Nuclear Lifetimes, Transitions and Moments (NLTM2022)

Report of Abstracts

Abstract ID : **29**

Measured transition strengths and nuclear moments: probing the emergence of nuclear collectivity around ^{132}Sn

Content

This talk will review some experimental methods applicable to the measurement of transition rates and nuclear moments around ^{132}Sn. For transition rates, the focus will be on Coulomb excitation and the Doppler broadened line shape (DBLS) method. For nuclear moments, the emphasis will be on magnetic moments measured by the transient field (TF) and recoil in vacuum (RIV) methods. It will be noted that Coulomb excitation with RIV enables the simultaneous measurement of the excitation probability, quadrupole moment and g factor of the first-excited 2^+ state of a radioactive beam. Experimental results will be surveyed and compared with shell model calculations, with a view to tracking and attempting to understand the emergence of quadrupole collectivity around ^{132}Sn.

Primary author(s) : Dr STUCHBERY, Andrew (Department of Nuclear Physics and Accelerator Applications, the Australian National University)

Status: ACCEPTED

Submitted by **BHATTACHARJEE, Tumpa** on **Thursday 27 January 2022**

Abstract ID : **30**

High-resolution in-beam gamma-ray spectroscopy and lifetime measurements with HiCARI

Content

Atomic nuclei gives rise to various exotic phenomena. In nuclei with very asymmetric proton-to-neutron ratios, the strong nuclear interaction drives shell evolution which alters the orbital spacing, and in some cases even the ordering present in stable nuclei. Such changes in the structure can have profound consequences for structure and dynamics of nuclei as well as the synthesis of elements in the universe. In-beam gamma-ray spectroscopy is an excellent tool to study the structure of the most exotic nuclei in the laboratory. In this talk, I will present the HiCARI project "High-resolution Cluster Array at RIBF". This hybrid array of segmented germanium detectors was constructed from contributions from around the world. The physics program includes a wide range of topics in nuclear structure addressing collective and single-particle structure of nuclei very far from stability.

Primary author(s) : Dr WIMMER, Kathrin (GSI Helmholtz Centre for Heavy Ion Research , Germany)

Status: ACCEPTED

Submitted by **BHATTACHARJEE, Tumpa** on **Thursday 27 January 2022**

Abstract ID : **31**

Lifetime measurements: Impact on high spin nuclear structure studies

Content

Lifetime measurements allow us to determine the reduced transition probability between excited nuclear states. As the electromagnetic transitions operators are exactly known, the reduced transition rates, in principle, allow us to get first hand knowledge about the nuclear wave functions of the connected states. In simple terms, one may consider that low reduced transition rates correspond to the participation of a single nucleon in the excitation process which typically occurs for the nuclei near the closed shells. Similarly, the high reduced transition probabilities indicate collective excitations. However, the nuclear level lifetime measurements can be quite challenging considering its variation. A compound nucleus typically takes around 10^{-9} seconds to reach the ground state since its formation. In this journey, it traverses through different types of states having varied lifetime. For example, the lifetime of the high spin collective states are typically sub-picoseconds while that for the low spin states are typically order of nano-seconds. Unfortunately, there is no universal method to measure such a wide range of lifetime. Physicists apply various direct method such as Delayed coincidence and indirect methods namely, Recoil Distance methods (RDM) which is also known as Recoil Distance Doppler-Shift (RDDS), Recoil Shadow Anisotropy method (RSAM), Doppler-Shift Attenuation method (DSAM). This presentation focuses on the DSAM techniques used in various experiments performed in Indian experimental setup. Emphasis will be given to the fact that how these measurements influence the physics interpretation of the nuclear structure of the nuclei under investigation and their underlying excitation mechanisms.

Primary author(s) : Dr DATTA, Pradip (Anandamohan College, Kolkata)

Status: ACCEPTED

Submitted by **BHATTACHARJEE, Tumpa** on **Thursday 27 January 2022**

Abstract ID : **32**

The Lives of Excited Nuclei & Their Measurements at the Femto Scale

Content

Measurements of level lifetimes have assumed much significance in the domain of nuclear structure research, particularly for catering to a stringent validation of the different excitation phenomena being unravelled in the contemporary endeavours. The most commonly encountered lifetimes in spectroscopic measurements are those in the range of few tens of femtoseconds to few picoseconds, which are measured using the Doppler Shift Attenuation Method (DSAM). This presentation aspires to discuss DSAM in the context of the recent developments [Das et al. Nucl. Instr. Meth. Phys. Res. A 841, 17(2017) and Bhattacharjee et al. Phys. Rev. C 90, 044319(2014)] led by our Group at the Kolkata Centre of UGC-DAE CSR. The same have facilitated expanding the applicability of DSAM to the widest choice of experimental conditions and deeper insights about the impact of residue trajectories on the observed Doppler shifts of the gamma-ray transition energies.

The developments in the area of lifetime measurements using DSAM have been a part of the inhouse research programme of Nuclear Physics Group at the UGC-DAE CSR, Kolkata Centre.

Primary author(s) : Dr RAUT, Rajarshi (UGC-DAE-CSR, Kolkata Center, Kolkata)

Status: ACCEPTED

Submitted by **BHATTACHARJEE, Tumpa** on **Thursday 27 January 2022**

Abstract ID : **33**

Doppler-Shift lifetime measurements with TIP and TIGRESS at TRIUMF

Content

Electromagnetic transition rates are recognized as observables critical for evaluation of nuclear structure effects and verification of nuclear models. Doppler-shift lifetime measurements in inverse kinematics provide an opportunity to directly access information about electromagnetic transition rates in a way which is fully independent on the reaction mechanism. As such, Recoil Distance and related Doppler Shift Attenuation Methods (DSAM), when implemented at stable and/or radioactive beam facilities, hold the promise of reaching far from stability and providing lifetime information for intermediate-spin excited states in a wide range of nuclei. In response to new opportunities opened by availability of re-accelerated beams from the ISAC-II facility at TRIUMF, a plunger-type recoil distance method device, the TIGRESS Integrated Plunger (TIP), has been constructed at Simon Fraser University to be used with the TIGRESS segmented Germanium array as part of the ISAC-II experimental program. The TIP is designed to achieve control of submicrometer shifts between target and degrader and can be run in a self-standing mode or to in tandem with a CsI array of charged particle detectors for reaction channel selection from fusion-evaporation reaction. A compact CsI array with digital readout has been developed as a part of the TIP facility and run using the TIP vacuum vessel in spectroscopy, DSAM, as well as RDM experiments. TIP is also designed to be coupled with the forthcoming TIGRESS auxiliary deuterated neutron detector array DESCANT and the electromagnetic spectrometer EMMA. A summary of the development and experimental program will be presented.

Primary author(s) : Dr STAROSTA , Krzysztof (for TIP/TIGRESS collaboration) (Simon Fraser University, Canada)

Status: ACCEPTED

Submitted by **BHATTACHARJEE, Tumpa** on **Thursday 27 January 2022**

Abstract ID : **34**

Spectroscopy and lifetime measurements with GRETINA

Content

Two of the compelling questions identified for nuclear science today are "How does subatomic matter organize itself and what phenomena emerge?" and "How did visible matter come into being and how does it evolve?". Excited-state lifetime measurements provide precise and model-independent nuclear structure data of key atomic nuclei to validate nuclear models and pin down scenarios of astrophysical processes. With the advent of advanced gamma-ray arrays such as GRETINA, new experimental techniques have been developed extending the reach of lifetime programs far from the valley of stability. This talk will provide a brief overview of new implementation of Doppler shift techniques with rare isotope beams and present recent science highlights including findings on shape coexistence phenomena in neutron-rich nuclei, shape evolution along N=Z, and properties of drip-line nuclei. Then discussion will focus on electromagnetic responses of weakly-bound neutron-rich nuclei and a possible interplay between a nuclear halo and deformation.

Primary author(s) : Dr IWASAKI, Hironori (Facility for Rare Isotope Bean, Michigan State University, USA)

Status: ACCEPTED

Submitted by **BHATTACHARJEE, Tumpa** on **Thursday 27 January 2022**

Abstract ID : **35**

Recent Results from Digital INGA and Development of Ancillary Detectors

Content

The Indian National Gamma Array (INGA) campaigns at the three accelerator facilities within India have contributed significantly in recent years to studies of nuclear structure. We will discuss the new developments related to the ancillary detector systems for fast timing measurements and charged particle tagging. We will present selected results associated with the novel excitation modes of atomic nuclei from experiments carried out with the array. A new design for a high resolution gamma detector array with double the photo-peak efficiency of the present INGA will be discussed in the end.

Acknowledgement: The author would like to acknowledge the support of INGA collaboration.

Primary author(s) : Dr PALIT, Rudrajyoti (Tata Institute of Fundamental Research, Mumbai, India)

Status: ACCEPTED

Submitted by **BHATTACHARJEE, Tumpa** on **Thursday 27 January 2022**

Abstract ID : **36**

Developments in the electronic technique of gamma-gamma fast-timing spectroscopy for measurements on nuclear level lifetime

Content

Picosecond sensitve time-difference measurements via the gamma-gamma coincidence technique is nowadays possible using $LaBr_3$(Ce) scintillator detectors with good energy and excellent time resolution. Details on the different components of a gamma-gamma fast-timing setup will be presented, as well as the basic centroid shift method that is used to analyze the experimental gamma-gamma time-difference distributions with uncertainty of a few picoseconds. The major source of uncertainty is due to time-correlated background, mainly Compton events and in addition low-energy inter-detector Compton-scattering events. Results on the detection and possible experimental suppression techniques will be presented. Finally, recently published analytical formula to correct for contributions from the normal Compton background will be tested using experimental and Geant4 simulated data.

Primary author(s) : JEAN-MARC , Regis (Institut fur Kernphysik, Koln, Germany)

Status: ACCEPTED

Submitted by **BHATTACHARJEE, Tumpa** on **Thursday 27 January 2022**

Abstract ID : **37**

Overview of gamma-gamma fast-timing measurements using the ROSPHERE array

Content

An overview of the recent exploitation of $LaBr_3$(Ce) detectors for fast timing measurements will be presented. First, the Romanian Array for Spectroscopy in Heavy Ion Reactions (ROSPHERE) installed at IFIN-HH in Bucharest will be introduced, including the various types of detectors that can be accommodated and the wide-range timing measurements that can be performed. Afterwards, the talk will concentrate on fast-timing measurements of excited nuclear states populated in decay spectroscopy or in-beam measurements, using a hybrid array of high-resolution detectors and of fast scintillators. Examples of research carried out in the last years at the 9 MV Tandem accelerator of IFIN-HH using ROSPHERE will be given, focusing on the medium and heavy-mass regions of the nuclear chart.

Primary author(s) : Dr SORIN, Pascu (Horia Hulubei National Institute for R&D in Physics and Nuclear Engineering (IFIN-HH), Romania)

Status: ACCEPTED

Submitted by **BHATTACHARJEE, Tumpa** on **Thursday 27 January 2022**

Abstract ID : **38**

FATIMA at GSI, Germany with Radioactive Ion Beams

Content

Recent leaps taken in the field of detector instrumentation and front-end electronics have allowed experimentalists to push the boundaries of the realm of nuclear physics and nuclear astrophysics. Radioactive ion beam laboratories like GSI in Germany, FRIB in USA and RIKEN in Japan have been leading these adventures to explore exotic physics, yet unknown to us. These studies include interesting experiments to measure lifetimes of exotic states of rare nuclei. This talk would give an overview of fast-timing detection techniques used at GSI to improve our understanding of the structure of nuclear matter far beyond the island of stable nuclei. In-house development of new front-end electronics to improve time resolution of scintillation detectors would also be discussed, along with fascinating results obtained with FATIMA at GSI over the radioactive ion beam campaign in 2020 and 2021.

Primary author(s) : Dr BANERJEE, Akashrup (Facility for Rare Isotope Bean, Michigan State University, USA)

Status: ACCEPTED

Submitted by **BHATTACHARJEE, Tumpa** on **Thursday 27 January 2022**

Abstract ID : **39**

VENTURE: The gamma - gamma fast timing array for Nuclear Structure Studies at VECC, Kolkata

Content

The experimental knowledge of nuclear level lifetime and quadrupole moment provides unique opportunity for the study of nuclear structure along with important parameters to verify validity of existing theoretical models. However, the nuclear excited states may have a wide range of lifetime (~10^{-15} sec to 10^{+15} sec) and most of them lie in the sub-nanosecond (ns) region. For successful measurement of lifetime down to few picosecond (ps) involves detectors having very fast signal processing time (e.g BaF_2) as well as high resolving power of energy (e.g Ge detector). However, none of the above detectors have both the required properties. In recent times, with the availability of some state-of-the-art scintillation detectors, viz., $LaBr_3$(Ce) which has better energy resolution along with comparable timing resolution with respect to BaF_2 detector and with the help of improved timing techniques, direct measurement of nuclear level lifetime in the ps range has been possible, almost in all types of experimental setups. The recently developed $CeBr_3$ detectors having slightly poor energy resolution compared to $LaBr_3$(Ce) and an improved time resolution could be considered as a viable alternative to $LaBr_3$(Ce), as it is limited by higher hygroscopic nature and self-activity compared to $CeBr_3$ detectors. These CeBr3 detectors has been used at VECC, Kolkata for nuclear lifetime measurement with Generalised Centroid Difference(GCD) and slope method through the development of gamma-gamma fast timing array VECC Array for Nuclear fast Timing and AngUlar CorRElation Studies (VENTURE)[1]. The array could be used in its stand-alone mode as well as coupled to the array of Clover HPGe detectors for complete spectroscopic measurements. The array has also been used for Quadrupole Moment measurement using gamma gamma perturbed angular correlation technique. Different setups of VENTURE array have been used to study nuclear structure [2,3,4,5,6] in different mass regions. In the present talk, the past, present and future of the array involving the developmental works and physics covered will be discussed.

References:

[1] S. S. Alam et al., Nucl. Instr. & Meth. **A874** (2017) 103.
[2] S. S. Alam et al., Phys. Rev. **C99** (2019) 014306.
[3] S. Basak et al., Phys. Rev. **C104** (2021) 024320.
[4] S. S. Alam et al., Eur. Phys. Jour. **A56** (2020) 269.
[5] Sangeeta Das et al., Nucl. Phys. **A1006** (2021) 122079.
[6] A. Adhikari et al., –under preparation.

Primary author(s) : Dr ALAM , Shaikh Safikul (On behalf of VENTURE working group) (Government General Degree College, Chapra, West Bengal)

Status: ACCEPTED

Submitted by **BHATTACHARJEE, Tumpa** on **Thursday 27 January 2022**

Abstract ID : **40**

The search for «missing links» of nuclear quadrupole moments – Where we stand

Content

Measurements for stable or reasonably long-lived (mostly ground) states by atomic and molecular spectroscopy and measurements for much shorter-lived excited states using nuclear condensed matter techniques like Moessbauer (ME) or perturbed angular distribution (PAD) (and correlation,PAC) spectroscopy. In all cases the direct experimental result is the product of the electric field gradient (efg) at the nuclear site with Q. The efg for atomic and simple molecular systems can now mostly be calculated by theory with good accuracy, while the present status of density functional calculations of solid-state systems used for short-lived excited states limits the accuracy mostly to the 10 to 20% level. Thus the efg of at least one matrix where data for exited states exist must be calibrated by measuring a ground state with known Q using magnetic (NMR) or quadrupole resonance (NQR). A short summary of the still missing relations between the results of Q for short-lived relative to long-lived states for 4sp, 5sp, 6sp elements will be presented. The sketched procedure is obviously not applicable to elements having no stable isotopes with I > 1/2. For Cd we have overcome this problem by measuring isolated Cd (and Hg) molecules with PAC. Similar experiments for Pb are in preparation at ISOLDE/CERN, as well as related ones for Sn.

Primary author(s) : Dr HAAS, Heinz (Conseil Européen pour la Recherche Nucléaire , Geneva)

Status: ACCEPTED

Submitted by **BHATTACHARJEE, Tumpa** on **Thursday 27 January 2022**

Abstract ID : **41**

Measurement of electromagnetic moments in high spin isomers – recent results in La

Content

Measurements of electromagnetic moments are important to understand the structure of nuclear states at high excitation energy and high angular momentum (high spin states). In this talk I shall give a brief overview on experimental techniques to measure magnetic dipole and electric quadrupole moments of nano-second isomeric states in nuclei, especially using the time differential perturbed angular distribution (TDPAD) technique. Experimental results obtained for some La isotopes using the Pelletron accelerator at TIFR will be discussed. The application of TDPAD technique towards studies of solid state phenomenon will be briefly discussed.

Primary author(s) : Dr MISHRA, Surendra Nath (Indian Institute of Science Education and Research, Berhampur, India)

Status: ACCEPTED

Submitted by **BHATTACHARJEE, Tumpa** on **Thursday 27 January 2022**

Abstract ID : **42**

Nuclear Structure Studies through Static Nuclear Moment Measurements

Content

The nuclear structure of nuclei is determined by the nucleon-nucleon interaction in a many-particle system, which forms the bound nuclei. Measurement of the properties of nuclei holds utmost importance for understanding the interactions that bind nucleons together under the extreme conditions of isospin. Static nuclear moments are the fundamental properties of nuclei that provide detailed information about the nuclear structure. The nuclear magnetic moment is sensitive to the nature of the single particles within the nucleons while the electric quadrupole moment is sensitive to the collective nature and hence provides information about nuclear deformation. Nuclei in the A ~ 130 mass region with protons just over 50 and neutrons fewer than 82 exhibit various intriguing properties including shape coexistence, suppression of pairing correlation, competing proton and neutron alignment, and triaxiality. Nuclei in this region have a complex shape due to the specific $h_{11/2}$ intruder orbital. In addition, theoretical calculations in the A ~ 130 region demonstrate that various shapes are coexisting. Consequently, the transitional region gives a unique chance to better understand how the intruders and other orbitals affect the nuclear structure at different deformations. The measurement of nuclear moments can be used to study the evolution of nuclear structure features in great detail. The presentation will discuss the importance of nuclear moments in the A ~ 130 mass region with some specific measurements.

Primary author(s) : Dr KAUR, Jasmeet (Guru Nanak Dev University , Amritsar); Dr BHATI, A K (Centre for Advanced Studies in Physics, Panjab University, Chandigarh, India)

Status: ACCEPTED

Submitted by **BHATTACHARJEE, Tumpa** on **Thursday 27 January 2022**

Abstract ID : **43**

Probing exotic nuclei through gamma-gamma fast timing measurements at VECC

Content

Lifetime measurement in low lying levels of nuclei around doubly magic ^{132}Sn is of contemporary interest. Such measurements provide important insight about the structure & the n-n interaction in the vicinity of double shell closure of ^{132}Sn. The validity of double shell closure near ^{132}Sn has been revealed by exploring the low-lying states of the nuclei having few proton (neutron) particles (holes) about Z = 50 and N = 82. However there is less of spectroscopic information available around ^{132}Sn because of the experimental difficulty in accessing this region by compound nuclear or transfer reactions using the available target-projectile combinations. In this context, the measurement of nuclear level lifetimes in low lying levels of $^{130-132}$Te & ^{133,135}Xe is very important. Complete details of experiments, measurement techniques and obtained results will be discussed in this talk.

In addition, a brief overview will be presented for gamma-gamma fast timing measurements carried out at VECC, Kolkata using VENTURE array.

Primary author(s) : Mr KUMAR, Devesh (Variable Energy Cyclotron Centre, Kolkata)

Status: ACCEPTED

Submitted by **BHATTACHARJEE, Tumpa** on **Thursday 27 January 2022**

Abstract ID : **44**

The evolution of B(E3) in Lanthanum isotopes

Content

The level structures of nuclei evolve from single particle to collective nature, as one goes away from Z=50 and N=82 shell gap. The transitional nuclei around A~135 with Z > 50 and N<82 which lie between the spherical and deformed regions show complex and rich level structures due to interplay of single-particle and collective excitation modes. Occupation of high-j orbitals for protons and neutrons is responsible for various structure phenomena for nuclei in this region, such as signature splitting, signature inversion, magnetic rotation, wobbling motion, chiral rotation and high spin isomers [1,2,3]. The lifetime measurement is crucial to deduce the transition probabilities B(Lλ), where L = E or M for electric or magnetic transition, respectively and λ is the order of multipolarity of the transition, between two connecting nuclear states. The lifetime of the $11/2^-$ state at 1004.6 keV in the ^{137}La nucleus populated by the reaction ^{130}Te(^{11}B, 4n) at 40-MeV beam energy, was measured using a hybrid array of HPGe clover and $LaBr_3$(Ce) detectors by electronic fast-timing technique, providing the value $T_{1/2}$ = 263 ± 12 ps. The reduced transition probability B(E3) = 23.3 ± 2.4 W.u. is found to be significantly larger compared to the values observed in lighter odd-A La isotopes [4]. The theoretical calculations of random-phase-approximation (RPA) was done to understand the physics behind large B(E3). The present work reports the lifetime measurement and experimental evidences of octupole correlation in Lanthanum (La) isotopes. Octupole correlation is essential property in order to describe the energy of low lying collective negative parity states and E1/E3 transition strengths.

Primary author(s) : Mr LASKAR, Md Sazedur Rahaman (Tata Institute of Fundamental Research, Mumbai)

Status: ACCEPTED

Submitted by **BHATTACHARJEE, Tumpa** on **Thursday 27 January 2022**

Abstract ID : **45**

Lifetime measurements in Pt and Tl isotopes populated via multi-nucleon transfer reactions

Content

Various Pt and Tl isotopes in the transitional region, which lie just below the heaviest doubly magic nucleus ^{208}Pb (Z = 82 and N = 126), have been studied using the Gammasphere and INGA detector arrays. Lifetimes ranging from few nanoseconds to hundreds of microseconds have been identified in these nuclei. The structure of Pt isotopes (Z = 78) exhibits coexistence between oblate, triaxial and prolate shapes, and there is found to be a complex interplay between intrinsic and collective degrees of freedom. Rotation-aligned isomeric states and oblate collective sequences have been established across Pt isotopes up to I = 26$\hbar$ with respect to their ground states[1-3],relatively high for this region, with previous information limited to the I ~ 10-20 $\hbar$ range[4-6]. Reduced E2 transition probabilities for the 12^+ isomeric states in even-A Pt isotopes indicate an abrupt reduction in collectivity in contrast to the gradual decrease near the respective ground states. The decay scheme of ^{202}Tl has been extended from I^π = 10^+ to I^π = 20^+ with the identification of a new $T_{1/2}$ = 215(10)μs isomer, originating from a four-nucleon excitation[7]. In Tl isotopes (Z = 81), with the approach of the proton shell closure at Z = 82, intrinsic excitations dominate and metastable states resulting from hindered transitions with higher multipole orders have been identified.

References:

[1] S.K. Tandel et al., Phys. Lett. B 750, 225 (2015)
[2] S.G. Wahid et al., Phys. Rev. C 92, 054323 (2015).
[3] S.G. Wahid et al., Phys. Rev. C 100, 014328 (2019).
[4] S.A. Hjorth, et al., Nucl. Phys. A 262, 328 (1976).
[5] G.A. Jones, et al., Acta Phys. Pol. B 36, 1323 (2005).
[6] A. Mauthofer, et al., Z. Phys. A 336, 263 (1990).
[7] S.G. Wahid et al., Phys. Rev. C 102, 024329 (2020).

Primary author(s) : Dr WAHID, S. Gholam (Department of Physics, University of Massachusetts Lowell, Lowell, Massachusetts 01854, USA; UM-DAE Centre for Excellence in Basic Sciences, Mumbai 400098, India)

Status: ACCEPTED

Submitted by **BHATTACHARJEE, Tumpa** on **Thursday 27 January 2022**

Abstract ID : **46**

Search for Triaxial Deformation using Coulomb Excitation and Beta Decay

Content

Collective shape degrees of freedom have been a major direction in the study of the nuclear finite many-body problem for over 50 years. There is widespread evidence for quadrupole deformations, primarily of large prolate spheroidal deformation with axially symmetric rotor degrees of freedom. This naturally leads to the question of whether or not axially asymmetric rotor degrees of freedom are exhibited by any nuclei, with the implication of triaxial shapes. With respect to best cases for observation of triaxial shapes near the ground state, two regions stand out. The first is the Os-Pt region and the second is the neutron-rich Mo-Ru region, where low-energy 2_2^+ states are consistent with such an interpretation. Furthermore, the neutron-rich Mo-Ru region is expected to undergo a relatively rare instance of prolate-to oblate shape evolution. Recent results from Coulomb excitation and beta-decay studies of neutron-rich Mo-Ru isotopes will be presented. These experiments were conducted at the CARIBU-ATLAS facility of ANL using GRETINA-CHICO2. A survey of the equipment, techniques, and results will be presented. In addition, a comparison of ^{106}Mo Coulomb excitation data with the old ECR and new EBIS ion sources will be highlighted.

*This material is based upon work supported by the U.S. Department of Energy, Office of Science, Office of Nuclear Physics.

Primary author(s) : ALLMOND, James Mitch (Oak Ridge National Laboratory , USA)

Status: ACCEPTED

Submitted by **BHATTACHARJEE, Tumpa** on **Thursday 27 January 2022**

Abstract ID : **47**

β-delayed neutron emission of exotic nuclei - update or upgrade ?

Content

β-delayed neutron emission is dominant for most neutron-rich nuclei and all isotopes on the r-process nucleosynthesis path, regardless of the astrophysical scenario. This two-step process combines beta decay and neutron emission; most models treat these two steps using independent models. With the new-generation facilities, access to very exotic isotopes was gained, which enabled a new perspective on understanding the fundamentals of this process. I will discuss the results of our decay spectroscopy measurements in ^{78}Ni and ^{132}Ni regions using various neutron arrays and how these results affected our modeling of beta-delayed neutron emission.

Primary author(s) : Dr GRZYWACZ, Robert (University of Tennesse, USA)

Status: ACCEPTED

Submitted by **BHATTACHARJEE, Tumpa** on **Thursday 27 January 2022**

Abstract ID : **48**

Current shell-model progress in the investigation of ^{132}Sn and ^{208}Pb regions

Content

Within the shell-model (SM) framework, enormous progress is achieved in the investigation of nuclei far from stability, by the development of a new generation of effective interactions using many-body perturbation theory. In this context, I start with an introduction to the main ingredients of realistic shell model calculations, by giving an overview of the construction of the effective Hamiltonians. Special focus is devoted to the recent N3LOP and H208 effective interactions, derived from free nuclear potentials, via many-body perturbation technique, which are developed for the ^{132}Sn and ^{208}Pb mass regions, respectively. Making use of these effective interactions, some selected results of nuclei from the two mass regions ^{132}Sn and ^{208}Pb will be discussed, by addressing a large amount of information on energy levels and electromagnetic transitions. It is noteworthy that some of these SM results are used as references in the interpretation of several new experimental measurements, proving the reliability of the effective interactions. Finally, I demonstrate the evolution of the collectivity in the two mass regions, where significant quadrupole correlations appear in some nuclei, with the signature
of nonaxial-band.

Primary author(s) : Dr NAIDJA, , Houda (Universit´e Constantine 1, Laboratoire de physique math´ematique et subatomique (LPMS), Constantine 25000, Algeria)

Status: ACCEPTED

Submitted by **BHATTACHARJEE, Tumpa** on **Thursday 27 January 2022**

Abstract ID : **49**

Shell model studies in nuclear β decay

Content

The effective value of g_A plays an important role when data on the astrophysical process, single and double beta decay are to be reproduced by the nuclear many-body calculations. Our group has recently extracted the information of the effective value of g_A in the different mass regions. In this talk I will present shell model results for the allowed and forbidden beta decay properties in the different mass regions of the nuclear chart [1-5]. In our recent study [2], we have reported a comprehensive shell model study of the logft values for the allowed and forbidden β^--decay transitions of ^{46}K and ^{47}K corresponding to recently available experimental data from the GRIFFIN spectrometer at TRIUMF-ISAC. Also, we have performed a systematic study of the shape factors and electron spectra for the second-forbidden nonunique β^--decays of ^{24}Na(4^+) $\longrightarrow$ ^{24}Mg(2^+) and ^{36}Cl(2^+) $\longrightarrow$ ^{36}Ar(0^+) using ab initio interactions [3]. Study of the electron spectral shapes as function of effective g_A for the second -forbidden nonunique β^--decays of ^{59}Fe($3/2^-$) $\longrightarrow$ ^{59}Co($7/2^-$) and ^{60}Fe(0^+) $\rightarrow$ ^{60}Co(2^+) which are possible best candidates for g_A sensitive electron spectral shape measurements will be also presented [4]. At the end, large-scale shell-model description for the first-forbidden beta-decay of ^{207}Hg into the one proton-hole nucleus ^{207}Tl will be presented[5].

References:
[1] V. Kumar, P.C. Srivastava, and H. Li, Nuclear β−decay half-lives for fp and fpg shell nuclei, J. Phys. G: Nucl. Part. Phys. G 43, 105104 (2016).
[2] P. Choudhary, A. Kumar, P.C. Srivastava and T. Suzuki, Structure of 46,47Ca from the β−decay of ^{46,47}K in the framework of the nuclear shell model, Phys. Rev. C 103, 064325(2021).
[3] A. Kumar, P.C. Srivastava, J. Kostensalo and J. Suhonen, Second-forbidden nonunique β-decays of ^{24}Na and ^{36}Cl assessed by the nuclear shell model, Phys. Rev. C 101, 064304 (2020).
[4] A. Kumar, P.C. Srivastava and J. Suhonen, Second-forbidden nonunique β-decays of ^{59,60}Fe:possible candidates for g_A sensitive electron spectral -shape measurements, Eur. Phys. J. A 57, 225 (2021).
[5] A. Kumar and P.C. Srivastava, Shell-model description for the first-forbidden beta-decay of ^{207}Hg into the one-proton-hole nucleus ^{207}Tl, Nucl. Phys. A 1014, 122255 (2021).

*Supported by SERB (India), CRG/2019/000556.

Primary author(s) : Dr SRIVASTAVA, Praveen C. (Department of Physics, Indian Institute of Technology-Roorkee, Roorkee 247667, India); KUMAR, Anil (Department of Physics, Indian Institute of Technology-Roorkee, Roorkee 247667, India)

Status: ACCEPTED

Submitted by **BHATTACHARJEE, Tumpa** on **Thursday 27 January 2022**

Abstract ID : **50**

Gamma-ray transition strength measurements to address a puzzling anomaly in ^{22}Na beta decay Awaited

Content

The 22Na nucleus (with N = Z = 11) presents an interesting system to study the interplay between weak, strong and electromagnetic interactions, as well as single-particle and collective degrees of freedom. In this talk I shall motivate why this is so and present some preliminary results from work done to address an observed anomaly in ^{22}Na beta decay, which appears to violate an assumed symmetry of fundamental interactions.

Primary author(s) : Dr TRIAMBAK, Smarajit (University of the Western Cape, South Africa)

Status: ACCEPTED

Submitted by **BHATTACHARJEE, Tumpa** on **Thursday 27 January 2022**

Abstract ID : **51**

DURGA: A novel facility in India to study capture gamma, fission fragment and decay spectroscopy

Content

The advent of high-efficiency & γ-ray spectrometers with multiple types of detectors, digital signal processing based data acquisition system, and the realistic possibility of taking a stride in the hitherto unknown territory of nuclear landscape are driving the low- and medium-energy nuclear physics into the path of exciting exploration. With this in consideration, a novel facility, DURGA (Dhruva Utilization in Research using Gamma Array), has recently been developed in DHRUVA reactor facility, Bhabha Atomic Research Centre, Mumbai, India. The concept and possible utilization of the aforesaid facility is very unique in the sense that it is the only facility in the country for carrying out "prompt" -ray spectroscopic investigation using thermal neutron beam. In the present configuration, the facility consists of six Compton-suppressed clover Germanium detectors and an equal number of $LaBr_3$(Ce) fast scintillators. The heart of the DURGA facility is a multi-frequency digitizer-based data acquisition system. The digital acquisition system has been tailor-made for an array of eight Compton suppressed Clover Ge detectors and sixteen $LaBr_3$(Ce) fast scintillators, with a provision of expansion in future. Low-spin, low-excitation energy regime has always been a fertile ground in γ-ray spectroscopy to explore several exotic nuclear phenomena, such as, β and γ vibration, multi-phonon structures, and even octupole-hexadecapole deformation. The facility is planned to be heavily used in studying Capture Gamma prompt and decay Spectroscopy (CGS). Nuclei with higher neutron to proton ratios are difficult to study in accelerator-based facilities using stable projectile and target combinations. One of the means to access and study the structure/properties of such nuclei is nuclear fission. Thermal neutron induced fission fragment spectroscopy will provide access to these difficult-to-reach nuclei, and study their medium- and high-spin nuclear structures in detail.

Primary author(s) : Dr MUKHOPADHYAY, Somsundar (Bhabha Atomic Research Center, Mumbai, India)

Status: ACCEPTED

Submitted by **BHATTACHARJEE, Tumpa** on **Thursday 27 January 2022**

Abstract ID : **52**

Penning Trap and its application in nuclear structure studies

Content

Penning Trap is an efficient tool for confining charged particles in free space and perform high precision measurements. Penning trap currently offers relative mass uncertainties down to 10^{-10} for radio-nuclides and better than 10^{-12} for stable species. Precision nuclear mass measurements will provide information about the path of the proton and neutron drip lines, the possible location of the island of stability in the super-heavy mass region, shell effects and magic numbers in region far away from stability lines, to name a few. This talk will give an overview of Penning Trap application in nuclear physics research and in particular discuss about the usage of VECC Penning trap in nuclear structure studies.

Primary author(s) : Dr SIKDAR, Arindam Kumar (Variable Energy Cyclotron Center, Kolkata); Dr DAS, P (Variable Energy Cyclotron Center, Kolkata); Dr BANERJEE, K (Variable Energy Cyclotron Center, Kolkata, India); Dr ROY, Amlan (Variable Energy Cyclotron Center, Kolkata, India)

Status: ACCEPTED

Submitted by **BHATTACHARJEE, Tumpa** on **Thursday 27 January 2022**

Abstract ID : **53**

Nuclear Structure studies using β detection with planar Ge detectors (LEPS)

Content

Nuclear isomers are excited quantum-mechanical states of a nucleus, in which a combination of various nuclear structure effects like single particle configuration of the states involved inhibits its decay. It endows it with a lifetime that is longer than expected. These isomers continue to be a frontier area of nuclear physics research since early days, and were first foreseen by Soddy in 1917 [1]. Systematics of long lived isomers in nuclei provides microscopic information on the nuclear interactions [2]. In recent times, long lived 0+ isomers bearing the signature of exotic shapes in nuclei are predicted theoretically [3,4]. Such exotic 0^+ levels are expected to undergo either E0 decays or particle decays to the neighboring nuclei since B(E2) and B(E1) at the exact tetrahedral symmetry limit vanishes.

Isomers with half-life ~sec or more can't be detected in an in-beam experiment and hence the decay measurement becomes very crucial. Identification of these beta decaying isomers can be done by studying the decay curves for the observed rays of the daughter and the $\gamma - \gamma$ coincidence measurements involving these transitions. Measurement of β decay end-point energies, when measured in coincidence with the daughter γ transitions, is also important in order to assign the excitation energy of the isomeric level, especially in absence of any isomeric transition decaying to the ground state of the parent. The β-decay logft values can be used to assign the spin of the isomeric level and the spin of the excited states of the daughter. Development and use of a $\beta - \gamma$ coincidence setup has been explored at VECC, Kolkata for performing $\beta - \gamma$ spectroscopic measurements utilizing planar segmented Ge detectors for detection of beta particles [5, 6]. In the present talk, the details of such setups and measurements used to study nuclear structure in ^{150}Pm and ^{150}Sm will be presented along with the future goals.

References:
[1] F. Soddy, Nature 99, 433 (1917).
[2] A. K. Jain et al., Rev. Mod. Phys. 70, 843 (1998).
[3] J. Dudek et al., Phys. Rev. Lett. 88, 252502 (2002).
[4] J. Dudek et al., Phys. Rev. C97, 021302(R) (2018).
[5] T. Bhattacharjee et al., NIM A767, 19 (2014).
[6] A. Saha et al., EPJ A56, 189 (2020).

Primary author(s) : Dr SAHA, Arunabha (Department of Physics, ICFAI University, Tripura)

Status: ACCEPTED

Submitted by **BHATTACHARJEE, Tumpa** on **Thursday 27 January 2022**

Abstract ID : **54**

New lifetime measurements for the 2_1^+ level in ^{112,120}Sn by the Doppler-shift attenuation method

Content

The tin (Sn; Z = 50) isotopes constitute the longest chain of semi-magic even-even nuclei between the ^{100}Sn (N = 50) and ^{132}Sn (N = 82) double-shell closures, seven of which, ^{112,114,116,118,120,122,124}Sn, are stable. These isotopes have become a prototypical benchmark of extensive microscopic theory and experiment, reflected in the large number of studies investigating the decay of their low-lying 2_1^+ excited state. The transition characteristics are inferred through the B(E2; $0_{g.s}^+ \rightarrow 2_1^+$) values, which, in principle, are contingent on the lifetime of the corresponding level, and are the most direct and unambiguous test of the collective nature of the transitions. There has been a considerable interest focused on the study of enhancement or suppression in collectivity of the excited 2_1^+ state in the stable Sn isotopes. Independent experiments on Coulomb excitation, heavy-ion scattering and 2_1^+ level lifetime measurements report discrepant transition probabilities, with the lifetime estimates indicating significantly reduced collectivity. A re-examination of the same has been carried out in the present work on two of the stable isotopes, ^{112,120}Sn. Low-lying levels in the ^{112,120}Sn isotopes have been excited by inelastic scattering with heavy ion beams. Level lifetime measurements have been carried out using the Doppler shift attenuation method, wherein the Doppler affected γ-ray peaks from the decay of the 2_1^+ level in each isotope have been analyzed using updated methodologies, and corresponding B(E2; $0_{g.s}^+ \rightarrow 2_1^+$) values become indicative of the underlying collectivity. The present results are discrepant with respect to existing lifetime estimates, but in compliance with systematic measurements of the B(E2;$0_{g.s.}^+ \rightarrow 2_1^+$) values in the stable Sn isotopes, by pure Coulomb excitation as well as heavy-ion induced inelastic collisions. The results are also found to be in good agreement with generalized seniority model as well as state-of-the-art Monte Carlo shell model (MCSM) calculations.

Primary author(s) : Dr KUNDU, Ananya (Tata Institute of Fundamental Research, Mumbai, India)

Status: ACCEPTED

Submitted by **BHATTACHARJEE, Tumpa** on **Thursday 27 January 2022**

Abstract ID : **55**

Lifetime measurement of astrophysically important states using Doppler technique

Content

The importance of lifetime measurements of nuclear levels has been recognized for a long time in the field of nuclear physics as well as nuclear astrophysics. One of the techniques to measure lifetimes of excited states in the range of fs up to ps is Doppler Shift Attenuation Method. When γ-rays of particular energy are emitted from a recoiling nucleus, while it slows down through the target medium, their energies are shifted depending on the angular position of the detector. The Doppler shifted γ-ray energy spectrum can then be used to extract the lifetime τ (or half-life $t_{1/2}$ = 0.693τ) of a decaying level. The total level width, $\Gamma = \hbar\tau$, can thus be calculated. These nuclear physics inputs will be utilized in calculating resonant proton capture reaction rates in the field of nuclear astrophysics. Therefore, they can be further used for network calculations to predict the elemental abundances. Here, I will discuss about the lifetime measurement of few astrophysically important states of 15O nucleus especially the lifetime of a sub-threshold resonance state at 6792 keV ($E_{c.m.}$ = -504 keV) using DSAM method. The accurate determination of the radiative width () of this state will reduce the uncertainty related to the ^{14}N (p, γ) ^{15}O reaction rate and thereafter the total CNO cycle reaction rate.

Primary author(s) : Dr SHARMA, Sathi (Mody University, India)

Status: ACCEPTED

Submitted by **BHATTACHARJEE, Tumpa** on **Thursday 27 January 2022**