix can reliably be produced using Monte Carlo radiation transport codes. Due to insufficient data regarding the neutron interaction cross sections above 20 MeV the detector response can only be measured directly at reference neutron facilities such as iThemba LABS (South Africa), where nanosecond pulsed neutron beams are produced in the energy range of 30-200 MeV.

We present characterisations of newly developed compact neutron spectrometers based on EJ-276 plastic scintillators, coupled to one or more SiPMs, and illustrate the use of various designs of these detectors for spectrometry based on the unfolding of light output spectra using both simulated and measured response matrices.

Attendance Type

Remote

Primary authors: HUTTON, Tanya (University of Cape Town); BUFFLER, Andy (University of Cape Town)

Co-authors: KIDSON, Miles (University of Cape Town); JARVIE, Erin (University of Cape Town)

Presenter: HUTTON, Tanya (University of Cape Town)

Session Classification: Session 14

Track Classification: Invited Talks

Contribution ID: **287** Type: **Oral**

Toroidal dipole mode in nuclei and other systems

V.O. Nesterenko

Bogoliubov Laboratory of Theoretical Physics, Joint Institute for Nuclear Research, Dubna, Moscow region, 141980, Russia

A toroidal dipole mode is a general phenomenon pertinent to both classical and quantum systems. In conventional fluid dynamics, this turbulence-induced mode is associated with the simplest vortical flow called Hill's vortex [1]. In solid-body physics [2], nanophysics and metamaterials [3] this is a second-order E1 effect leading to fantastic applications of the microwave-infrared fields [2,3].

During last decades, the toroidal E1 mode in nuclei attracts a high attention [4-10]. Its nuclear realization can give a fundamentally new information on the properties of this mode. I give a short review on the toroidal dipole in various systems and report a recent progress in investigation of E1 toroidal resonance in nuclei (interplay of the toroidal and pygmy E1 resonances [6], individual low-energy E1 toroidal states in light deformed nuclei [7,8], relation with cluster modes in light nuclei [9], toroidal resonance and nuclear vorticity, possible ways for identification of individual toroidal states in experiment [10]).

[1] M.J.M. Hill, Phil. Trans. Roy. Soc., A185, 213 (1984).
[2] V.M. Dubovik and V.V. Tugushev, Phys. Rep. 187, 145 (1990).
[3] T. Kaelberer, V.A. Fedotov, N. Papasimakis, D.P. Tsai and N.I. Zheludev, Science 330, 1510 (2010).
[4] V.O. Nesterenko, J. Kvasil, A. Repko, W. Kleinig, and P.-G. Reinhard, Phys. Atom. Nucl. 79, 842 (2016).
[5] A. Repko, V.O. Nesterenko, J. Kvasil, and P.-G. Reinhard, Eur. Phys. J. A55, 242 (2019).
[6] A. Repko, P.-G. Reinhard, V.O. Nesterenko, and J. Kvasil, Phys. Rev. C87, 024305 (2013).
[7] V.O. Nesterenko, A. Repko, J. Kasil, and P.-G. Reinhard, Phys. Rev. Lett. 120, 182501 (2018).
[8] Yoshiko Kanada-En'yo and Yuki Shikata, Phys. Rev. C95 064319 (2017).
[9] P. Adsley, V.O. Nesterenko, et al, Phys. Rev. C103, 044315 (2021).
[10] V.O. Nesterenko, A. Repko, J. Kvasil, and P.-G. Reinhard, Phys. Rev. C100, 064302 (2019).

Attendance Type

In-person

Primary author: Prof. NESTERENKO, Valentin (Joint Institute for Nuclear Research (Dubna, Russia))

Presenter: Prof. NESTERENKO, Valentin (Joint Institute for Nuclear Research (Dubna, Russia))

Track Classification: Nuclear Structure, Reactions and Dynamics

Contribution ID: **288** Type: **Invited Talk**

Results and Perspectives of the LUNA Experiment

Wednesday, 29 November 2023 14:25 (25 minutes)

Pioneering nuclear reaction studies of astrophysical interest have been carried out at the Laboratory for Underground Nuclear Astrophysics (LUNA) for about three decades (see [1] for a recent review). Shielded by 1.4 km of rock under the Gran Sasso mountain, LUNA benefits from a million-fold reduction in cosmic-ray induced background compared to surface laboratories. This has made it possible, often for the first time, to push measurements towards the lowest energy frontiers of thermonuclear fusion.

Direct experimental studies of hydrogen-burning reactions (pp-chain, CNO-, NeNa- and AlMg-cycles) in various astrophysical sites have led to significant improvements in our understanding of the lives and deaths of stars and the origin of the chemical elements in the Universe.

In this talk, I will review some recent highlights on Big-Bang and stellar nucleosynthesis processes, and present exciting opportunities for upcoming studies of helium- and carbon-burning reactions at the recently installed 3.5MV accelerator.

[1] M. Aliotta, A. Boeltzig, R. Depalo, G. Gyurky, Ann. Rev. of Nucl. Part. Sci. 72 (2022) 177-204

Attendance Type

Remote

Primary author: ALIOTTA, Marialuisa (University of Edinburgh)

Presenter: ALIOTTA, Marialuisa (University of Edinburgh)

Session Classification: Session 3

Track Classification: Invited Talks

Contribution ID: **289** Type: **Oral**

The Oslo Method at iThemba LABS

Wednesday, 29 November 2023 14:50 (15 minutes)

The Oslo Method is a powerful tool that allows for detailed studies of the Nuclear Level Density (NLD) and γ-ray strength function (γSF) at energies below the neutron separation energy. In the last decade, several Oslo Method experiments have been performed at iThemba LABS, most notably with inverse-kinematics. Coupling the Oslo Method with inverse kinematics allows for study of nuclei that otherwise would have been inaccessible due to chemical properties or short half-life. The first ever inverse-Oslo method experiment was performed at iThemba LABS in 2015 where an $^{86}\mathrm{Kr}$ beam impinged on a deuterated polyethylene target [1]. Following the success of this experiment two more inverse-kinematics experiments was performed with $^{84}\mathrm{Kr}$ and $^{132}\mathrm{Xe}$ beams, to study the NLD and γSF of $^{85}\mathrm{Kr}$ and $^{133}\mathrm{Xe}$, respectively.

It has been suggested that for very hot plasmas the nucleus should interact with electrons (Nuclear Plasma Interaction/NPI), as the level spacing within the quasi-continuum would be on a similar scale as the electron energies [2]. The strength of the interaction would be strongly affected by the magnitude of the γSF at low energy and accurate measurement of the low energy region of the γSF is critical to give accurate theoretical estimates for the magnitude of this effect. The effect of NPI has been tested on $^{133}\mathrm{Xe}$ at Lawrence Livermore National Laboratory [2], which is the main motivation for measuring the γSF and NLD of $^{133}\mathrm{Xe}$.

The reason for investigating the NLD and γSF of $^{85}\mathrm{Kr}$ is due to the significant structural changes that nuclei near magic numbers typically undergo. By examining NLD and γSF data for $N = 49$ and $N = 51$ isotopes of Kr, valuable information about these structural changes can be revealed. Additionally, the mass region around $\mathrm{A} \sim 80$ is important for nucleosynthesis, as $^{85}\mathrm{Kr}$ functions as a branching point nucleus for the s-process, and nuclei within this range can have an impact on the weak r-process. Therefore, the existence of a low energy enhancement in this region could have a significant impact on nucleosynthesis models [3].

In this talk I will present the results of inverse-Oslo experiments performed at iThemba LABS, as well as the NLD and γSF of $^{63}\mathrm{Ni}$, which has been measured with the Oslo Method with normal kinematics at iThemba LABS [4].

[1] V. W. Ingeberg et al., EpJ A **56**, 68 (2020)
[2] D. L. Bleuel et al., Plasma and Fusion Research **11**, 3401075 (2016)
[3] A. C. Larsen and S. Goriely, Phys. Rev. C **82**, 14318 (2010)
[4] V. W. Ingeberg et al., Phys. Rev. C **106**, 054315 (2022)

Attendance Type

In-person

Primary author: INGEBERG, Vetle Wegner (Department of Physics, University of Oslo)

Presenter: INGEBERG, Vetle Wegner (Department of Physics, University of Oslo)

Session Classification: Session 3

Track Classification: Nuclear Astrophysics

Contribution ID: **290** Type: **Oral**

Investigating the character of the PDR in 96Mo via one-nucleon transfer reactions

Thursday, 30 November 2023 16:45 (15 minutes)

The low-lying E1 strength which has been termed the pygmy dipole resonance (PDR), manifests as a concentration of 1^- states below and around the neutron threshold. It has thus far been observed in neutron-rich nuclei and its study may have implications on the nuclear equation of state and nucleosynthesis. Since its discovery, there has been a great deal of work in an attempt to understand its nature, both theoretically and experimentally. The degree to which the dipole states are collective is amongst the characteristics of the PDR under scrutiny. This study is an attempt to probe the nature of the PDR, specifically the single-particle or collective character of these states. One-nucleon transfer reactions are the probes of choice for this goal due to their selectivity in probing single-particle configurations. The neutron stripping reaction, ^{97}Mo(p,d)^{96}Mo and the neutron pickup reaction ^{95}Mo(d,p)^{96}Mo, were used to populate the nucleus of interest,^{96}Mo. The experiment was conducted at the MAGNEX facility of INFN-LNS in Catania, Italy. The ejectiles were momentum-analyzed by the MAGNEX spectrometer and detected by its focal-plane detection system. In this talk, the results of this experiment will be presented.

This work is based on the research supported in part by the National Research foundation (NRF) of South Africa grant number 118846

Attendance Type

In-person

Primary authors: KHUMALO, Thuthukile (iThemba LABS); PELLEGRI, Luna (University of the Witwatersrand and iThemba LABS); Prof. WIEDEKING, Mathis (University of the Witwatersrand and iThemba LABS); CAPPUZZELLO, Francesco (University of Catania and INFN-LNS, Italy); CAVALLARO, Manuela (INFN - LNS); Dr CARBONE, Diana (INFN-LNS); SPATAFORA, Alessandro (INFN-LNS); Dr ADSLEY, Phillip (Department of Physics and Astronomy, Texas AM University, Texas, USA.); AGODI, Clementina (INFN.LNS); Dr BRISCHETTO, Giuseppe (Department of Physics and Astronomy "E. Majorana", Universita Degli Studi di Catania, Catania, Italy); Dr CALABRESE , S. (Dipartimento di Fisica e Astronomia "Ettore Majorana", Universit \'a di Catania, Catania, Italy and INFN – Laboratori Nazionali del Sud, Catania, Italy); Dr CIRALDO, Irene (INFN Laboratori Nazionali del Sud, Catania, Italy); Dr ISAAK, Johann (TU Darmstadt); JIVAN, Harshna (University of the Witwatersrand); Dr JONGILE, Sandile (SSC Laboratory, iThemba LABS, Cape Town, 7100); Dr LA FAUCI, Lara (INFN Laboratori Nazionali del Sud, Catania, Italy); LANZA, Edoardo G.; Mr MALATJI, Kgashane (iThemba LABS, Stellenbosch University); NETSHIYA, Adivhaho (iThemba LABS, WITS); NEVELING, Retief (iThemba LABS); SIDERAS-HADDAD, Elias (Wits University); SGOUROS, Onoufrios (INFN-LNS); SOUKERAS, Vasileios (University of Catania and INFN - LNS); Dr TORRESSI, Domenico (INFN Laboratori Nazionali del Sud, Catania, Italy)

Presenter: KHUMALO, Thuthukile (iThemba LABS)

Session Classification: Session 5

Track Classification: Nuclear Structure, Reactions and Dynamics

Contribution ID: **291** Type: **Oral**

Description Of Low-Lying Collective States in Osmium Isotopes in the Boson Expansion Theory

Thursday, 30 November 2023 17:30 (15 minutes)

Neutron-rich nuclei with A ~ 190 provide a characteristic testing ground for microscopic theories of nuclear structures. There are quite a few indications that a prolate-oblate shape transition takes place at around N = 116 in this region [1, 2].

The microscopic description of anharmonicities in nuclear quadrupole collective motions, in terms of the fermion degrees of freedom, is a long-standing and fundamental subject in the study of nuclear many-body systems. The boson expansion theory (BET) is a promising method for the subject if the coupling to non-collective states is faithfully included in the calculation [3]. It allows us to take into account higher-order terms neglected in the RPA, and the adiabatic condition for particle motions can be avoided.

In this work, the low-lying collective states in osmium isotopes are investigated microscopically by means of the BET with the self-consistent eff ective interactions [4]. The fermion Hamiltonian is comprised of the QQ interaction with its self-consistent higher-order (many-body) terms [5], monopole- and quadrupole-pairing interactions in addition to the spherical limit of the Nilsson Hamiltonian. The Kishimoto-Tamura method of normal-ordered linked-cluster expansion of the modified Marumori boson mapping [6] is applied to construct the microscopic boson image of the Hamiltonian and that of the E2 operator. The potential energy surfaces and the structures of boson wave functions for some relevant low-lying collective states are illustrated [7]. Calculated level structures and electromagnetic properties are compared with the available experimental data.

[1] P. Sarriguren, R. R.-Guzmán and L. M. Robledo, Phys. Rev. C 77 (2008) 064322.
[2] N. Al-Dahan et al., Phys. Rev. C 85 (2012) 34301.
[3] A. Klein and E. R. Marshalek, Rev. Mod. Phys. 63 (1991) 375.
[4] H. Sakamoto and T. Kishimoto, Nucl. Phys. A501 (1989) 205; ibid. 242.
[5] H. Sakamoto, J. Phys.: Conf. Ser. 1023 (2018) 012003.
[6] T. Kishimoto and T. Tamura, Phys. Rev. C 27 (1983) 341.
[7] H. Sakamoto, Phys. Rev. C 104 (2021) 034304; J. Phys.: Conf. Ser. 1555 (2020) 012023.

Attendance Type

In-person

Primary author: SAKAMOTO, Hideo (Gifu University)

Presenter: SAKAMOTO, Hideo (Gifu University)

Session Classification: Session 5

Track Classification: Nuclear Structure, Reactions and Dynamics

Contribution ID: **292** Type: **Oral**

Microscopic analysis of proton-nucleus scattering data at energies from 200 to 1000 MeV

Sunday, 3 December 2023 10:05 (15 minutes)

The cross sections of proton-nucleus scattering at eneries from 200 to 1000 MeV are calculated within the microscopic model of folding optical potential. Such potential is determined by the amplitude of scattering of an incident proton on the bound nuclear nucleon which itself depends on three parameters, namely the total nucleon-nucleon scattering cross section, the ratio of real to imaginary parts of the scattering amplitude at forward angles, and also the slope parameter. These "inmedium" scattering amplitude parameters are adjusted to the experimental data on elastic proton-nucleus scattering and compared with the "free" ones known from analysis of proton-nucleoun scattering data. Such analysis allows one to estimate effect on nuclear matter on the scattering amplitude.

Attendance Type

In-person

Primary authors: ZEMLYANAYA, Elena (Joint Institute for Nuclear Research, Dubna, Russia); LUKYANOV, Valery (Joint Institute for Nuclear Research, Dubna, Russia); LUKYANOV, Konstantin (Joint Institute for Nuclear Research, Dubna, Russia); ABDUL-MAGEAD, Ibrahim (Cairo university, Kairo, Giza, Egypt)

Presenter: ZEMLYANAYA, Elena (Joint Institute for Nuclear Research, Dubna, Russia)

Session Classification: Session 13

Track Classification: Nuclear Structure, Reactions and Dynamics

Contribution ID: **293** Type: **Oral**

123I-ADAM10 inhibitor as a new theranostic agent for cervical cancer

Thursday, 30 November 2023 14:40 (15 minutes)

The aim of this study is to evaluate the suitability of ADAM10 as a target for imaging cervical cancer using a 123I-radiolabelled ADAM10 inhibitor. A Disintegrin and Metalloproteinases (ADAMs) exhibit proteolytic activity like matrix metalloproteinases and ADAM10 sheds a range of membrane-bound proteins that play a role in cancer progression, radioresistance and the tumor micro-environment. First, the therapeutic and radiosensitizing effects of the non-radiolabelled ADAM10 inhibitor (GI254023X, GI) were evaluated in cervical cancer cells (Hela, C33A). This includes effects on proliferation, clonogenicity, migration, invasion, apoptosis, DNA damage and adhesion. Preliminary results show an inhibition of migration but no effect on cell cycle progression, apoptosis, nor radiosensitizing effects. Secondly, GI was radiolabelled with Iodine-123 (98% radiochemical purity, ± 44 MBq/mL). 123I-GI is enantiomerically pure with a thermal stability up to 125℃. Whole blood and protein binding studies confirmed a 34% binding to read blood cells with 66% activity located in serum (0-1-2-24 hrs). Within the serum, 33% was protein bound. The partition coefficient indicated a lipophilicity of 0.555. Preliminary in vitro studies demonstrated that 123I-GI was taken up in cervical cancer cells. Blocking studies with an overdose of cold GI did not affect the uptake of 123I-GI in Hela/C33A cells. The effect of 123I-GI on clonogenicity of Hela/C33A cells is ongoing (auger effect). The potential of 123I-GI as a cancer diagnostic agent will further be investigated using a xenograft cervical cancer model. The biodistribution, pharmacokinetics and targeting will be determined in vivo (µSPECT-CT and autoradiography). All these in vitro, ex vivo and in vivo validations of GI and 123I-GI will give more insights into the cell surface protein's activity, function and its role in tumorigenesis. This will set the scene for evaluating GI linked to the alpha therapeutic nuclide 211At or the beta emitting 131I. This study will be the first step in establishing a pipeline for theranostics research at iThemba LABS.

Attendance Type

Remote

Primary authors: BOLCAEN, Julie (Radiobiology, Radiation Biophysics, iThemba LABS, Cape Town); Dr NAIR, Shankari (iThemba LABS); Dr DRIVER, Cathryn HS (Radiochemistry, South African Nuclear Energy Corporation (NECSA), Pelindaba, Brits 0240, South Africa); MULLER, Xanthene (iThemba LABS); Dr VANDEVOORDE, Charlot (Biophysics Department, GSI Helmholtzzentrum für Schwerionenforschung, 64291 Darmstadt, Germany); FISHER, Randall (Division of Radiation Biophysics, NRF iThemba LABS); Prof. EBENHAN, Thomas (Department of Nuclear Medicine, University of Pretoria Steve Biko Academic Hospital, Pretoria 0001, South Africa); Dr ZEEVAERT, Jan Rijn (Department of Radiochemistry, South African Nuclear Energy Corporation, Pretoria 001, South Africa.)

Presenter: BOLCAEN, Julie (Radiobiology, Radiation Biophysics, iThemba LABS, Cape Town)

Session Classification: Session 7

Track Classification: Applied Nuclear Physics

Contribution ID: **294** Type: **Oral**

Proton-neutron pairing and α-like quartet condensation in N=Z nuclei

The abstract is attached in the pdf format

Attendance Type

In-person

Primary authors: SANDULESCU, Nicolae (National Institute of Physics and Nuclear Engineering (IFIN-HH), Magurele, Romania); Dr SAMATARO, Michelangelo (INFN- Sezione di Catania, Catania, Italy)

Presenter: SANDULESCU, Nicolae (National Institute of Physics and Nuclear Engineering (IFIN-HH), Magurele, Romania)

Session Classification: Session 10

Track Classification: Nuclear Structure, Reactions and Dynamics

Contribution ID: **295** Type: **Oral**

Manifestation of nuclear structure in low-energy total reaction cross sections

Friday, 1 December 2023 12:50 (15 minutes)

The study of the total cross sections for the reactions involving neutron-rich weakly bound nuclei makes it possible to obtain information on their structure (halo, skin, clustering, etc.) and its manifestation in nuclear reactions.

For example, the outer neutrons of the ^{9}Li nucleus with an energy of separation of 4 MeV have a compact space distribution that may be called skin. The results of experiments on measuring total cross sections for the ^{9}Li+^{28}Si reaction as a function of the beam energy in the range $E = 5A{-}50A$ MeV [1,2] showed that, in the energy range $E = 10A - 20A$ MeV, the values of the total cross section for the ^{9}Li+^{28}Si reaction are much larger than those for the ^{7}Li+^{28}Si reaction [2]. Such an enhancement could not be explained by the theoretical models existing at the time. In [1], it was assumed that the reason for the enhancement was related to the properties of the shell of the relatively weakly bound outer neutrons and its evolution in the process of collision with the target nucleus. This assumption provided good agreement of calculations with the experimental data.

In the ^{11}Li nucleus, the outer neutrons are even more weakly bound — their energy of separation is 0.4 MeV, which leads to an extended space distribution called halo. The enhancement of the cross section for the ^{11}Li+^{28}Si reaction compared to those for the ^{9}Li+^{28}Si and ^{7}Li+^{28}Si reactions was experimentally observed in the entire energy range, up to $50A$ MeV; this enhancement was theoretically explained by neutron transfer from the extended halo shell to the states of the continuous spectrum [3].

Clustering in light nuclei is especially pronounced in the isotopes of beryllium; their moment of inertia turned out to be very large, which is consistent with their 2α-cluster structure characterized by a large deformation (e.g., [4]). Calculations also yielded a dumbbell-shaped structure due to the pronounced 2α-clustering (e.g., [5]). In this work, we discuss the manifestation of the structures of the ^{10,11,12}Be isotopes in the reactions with the ^{28}Si target measured using a multidetector gamma spectrometer [6] in comparison with the experimental data on the total reaction cross sections for the ^{7,9,11}Li isotopes [1—3] and ^{4,6}He.

[1] Yu.E. Penionzhkevich, Yu.G. Sobolev, V.V. Samarin, M.A. Naumenko, Phys. At. Nucl. 80, 928 (2017).

[2] Yu.G. Sobolev, Yu.E. Penionzhkevich, D. Aznabaev, E.V. Zemlyanaya, M.P. Ivanov, G.D. Kabdrakhimova, A.M. Kabyshev, A.G. Knyazev, A. Kugler, N.A. Lashmanov, K.V. Lukyanov, A. Maj, V.A. Maslov, K. Mendibayev, N.K. Skobelev, R.S. Slepnev, V.V. Smirnov, D. Testov, Phys. Part. Nucl. 48, 922 (2017).

[3] Yu.E. Penionzhkevich, Yu.G. Sobolev, V.V. Samarin, M.A. Naumenko, N.A. Lashmanov, V.A. Maslov, I. Sivacek, S.S. Stukalov, Phys. Rev. C 99, 014609 (2019).

[4] Yu.E. Penionzhkevich, R.G. Kalpakchieva, Light exotic nuclei near the boundary of neutron stability (World Scientific Publishing Co. Pte. Ltd., Singapore, 2022).

[5] Q. Zhao, Y. Suzuki, J. He, B. Zhou, M. Kimura, Eur. Phys. J. A 57, 157 (2021).

[6] V.V. Samarin, Yu.G. Sobolev, Yu.E. Penionzhkevich, S.S. Stukalov, M.A. Naumenko, I. Sivacek, Phys. Part. Nucl. 53, 595 (2022).

Attendance Type

In-person

Primary authors: Prof. SAMARIN, Viacheslav (Joint Institute for Nuclear Research, Dubna, Russia); NAUMENKO, Mikhail (Joint Institute for Nuclear Research, Dubna, Russia); Prof. PENIONZHKEVICH, Yuri (Joint Institute for Nuclear Research, Dubna, Russia); Dr SOBOLEV, Yuri (Joint Institute for Nuclear Research, Dubna, Russia); Mr STUKALOV, Sergey (Joint Institute for Nuclear Research, Dubna, Russia)

Presenter: NAUMENKO, Mikhail (Joint Institute for Nuclear Research, Dubna, Russia)

Session Classification: Session 8

Track Classification: Nuclear Structure, Reactions and Dynamics

Contribution ID: **296** Type: **Oral**

Study of isoscalar giant monopole resonance in tin isotopes

Sunday, 3 December 2023 09:50 (15 minutes)

The investigation of compressional-mode giant resonances, specifically the isoscalar giant monopole resonance (GMR), continues to captivate the interest of nuclear physicists. This research is centered on the meticulous analysis of isoscalar monopole resonances within the 112-124Sn isotopic mass chain, aiming to glean profound insights into nuclear matter compressibility. The lingering disparity between experimentally observed GMR energies and theoretical calculations has sparked a fundamental question: Why do theoretical predictions tend to overestimate experimental values, and which interaction model offers the most accurate depiction of empirical data.
In this study, the power of the relativistic Quasiparticle Finite Amplitude Method has been harnessed to systematically explore the intricate characteristics of isoscalar monopole strength across the 112-124Sn isotopic mass chain. To achieve this, a systematic calculation has been performed to obtain strength functions and centroid energies by utilizing the density-dependent meson-exchange and point coupling parameterizations in an axially deformed harmonic oscillator basis. This approach enabled us to discern nuanced patterns in the isoscalar monopole resonance and assess its behavior with respect to different interactions. The obtained results are compared with the experimental data and other available theoretical approaches. For the specific case of 116Sn, the results are compared with the theoretical predictions derived from Skyrme interactions. The findings indicate that the density-dependent meson-exchange interaction aligns well with the available experimental data, outperforming other considered interactions. This highlights the efficacy of the relativistic Quasiparticle Finite Amplitude Method in conjunction with the density-dependent meson-exchange interaction for predicting GMR characteristics.

Attendance Type

Remote

Primary authors: DEVI, Rani (University of Jammu); SHARMA, Sumedha (University of jammu)

Presenter: DEVI, Rani (University of Jammu)

Session Classification: Session 13

Track Classification: Nuclear Structure, Reactions and Dynamics

Contribution ID: **297** Type: **Oral**

The PANDORA Project: Investigating Photonuclear Reactions in Light Nuclei.

Friday, 1 December 2023 15:35 (15 minutes)

The PANDORA (Photo-Absorption of Nuclei and Decay Observation for Reactions in Astrophysics) project focuses on the experimental and theoretical analysis of photo-nuclear reactions involving light nuclei with a mass below A = 60. This is of particular importance in the scope of ultra-high-energy cosmic ray research where the main mode of energy attenuation as it travels through the cosmos is determined by the electromagnetic interaction of the nucleus with the cosmic microwave background through the isovector giant dipole resonance. Currently, propagation calculations and reaction models are plagued by a shortage of reliable experimental data sets for important nuclei. By utilizing virtual photon experiments conducted at iThemba LABS(South Africa) and RCNP (Japan), as well as real photon experiments carried out at ELI-NP (Romania) , it becomes feasible to extract crucial information such as the isovector giant dipole resonance (IVGDR) E1 strength and the branching ratios for particle decay for light nuclei.

This study will focus on the virtual photon absorption method employed at iThemba LABS and RCNP using high energy inelastic proton scattering at 0° scattering angle using a magnetic spectrometer, combined with silicon particle coincidence and LaBr3 gamma coincidence measurements. An initial extraction of the photoabsorption cross section of a dataset of Mg^{24} will be shown along with preliminary results from a recent experiment at RCNP.

Attendance Type

In-person

Primary author: BEKKER, Jacob (University of the Witwatersrand)

Co-authors: PELLEGRI, Luna (University of the Witwatersrand and iThemba LABS); NEVELING, Retief (iThemba LABS); Dr SÖDERSTRÖM, Pär-Anders (ELI-NP); Mrs GAVRILESCU, Andreea (ELI-NP, SDIALA/Politehnica University of Bucharest)

Presenter: BEKKER, Jacob (University of the Witwatersrand)

Session Classification: Session 9

Track Classification: Nuclear Structure, Reactions and Dynamics

Contribution ID: **298** Type: **Invited Talk**

iThemba LABS a hub for research training and development

Director: Prof Makondelele Victor Tshivhase
As the sole research infrastructure of its kind in the African continent, iThemba LABS has become the hub to a vibrant research, human capital development, and collaboration network for nuclear science that includes the South African universities, research institutions and international counterparts.
The iThemba LABS K=200 separated sector cyclotron (SSC), one of the accelerator complexes comprising 5 accelerators, has been used for nuclear physics research, particle (neutron and proton) therapy, and radioisotope production since its commissioning in 1986. In the 30 years of the SSC's operation, the beam time has been equally divided between the three programs, which severely limited the competitiveness of the nuclear physics research program. Phase 1 of the South African Isotope Facility involved the acquisition of a 70 MeV cyclotron radioisotope production and a low-energy rare ion beam facility. The SSC will now be dedicated to nuclear physics research and research and development of alpha emitters and theranostics (therapy and diagnostic) radioisotopes.
Nuclear Physics research at iThemba LABS serves as the backbone of research at iThemba LABS and the research programs in the next 5 to 10 years will be focused on niche areas where the laboratory's research program will complement the research carried out at cognate laboratories around the world. The status of the South African Isotope Facility, and future plans for the establishment of the rare ion beam facility at iThemba LABS will be presented.

Attendance Type

In-person

Primary author: Dr TSHVHASE, Makondelele Victor

Presenter: Dr TSHVHASE, Makondelele Victor

Track Classification: Invited Talks

Contribution ID: **299** Type: **Workshop**

Recent experimental activities in normal kinematics investigating clustering in nuclear systems by means of quasi free scattering

Saturday, 2 December 2023 09:30 (25 minutes)

Formation of clusters in nuclei is a topic of great interest and fundamental importance throughout the history of nuclear physics. In light nuclei, development of cluster structure in states close to the corresponding decay threshold is a well established phenomenon, and significant progress has been made in search for novel cluster states in light nuclei, such as the α-condensate states (e.g Hoyle state) and the 3-α-linear-chain states in carbon isotopes. Cluster formation in dilute nuclear matter including the low-density surface of heavy nuclei has not been well studied experimentally, although it has been theoretically predicted. Such a non-homogeneous phase of nuclear matter plays an important role in understanding the structure of the neutron star and the supernovae explosion. In this talk, I will discuss the results of our recent experiment measuring the formation of alpha clusters at the surface of stable tin isotopes by using quasi-free (p,pα) reaction in normal kinematics with the high-resolution spectrometers of RCNP, Osaka University.

Attendance Type

Remote

Primary author: YANG, Zaihong (Peking University)

Presenter: YANG, Zaihong (Peking University)

Session Classification: Workshop Session C

Track Classification: Workshop Talks

Contribution ID: **300** Type: **Oral**

Nature of the low-spin states in the moderately-deformed triaxial ^{193}Au nucleus

Thursday, 30 November 2023 12:25 (15 minutes)

It was recently proposed that odd-mass triaxial nuclei can exhibit wobbling motion at low spins. Excited bands identified as wobbling were reported in several nuclei, including two gold isotopes; ^{183}Au and ^{187}Au. These Au isotopes are good candidates for studying such phenomena as the nuclei in this mass region are strongly affected by the triaxial degree of freedom [1 - 2]. An excited band with $\pi h_{9/2}$ nature in ^{183}Au was associated with transverse wobbling, where the odd proton is oriented along the short nuclear axis, [3]. Conversely, in ^{187}Au an excited band with $\pi h_{9/2}$ nature was associated with longitudinal wobbling where the proton is oriented along the intermediate axis, [4]. The proposed different alignment of the angular momentum of the valence proton in these two Au isotopes is quite interesting, as the proton Fermi level is expected to be similar. The most important experimental evidence supporting the proposed wobbling nature of the excited bands in these two Au isotopes was the large magnitude of the measured mixing ratios of transitions linking the excited and the yrast $\pi h_{9/2}$ bands. Recently, new measurements of mixing ratios for these linking transitions were carried out in ^{187}Au [5]. The new results suggested that the M1 component was dominant, thus ruling out the previously proposed wobbling nature. These contrasting results highlight the difficulty of such measurements and indicate the need for further investigations, particularly focusing on the Au isotopes.

In the present study, excited low-spin states of ^{193}Au were studied using the tape station set-up at iThemba LABS. These states were populated in the β-decay that followed the ^{197}Au(p,5n)^{93}Hg reaction at E_p=50 MeV. The emitted γ rays were detected with three Compton-suppressed clover detectors and one Compton-suppressed segmented clover. In addition a Si(Li) detector was used for the emitted internal conversion elections. More than 130 new transitions were placed in ^{193}Au at low spins. Mixing ratios were measured for several transitions in ^{193}Au through internal conversion analysis and angular correlation measurements. Experimental results on the low-spin states in ^{193}Au will be presented and discussed.

[1] E.A. Gueorgieva et al., Phys. Rev. C 64, 064304 (2001).
[2] E.A. Gueorgieva et al., Phys. Rev. C 69, 044320 (2004).
[3] S. Nandi, et al., Phys Rev Lett 125.13, 132501 (2020).
[4] N. Sensharma, et al., Phys Rev Lett 124.5, 052501 (2020).
[5] S. Guo, et al., Phys. Lett. B, 828, 137010 (2022).

Attendance Type

In-person

Primary author: MTHEMBU, Sinegugu (iThemba LABS)

Co-authors: LAWRIE, Elena (iThemba LABS); LAWRIE, Kobus (iThemba LABS); BARK, Robert (iThemba LABS); BUCHER, Thifhelimbilu Daphney (iThemba LABS); STEYN, Deon (iThemba LABS); ORCE, Nico (University of the Western Cape); MAJOLA, Siyabonga (UCT/IThemba LABS); MDLETSHE, Linda (University of Zululand); SITHOLE, makuhane (University of Venda); WAKUDYANAYE, Ignasio (The University of the Western Cape); MAKHATHINI, Lucky (IiThemba LABS); SHABANE, Skhanyiso Lwazi

(iThemba Labs student)

Presenter: MTHEMBU, Sinegugu (iThemba LABS)

Session Classification: Session 6

Track Classification: Nuclear Structure, Reactions and Dynamics

Contribution ID: **301** Type: **Oral**

Extraction of level density of 2+ states in 208Pb and 120Sn nuclei from high energy-resolution (p,p') experiments

Sunday, 3 December 2023 09:20 (15 minutes)

The level density of 2+ states in 208Pb and 120Sn nuclei have been extracted in the energy region of the isoscalar giant quadrupole resonance (ISGQR) from a fluctuation analysis of high-energy-resolution (p,p') data taken at incident energies of 200 MeV at the K600 magnetic spectrometer of iThemba LABS, South Africa. The shape of the background was determined from the discrete wavelet transform of the spectra using a Discrete Wavelet Transform (DWT) function normalized at the lowest particle separation threshold. The experimental results are compared with the available phenomenological and microscopic models. This forms part of important quantities used as inputs to the nuclear astrophysical calculations.

Attendance Type

In-person

Primary author: USMAN, Iyabo (University of the Witwatersrand)

Co-authors: CARTER, John (School of Physics, Wits University); VON NEUMANN-COSEL, Peter (Institut fuer Kernphysik, Technische Universitaet Darmstadt); NEVELING, Retief (iThemba LABS); SMIT, Ricky (iThemba LABS); SIDERAS-HADDAD, Elias (Wits University); FEARICK, Roger (University of Cape Town)

Presenter: USMAN, Iyabo (University of the Witwatersrand)

Session Classification: Session 13

Track Classification: Nuclear Structure, Reactions and Dynamics

Contribution ID: **302** Type: **Oral**

Portable African Neutron-Gamma Laboratory for Innovative Nuclear Science.

Saturday, 2 December 2023 14:55 (15 minutes)

The Portable African Neutron-Gamma Laboratory for Innovative Nuclear Science (PANGoLINS) project aims to further investigate measurements of neutrons which forms an important component part on site or in transit and the detection of both fissile material for the use in decarbonised energy sources or disposal thereof. iThemba LABS has pioneered a mobile gamma-ray detection unit which allows a user to operate in the field and chart the location, strength and energy of gamma radiation. This project allows not only for investigation of neutrons but anticipates the value add on other features that are outdated i.e. battery pack and reducing current, temperature monitoring that impacts data and overall analysis. Benefits of the outcome of this project includes economic impact, contribution to GDP etc., increased highly skilled capacity and knowledge base and increased capabilities for technically innovation and social impact including improvement in quality of life, poverty alleviation and the potential impact in lowering barriers to entry for other South African technology innovations.
An overview of the project, it progress and potential outcomes will be presented.

Attendance Type

In-person

Primary authors: JONES, Pete (iThemba LABS); Ms HART, Shanyn-Dee (University of the Witwatersrand); VAN NIEKERK, Ferdie (Tshwane University of Technology); PELLEGRI, Luna (University of the Witwatersrand and iThemba LABS); STODART, Nieldane; WOODBORNE, Stephan

Presenter: JONES, Pete (iThemba LABS)

Session Classification: Session 11

Track Classification: New Facilities and Instrumentation

Contribution ID: **303** Type: **Invited Talk**

IAEA activities in support of sustainable development of accelerator facilities and the IAEA Ion Beam Facility Project

Wednesday, 29 November 2023 12:05 (25 minutes)

Due to their unique analytical and irradiation capabilities, ion beam accelerators play a major role in solving problems of modern society related to environmental pollution and monitoring, climate change, water and air quality, forensics, cultural heritage, agriculture, development of advanced materials for energy production via fission or fusion, and many other fields. Moreover, particle beams delivered from almost 20.000 accelerators worldwide are used for industrial applications and high-tech services resulting in business revenues in the billion-dollar scale, which clearly demonstrates the decisive contribution of particle accelerators to the increase of competitiveness of economies worldwide and the welfare of modern society in general.
For all these reasons, accelerator-based applications are among the thematic areas, where the International Atomic Energy Agency (IAEA) supports its member states in strengthening their capacity to adopt and benefit from the use of accelerators. In this context, the IAEA Physics Section implements various activities in support of accelerator-based research and applications that focus on
• promoting the utilization of accelerators in support of applied research in almost all fields with high societal and economic impact,
• enhancing utilization of existing accelerator infrastructures by enabling facility access for scientists from developing countries without such facilities,
• assisting scientists from developing countries in carrying out feasibility and infrastructure assessment studies and establishing new accelerator facilities.
• assisting Member States in installing, operating and maintaining their accelerator facilities and associated instrumentation

In addition to the aforementioned activities a feasibility study for an ion beam accelerator facility (IBF) at the IAEA laboratories in Seibersdorf was performed in order to assess the interest of Member States in using this facility. Forty Member States have quantified their needs through replies to a properly designed questionnaire. The analysis of the questionnaires showed high demand in training in accelerator technologies and associated Ion Beam Analysis (IBA) techniques, as well as in analytical services in almost all areas of IBA applications. An appropriate accelerator design, matching the IAEA's programme for capacity building and provision of products and services across many fields of interest for the Member States, was identified.

Under these developments, the need of a project aiming at establishing an ion beam facility at Seibersdorf was justified. The main objective of the IBF project is to establish a state-of-the-art accelerator facility at the IAEA laboratories in Seibersdorf to cover the identified Member States' needs for training scientists and engineers in operating and applying ion beam accelerator technologies and to provide a range of associated services. The expected outcome of the project is to enhance the capacity and capability of the IAEA to address the rising demand of Member States to provide assistance in promotion of applied research using accelerator technologies for a large variety of medical and industrial applications.

This presentation aims at disseminating the IAEA tools and activities in support of accelerator-based research and applications are implemented. Moreover, details on the feasibility study, the instruments, and facilities to become available through the IBF project, including preliminary estimates of the resources, will be presented.

Attendance Type

Remote

Primary author: CHARISOPOULOS, Sotirios (IAEA)

Co-authors: Mr SKUKAN , Natko (IAEA); Dr KANAKI, Kalliopi (IAEA); Dr RIDIKAS, Danas (IAEA)

Presenter: CHARISOPOULOS, Sotirios (IAEA)

Session Classification: Session 2

Track Classification: Invited Talks

Contribution ID: **304** Type: **Oral**

Immunological Changes During Space Travel: A Ground-Based Evaluation of the Impact of Neutron Dose Rate on Plasma Cytokine Levels in Human Whole Blood Cultures

Thursday, 30 November 2023 14:55 (15 minutes)

Considering the upcoming long-duration spaceflight missions, a better understanding of the impact of spaceflight exposome on human health is urgently warranted. Consequently, particle accelerator facilities implement ground-based, Radiobiology experiments investigating the health effects of simulated-space environments with simulated-psychological or physical stressors. iThemba LABS is such a facility, with a proton vault enabling Spaceflight Radiobiology. Historically, the immune system is notably highly sensitive to spaceflight stressors although, there's limited information on the impact of the complex space radiation environment on the astronauts' immune functioning. This pilot study presents a first step in implementation of ground-based setups with neutron irradiation, which is an important intra-spacecraft radiation component.
Whole-blood samples (n=8) were exposed to 0.125 or 1Gy of neutron irradiation (fluence-weighted average energy 29.8MeV) at a lower 0.015Gy/min (LDR) or higher 0.400Gy/min dose rate (HDR). Post-irradiation, blood samples were stimulated with lipopolysaccharide (LPS), heat-killed Listeria monocytogenes (HKLM) or pokeweed mitogen (PWM), before 24hrs incubation. Cell-mediated immunity was examined using the Cytokine Release Assay to analyse interleukin-2 (IL-2), interferon-gamma (IFN-γ), tumour necrosis factor-alpha (TNF-α) and interleukin-10 (IL-10) plasma levels.
Stimulants significantly increased all cytokine levels except IL-2, where only PWM induced significant increases. Generally, no statistically-significant changes were observed in IL-2, IFN γ, and TNF α concentrations, irrespective of dose or dose rate, when compared to stimulated, sham-irradiated controls. After PWM-stimulation, IL-10 levels were significantly increased at 0.125Gy HDR and 1Gy LDR. Pooled analysis showed that HDR significantly increased IL-2 titres (under PWM-stimulation) and IFN-γ titres (with all stimulants), but significantly decreased TNF-α secretion, without stimulation.
Limited sample numbers restricted strong conclusions in this pilot study investigating the effect of neutron radiation as a single-stressor on cytokine secretion, induced by various stimulants. An interesting dose rate effects was observed, which encourages future investigations into the synergistic effects of multiple spaceflight stressors on immune functioning.

Attendance Type

Remote

Primary authors: FISHER, Randall (Division of Radiation Biophysics, NRF iThemba LABS); Dr NAIR, Shankari (Radiochemistry, Bayer, Berlin, Germany); Prof. BAATOUT, Sarah (Radiobiology Unit, Institute for Environment, Health and Safety, Belgian Nuclear Research Center (SCK CEN)); Mr VERMEESEN, Randy (Radiobiology Unit, Institute for Environment, Health and Safety, Belgian Nuclear Research Center (SCK CEN)); Dr FISHER, Farzana (Department of Medical Biosciences, Faculty of Natural Sciences, University of the Western Cape, Cape Town, South Africa); MULLER, Xanthene (iThemba

LABS); Mr DU PLESSIS, Peter (Division of Radiation Biophysics, Separated Sector Cyclotron Laboratory, NRF iThemba LABS); Dr ENGELBRECHT-ROBERTS, Monique (NRF-iThemba LABS); NDIMBA, Roya (iThemba LABS); BOLCAEN, Julie (Radiobiology, Radiation Biophysics, iThemba LABS, Cape Town); NIETO CAMERO, Jaime (iThemba LABS); DE KOCK, Evan (iThemba LABS); Dr BASELET, Bjorn (Radiobiology Unit, Institute for Environment, Health and Safety, Belgian Nuclear Research Center (SCK CEN)); Dr VANDEVOORDE, Charlot (Biophysics Department, GSI Helmholtzzentrum für Schwerionenforschung, 64291 Darmstadt, Germany)

Presenter: FISHER, Randall (Division of Radiation Biophysics, NRF iThemba LABS)

Session Classification: Session 7

Track Classification: Applied Nuclear Physics

Contribution ID: **305** Type: **Oral**

Photon Strength Function studies at iThemba LABS

Wednesday, 29 November 2023 12:45 (15 minutes)

The study of nuclear statistical properties is of importance not only in nuclear waste transmutation [1] and nuclear fuel cycles [2] but also in nuclear structure and nuclear astrophysics studies [3]. These statistical properties - the nuclear level density (NLD), which describes the number of available energy levels in a nucleus for a given excitation energy, and the photon strength function(γSF), which is the electromagnetic decay probability for a nucleus to either emit or absorb a gamma-ray, are critical ingredients into calculations of radiative neutron capture cross sections, which are in turn, used to constrain nucleosynthesis processes.

In this presentation, measurements of nuclear level densities and photon strength functions performed at iThemba LABS and their applications will be discussed. I will also introduce the newly built low-energy nuclear physics beamline at iThemba LABS' Tandetron facility, which is capable of holding 9 HPGe detectors, covering an angular range of 26-141 degrees.

[1] N. Colonna et al., Energy Environ. Sci. 3, (2010) 1910.
[2] Report of the Nuclear Physics and Related Computational Science R\&D for Advanced Fuel Cycles Workshop, DOE Offices of Nuclear Physics and Advanced Scientific Computing Research (2006).
[3] M. Arnould and S. Goriely, Phys. Rep. 384 (2003) 1–84.

This work is based on the research supported by the National Research Foundation of South Africa Grant Number 133636 and 118846

Attendance Type

In-person

Primary authors: Mr NETSHIYA, Adivhaho (iThemba LABS, WITS); Dr BAHINI, Armand (University of the Witwatersrand, Johannesburg); Dr KHESWA, Bonginkosi (University of Johannesburg); Mr BEKKER, Jacob (University of the Witwatersrand); MALATJI, Kgashane (iThemba LABS); Dr DONALDSON, Lindsay (iThemba Laboratory for Accelerator Based Sciences); Dr PELLEGRI, Luna (University of the Witwatersrand and iThemba LABS); Prof. WIEDEKING, Mathis (University of the Witwatersrand and iThemba LABS); Dr JONES, Pete (iThemba LABS); Prof. ADSLEY, Phillip (Department of Physics and Astronomy, Texas AM University, Texas, USA.); Ms MOLAENG, Refilwe (iThemba LABS); Dr NEVELING, Retief (iThemba LABS); Dr JONGILE, Sandile (iThemba LABS); Ms MAGAGULA, Sebenzile Pretty Engelinah (IThemba Labs and University of the Witwatersrand); Ms HART, Shanyn-Dee (University of the Witwatersrand); Mr BINDA, Sifundo (iThemba LABS and Wits University); Ms THUMALO, Thuthukile (iThemba LABS)

Presenter: MALATJI, Kgashane (iThemba LABS)

Session Classification: Session 2

Track Classification: Nuclear Structure, Reactions and Dynamics

Contribution ID: **306** Type: **Oral**

Mass measurement of the low-lying isomeric states in 100Y and 102Y

Saturday, 2 December 2023 12:35 (15 minutes)

Beta-decaying, high-spin, spin-trap isomers have been observed in 96Y, 98Y and 100Y with half-lives ranging from 9 to 0.9 seconds [Ab08,Ch20,Si21]. However, in 102Y there are two beta-decaying states which have similar half lives (t 1/2 = 360(40) ms [Sh83] and 300(10) ms [Hi91]) and a small energy difference, making it difficult to measure their relative energy and to ascertain if the high-spin state is the ground state or the isomeric state. This presentation will report on the use of the Phase Imaging – Ion cyclotron Resonance (PI-ICR) method [El13] at the JYFLTRAP double Penning trap at the IGISOL facility at the University of Jyväskylä, Finland to measure the relative energies of the beta-decaying states in 102Y and re-measure 100Y.

The nuclei of interest were produced via nuclear fission of 238U using a 30 MeV proton beam. In 100Y a value of 147.8(42) keV has been measured for the excitation energy of the isomeric state, which overlaps with the previously measured value of 145(15) keV [Ha07] and reduces the experimental error by a factor of 4. In 102Y the closeness in energy of the 2 states makes the analysis quite complicated and although the two states were not fully separated, the observed mass distribution can be fitted with a bi-modal distribution which indicates an excitation energy of 12.3 (16) keV for the isomeric state. Details of the experiment and of the analysis procedures will be discussed.

References

[Ab08] D.Abriola and A.A.Sonzogni, Nuclear Data Sheets 109 (2008) 2501.
[Ch20] J.Chen and B.Singh, Nuclear Data Sheets 164 (2020) 1.
[El13] S.Eliseev et al., Applied Physics B: Lasers and Optics 114 (2013) 396.
[Ha07] U.Hager et al., Nuclear Physics A793 (2007) 20.
[Hi91] John C. Hill et al., Physical Review C43 (1991) 2591.
[Sh83] K.Shizuma et al., Physical Review C27 (1983) 2869.
[Si21] B.Singh and J.Chen, Nuclear Data Sheets 172 (2021) 1.

Attendance Type

In-person

Primary author: BRUCE, Alison (University of Brighton)

Presenter: BRUCE, Alison (University of Brighton)

Session Classification: Session 10

Track Classification: Nuclear Structure, Reactions and Dynamics

Contribution ID: **307** Type: **Oral**

Production and study of neutron rich heavy nuclei.

Sunday, 3 December 2023 12:20 (15 minutes)

The heavy neutron rich nuclei are very important for nuclear physics investigations, for the understanding of astrophysical nucleosynthesis and r-process. In this region is located the closed neutron shell N=126 which is the last so-called "waiting point". 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.

A new setup, based on stopping nuclei in the gas cell and subsequent resonance laser ionization and separation by magnetic field is under stage of realization at Flerov lab. JINR. This setup is devoted to synthesis and study of new neutron rich heavy nuclei formed in low energy multi-nucleon transfer reactions.

A creation and 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. It could be helpful also for finding a new way for production of heavy and superheavy nuclei.

The current status of this investigation and its possible extension to the superheavy elements in combination with MR-TOF and Penning trap mass measurement will be discussed.

Attendance Type

In-person

Primary author: ZEMLYANOY, Sergey (Joint Institute for Nuclear Research)

Co-authors: AVVAKUMOV, Konstantin (JINR); ZUZAAN, Batsuren (JINR); Dr KUDRYAVTSEV, Yuri (Instituut voor Kern- en Stralingsfysica, Leuven, Belgium); Dr FEDOSSEEV, Valentine (CERN, Switzerland); Dr BARK, Robert (iThemba LABS, Nat. Research Foundation, South Africa)

Presenter: ZEMLYANOY, Sergey (Joint Institute for Nuclear Research)

Session Classification: Session 14

Track Classification: Neutron Physics

Contribution ID: **308** Type: **Oral**

Halo-EFT description of one-neutron halo nuclei with core excitation

Saturday, 2 December 2023 12:05 (15 minutes)

Halo nuclei are fascinating short-lived nuclear systems found near the driplines.
In standard reaction models, halo nuclei are usually described as an inert core with one or two weakly bound nucleons. However, some breakup data suggest that the dynamics of the reaction is influenced by the excitation of the core to its excited states in a significant way [1].

Halo-EFT has been shown to give a good description of halo nuclei within reaction models [2]. Accordingly, we extend it to include core excitation considering a rigid-rotor model of the core [3]. As a study case, we take ^{11}Be which is a typical one-neutron halo nucleus.
Its core deformation is then treated at the first order of perturbations to include effectively the 2^+ excited state of ^{10}Be in the description of ^{11}Be.

We perform a coupled-channels study of the bound states of ^{11}Be where the low energy constants are fitted to reproduce an *ab initio* calculation [4]. For the ground state, the inclusion of core excitation allows us to better reproduce the *ab initio* predictions (wavefunction and phaseshift). In contrast, for the first excited state, core excitation does not have much influence on the calculations, confirming that this is a shell model state. This simple few-body model will enable us to study the influence of core excitation in nuclear reactions. It will also provide a better understanding of the complicated No Core Shell Model (NCSM) results [4].

[1] R. de Diego, *et al.*, *Phys. Rev. C* 95, 044611 (2017).
[2] P. Capel, *et al.*, *Phys. Rev. C* 98, 034610 (2018).
[3] F.M. Nunes, *et al.*, *Nucl. Phys. A* 596, 171 (1996).
[4] A. Calci, *et al.*, *Phys. Rev. Lett.* 117, 242501 (2016).

Attendance Type

In-person

Primary author: KUBUSHISHI, Live-Palm (Johannes Gutenberg-Universität Mainz)

Co-author: Prof. CAPEL, Pierre (Johannes Gutenberg-Universität Mainz)

Presenter: KUBUSHISHI, Live-Palm (Johannes Gutenberg-Universität Mainz)

Session Classification: Session 10

Track Classification: Nuclear Structure, Reactions and Dynamics

Contribution ID: **309** Type: **Oral**

Recent results and prospects for research with radioactive beams at the FLNR

Wednesday, 29 November 2023 12:30 (15 minutes)

A significant part of the upgrade of the Dubna Radioactive Ion Beams facility was putting in operation a new high acceptance device - the ACCULINNA-2 fragment separator, http://flerovlab.jinr.ru/accullina-ii/. It's the new in-flight facility for operating with low energy 30-60 AMeV primary beams with 3 ≤ Z ≤ 36 delivered by U-400M cyclotron. The new separator provides high quality secondary beams what opened new opportunities for experiments with RIBs in the intermediate energy range 10÷50 AMeV. Since 2018 a few experimental studies have been carried out at the ACCULINNA-2 setup [1-4]. Recent experimental results on 6,7H, 7He will be presented. A new experimental program with RIBs at the FLNR starting in 2024 and potential of using additional equipment as radio frequency filter, zero angle spectrometer, cryogenic tritium target and new detectors development will be discussed.

1. G. Kaminski, et al., "Status of the new fragment separator ACCULINNA-2 and first experiments", Nucl. Instrum. Methods Phys. Res. B 463 (2020) 504-507.
2. A.A. Bezbakh et al., Evidence for the first excited state of 7H", Phys. Rev. Lett. 124 (2020) 022502.
3. I.A. Muzalevskii, et al., "Resonant states in 7H: Experimental studies of the 2H(8He,3He) reaction", Physical Review C 103 (2021) 044.
4. E.Yu. Nikolskii, et al., "6H states studied in the 2H(8He,4He) reaction and evidence of an extremely correlated character of the 5H ground state", Physical Review C 105 (2022) 064605.

Attendance Type

In-person

Primary authors: KAMINSKI, Grzegorz (Flerov Laboratory of Nuclear Rections, Joint Institute for Nuclear Research); FOR ACCULINNA-2 COLLABORATION

Presenter: KAMINSKI, Grzegorz (Flerov Laboratory of Nuclear Rections, Joint Institute for Nuclear Research)

Session Classification: Session 2

Track Classification: New Facilities and Instrumentation

Contribution ID: **310** Type: **Invited Talk**

The NUMEN project: nuclear response to weak interaction investigated by nuclear reactions

Friday, 1 December 2023 12:25 (25 minutes)

The physics of neutrinoless double beta (0νββ) decay has important implications on particle physics, cosmology and fundamental physics. It is the most promising process to access the effective neutrino mass. To determine quantitative information from the possible measurement of the 0νββ decay half-lives, the knowledge of the Nuclear Matrix Elements (NME) involved in the transition is mandatory. The possibility of using heavy-ion induced double charge exchange (DCE) reactions as tools toward the determination of the NME is at the basis of the NUMEN project [1]. The basic points are that the initial and final state wave functions in the two processes are the same and the transition operators are similar, including in both cases a superposition of Fermi, Gamow-Teller and rank-two tensor components. Full understanding of the DCE reaction mechanism is fundamental to disentangle the reaction part from the nuclear structure aspects relevant for the 0νββ decay NMEs. The most crucial and debated aspect in the DCE and SCE nuclear reactions is the competition between the direct process, proceeding via the meson-exchange paths, and the sequential ones proceeding through the transfer of several nucleons.
The availability of the MAGNEX spectrometer [2] for high resolution measurements of the DCE reactions is essential to obtain high resolution energy spectra and accurate cross sections at very forward angles, including zero degree, and allows the concurrent measurement of the other relevant reaction channels (elastic and inelastic scattering, one- and two-nucleon transfer reactions and single charge exchange). The strategy applied to study such full net of reactions is to theoretically analyze the experimental data using state-of-the-art nuclear structure and reaction theories in a unique comprehensive and coherent theoretical calculation. This multichannel approach has been recently applied to analyze some nets of nuclear reactions, for example involving the ^{18}O + ^{40}Ca system. Moreover, the absolute cross sections of some DCE reactions populating nuclei of interest for the 0νββ decay have been measured for the first time. All of these results will be presented and discussed at the Conference.

[1] F.Cappuzzello et al., Eur. Phys. J. A 54 (2018) 72.
[2] F.Cappuzzello et al., Eur. Phys. J. A 52 (2016) 167.

Attendance Type

In-person

Primary authors: CARBONE, Diana (INFN-LNS); FOR THE NUMEN COLLABORATION

Presenter: CARBONE, Diana (INFN-LNS)

Session Classification: Session 8

Track Classification: Invited Talks

Contribution ID: **311** Type: **Invited Talk**

Collective Modes studies at the CCB in Krakow

The atomic nuclei, although they are quantal objects, may exhibit many features, which are known from the macroscopic world. To one of them belong different types of collective vibration, known as Giant Resonances, or recently studied, and important for the understanding of the creation of elements in the Universe, so called Pygmy Resonances. The studies of the gamma decay of the Giant and Pygmy Resonances continue to be the hot topics, and are conducted by many groups in the world.

Recently this topic became one of the main research subjects at the proton therapy center CCB (Cyclotron Center Bronowice) at IFJ PAN Krakow. This facility became recently one of the Transnational Access facilities of the EC EURO-LABS project. The collective vibrations in stable nuclei were excited via the inelastic scattering of the fast (70-230 MeV) protons from the Proteus cyclotron in CCB. The scattered protons were detected in the detector KRATTA (Krakow Array of Triple Telescope Array), providing information of the excitation energy. The high-energy gamma-rays were measured in the 2 PARIS (Photon Array for studies with Radioactive Ion and Stable beams) clusters and 4 large volume LaBr3 scintillators.

In the talk I will summarize the status of the current knowledge of Collective Vibrational Modes (Giant and Pygmy Resonances), I will describe the proton therapy facility in Krakow and the recently achieved results from the studies of the gamma decay of Giant Quadrupole Resonances and Pygmy Resonances, brief description of other research topics conducted at CCB, as well as the research plans for the near future. I will also mention the access opportunities within the EURO-LABS project

In addition, if time permits, I will inform about the status and plans of constructing the PARIS array, being essential for the Collective Vibrational Modes studies in Kakow and other facilities in Europe.

Attendance Type

In-person

Primary author: Prof. MAJ, Adam (IFJ PAN Krakow)

Presenter: Prof. MAJ, Adam (IFJ PAN Krakow)

Track Classification: Invited Talks

Contribution ID: **312** Type: **Invited Talk**

Quantifying uncertainties due to irreducible three-body forces in deuteron-nucleus reactions

Saturday, 2 December 2023 16:30 (25 minutes)

Deuteron-induced nuclear reactions are typically described within a Faddeev three-body model consisting of a neutron, proton, and the nucleus interacting through pairwise forces. While Faddeev techniques enable the exact description of the three-body dynamics, their predictive power is limited in part by the omission of irreducible three-body nucleon-nucleon-nucleus forces. An alternative approach for describing deuteron-nucleus reactions is ab initio theory, where the system is described from first principles, starting from individual nucleons and the interactions amongst them. We adopt the ab initio no-core shell model (NCSM) coupled with the resonating group method (RGM) to compute microscopic nucleon-nucleus interactions and use them to describe deuteron-induced reactions by means of momentum space Faddeev calculations, beginning with ^{2}H+^{4}He scattering. Simultaneously, we also carry out ab initio calculations of the same deuteron-induced scattering process within the NCSM/RGM approach. I will show that the effects of irreducible three-body forces arising from antisymmetrizing the six-nucleon system are significant and impact bound state energies as well as cross sections. This observation paves the way for improved calculations of deuteron-nucleus reactions based on three-body Faddeev models.

Attendance Type

In-person

Primary author: HLOPHE, Linda (Michigan State University and Los Alamos National Laboratory)

Presenter: HLOPHE, Linda (Michigan State University and Los Alamos National Laboratory)

Session Classification: Session 12

Track Classification: Invited Talks

Contribution ID: **313** Type: **Workshop**

Deuteron quasi-free scattering reactions: a tool to probe nucleon-nucleon short-range correlations in atomic nuclei

Friday, 1 December 2023 17:05 (25 minutes)

The experimental evidence points to the existence, at short distances, of strongly correlated neutron-proton pairs much like they are in the deuteron or in free scattering processes.
As it moves through the nuclear medium, a "bare" nucleon in the presence of the nucleon-nucleon interaction becomes "dressed" in a quasi-deuteron cloud, about 20% of the time. Our phenomenological analysis of the independent-particle model content in a dressed nucleon [1] has an isospin dependence which is also reflected on the dressed amplitude. Thus, the qualitative arguments above, suggest that quasi-free scattering (QFS) of deuterons could offer a sensitive probe to examine these concepts.
In this contribution, we will discuss these ideas and present an experiment that aims at measuring the (p,pd) QFS cross-section for knocking out a deuteron in ^{10,14,16}C relative to ^{12}C as a tool to probe short-range correlations and their isospin dependency.

[1] S. Paschalis, M. Petri, A.O. Macchiavelli, O. Hen, and E. Piasetzky, Physics Letters B 800 (2020) 135110

Attendance Type

In-person

Primary authors: PETRI, Marina (University of York); Dr PASCHALIS, Stefanos (University of York); MACCHIAVELLI, Augusto (Oak Ridge National Laboratory)

Presenter: PETRI, Marina (University of York)

Session Classification: Workshop Session B

Track Classification: Workshop Talks

Contribution ID: **314** Type: **Oral**

39Ca and its relevance in nuclear astrophysics

Friday, 1 December 2023 15:05 (15 minutes)

Elemental abundances are excellent probes of classical novae (CN). Sensitivity studies show that ^{38}K(p,γ)^{39}Ca reaction-rate uncertainties modify the abundance of calcium by a factor of 60 in CN ejecta. Existing direct [1,2] and indirect measurements [3,4] are in contradiction concerning the energies and strengths of important resonances in the ^{38}K(p,γ)^{39}Ca reaction. Direct measurements of the lowest three known ℓ = 0 resonances at $E_{\rm r}$ = 386, 515, and 679 keV have greatly reduced the uncertainties on the reaction rate for this reaction [1,2]. However, considerable uncertainty remains in the spectroscopy of ^{39}Ca and subsequently, in the ^{38}K(p,γ)^{39}Ca reaction rate. A subsequent ^{40}Ca(^{3}He,^{4}He)^{39}Ca experiment using the SplitPole at TUNL [3] concluded that one of the resonances ($E_{\rm r}$ = 701.3 or $E_{\rm r}$ = 679 keV depending on the source of the nuclear data) may have been misplaced in the DRAGON target during the direct measurement and that tentative new states at $E_{\rm x}$ = 5908, 6001, and 6083 keV ($E_{\rm r}$ = 137, 230, and 312 keV) could correspond to important resonances in ^{38}K(p,γ)^{39}Ca. Resonance energies have an exponential effect on the reaction rate and the possible new resonances induce a 40\% uncertainty in the ^{38}K(p,γ)^{39}Ca reaction rate [3]. To resolve these, ^{39}Ca was studied using the ^{40}Ca(p,d)^{39}Ca reaction at forward angles with a proton beam energy of 66 MeV using the K600 magnetic spectrometer. These measurements are aimed at verifying the properties of levels in the region where discrepancies between various experiments persist. Preliminary results from the measurements will be presented.

[1] Lotay et al. PRL 116,132701 (2016)
[2] Christian et al. PRC 97 025802 (2018)
[3] Setoodehnia et al. PRC 98 055804 (2018)
[4] Hall et al. PRC 101, 015804 (2020)

This work is based on the research supported by the National Research Foundation (NRF) doctoral postgraduate scholarship (UID 141287) and the Southern African Institute for Nuclear Technology and Sciences (SAINTS) Prestigious Doctoral Scholarship.

Attendance Type

In-person

Primary author: BINDA, Sifundo (iThemba LABS and Wits University)

Co-authors: Dr ADSLEY, Phillip (Department of Physics and Astronomy, Texas AM University, Texas, USA.); Dr DONALDSON, Lindsay (iThemba Laboratory for Accelerator Based Sciences); Dr PELLEGRI, Luna (University of the Witwatersrand and iThemba LABS); Dr BAHINI, Armand (iThemba LABS); Mr BEKKER, Jacob (University of the Witwatersrand); Dr BRUMMER, Johann (iThemba LABS); Ms KHUMALO, Thuthukile (Wits University and iThemba LABS); Dr MALATJI, Kgashane (iThemba LABS); MOLAENG, Refilwe Emil (University of the Witwatersrand and iThemba LABS); Dr NEVELING, Retief (iThemba LABS)

Presenter: BINDA, Sifundo (iThemba LABS and Wits University)

Session Classification: Session 9

Track Classification: Nuclear Astrophysics

Contribution ID: **315** Type: **Workshop**

Study on short-range correlations in unstable neutron-rich nuclei

Friday, 1 December 2023 17:35 (25 minutes)

The short range correlation (SRC), is a peculiar new phenomenon that is relevant to the most dense part of the nucleus, as the SRC happens when the nucleon-nucleon pair is close to each other by only about a half of their normal average distance. Due to the Heisenberg's uncertainty principle, the SRC nucleons have much higher momentum than the Fermi momentum, contrary to the conventional, standard picture of nuclei where nucleon momenta are limited to the Fermi momentum. To establish a comprehensive understanding of nuclei, new insights from experimental and theoretical investigations on SRC are required.

So far, the SRC has been studied only for "stable" nuclei. One of the current issues on SRC is how the asymmetry of proton and neutron numbers affect the SRC. To address the question, unstable neutron-rich nuclei provide a great opportunity. Unstable neutron-rich nuclei typically have large neutron excess, which enables to study the proton-neutron-asymmetry dependence in a wide range. Furthermore, the question how SRC pair behaves in extreme neutron-rich environment arises and such a question may provide key information on the equation of state for neutron stars.

Aiming at studying the SRC in neutron-rich short-lived nuclei, we propose a novel method, namely proton-induced deuteron-knockout reaction with fast beams of unstable neutron-rich nuclei in inverse kinematics, to measure the momentum distribution inside SRC pairs. The experiment will be conducted using the SAMURAI spectrometer at the RI beam factory, RIKEN. In this presentation, the new method will be discussed, and experimental details will be given.

Attendance Type

In-person

Primary author: WANG, He

Presenter: WANG, He

Session Classification: Workshop Session B

Track Classification: Workshop Talks

Contribution ID: **316** Type: **Invited Talk**

Physics results with the ultimate AGATA-MUGAST-VAMOS setup and ISOL beams at GANIL

Wednesday, 29 November 2023 11:40 (25 minutes)

The AGATA-MUGAST-VAMOS set-up, which was recently available at GANIL for a direct reaction campaign, combined the state-of-the-art gamma-ray tracking array AGATA with the highly-segmented silicon array MUGAST and the large-acceptance magnetic spectrometer VAMOS. The mechanical and electronics integration provided a maximum efficiency for each device. The superb sensitivity of the complete set-up offered a unique opportunity to perform exclusive measurements of direct reactions with radioactive beams delivered by the SPIRAL1 facility at GANIL, France.

An experimental campaign using radioactive ISOL beams was performed during 2019-2021 using the cutting-edge combined setup, covering physics cases ranging from oxygen-14 to argon-46, and topics from nuclear structure and dynamics to astrophysics.

In this contribution I'll review the performance of the setup an focus on high-impact physics results of the experimental campaign.

Attendance Type

In-person

Primary author: MENGONI, Daniele (Universita e INFN, Padova)

Presenter: MENGONI, Daniele (Universita e INFN, Padova)

Session Classification: Session 2

Track Classification: Invited Talks

Contribution ID: **317** Type: **Oral**

NICA facility for applied research: New gates for cooperation in life sciences, material sciences and novel nuclear technologies

Wednesday, 29 November 2023 16:30 (15 minutes)

The talk will cover recent initiatives and options be provided by NICA facility for applied research be performed with ion beams. NICA (Nuclotron-based Ion Collider fAcility) is a new accelerator complex designed at the Joint Institute for Nuclear Research to study properties of dense baryonic matter. Besides the fundamental physics issues, the NICA team is also working under construction of special beamlines for applied research, including biomedical applications, space research, radiation materials science, radiation testing of microelectronics and novel developments for ADS. The Applied Research Infrastructure for Advanced Developments at NICA fAcility, recently named ARIADNA, will include: (1) beamlines with magnetic optics, power supplies, beam diagnostics systems, cooling systems, etc., (2) several experimental zones equipped with target stations for users (detectors, sample holders, irradiation control and monitoring system, etc.) and (3) supporting user infrastructure (areas for deployment of user equipment, for sample preparation and post-irradiation express analyses).

Overall scope of applied research be performed using ARIADNA beamlines includes but limited to radiation protection in space, radiation testing of microelectronics, materials research with ion beams and novel technology for radiation waste processing.

Zone 1 and its experimental station is designed for studying radiation damage to decapsulated microcircuits with low-energy ion beams extracted from the HILAC at the energy of 3.2 MeV/nucleon. The spectra of available particles will include protons and ions with Z = 2 to 92, which enables simulating certain aspects of exposure of non-biological samples to low-energy component of space radiation. Zone 2 will provide an opportunity for irradiation of different samples with intermediate-energy ion beams of 150–1000 MeV/nucleon. Zone 2 includes two target stations designed for space radiobiology studies, radiation materials science and investigating the radiation damage to capsulated microelectronics. At both target stations the following ions are expected to be available: 12C6+, 40Ar18+, 56Fe26+, 84Kr36+, 131Xe54+, 197Au79. Considering the recent trends and multiple requests raised by potential users, there is an intent to extend acceleration techniques towards realistic simulation of galactic cosmic rays with NICA beams, including implementation of the specific acceleration regime with rapid switching of ions and energies. Zone 3 is designed for development of novel nuclear power technologies, including development of ADS. The beams of 1H1+, 2D1+, 12C6+, 40Ar18+ and 7Li3 with energies of 0.3-4 GeV/nucleon are planned to be available at the target station of this zone. Zone 4 is intended for long-term exposure of materials science and biological samples to heavy ions with energies of 1-4 GeV/nucleon. The recent test experiments in this zone were performed with 3.8 GeV/nucleon 124Xe54+ ions.

The talk will particularly demonstrate the sample activities recently performed at NICA and plans on forthcoming applied research programmes, including those being implemented within the ARIADNA collaborations. The ways of getting involved in ARIADNA collaborations will also be shared.

Attendance Type

In-person

Primary author: BELOV, Oleg (Joint Institute for Nuclear Research)

Presenter: BELOV, Oleg (Joint Institute for Nuclear Research)

Session Classification: Session 4

Track Classification: Applied Nuclear Physics

Contribution ID: **318** Type: **Invited Talk**

Electromagnetic and rare isotope knockout reactions as complementary and adjustable lenses for a quest in understanding nuclei

Saturday, 2 December 2023 16:55 (25 minutes)

Electron scattering and rare isotopes are unique complementary techniques that provide powerful magnifying glasses to probe the interactions between nucleons inside nuclei. Over more than a quarter century, the 4 GeV and now 12 GeV (un)polarized electron beam of the Thomas Jefferson National Accelerator Facility (Newport News, Virginia, USA) has unraveled unprecedented insights into nuclear physics such as nucleons correlations and parton distributions, using (e,e'p) and (e,e'n) reactions on various targets. On May 10, 2022, the Facility for Rare Isotope Beams (East Lansing, Michigan, USA) started its highly anticipated experimental nuclear astrophysics program, opening a new window into our current understanding of a large number of predicted unstable (neutron and proton rich) nuclei. One of its main contributors is the MoNA Collaboration composed of primarily undergraduate institutions that has established itself as one of the dominant groups in the study of neutron-rich nuclei using (primarily) nucleon knockout reactions and the invariant mass technique. Scientific discoveries have historically been rooted in the desire for some to take on a quest to tackle the unknown, often with relentless commitments and efforts, and sometimes bold actions that have proven to uncover new pathways. This talk will provide some brief reviews on the role and successes as well as future prospects of nuclear physics experiments and theories at these facilities as they pertain to my journey in becoming a nuclear physicist, including programs to broaden participation for workforce development in nuclear science.

Attendance Type

In-person

Primary author: GUEYE, Paul (Facility for Rare Isotope Beams/Michigan State University)

Presenter: GUEYE, Paul (Facility for Rare Isotope Beams/Michigan State University)

Session Classification: Session 12

Track Classification: Invited Talks

Contribution ID: **319** Type: **Oral**

Testing the generalized Brink-Axel hypothesis in heavy nuclei

Thursday, 30 November 2023 17:00 (15 minutes)

Quasicontinuum gamma decay following compound reactions - commonly called Oslo method - is probably the most important source of information on the gamma strength functions and level densities of nuclei below particle threshold. A fundamental assumption in the analysis of Oslo-type data (and in fact all astrophysical reaction network calculations) is the generalized Brink-Axel (BA) hypothesis, whose applicability to the low-energy regime is under debate (see [1] and references therein). Since all other methods are based on the measurement of photoabsorption from the ground state, a test of the equivalence of results from absorption and emission experiments in the same nuclei postulated by the BA hypothesis is most important. I will discuss inelastic proton scattering experiments performed at RCNP in extreme forward kinematics, where relativistic Coulomb excitation dominates the cross sections [2]. Such data provide information on the E1 [3] and M1 [4] parts of the GSF and their sum can be directly compared to the compound-nucleus decay experiments. Furthermore, their very good energy resolution permits the extraction of level densities [5-7] and thereby an independent test of the normalization methods applied in the analysis of Oslo-type data.
[1] M. Markova et al., Phys. Rev. Lett. 127, 182501 (2021)
[2] P. von Neumann-Cosel and A. Tamii, Eur. Phys. J. A 55, 110 (2019)
[3] S. Bassauer et al., Phys. Rev. C 102, 034327 (2020)
[4] S. Bassauer, P. von Neumann-Cosel and A. Tamii, Phys. Rev. C 94, 054313 (2016)
[5] I. Poltoratska et al., Phys. Rev. C 89, 054322 (2014)
[6] D. Martin et al., Phys. Rev. Lett. 119, 182503 (2107)
[7] M. Markova et al., Phys. Rev. C 106, 034322 (2022)

Attendance Type

In-person

Primary author: VON NEUMANN-COSEL, Peter (Institut fuer Kernphysik, TU Darmstadt)

Presenter: VON NEUMANN-COSEL, Peter (Institut fuer Kernphysik, TU Darmstadt)

Session Classification: Session 5

Track Classification: Nuclear Astrophysics

Contribution ID: **320** Type: **Oral**

Low-energy dipole response in the Sn isotope chain: Pygmy or not pygmy?

Thursday, 30 November 2023 17:15 (15 minutes)

The observation of resonance-like structure in the electric dipole response of heavy nuclei at energies around or below the neutron, commonly termed pygmy dipole resonance (PDR), has been a topic leading to considerable experimental and theoretical activities in recent years [1-4]. The interest has been triggered by attempts to understand the underlying structure but also because of its impact on the cross sections of (n,γ) reactions relevant for the nucleosynthesis of heavy elements. Qualitatively all mean-field based models predict the appearance of such a mode, however, with a broad range of predicted strengths and energy centroids depending on the chosen interaction and model space. Many theoretical studies interpret the PDR to arise from neutron skin oscillations, which implies a dependence of the PDR strength on neutron excess. The chain of Sn isotopes represents a particularly interesting case to test the impact of neutron excess on the low-energy E1 response in a systematic manner because their g.s. structure changes little. Here, we report results from a systematic investigation of the gamma strength functions (GSFs) in Sn isotopes with mass numbers between 111 and 124. It is based on a combined data set from Oslo-type experiments (as described in Ref. [5]) and a study of the (p,p') reaction [6] at very forward angles, together covering an energy range 2 - 20 MeV. This allows a decomposition of the low-energy dipole response with minimal assumptions into contributions from the tail of the giant dipole resonance and possible resonance-like structures on top. The excess strength is dominated by a peak at about 8 MeV seen in the isovector response only. For masses ≥118, the data demand the inclusion of a second peak centered at about 6.5 MeV and identified as the PDR by comparison with isoscalar probes [7,8] and (γ,γ') experiments [9,10]. Its strength corresponds to 0.1 - 0.5% of the TRK sum rule (much smaller than predicted in most theoretical investigations) but exhibits an approximately linear increase with mass number. The results are also compared to ab initio-based microscopic models [11].

Supported by the Research Council of Norway (project number 316116), the DFG under contract SFB 1245 (project 279384907), the GANIL visitor program, US-NSF grant PHY-2209376, and US-NSF career grant PHY-1654379.

[1] N. Paar, D. Vretenar, E. Khan, and G. Colò, Rep. Prog. Phys. 70, 691 (2007).
[2] D. Savran, T. Aumann, and A. Zilges, Prog. Part. Nucl. Phys. 70, 210 (2013).
[3] A. Bracco, E. Lanza, and A. Tamii, Prog. Part. Nucl. Phys. 106, 360 (2019).
[4] E. Lanza, L. Pellegri, A. Vitturi, and M. Andrés, Prog. Part. Nucl. Phys. 129, 104006 (2023).
[5] M. Markova et al., Phys. Rev. Lett. 127, 182501 (2021); Phys. Rev. C 106, 034322 (2022); Phys. Rev. C 108, 014315 (2023).
[6] S. Bassauer et al., Phys. Rev. C 102, 034327 (2020).
[7] J. Endres et al., Phys. Rev. Lett. 105, 212503 (2010).
[8] L. Pellegri et al., Phys. Lett. B 738, 519 (2014).
[9] K. Govaert et al., Phys. Rev. C 57, 2229 (1998).
[10] B. Özel-Tashenov et al., Phys. Rev. C 90, 024304 (2014).
[11] E. Litvinova, arXiv:2308.07574 (2023).

Attendance Type

In-person

Primary author: VON NEUMANN-COSEL, Peter (Institut für Kernphysik, Technische Universität Darmstadt, D-64289 Darmstadt, Germany)

Presenters: VON NEUMANN-COSEL, Peter (Institut für Kernphysik, Technische Universität Darmstadt, D-64289 Darmstadt, Germany); MARKOVA, Maria (University of Oslo); Dr LARSEN, Ann-Cecilie (University of Oslo); LITVINOVA, Elena (Western Michigan University)

Session Classification: Session 5

Track Classification: Nuclear Structure, Reactions and Dynamics

Contribution ID: **321** Type: **Oral**

Sub-barrier Fusion Excitation Functions of Heavy-Ion Systems

Saturday, 2 December 2023 12:20 (15 minutes)

One of the yet unsettled problems in heavy-ion fusion near and below the barrier is the relative influence of nucleon transfer channels and couplings to collective modes on the cross sections. We recall two relevant papers [1] where that influence, and the moments of fusion-barrier distributions were investigated.

In this contribution, we present a new analysis of several systems, based on the combined observation of the energy-weighted excitation functions Eσ in relation to their first energy derivatives d(Eσ)/dE (slopes). That derivative is proportional to the s-wave transmission coefficient and to the square of the barrier radius. This representation helps our understanding of the situation.

The two-dimensional plot of d(Eσ)/dE vs Eσ for 48Ca,36S + 48Ca, obtained from Refs. [2, 3] is interesting. In this type of plot trivial Coulomb barrier differences between the two systems are eliminated to a large extent. The colliding nuclei are closed-shell or magic, and, at sub-barrier energies, the two data sets are completely overlapping. Indeed the Wong formula [4] implies that the slope and the excitation function are proportional to each other for all cross sections in that energy range. The proportionality constant is 2π/h¯ω, i.e. inversely proportional to the second radial derivative of the barrier approximated by a parabola. In the cited example the overlap of the two data sets implies that the two barriers have approximately the same width.

Other cases behave differently, like 40Ca + 96Zr [5] and 58Ni + 64Ni [6], where neutron transfer couplings are dominant, compared to 40Ca + 90Zr [7] and 64Ni + 64Ni [8], respectively. In either case, the system where transfer couplings are dominant, lies below the other case, meaning that the effective one-dimensional barrier is thinner. This mimics a wider barrier distribution produced by couplings, extending to lower energies and leading to a cross section enhancement vs energy, as observed. A full systematics will be shown in the talk, with more detailed and quantitative considerations for the various
cases.

[1] C. L. Jiang et al., Phys. Rev. C 89 (2014) 051603(R); K. E. Rehm et al., Phys. Rev. C 94 (2016) 044612
[2] A.M. Stefanini, G. Montagnoli et al., Phys. Lett. B 679 (2009) 95
[3] A.M. Stefanini, G. Montagnoli et al., Phys. Rev. C 78 (2008) 044607
[4] C. Y. Wong, Phys. Rev. Lett. 31 (1973) 766
[5] A.M. Stefanini, G. Montagnoli et al., Phys. Lett. B 728 (2014) 639
[6] A.M. Stefanini, G. Montagnoli, M. Del Fabbro et al., Phys. Rev. C 100 (2019) 044619
[7] H. Timmers et al., Nucl. Phys. A 633 (1998) 421
[8] C. L. Jiang et al. Phys. Rev. Lett. 93 (2004) 012701

Attendance Type

Remote

Primary authors: STEFANINI, Alberto M. (INFN - LNL); MONTAGNOLI, Giovanna (Università di Padova); DEL FABBRO, Mirco (Dipartimento di Fisica e Scienze della Terra Univ. di Ferrara and INFN

Padova); Dr CORRADI, Lorenzo (INFN - LNL); FIORETTO, Enrico (INFN - LN L); SZILNER, Suzana (dr)

Presenter: STEFANINI, Alberto M. (INFN - LNL)

Session Classification: Session 10

Track Classification: Nuclear Structure, Reactions and Dynamics

Contribution ID: **322** Type: **Oral**

Study of the K quantum number of pygmy states in 154Sm

Thursday, 30 November 2023 16:30 (15 minutes)

This study aims to understand the Pygmy Dipole Resonance (PDR) in the deformed 154Sm nucleus. Despite previous efforts, the interpretation of the behavior and nature of this low-energy resonance remains unclear with respect to the effects of neutron excess and deformation in nuclei. This further limits the predictive power of exotic nuclei properties. The current study uses the (γ, γ′) technique to explore dipole states from 3.5 MeV to the neutron separation threshold (8 MeV). The experiment was performed with the improved γ 3 setup available at the HIγS facility of the Triangle Universities Nuclear Laboratory. The setup allows for measurements by the asymmetry method of the character of the populated transitions in order to distinguish between the contribution of 1− and 1+ states which in particular is important in the study of a deformed nucleus. The high beam resolution mode (< 2%) available at HIγS allows for the measurement of the decay branching ratio to the first 2 + state. This will help to identify the K quantum number of different excited states and the PDR as a function of excitation energy. The motivation for the study along with experimental details will be provided. The initial data analysis will be discussed and an overview of future comparisons will be given.

Attendance Type

In-person

Primary author: MOLAENG, Refilwe (iThemba LABS and University of the Witwatersrand)

Co-authors: DONALDSON, Lindsay (iThemba Laboratory for Accelerator Based Sciences); PELLEGRI, Luna (University of the Witwatersrand and Themba Laboratory for Accelerator Based Sciences); USMAN, Iyabo (University of the Witwatersrand); PAPST , Oliver (Technische Universität Darmstadt); KLEEMANN , Jörn (Technische Universität Darmstadt); HEUMÜLLER , Marc (Technische Universität Darmstadt); PRIFTI , Kiriaki (Technische Universität Darmstadt); JANSSENS , Robert (University of North Carolina); GUPTA , Amrita (Technische Universität Darmstadt); AYANGEAKAA , Akaa Daniel (University of North Carolina and Triangle Universities Nuclear Laboratory); JOHNSON , Samantha (University of North Carolina and Triangle Universities Nuclear Laboratory); FINCH , Sean W. (Duke University and Triangle Universities Nuclear Laboratory); SARACINO , Antonella (University of North Carolina and Triangle Universities Nuclear Laboratory); LÖHER, Bastian (GSI Helmholtzzentrum für Schwerionenforschung GmbH); GRIBBLE , David (University of North Carolina andTriangle Universities Nuclear Laboratory); JAMES, Xavier (University of North Carolina and Triangle Universities Nuclear Laboratory); KOWALEWSKI , Tyler (University of North Carolina and Triangle Universities Nuclear Laboratory); SENSHARMA , Nirupama (University of North Carolina and Triangle Universities Nuclear Laboratory); PIETRALLA , Norbert (Technische Universität Darmstadt); ISAAK, Johann (Technische Universität Darmstadt); WERNER, Volker (Technische Universität Darmstadt); SAVRAN , Deniz (GSI Helmholtzzentrum für Schwerionenforschung GmbH); ADSLEY , Philip (Texas A&M University); WELLONS , Benjamin (Texas A&M University); CARROLL , James (U.S. Army Combat Capabilities Development Command Army Research Laboratory); CHIARA , Christopher (U.S. Army Combat Capabilities Development Command Army Research Laboratory); SANTUCCI , John (Texas A&M University)

Presenter: MOLAENG, Refilwe (iThemba LABS and University of the Witwatersrand)

Session Classification: Session 5

Track Classification: Nuclear Structure, Reactions and Dynamics

Contribution ID: **323** Type: **Oral**

Effects of exposure to neutrons and protons on neurochemical parameters of brain monoamine metabolism, behavioral and cognitive capacities of Sprague Dawley rats

Wednesday, 29 November 2023 16:15 (15 minutes)

Radiation damage to the central nervous system (CNS) has become an intriguing health problem of the last decades, largely due to the issues of radiation hazard of human deep-space flights and brain radiation therapy issues. In spite of recent intensive research in this field, the fundamental properties of regulatory pathways associated with radiation-induced CNS impairments remain mostly unclear. The complex assessment of multiple brain metabolic systems is of utmost importance in this regard. Another issue mainly related to the space radiation exposure is the combined effect induced in CNS by composition of different radiation modalities. Given the gap of knowledge regarding such exposures, we evaluated the effects of exposure both to neutrons and protons in order to probe a mixed outcome evaluated through the analysis of neurochemical parameters and cognitive functions in Sprague Dawley rats. Animals were exposed to a single dose of 1 Gy of neutrons or protons separately or 0.5 and 0.5 Gy of neutrons and protons sequentially to get a combined effect. Measurements of neuromodulator concentrations were performed in the prefrontal cortex, nucleus accumbens, hypothalamus, hippocampus, striatum, pituitary gland and cerebellum. The concentrations of the substances were measured with the LC304T high-performance liquid chromatography (HPLC) system. The data sets were taken 30 and 90 days after exposure. The animals' behavior was studied using the open field exploration test and elevated plus maze test, which enables assessment of novel environment exploration, general locomotor activity, and anxiety-like behavior in rodents. We observed differences in patterns of action of neutrons, protons and combined exposure. In particular, the prefrontal cortex demonstrated a more pronounced effect after proton irradiation compared to neutrons and a mixture of two radiation modalities. The talk will share the results of comparative analysis of neurochemical and behavioral data taken in the experiment.

Attendance Type

In-person

Primary authors: BELOKOPYTOVA, Kseniia (Joint Institute for Nuclear Research); BELOV, Oleg (Joint Institute for Nuclear Research)

Presenter: BELOKOPYTOVA, Kseniia (Joint Institute for Nuclear Research)

Session Classification: Session 4

Track Classification: Applied Nuclear Physics

Contribution ID: **324** Type: **Oral**

Determination of the response function of the LaBr3(Ce) detector for g-quanta, formed during inelastic scattering of neutrons with an energy of 14.1 MeV on oxigen nuclei

Thursday, 30 November 2023 14:25 (15 minutes)

The work is devoted to determining the response function of the detector LaBr3(Ce) for γ -quanta, formed during inelastic scattering of neutrons with energy of 14.1 MeV on the nuclei 16O. In gamma spectrometry, output pulses are recorded, the amplitudes of which are proportional to the energy lost in the detection medium by incident photons. One of the main tasks of radiation detection is to restore radiation characteristics from signals measured at the outputs of detectors. For this, it is necessary to know, first of all, the general characteristics of detectors as converters of radiation into signals. The main characteristic of the detector is its response function, which can be defined as the probability that a particle with given properties generates a certain signal in the detector that will be registered by the device. The article presents the results of modeling the response function of a scintillation detector based on a LaBr3(Ce) crystal for gamma radiation from inelastic fast neutron scattering in order to study the mechanism of its formation.
This work was supported by the RSCF grant 23-12-00239.

Attendance Type

In-person

Primary authors: GROZDANOV, Dimitar; FEDOROV, Nikita (JINR); Dr KOPATCH, Yuri

Presenter: GROZDANOV, Dimitar

Session Classification: Session 7

Track Classification: Applied Nuclear Physics

Contribution ID: **325** Type: **Oral**

Experimental investigation of the (n,xγ) reactions using tagged neutron method

Sunday, 3 December 2023 11:50 (15 minutes)

Neutron-induced reactions is a unique tool for investigation of the structure of the atomic nuclei. Analysis of the neutron inelastic scattering data as well as information about processes with charged particle emission allows one to estimate shape and radii of nuclei and deduce the reaction mechanism.

The γ-radiation emitted by excited products of neutron-induced reactions carries information about their properties. Precise information about spectra of γ-quanta and cross-sections of their emission are important for modeling of nuclear facilities, improvement of well logging technique and development of compact setups for elemental analysis. The currently available data is replete with inaccuracies and incomplete [1].

A new experimental setup for measurement of the γ-quanta emission cross-sections was constructed in the framework of the TANGRA (Tagged Neutrons & Gamma Rays) project based on the 9-years experience [2-6]. Usage of the tagged neutron method significantly decrease the amount of background events and requires specific data processing procedures and impacts on the experimental setup structure.

The design of the new experimental setup and data processing features will be discussed.

This work is supported by the RSCF grant 23-12-00239.

1. S. P. Simakov et al. Status of Experimental and Evaluated Discrete Gamma-Ray Production at En=14.5 MeV. IAEA, Vienna, Austria. 1998.
2. I.N. Ruskov et al., Phys. Proc. 64, 163 (2015).
3. D.N. Grozdanov et al., Phys. Atom. Nucl. 5, 588 (2018).
4. N.A. Fedorov, D.N. Grozdanov, V.M. Bystritsky et al., Eur. Phys. J. Web of Conf. 177, 02002 (2018).
5. N.A. Fedorov et al., Phys. Atom. Nucl. 82, 343 (2019).
6. N.A. Fedorov et al., EPJ A 57, 194 (2021).

Attendance Type

In-person

Primary author: FEDOROV, Nikita (JINR)

Co-authors: GROZDANOV, Dimitar; FILONCHIK, Polina (JINR, MIPT); Dr KOPATCH, Yuri (JINR); Dr TRETYAKOVA, Tatiana (JINR, MSU); Dr RUSKOV, Ivan (INRNE BAS); Mr HRAMCO, Konstantin (JINR)

Presenter: FEDOROV, Nikita (JINR)

Session Classification: Session 14

Track Classification: Neutron Physics

Contribution ID: **326** Type: **Oral**

Measurement of gamma-rays emission cross-sections in neutron-induced reactions in SiO2 sample

Sunday, 3 December 2023 12:05 (15 minutes)

Silicon is one of the important elements used in modern technics. Information about gamma-rays spectrum of silicon can be used in elemental analysis of various objects. The usage of compact D-T neutron generators with an energy of 14.1 MeV makes it possible to create compact portable setups, as well as to implement the tagged neutrons method by detecting the accompanying alpha particle emitted in the $T(D,n)\alpha$ reaction. In this work gamma-rays cross-sections of (n,X) reactions induced by 14.1 MeV neutrons in SiO_2 sample were measured using new experimental setup in the framework of the TANGRA project experimental program.

Attendance Type

In-person

Primary authors: FILONCHIK, Polina (JINR, MIPT); FEDOROV, Nikita (JINR); GROZDANOV, Dimitar; Dr KOPATCH, Yuri; Dr TRETYAKOVA, Tatiana (JINR, MSU); Mr HRAMCO, Konstantin (JINR); Dr RUSKOV, Ivan (INRNE BAS)

Presenter: FILONCHIK, Polina (JINR, MIPT)

Session Classification: Session 14

Track Classification: Neutron Physics

Contribution ID: **328** Type: **Invited Talk**

Understanding Stellar Explosions with Nuclear Physics

Friday, 1 December 2023 14:00 (25 minutes)

Across the periodic table, the majority of the elements are created at least in part in explosive stellar environments. For elements up to mass ~100, explosive nucleosynthesis often occurs through thermonuclear runaway in hydrogen- and helium-rich environments driving events such as classical novae, Type I X-ray bursts, and Type Ia Supernovae, and resulting in the production of exotic proton-rich nuclei. On the other side of the chart of nuclides, more than half of the heavy elements are synthesized through the r-process occurring in neutron-rich explosive environments, such as neutron-star mergers. While for some of these explosive events (e.g. X-ray bursts) a wealth of observational data exists, events such as neutron star mergers have only recently been observed for the first time as we enter the multi-messenger era. However, in all cases to understand these explosions and make comparisons with such observations, accurate nuclear data is required. This includes nuclear masses, lifetimes, and reaction cross sections to determine reaction rates. For some unique cases, these reaction rates can be measured directly with the availability of intense radioactive ion beams from new and upgraded accelerator facilities. However, more often such beams are not available and the nuclear data required to calculate reaction rates of interest must be obtained via indirect techniques. A selection of recent results from both direct and indirect methods and the impact of such results will be discussed, along with an outlook on such studies for the near-term future.

Attendance Type

In-person

Primary author: DEIBEL, Catherine

Presenter: DEIBEL, Catherine

Session Classification: Session 9

Track Classification: Invited Talks

Contribution ID: **329** Type: **Invited Talk**

Nuclear structure via Coulomb excitation

Wednesday, 29 November 2023 10:30 (25 minutes)

Coulomb excitation is a well-established and powerful experimental technique for probing the structure and dynamics of nuclei in a model-independent way. The technique is especially sensitive to the quadrupole shape degrees of freedom as it selectively excites low-lying collective states with cross sections that directly measure the E2 matrix elements involved in the excitation. In particular, the technique allows the determination of transitional and diagonal E2 matrix elements between low-lying states, the most direct and unambiguous measure of the collective shape parameters. In addition, the technique provides unique and model-independent information on the relative signs of the diagonal E2 matrix elements, thus allowing a link between reduced transition probabilities and spectroscopic quadrupole moments and the β,γ shape parameters of the Bohr Hamiltonian. In this presentation, I will explain the principles and applications of Coulomb excitation as a tool for exploring quadrupole collectivity in nuclei. I will also briefly review the theoretical framework of Coulomb excitation, describe experimental setups and methods, and present recent studies that illustrate its contribution to our understanding of shape dynamics in neutron-rich nuclei.

Attendance Type

In-person

Primary author: AYANGEAKAA, Akaa Daniel (University of North Carolina at Chapel Hill)

Presenter: AYANGEAKAA, Akaa Daniel (University of North Carolina at Chapel Hill)

Session Classification: Session 1

Track Classification: Invited Talks

Contribution ID: **330** Type: **Invited Talk**

Experiments to constrain neutron-capture rates for the intermediate and the rapid neutron-capture process

Wednesday, 29 November 2023 14:00 (25 minutes)

Great progress has been made regarding our understanding of heavy-element nucleosynthesis in recent years. In particular, the 2017 discovery of a neutron-star merger with its kilonova confirmed that such astrophysical sites can produce heavy elements through the rapid neutron-capture process. At the same time, as more and more high-quality observations become available, the heavy-element nucleosynthesis puzzle becomes more and more complex. For example, some very old stars in the Galactic halo show peculiar element distributions that might only be explained invoking an intermediate neutron-capture process.

In this talk, some aspects of the rapid and intermediate neutron-capture processes will be discussed, with particular emphasis on neutron-capture rates that are crucial for realistic abundance calculations. Experimental efforts to obtain indirect constraints of these rates by means of the Oslo method and the beta-Oslo method will be presented.

Attendance Type

In-person

Primary author: LARSEN, Ann-Cecilie (University of Oslo)

Presenter: LARSEN, Ann-Cecilie (University of Oslo)

Session Classification: Session 3

Track Classification: Invited Talks

Contribution ID: **331** Type: **Invited Talk**

MAGNEX-FPD at iThemba LABS: enabling the heavy-ion detection capability at the K600 spectrometer facility

Saturday, 2 December 2023 14:00 (25 minutes)

In 2019, a new project focused on implementing the MAGNEX Focal Plane Detector (FPD) at the K600 spectrometer facility at iThemba LABS was started with the aim to facilitate experiments involving heavy-ion beams. The primary intention was to investigate Double Charge Exchange (DCE) reactions and competing quasi-elastic channels at various incident energies, expanding upon the research conducted at the INFN-Laboratori Nazionali del Sud (LNS) in Catania, Italy, as part of the NUMEN project. Once fully commissioned the K600+MAGNEX-FPD configuration will not only allow to perform nuclear structure and reaction studies with heavy-ion beams but it will also enable the capability to use low-energy light-ion beams that up to now was forbidden due to the characteristics of the K600-FPD.

The MAGNEX FPD has been successfully transported and tested in a stand-alone configuration at iThemba LABS. Presently, the MAGNEX-FPD is being coupled to the mechanics of the K600 medium dispersion focal plane. This phase will be followed by a commissioning step with low-energy beams and radioactive sources, to characterize the facility in terms of particle identification, energy and angle resolution and detection efficiency. In this picture it is foreseen also the use of the African LaBr3:Ce array (ALBA), made up of 21 large-volume LaBr3:Ce detectors, available in the full configuration at iThemba LABS, to allow particle-gamma coincidence measurements.

A general overview of the project and the scientific cases that could be studied will be presented.

Attendance Type

In-person

Primary author: PELLEGRI, Luna (University of the Witwatersrand and iThemba LABS)

Co-authors: CAPPUZZELLO, Francesco (University of Catania and INFN-LNS, Italy); CAVALLARO, Manuela (INFN - LNS); NEVELING, Retief (iThemba LABS); AGODI, Clementina (INFN.LNS); BAHINI, Armand (University of the Witwatersrand, Johannesburg); BEKKER, Jacob (University of the Witwatersrand); BINDA, Sifundo (iThemba LABS and Wits University); Dr BRUMMER, Johann (iThemba LABS); Dr BRISCHETTO, Giuseppe (Department of Physics and Astronomy "E. Majorana", Universita Degli Studi di Catania, Catania, Italy); Dr CARBONE, Diana (INFN-LNS); Dr CIRALDO, Irene (INFN Laboratori Nazionali del Sud, Catania, Italy); Dr DELAUNAY, Franck (Univ. of Catania / INFN-LNS); DONALDSON, Lindsay (iThemba Laboratory for Accelerator Based Sciences); EKE, Canel (Akdeniz University); Dr FISICHELLA , M. (INFN – Laboratori Nazionali del Sud, Catania, Italy); KHUMALO, thuthukile (iThemba LABS); JONGILE, Sandile (iThemba LABS); MOLAENG, Refilwe Emil (University of the Witwatersrand and iThemba LABS); SGOUROS, Onoufrios (INFN-LNS); SOUKERAS, Vasileios (University of Catania and INFN - LNS); SPATAFORA, Alessandro (INFN-LNS); Dr TORRESI, D. (INFN – Laboratori Nazionali del Sud, Catania, Italy); FOR THE NUMEN COLLABORATION

Presenter: PELLEGRI, Luna (University of the Witwatersrand and iThemba LABS)

Session Classification: Session 11

Track Classification: Invited Talks

Contribution ID: **332** Type: **Oral**

Properties of nuclei beyond 132Sn: importance for nuclear physics and astrophysics

Thursday, 30 November 2023 11:55 (15 minutes)

Neutron-rich nuclei close to the r-process path and waiting point nuclei give extremely essential information about intrinsic nuclear properties vital both for nuclear physics and for astrophysics. They reveal how structure effects are of importance for theoretical modeling and can be crucial to understand deviations of microscopic-macroscopic self-consistent models treating both neutron and gamma emission [1,2] from data.

Such studies can be performed on long-lived excited and ground states, predominantly disintegrating by beta decay being on the neutron-excess side of the stability line. Some of the nuclei in the neighborhood of 132Sn, although exotic and neutron-rich, have rather simple structures dominated by shell effects and the evolution of low-lying proton-neutron orbitals [3,4]. Furthermore, these effects are possible to study in beta-decay coincidences with gamma-ray detection. Recently, we performed several investigations reporting on structure [3-6] and also FF/GT rates and Pn, P2n ratios by spectroscopy [4,6]. Confronted with purely neutron-emission detection methods and T1/2 measurements [8,9], they provide complementary and rather complete data sets to better describe astrophysical scenarios away from the stability line. Examples will be presented in this work together with, whenever available from the structural point of view, a theoretical picture.

[1] P. Möller et al., At. Dat. Nucl. Dat. Tabl. 125, 1 (2019).
[2] F. Minato et al., Phys. Rev. C 104, 044321 (2021).
[3] R. Lozeva et al., Phys. Rev. C 93, 014316 (2016).
[4] R. Lozeva et al., Phys.Rev. C 98, 024323 (2018).
[5] G. Häfner et al., Phys. Rev. C 104, 014316 (2021)
[6] M. Si et al., Phys. Rev. C 106, 014302 (2022).
[7] V. Phong et al., Phys. Rev. Lett. 129, 172701 (2022).
[8] J. Liang et al. Nucl Dat. Sh. 168, 1 (2020).

Attendance Type

In-person

Primary author: LOZEVA, Radomira

Presenter: LOZEVA, Radomira

Session Classification: Session 6

Track Classification: Neutron Physics

Contribution ID: **333** Type: **Invited Talk**

Medical applications with heavy/radioactive ion beams

Wednesday, 29 November 2023 15:50 (25 minutes)

Particle accelerator institutes have extensively contributed to biomedical research programs worldwide, which are of particular importance for their societal benefit and impact on human health. Ionizing radiation possesses the ability to directly damage the DNA structure of cells, causing DNA breaks, which can ultimately result in cell death.
This property has been used since many years for cancer treatment and sparked the interest of the nuclear physics research community to develop charged particle therapy at the end of last century. The technique exploits the Bragg peak of charged particles in order to reduce toxicity and improve local control compared to conventional X-ray based radiotherapy for cancer treatment. Cyclotrons and synchrotrons for charged-particle therapy are blooming worldwide and nowadays, the field is characterized by a fast succession of technological advances in additional to intense preclinical research programs on topics such as FLASH and spatially fractionated mini-beams with both protons and heavy ions. While the underlying radiobiological mechanisms of these new techniques are still a topic of active debate, several studies have already illustrated that these novel beam delivery methods largely reduce normal tissue toxicity in animal models.
In parallel, several imaging techniques are making use of radiation properties to improve the diagnosis and the efficiency of cancer treatments. This brings us to another, main medical application of accelerator produced beams, which is the production of radioisotopes for imaging, therapy, or both under the theranostics umbrella. Major advances in theranostics are expected by the introduction of α-particle and Auger electron emitting isotopes, due to their higher cytotoxic effectiveness to kill radioresistant tumour cells compared to more conventionally used β-emitters. Improvements in radiation dosimetry and genomic assessment of radiosensitivity will guide precision theranostics to avoid both undertreatment and off-target toxicity.
Research in space radiation protection also needs accelerators to simulate the cosmic radiation that astronauts encounter in the space environment and particularly beyond lower earth orbit. In fact, most of our knowledge on radiation risk in space comes from experiments at ground-based particle accelerators.
We are currently facing an era in which several new accelerator centers are under construction and existing facilities are upgraded. Those facilities will soon deliver their first beams of higher intensity and energy than we could ever produce before and all these institutes have ambitious biomedical research programs that are innovative and potentially can lead to breakthrough discoveries. High energy is obviously important for to mimic high energy cosmic rays for space radiation research, but can also be useful for particle radiography in order to reduce range uncertainty in particle therapy. The higher intensity can also be a potential major breakthrough in particle therapy, where ultrafast treatments are convenient for clinical workflow and the mitigation of the problem of moving targets. Finally, radioactive ion beams (RIB), one of the main nuclear physics topics that justify the construction of new nuclear physics facilities, are potentially an extraordinary tool for cancer therapy as they allow the online visualization of beams during irradiation and for the production of novel radioisotopes.

Attendance Type

In-person

Primary author: VANDEVOORDE, Charlot (GSI Helmholtz Center for Heavy Ion Research)

Presenter: VANDEVOORDE, Charlot (GSI Helmholtz Center for Heavy Ion Research)

Session Classification: Session 4

Track Classification: Invited Talks

Contribution ID: **334** Type: **Oral**

The K600 magnetic spectrometer and the CAKE silicon detector array: measurements relevant to type-I X-ray bursts

Friday, 1 December 2023 15:50 (15 minutes)

The K600 magnetic spectrometer and the CAKE silicon detector array form a powerful tool for coincidence measurements in many nuclear physics measurements including nuclear astrophysics. These instruments have been used, among others, in studies measuring proton decays from α-unbound states in ^{22}Mg through the ^{24}Mg$(p,t)^{22}$Mg reaction to study the ^{18}Ne$(\alpha,p)^{21}$Na cross section relevant in type-I X-ray bursts (XRBs). The thermonuclear reaction rate of ^{18}Ne$(\alpha,p)^{21}$Na is one of the important rates that affect the behaviour of the XRB lightcurve. This talk will examine the ^{22}Mg$(p,t)^{22}$Mg experiment that was performed at iThemba LABS, Cape Town and discuss future experiments with the ^{28}Si$(p,t)^{26}$Si reaction to study proton decays from α-unbound states in ^{26}Si to study the cross section and thermonuclear reaction rate of ^{22}Mg$(\alpha,p)^{25}$Al and its influence on type-I XRBs.

Attendance Type

In-person

Primary author: BRUMMER, Johann Wiggert (iThemba LABS)

Co-authors: Dr ADSLEY, Phillip (Department of Physics and Astronomy, Texas AM University, Texas, USA.); BAHINI, Armand (University of the Witwatersrand, Johannesburg); BEKKER, Jacob (University of the Witwatersrand); BINDA, Sifundo (iThemba LABS and Wits University); DONALDSON, Lindsay (iThemba Laboratory for Accelerator Based Sciences); JONGILE, Sandile (iThemba LABS); KHUMALO, thuthukile (iThemba LABS); MOLAENG, Refilwe (iThemba LABS); NEVELING, Retief (iThemba LABS); PELLEGRI, Luna (University of the Witwatersrand and iThemba LABS)

Presenter: BRUMMER, Johann Wiggert (iThemba LABS)

Session Classification: Session 9

Track Classification: Nuclear Astrophysics

Contribution ID: **335** Type: **Invited Talk**

The Universe in the Laboratory

Friday, 1 December 2023 14:25 (25 minutes)

"Astrophysics is applied nuclear physics". This statement of Willy Fowler, the father of nuclear astrophysics, summarizes that nuclear processes are at the origin of the synthesis of the elements in the Universe and also the engine of the astrophysical objects which produce them. This includes the synthesis of the lightest elements during the Big Bang, but also the evolution of stars during their long lifetimes spent in hydrostatical equilibrium. Driven by novel astronomical observational tools, much focus has been recently put on extreme astrophysical objects like supernovae, neutron stars and their mergers. These events involve conditions of temperature, density and also neutron excess which present a challenge to study the related nuclear physics in the laboratory. However, modern facilities, operational and planned, promise decisive breakthroughs in the near future. It will be possible at FAIR to create matter by ultrarelativistic heavy-ion collisions which correspond to the density/temperature regime reached in neutron star mergers or core-collapse supernovae. At radioactive ion-beam facilities, like RIKEN, FRIB und later FAIR, it is possible to produce and study many of the short-lived neutron-rich nuclei which determine the dynamics of r-process nucleosynthesis. Due to the milestone event GW170817 neutron star mergers have been established as one astrophysical site of the r-process.
Simulations of such events are formidable challenges due to the strong interplay of nuclear, neutrino and atomic physics.

The talk will introduce the astrophysical events and discuss the nuclear
challenges and future perspectives.

Attendance Type

In-person

Primary author: LANGANKE, Karlheinz (GSI Darmstadt)

Presenter: LANGANKE, Karlheinz (GSI Darmstadt)

Session Classification: Session 9

Track Classification: Invited Talks

Contribution ID: **336** Type: **Invited Talk**

Nuclear structure studies relevant for new physics searches with xenon detectors

Wednesday, 29 November 2023 10:05 (25 minutes)

Xenon detector experiments have provided some of the most sensitive searches of physics beyond the standard model (BSM). These campaigns have placed emphasis on observing dark matter interactions and/or neutrinoless double beta decays (0ν2β). Several next-generation experiments aim to build on this work and probe for BSM physics with significantly improved sensitivity. In relation to the above, this talk will present results from recent two-nucleon transfer studies in the A = 136 region. The measurements are used to robustly test predictions made with Hamiltonians that are also used to evaluate the nuclear matrix element for 136Xe 0ν2β. Further implications concerning the detection of solar neutrinos and fermionic dark matter candidates in large xenon-based detectors will also be briefly presented.

Attendance Type

In-person

Primary author: TRIAMBAK, Smarajit (University of Western Cape)

Presenter: TRIAMBAK, Smarajit (University of Western Cape)

Session Classification: Session 1

Track Classification: Invited Talks

Contribution ID: **337** Type: **Invited Talk**

Overview of the nEXO experiment

Friday, 1 December 2023 12:00 (25 minutes)

nEXO is a next-generation experiment that aims to observe the neutrinoless double beta decay of ^{136}Xe to ^{136}Ba. The experiment will use 5 tonnes of liquid xenon (LXe) enriched to 90% in ^{136}Xe in a single-phase, monolithic time projection chamber (TPC). Ionization electrons and scintillation light will be detected with a segmented anode and an array of VUV-sensitive silicon photomultiplier (SiPM) detectors within the TPC, respectively, allowing the measurement of the energy, position and multiplicity of each event. This talk will highlight some recent developments in the conceptual design of the detector and related R&D. These improvements enable a neutrinoless double beta decay half-life sensitivity of 1.35×10^{28} years after 10 years of data taking, which covers the entire parameter space associated with the inverted neutrino masses ordering.

Attendance Type

In-person

Primary author: TRIAMBAK, Smarajit (University of Western Cape)

Presenter: LENARDO, Brian (SLAC National Accelerator Laboratory)

Session Classification: Session 8

Track Classification: Invited Talks

Contribution ID: **338** Type: **Workshop**

Proton-induced knockout (p,2N) reactions on stable nuclei as a tool to determine spectroscopic factors

Thursday, 30 November 2023 09:30 (25 minutes)

Proton-induced knockout reactions provide a direct mean of studying the single particle or cluster structures of target nuclei. However, due to the nature of hadron probe, these reactions can suffer significant disturbances from the nuclear surroundings and the quantitative theoretical treatment of such processes can also be challenging. In this talk, firstly we review the experimental and theoretical progress in this field. The spectroscopic factors extracted using (p,2N) data at intermediate energies are consisted with those determined using (e,e'p) data, typically within a 15% deviation, when the geometrical parameters are the same as those employed in the (e,e'p) analysis. However, when the goal is to use the (p,2N) reactions as a spectroscopic tool, it is preferable to determine the geometrical parameters in a self-consistent manner. Thus we further performed a calculation using wave functions generated in a relativistic Hartree model. The spectroscopic factors deduced from this self-consistent calculation and from the previous standard calculation using a global optical potential agree with the relevant (e,e'p) results mostly within 15% for light nuclei. This result is encouraging for extending to similar studies of unstable nuclei, for which the properties are not well-known and the parameters for DWIA calculations cannot be pre-determined. However, those for the 208Pb target are significantly large compared with the (e,e'p) results. In this case, the DWIA results are very sensitive to the radius parameters of the bound-state potential, and thus a careful treatment is required.

Attendance Type

Remote

Primary author: WAKASA, Tomotsugu (Kyushu University)

Presenter: WAKASA, Tomotsugu (Kyushu University)

Session Classification: Workshop Session A

Track Classification: Workshop Talks

Contribution ID: **339** Type: **Invited Talk**

Constraining the nuclear matter equation of state at supra-normal densities

Saturday, 2 December 2023 11:15 (25 minutes)

Understanding the equation of state (EOS) of asymmetric nuclear matter is of fundamental importance and underpins our knowledge of many aspects of nuclear physics and astrophysics. It governs the behaviour of cosmological events like of type II supernova explosions and neutron star mergers, and the properties neutron stars, as well as the characteristics of neutron rich nuclei and the process of heavy-ion reactions. Heavy ion-reactions at incident energies of several hundredths of MeV/u are the only means to study nuclear matter characteristics at supra-normal densities in the laboratory. Whereas a multitude of existing experimental observables is constraining the nuclear matter equation of state at densities below ground state density, the experimental data at supra-normal densities are still limited. Bayesian inference is used to combine data from astrophysical multi-messenger observations of neutron stars and from heavy-ion collisions with microscopic nuclear theory calculations to improve our understanding of dense matter. However, very few experimental data from heavy ion reactions exist at supra-saturation densities i.e. r»2r0 and above.

The talk will present the status on the experimental constraints from heavy-ion collisions on the properties of asymmetric nuclear matter and the future perspectives at GSI/FAIR.

Attendance Type

In-person

Primary author: LEIFELS, Yvonne (GSI)

Presenter: LEIFELS, Yvonne (GSI)

Session Classification: Session 10

Track Classification: Invited Talks

Contribution ID: **341** Type: **Workshop**

Spectroscopic Studies with Quasi-Free Knockout Reactions

Thursday, 30 November 2023 10:00 (25 minutes)

Quasi-free knockout reactions have been established in the past years as a versatile spectroscopic tool to study exotic nuclei accelerated to high energy of few hundred MeV/nucleon. The advantage of inverse kinematics is the possibility of kinematical complete measurements of the reaction including the detection of the remaining residue after the knockout. The applications of quasi-free knockout reactions are meanwhile manifold, examples are the study of the single-particle structure by single-nucleon knockout like (p,2p), or the population of nuclei beyond the drip line by nucleon or cluster knockout reactions as (p,2p) and (p,p alpha). In this presentation we will discuss recent examples from GSI and the RIBF addressing the aforementioned processes and topics.

Attendance Type

Remote

Primary author: AUMANN, Thomas

Presenter: AUMANN, Thomas

Session Classification: Workshop Session A

Track Classification: Workshop Talks

Contribution ID: **342** Type: **Invited Talk**

Artificial Intelligence in Nuclear Physics

Saturday, 2 December 2023 15:40 (25 minutes)

Artificial Intelligence (AI) and Machine Learning (ML) are rapidly developing fields providing data-driven algorithms to predict, classify, and make decisions based on data. Nuclear Physics Research is data-driven and AI/ML techniques have been implemented for experiment and accelerator control, in theoretical applications, and in data processing and analysis. These algorithms open possibilities for automation, thereby augmenting human capabilities. Additionally, Open Science is enabled by simultaneous analyses of multiple data sources, leading to scientific knowledge. This talk will summarize current applications of AI/ML in nuclear physics, as well as accelerator applications, and will cover upcoming initiatives and research in AI/ML.

Attendance Type

Remote

Primary author: BOEHNLEIN, Amber (Jefferson Lab)

Presenter: JESKE, Torri (Jefferson Lab)

Session Classification: Session 12

Track Classification: Invited Talks

Contribution ID: **343** Type: **Workshop**

Contributions of Prof Anthony Cowley to the field of knockout reaction studies

Thursday, 30 November 2023 09:00 (25 minutes)

Knockout reaction studies have historically been used as an ideal mechanism to probe the nature of nuclear structure, especially single-particle properties of nuclei by means of proton knockout reactions such as (p, 2p). Nucleon-induced knockout reactions have also proven useful to unravel details of the nucleon-nucleon interaction, as well as the notion of ground state α-clustering in nuclei through (p, pα) reaction studies. From the early (p, 2p) knockout reaction experiments performed on light 2H, 3He and 4He targets in the 1970's, to his recent 2021 publication looking at the extent to which knockout, as opposed to a pickup reaction mechanism contributes in preequilibrium (p, α) reactions, Anthony Cowley leaves behind a legacy of experimental nuclear physics research and training in South Africa. In this talk we will look at knockout reactions through the different experimental contributions that Anthony Cowley made throughout his 50-year career in nuclear physics research.

Attendance Type

In-person

Primary author: VAN ZYL, JJ (Stellenbosch University)

Presenter: VAN ZYL, JJ (Stellenbosch University)

Session Classification: Workshop Session

Track Classification: Workshop Talks

Contribution ID: **344** Type: **Workshop**

Quasi free scattering in inverse kinematics - From GSI – via RIBF – to FAIR

Quasi free scattering in inverse kinematics is a powerful tool allowing to explore the nuclear landscape at its outskirts.

The inverse kinematics allows the full detection of weakly and strong bound states in complete kinematics (1) through the detection of gammas and particle unstable states through the invariant mass method.

The ALADiN-LAND reaction setup fed by the FRS fragment separator has evolved to the R3B reaction experiment with relativistic rare isotope beams. GSI is currently evolving in the FAIR facilities where the R3B experiment will be installed at the high energy branch (HEB) of the novel Super-FRS superconducting large acceptance fragment separator. The very clean selection criteria for the QFS mechanism have recently allowed for the population of the 4n system at a missing mass study (2) at the SAMURAI experiment at the RIBF facility in Wako, Japan. At the same reaction setup the first of series prototype of the NeuLAND neutron detector for the R3B experiment at GSI and FAIR has been tested and could be used in the detection of 28O (3) with coincident 4n even reconstruction. Future prospects of the full R3B setup at the FAI facility will be presented with a status of the facility.

1) Panin, V., et al., Phys. Lett. B797, 134802 (2019)
2) Duer, M., et al., Nature 606, 678 (2022)
3) Kondo, Y. et al., Nature 621, 17 (2023)

Attendance Type

In-person

Primary author: SIMON, Haik (GSI Helmholtzzentrum für Schwerionenforschung GmbH (GSI))

Presenter: SIMON, Haik (GSI Helmholtzzentrum für Schwerionenforschung GmbH (GSI))

Session Classification: Workshop Session C

Track Classification: Workshop Talks

Contribution ID: **345** Type: **Invited Talk**

Physics results and perspectives at GANIL/SPIRAL2

Sunday, 3 December 2023 11:25 (25 minutes)

GANIL/SPIRAL2 presently offers unique opportunities in nuclear physics and in many other fields that arise from not only the provision of low-energy stable beams, fragmentation beams, re-accelerated radioactive species, and recently neutron beams but also from the availability of a wide range of state-of-the-art spectrometers and instrumentation. A few examples of recent highlights will be presented together with upcoming new scientific opportunities with ongoing projects.

Attendance Type

Remote

Primary author: SAVAJOLS, Hervé (GANIL)

Presenter: SAVAJOLS, Hervé (GANIL)

Session Classification: Session 14

Track Classification: Invited Talks

Contribution ID: **346** Type: **not specified**

Welcome from the Conference Organisers

Wednesday, 29 November 2023 09:00 (5 minutes)

Presenter: DONALDSON, Lindsay (iThemba Laboratory for Accelerator Based Sciences)

Session Classification: Welcome and Opening

Contribution ID: **347** Type: **not specified**

Welcome from iThemba LABS

Wednesday, 29 November 2023 09:05 (10 minutes)

Presenter: TSHIVHASE, Victor (iThemba LABS)

Session Classification: Welcome and Opening

Contribution ID: **348** Type: **not specified**

Message from the NRF

Wednesday, 29 November 2023 09:15 (15 minutes)

Presenter: PATERSON, Angus (National Research Foundation)

Session Classification: Welcome and Opening

Contribution ID: **349** Type: **not specified**

Keynote Address

Wednesday, 29 November 2023 09:30 (30 minutes)

Presenter: MANAMELA, Buti (Department of Higher Education, Science and Innovation)

Session Classification: Welcome and Opening

Contribution ID: **350** Type: **not specified**

Vote of thanks and handover to Session 1 Chair

Wednesday, 29 November 2023 10:00 (5 minutes)

Presenter: DONALDSON, Lindsay (iThemba Laboratory for Accelerator Based Sciences)

Session Classification: Welcome and Opening

Contribution ID: **351** Type: **Invited Talk**

What can we learn from the electromagnetic dipole response response in atomic nuclei?

Thursday, 30 November 2023 15:40 (25 minutes)

The gamma-ray decay of nuclear states in the quasi-continuum offers valuable insights into nuclear structure effects and constraints on nucleosynthesis processes. Measurement of Nuclear Level Densities (NLDs) and Photon Strength Functions (PSFs) has played a pivotal role, and will continue to do so, as we enter a highly promising era for innovative measurements. This is primarily due to the establishment of advanced research infrastructure by numerous institutes worldwide. These institutes have made significant enhancements to particle and gamma-ray detection efficiencies, as well as the development or upgrade of radioactive ion beam facilities. Concurrently, new experimental and analytical techniques have emerged, enabling more reliable studies of PSFs and NLDs, even for unstable nuclei. This progress undoubtedly promises unparalleled insights into nuclear structure and provides crucial reaction rates for nucleosynthesis processes.

In this presentation, I will provide an overview of the major experimental and analytical advancements made and how they have laid the groundwork for ambitious measurements of PSFs and NLDs at radioactive and stable ion beam facilities. Additionally, I will discuss recent progress in investigating the nuclear structure underlying resonances, with a particular focus on the scissor's mode and the unexplained low-energy enhancement. The measurement of PSFs and NLDs also significantly enhance our understanding of nucleosynthesis processes, as will be demonstrated.

This work is supported by the National Research Foundation of South Africa under grant number 118840.

Attendance Type

Presenter: WIEDEKING, Mathis (University of the Witwatersrand and iThemba LABS)

Session Classification: Session 5

Contribution ID: **352** Type: **Workshop**

Introduction and Overview of Short-Range Correlations

Friday, 1 December 2023 16:35 (25 minutes)

Presenter: HEN, Or (MIT)

Session Classification: Workshop Session B

Contribution ID: **353** Type: **Oral**

Searching for the Soft Monopole

Sunday, 3 December 2023 12:35 (15 minutes)

The isospin asymmetry of neutron-rich nuclei is expected to impact the excitation energy spectra of such nuclei. The resulting exotic excitation modes which may occur are thus considered to be related to the existence of a neutron excess. The soft monopole resonance, simplistically viewed as the compression of dilute neutron matter in the region of the neutron skin, represents a possible excitation mode occurring due to neutron excess. Theoretical calculations predicted that the mode exists in neutron-rich, however, there has not been a lot of experimental work studying the soft monopole excitation. A possible method for the observation of this excitation mode through inelastic alpha scattering will be explored.

Attendance Type

Presenter: NEVELING, Retief (iThemba LABS)

Session Classification: Session 14