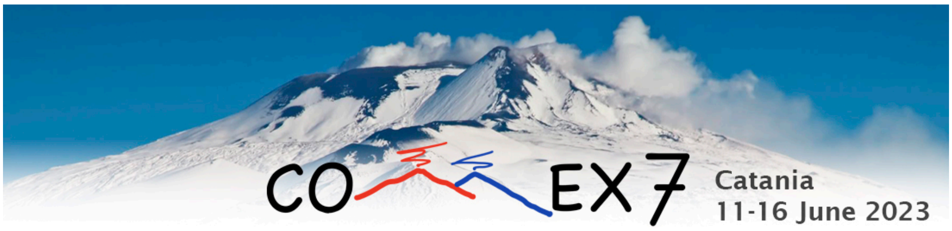
7th International Conference on Collective Motion in Nuclei under Extreme Conditions (COMEX7)



Book of Abstracts

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In memory of Ricardo Broglia and Peter Schuck

Monday, 12 June 2023 09:45 (15 minutes)

Presenter: BALDO, Marcello (CT)

Status of DFT calculations for collective states and application to the monopole resonances

Monday, 12 June 2023 10:00 (30 minutes)

Gianluca ColÃ²[1,2]
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Collective nuclear states, like giant resonances, provide a clear signature of several parameters that control the behaviour of the nuclear equation of state (EoS). A well-known example is the link between Giant Monopole Resonance (GMR) energy and nuclear incompressibility.
In this talk, I will discuss recent theoretical advances that are crucial for solving some remaining â□□puzzlesâ□□ associated with the value of nuclear incompressibility. In the recent past, it has been argued that some nuclei are â□□softâ□□ in the sense that the value of incompressibility that we deduce from their GMR energy is lower than the standard value obtained from, e.g., 208Pb. I will explain how the puzzle related to the softness of Sn and Ca isotopes can be explained.
The problem of the GMR in deformed nuclei will also be addressed. The need to go experimentally toward neutron-rich systems will be emphasised as a future prospect.

Presenter: COLÃ□, Gianluca

Isoscalar giant monopole strength in ^{58}Ni, ^{90}Zr, ^{120}Sn and ^{208}Pb

Monday, 12 June 2023 10:30 (15 minutes)

Background: Inelastic α-particle scattering at energies of a few hundred MeV and very-forward scattering angles including 0° has been established as a tool for the study of the isoscalar giant monopole (IS0) strength distributions in nuclei. This compressional mode of nuclear excitation can be used to derive the incompressibility of nuclear matter.

Objective: An independent investigation of the IS0 strength in nuclei across a wide mass range was performed using the 0° facility at iThemba Laboratory for Accelerator Based Sciences (iThemba LABS), South Africa, to understand differences observed between IS0 strength distributions in previous experiments performed at the Texas A\&M University (TAMU) Cyclotron Institute, USA and the Research Center for Nuclear Physics (RCNP), Japan.

Methods: The isoscalar giant monopole resonance (ISGMR) was excited in ^{58}Ni, ^{90}Zr, ^{120}Sn and ^{208}Pb using α-particle inelastic scattering with 196 MeV α beam and scattering angles $\theta_{\text{Lab}} = 0^\circ$ and 4°. The K600 magnetic spectrometer at iThemba LABS was used to detect and momentum analyze the inelastically scattered α particles. The IS0 strength distributions in the nuclei studied were deduced with the difference-of-spectra (DoS) technique including a correction factor for the 4° data based on the decomposition of $L > 0$ cross sections in previous experiments.

Results: IS0 strength distributions for ^{58}Ni, ^{90}Zr, ^{120}Sn and ^{208}Pb are extracted in the excitation-energy region $E_{\text{x}} = 9 - 25$ MeV. Using correction factors extracted from the RCNP experiments, there is a fair agreement with their published IS0 results. Good agreement for IS0 strength in ^{58}Ni is also obtained with correction factors deduced from the TAMU results, while marked differences are found for ^{90}Zr and ^{208}Pb.

Conclusions: There are clear structural differences in the IS0 strength distributions of ^{90}Zr and ^{208}Pb extracted from different measurements. This affects the determination of the nuclear matter incompressibility mainly based on the ISGMR centroids of those two nuclei.

Presenter: BAHINI, Armand (iThemba Laboratory for Accelerator Based Sciences)

The study of giant dipole resonances with quasiparticle vibration coupling approach

Monday, 12 June 2023 11:15 (30 minutes)

The giant dipole resonance (GDR) represents an important mode of nuclear collective vibrations, which not only reveals rich information of nuclear structure, but also has direct link to basic properties of nuclear EoS.
The unified description of GDR including both centroid energies and widths in light and heavy nuclei has always been a difficult problem for theoretical models. Based on Skyrme density functionals, the self-consistent quasiparticle random phase approximation (QRPA) plus quasiparticle vibration coupling (QPVC) approach has been developed recently. With this approach, we will study to what extent this problem can be solved.
Even if the centroid energy and width of GDR can be well described, a more detailed understanding of the wave functions of GDR is still missing to a large extent. We will show that this information can be extracted by gamma decay of GDR to low-lying states with particle vibration coupling (PVC) approach. By comparing the decay widths between GDR to 21+ and giant quadrupole resonance (GQR) to 31- , a much larger weight of the 31- component in the GQR wave function of 208Pb is deduced, with respect to the weight of the 21+ component in the GDR wave function.
Although the QPVC effect is important in describing both energies and widths of GDR, it will keep

the dipole polarizability the same as the QRPA level. Therefore, the correlation between dipole polarizability and properties of symmetry energy remains the same at QPVC level. We will also introduce a good correlation between dipole polarizability and symmetry energy slope in neutron-rich Sn isotopes, which helps us to constrain the behavior of symmetry energy at high densities.

Presenter: NIU, Yifei (School of Nuclear Science and Technology, Lanzhou University, Lanzhou 730000, China)

Feeding of the residual states with GDR gamma decay studied by nuBall coupled to PARIS

Monday, 12 June 2023 11:45 (30 minutes)

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A study of the Î³-decay of GDR formed in a hot ^{192}Pt compound nucleus was performed at IJCLab Orsay. The main goal of the experiment was to explore a link between deformations of the compound and residual nuclei by investigating the GDR emission from the ^{192}Pt compound nucleus in its 4n decay channel leading to the ^{188}Pt residue. ^{188}Pt is a nucleus known for its ground state prolate shape and tri-axial band based on 12^+ state. The experimental method which can deliver information on feeding of states of different deformations was based on simultaneous measurement of Î³âdecay of the GDR and low-energy Î³-rays. The high energy gamma rays from the GDR decay measured using PARIS phoswiches provided information on compound nucleus properties, particularly on its effective shape. Discrete transitions in evaporation residues, measured by nuBall array, were used to select the final products of specific deformations. As a result, despite rather low statistics, the GDR strength functions measured for the particular decay paths were obtained.
During the talk I will also present preliminary results from more recent experiment within nuBall2 + PARIS campaign at IJCLab. It aimed at the measurement of high-energy gamma GDR decay from ^{80}Sr compound nucleus leading to ^{76}Kr evaporation residue. In the ^{76}Kr nuclei coexistence of the prolate and oblate shape bands is well known, that together with much higher statistics than in the previous experiment for ^{188}Pt, will allow to check the correlation between compound nucleus GDR shape and deformation of the different bands.

Presenter: CIEMALA, Michal Lukasz

Finite temperature effects on nuclear excitations and weak interaction processes

Monday, 12 June 2023 12:15 (30 minutes)

Presently, the nuclear energy density functionals (NEDF) have become a standard framework to study the nuclear properties and collective excitations over the entire nuclide chart. Among different excitation modes of nuclei, the spin-isospin excitations are known as fundamental modes of excitation in nuclei that gained considerable attention with the advances in experimental facilities and progress in theoretical models [1]. The precise knowledge about their structure not only important for nuclear physics but also for the nuclear astrophysics [1]. Especially in the calculation of nuclear weak interaction processes such as beta decay, electron capture, and neutrino-nucleus scattering, accurate knowledge of the spin-isospin excitations is necessary. Recently, we developed the finite temperature quasiparticle random phase approximation (FT-QRPA) based on the relativistic and non-relativistic nuclear energy density functionals to study the collective excitations in nuclei [2, 3]. Then, a self-consistent model was developed by unifying the models for the description of nuclear properties and excitations to calculate the weak interaction rates in hot stellar environment [4,5].

In this talk, I will first present some recent results on the temperature dependence of the various nuclear excitation modes and discuss the interplay between pairing and temperature effects in open-shell nuclei and below the critical temperatures for the shape phase transition. In the second part of this talk, I will discuss the impact of temperature on the electron capture rates and beta decay properties within the relativistic energy density functional framework, relevant to astrophysical environments.

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Presenter: YÃKSEL, Esra (University of Surrey)

Study of the Pygmy Dipole Resonance using neutron inelastic scattering at GANIL-SPIRAL2/NFS

Monday, 12 June 2023 14:15 (30 minutes)

The pygmy dipole resonance (PDR) is a vibrational mode described as the oscillation of a neutron skin against a core symmetric in number of protons and neutrons. The PDR has been the subject of numerous studies, both experimental and theoretical [1,2,3]. Indeed, the study of the PDR has been and still is of great interest since it allows to constrain the symmetry energy, an important ingredient of the equation of state of nuclear matter that describes the matter within neutron stars [4]. Moreover, the PDR is predicted to play a key role in the r-process via the increase of the neutron capture rate [5]. However, despite numerous experiments dedicated to the study of the PDR, a consistent description is still discussed. In this context, we propose to study the PDR using a new probe: the neutron inelastic scattering reaction (n,nâg).

An experiment to study the pygmy resonance in 140Ce using the (n,nâg) reaction has just been carried out. This experiment has been made possible thanks to the high-intensity proton beam of the new accelerator SPIRAL2 at GANIL and the NFS (Neutron For Science) facility. The experimental setup consisting of the new generation multi-detectors PARIS [6], for the detection of gammas coming from the de-excitation of the PDR, and MONSTER [7], for the detection of scattered neutrons, was used.

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Presenter: VANDEBROUCK, Marine (CEA Saclay)

The low-lying electric dipole strength in nuclei: the role of deformation

Monday, 12 June 2023 14:45 (30 minutes)

The electric dipole response in nuclei is characterised at high energies by the isovector Giant Dipole Resonance (IVGDR) and, for neutron-rich nuclei, by the Pygmy Dipole Resonance (PDR) around the neutron separation energy. Even though these two excitation modes have been extensively studied, some of their characteristics are still not understood. This talk will concentrate on the discussion of the role of deformation in the excitation of the PDR. The results of an experiment conducted at iThemba LABS to study the isoscalar low-lying dipole strength will be presented. Moreover, the uncertainties in the theoretical predictions and experimental measurements of the IVGDR in medium-light nuclei will be introduced together with a presentation of the PANDORA project which goal is to overcome these limitations.

Presenter: PELLEGRI, Luna (iThemba LABS/ Univeristy of the Witswatersand)

A PDR study on ^{142}Nd

Monday, 12 June 2023 15:15 (20 minutes)

The nature of the pygmy dipole resonance (PDR) excitation mode is an ongoing topic of discussion. In order to improve our understanding of the PDR the isoscalar E1 response in the 142Nd nuclues was studied at iThemba LABS using the (alpha,alpha' gamma) reaction at an incident beam energy of 120 MeV. The scattered particles were detected with the K600 magnetic spectrometer, while the subsequent gamma decay was measured by the BaGeL (Ball of Germanium and LaBr detectors) array. These results can be used together with existing data on 144Sm, 140Ce and 138Ba for an isoscaler probe, as well as data on 144Sm, 142Nd, 140Ce and 138Ba with a isovector probe, to evaluate the behaviour of the pygmy dipole resonance as the N/Z ratio changes along the neutron magic number N=82. The results of this experimental study will be presented in this talk.

Presenter: NEVELING, Retief (iThemba LABS)

Quartet structure of N = Z nuclei

Monday, 12 June 2023 16:05 (30 minutes)

The phenomenon of quarteting in even-even $N = Z$ nuclei has a long history in nuclear structure [1]. In spite of that, several unexplored and yet interesting aspects of this phenomenon have come to light only in recent years. In Ref. [2], we have evidenced on analytic grounds the key role played by the isovector pairing in the phenomenon of nuclear quarteting. We have indeed shown that α-like quartets, i.e., correlated four-body structures made by two protons and two neutrons, do represent the distinctive feature of the exact eigenstates of this Hamiltonian in $N = Z$ even-even systems.
But how do quartets evolve in the presence of a general Hamiltonian? I will provide a description of deformed $N = Z$ nuclei in the sd and pf shells in a formalism of α-like quartets. I will show how these quartets can be built by resorting to the use of proper intrinsic states and I will perform configuration-interaction calculations in spaces built with these quartets [3]. As a peculiarity of this approach, which improves a technique employed in previous works [4,5], it will be shown that the spectra of these nuclei can be organized in bands associated with the various intrinsic states built in terms of quartets. It will also be shown that the same bands simply result from the angular momentum projection of these intrinsic states. Comparisons with experiment and shell model results will be provided.

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Presenter: SAMBATARO, Michelangelo (Istituto Nazionale di Fisica Nucleare)

Shape changes, quadrupole collectivity and configuration invertions along N = Z

Monday, 12 June 2023 16:35 (30 minutes)

In nuclei along the N = Z line, as protons and neutrons occupy the same valence orbitals, proton-neutron correlation properties and quadrupole-quadrupole interactions emerges. In heavy even N = Z nuclei the competition between prolate and oblate quadrupole coherence is hitherto not measured. Well-developed deformation in the upper fpg shell starts from 68Se. In 68Se, the intrinsic deformation of the ground-state band has been interpreted as oblate, while a prolate deformation is assigned to the excited band that soon becomes yrast. The tendency leads to the emergence of shape coexistence, which are predicted in the strongly deformed 72Kr, 80Zr and 84Mo [1].
In this study, exploiting an 86Mo radioactive beam produced at NSCL, we measured the lifetime of the first 2+ state in 84Mo and 86Mo using the GRETINA array and a plunger setup. The reduced transition probability B(E2; 2+ â 0+) of the Mo isotopes were deduced, thereby understanding their quadrupole collectivity and deformation.
The experimental results will be presented along with their interpretation with state-of-the-art calculations using ZBM3 effective interaction.

References
[1] A. P. Zuker, A. Poves, F. Nowacki, and S. M. Lenzi, Phys. Rev. C 92, 024320 (2015).

Presenter: RECCHIA, Francesco (Istituto Nazionale di Fisica Nucleare)

Mirror energy differences as a probe for cross-shell excitations in ^{43}Sc-^{43}Ti mirror pair

Monday, 12 June 2023 17:05 (15 minutes)

Studying the nuclei along and near the N = Z line is the best way to find answers to some fundamental questions in nuclear structure, such as charge-dependence of the nuclear interaction or the role of the proton-neutron pairing. The differences between the excitation energy of isobaric analogue states (IAS), called mirror energy differences (MED), are signatures of isospin symmetry breaking (ISB) in mirror nuclei [1]. Despite our deep understanding of the electromagnetic interaction, the differences in the experimental binding energies in mirror nuclei cannot be reproduced theoretically [2], thus pointing that the ISB could arise also from the residual nuclear interaction [1].
Cross-shell particle-hole excitations from the sd to the fp shells in the mid-shell 42â€Aâ€54 nuclei generate rotational bands of non-natural parity which are particularly sensitive to the electromagnetic spin-orbit interaction. In the 43Sc-43Ti mirror pair such positive-parity bands should extend up to 27/2+. There is a competition between proton-hole and neutron-hole excitations from the sd orbitals and the MED are very sensitive to cross-shell single-particle excitations and can be used to understand which type of nucleons are excited across the shell gap.
To explore this phenomena, we performed spectroscopic studies extending the level scheme of 43Ti up to the 25/2+. Excited states of 43Ti were populated in a fusion-evaporation reaction in JYFL, Jyvaskyla. The prompt Î³-rays were detected with JUROGAM 3 spectrometer while the evaporation residues were selected with MARA separator. Comparison of the IAS in the A=43 mirror pair allowed us to pinpoint the isospin dependence that has a strong effect on the band structures.

Indeed, we find that the competition between protons and neutrons promoted from the d3/2 orbital yields MED as high as 250 keV. This can be interpreted within the Shell Model as the effect of ISB nuclear force, found to be as strong in this mass region as that of the Coulomb component [1,3].

References

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Presenter: REZYNKINA, Kseniia (Istituto Nazionale di Fisica Nucleare)

Properties of rotational bands from symmetry breaking and restoration

Monday, 12 June 2023 17:20 (15 minutes)

Deformed nuclei manifest collective excitations also in the form of rotational bands. Through the properties of these rotational bands, such as the inertia, the characteristics of the nuclei can be studied. For example, the deformation and structure configuration of nuclei defines their inertia. Changes of configuration at increasing spin give rise to rapid changes in the inertia, hence excitation energy, known as backbanding.

We recently developed a model exploiting the generator coordinate method with effective low-energy Hamiltonian [1]. This model is used to probe the properties of deformed and open-shell systems allowing for a detailed description of low-energy many-body correlations by way of symmetry breaking and restoration through projection. It has been expanded to treat odd nuclei and calculate spectroscopic factors [2] with the objective of developing an optical potential that emerges from the the collective description of states [3].

In this talk, I will provide an analysis of the spectroscopic properties of Mg and Cr odd and even isotopes, together with excitation spectra and quadrupole transitions. From this microscopic model the correlated many-body wavefunctions it is possible to see the configuration that are composing specific states and the change of wavefunction in terms of deformation along different transitions.

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[3] J. BostrÃ¶m et al., Spectroscopic factors with generator coordinate method and application to ^{25}Mg states, Journ Phys. Conf. Ser. to be published.

Presenter: IDINI, Andrea (Lund University)

Axial quadrupole and octupole dynamics in heavy even-even nuclei

Monday, 12 June 2023 17:35 (15 minutes)

A phenomenological collective model [1] is proposed for the simultaneous description of alternate parity bands in even-even nuclei. The model is based on a quadrupole-octupole axially symmetric version of the Bohr Hamiltonian and depends on two parameters. The phenomenology behind the free parameters offers a systematic description of the rotation-vibration dynamics of alternate parity bands observed in the isotopic chains of Ra, Th, U, and Pu nuclei. As a result, the A = 224â228 mass region of the Ra and Th nuclei was identified as critical for the transition between static and dynamic octupole deformation, which commences at different spins. The model's performance in matching the experimental data is exploited for predictions regarding energies of unobserved states of the yrast sequence and of the excited bands. Few available measurements on the E1, E2, and E3 transition rates are also well reproduced by the proposed model, which moreover predicts a specific spin dependence for the transitional nuclei.

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Presenter: BUDACA, Radu (Horia Hulubei National Institute for Physics and Nuclear Engineering)

The Facility for Rare Isotope Beams and the first year

Tuesday, 13 June 2023 09:00 (30 minutes)

Presenter: BROWN, Kyle (MSU)

Overview of the MUGAST silicon array at GANIL

Tuesday, 13 June 2023 09:30 (30 minutes)

MUGAST [1] is a state-of-the-art silicon array combining trapezoidal and square shaped double-sided silicon strip detectors (DSSD) to four MUST2 [2] telescopes. Coupled to a gamma-ray spectrometer, the excellent angular coverage and compacity of the MUGAST array make it an ideal tool for the study of transfer reactions. It is a first step toward the development of the new generation of silicon arrays using PSA for particle identification, such as the future GRIT array [3] developped by our collaboration.
In recent years, MUGAST has been widely used at GANIL. First with the AGATA gamma-ray spectrometer and the VAMOS large acceptance spectrometer for the study of ISOL beams from the

SPIRAL1 facility. It is now coupled to the EXOGAM gamma-ray spectrometer and to a new zero degree detection system at the end of the LISE fragmen- tation beamline.
In this talk, a summary of previous results from the 2019-2021 MUGAST-VAMOS- AGATA campaign will be presented, followed by a description of the newly installed ex- perimental setup at LISE, the opportunities it opens up and its performance.

References

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Presenter: ALCINDOR, ValÃ©rian (TU-Darmstadt)

Latest results on the FRAISE facility and possible physics cases at INFN-LNS

Tuesday, 13 June 2023 10:00 (30 minutes)

N.S. Martorana[1,2], L. Acosta[3], A. Amato[2], G. Cardella[5], A. Caruso[2], L. Cosentino[2], M. Costa[2], E. De Filippo[5], G. De Luca[2], E. Geraci[1,5], B. Gnoffo[1,5], C. Guazzoni[4], C. Maiolino[2], E.V. Pagano[2], S. Passarello[2], S. Pirrone[5], G. Politi[5], S. Pulvirenti[2], F. Risitano[5,6], F. Rizzo[1,2], A.D. Russo[2], P. Russotto[2], D. Santonocito[2], A. TrifirÃ³[5,6], M. Trimarchi[5,6], S. Tudisco[2], G. Vecchio[2]

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The study of nuclear reactions using high-intensity Radioactive Ion Beams (RIBs), especially for nuclei far from the beta stability valley, is one of the most attractive directions in current nuclear physics. Indeed, most of the current knowledge on the nuclear structure is limited to nuclei close to the stability valley, and only studies made possible by the availability of RIBs allow for further exploring such knowledge in uncharted territories of the nuclei chart. In this framework, at the Laboratori Nazionali del Sud of INFN (INFN-LNS) [1-5] the construction of the FRAISE (FRAgment In-flight SEparator) apparatus will allow to perform a plethora of studies concerning unstable nuclei close to and far from the stability valley. FRAISE will be a very competitive facility for the production of light and medium mass unstable nuclei in the Fermi energy regime, with intensities in the range of 103-107 pps. The beam tuning and the transport are key aspects to deliver high-quality beams and for such purpose diagnostics and tagging systems, based on the SiC technology and capable to operate also in radioactively harsh environments, have been developed in these years. In this contribution, we report the latest news on the FRAISE apparatus, with a particular focus on the diagnostics and tagging devices as well as on the possible physics cases.

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Presenter: MARTORANA, Nunzia Simona (Istituto Nazionale di Fisica Nucleare)

Strength Function of Pairing Vibrations in the Continuum Beyond RPA

Tuesday, 13 June 2023 11:00 (30 minutes)

Presenter: BARRANCO, Francisco (University of Seville)

The Giant pairing vibration from an experimental point of view

Tuesday, 13 June 2023 11:30 (30 minutes)

M. AssiÃ©
IJCLab, UniversitÃ© Paris-Saclay CNRS-IN2P3, 91405 Orsay, France

A Giant Pairing Vibrations (GPV) is a collective mode in the two-neutron transfer channel [1]. From the theoretical point of view, this mode is of fundamental importance since it is analogous to a giant resonance. It is a L=0 transition mode from an A nucleus to a AÂ±2 nucleus. The GPV is expected to manifest itself as a large bump in the 2 neutrons transfer energy spectrum. Various independent theoretical calculations converge in predicting the GPV as a strong mode (few mb) typically located around 13 MeV in ^{208}Pb in the 2 neutron L=0 transfer channel [1,2]. The collectivity of the GPV is supposed to increase with the mass of the nucleus. Therefore, its strength is expected to be maximum for heavy nuclei, such as Sn or Pb isotopes.
This mode has been searched for in the 70s and has regained interest in the 2000s with new investigation through (p,t) transfer reactions mostly [3]. Recent experiments have provided evidence for this mode in ^{14,15}C [4] but, despite sensitive studies, it has not been definitively identified in Sn or Pb nuclei where pairing correlations are known to play a crucial role near their ground states. I will present a review and current status of the search for the GPV in â��heavy nucleiâ��. I will also present preliminary results on the measurement performed at TRIUMF to measure ^{116}Sn(^{6}He,^{4}He) with the IRIS set-up.

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Presenter: ASSIÃ�, MarlÃšne (IPN Orsay)

Nuclear Josephson-like Î³-emission

Tuesday, 13 June 2023 12:00 (20 minutes)

Nucleon pair transfer processes between superfluid nuclei in heavy ion reactions have been considered [1-6] as possible analogues of the transfer of Cooper pairs [7] of electrons through Josephson Junctions [8]. In this contribution we present a new viewpoint on the subject [9,10] based on the alternating current (ac) Josephson effect and associated electromagnetic radiation emitted in the process (see e.g. [11] and references therein; see also [12]). We implement the quantum mechanical description of the coupling of the electric dipole associated with the (2n)-transfer reaction process, establishing the connection between the dynamics of the collision process and the number and energy dependence of the emitted Î³ photons, thus providing a quantitative signature of the (ac) Josephson-like nature of the phenomenon.
We will present predictions of the Î³-angular distributions, analyzing powers and strength functions associated with the reaction 116Sn +60Niâ62Ni+ 114Sn. The absolute differential cross sections were measured at various bombarding energies at the Laboratori Nazionali di Legnaro (LNL) [13, 14]. A new dedicated measurement aimed at the detection of the predicted radiation has just been carried out.

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Presenter: VIGEZZI, Enrico (Istituto Nazionale di Fisica Nucleare)

Excited states of zero seniority based on a pair condensate *

Tuesday, 13 June 2023 12:20 (15 minutes)

We study two types of excited states of zero seniority generated from a ground state described by a pair condensate [1]. One type is obtained by breaking a pair from the ground state condensate and replacing it by â⊠⊠excitedâ⊠⊠ collective pairs built on time-reversed single-particle orbits. The second type is described by a condensate of identical excited pairs. The structure of these excited states is analysed for the valence neutrons of ^{108}Sn. For a state-depending pairing interaction, the first type of excited states agree well with the J=0 states which are known in ^{108}Sn. The states corresponding to the excited pair condensate (EPC) appear at low energies, around the energy of the second excited state of the first type, and they do not have a simple correspondence with the exact eigenstates of the pairing Hamiltonian. At a much higher excitation energy, of about 20 MeV, we have found an EPC state which is similar in structure to an exact eigenstate. It is shown that this EPC state has the features of a giant pairing vibration.

[1] Th. Popa, N. Sandulescu, and M. Sambataro, Phys. Rev. C, in press

Presenter: POPA, Th. (National Institute of Physics and Nuclear Engineering, 76900 Bucharest, Romania)

Linear response of warm nuclei with thermal and pairing fluctuations.

Tuesday, 13 June 2023 12:35 (5 minutes)

The study of Giant Dipole Resonance (GDR) has been of great interest to researchers for several years. The GDR at high temperatures (T) and angular momenta (J) has been extensively researched as it helps reveal several essential structural properties of the nucleus under extreme conditions. However, there is much to discover about nuclei properties in the low-temperature regime ($T < 1$ MeV). In particular, the GDR at low temperatures is less explored but still intriguing. In this temperature region, there is a strong interplay between the quantal fluctuations (shell), the thermal fluctuations (shape), and the pairing interaction. These factors are critical in understanding the behavior of the GDR at low temperatures. To further investigate this interplay, we present a microscopic model based on the random phase approximation (RPA), which has been extended to finite temperature. The proposed model calculates fluctuations in shape and pairing field within the thermal shape fluctuation model (TSFM) and extends to include fluctuations in the pairing field. The shell corrections and the results of the microscopic model for the GDR are calculated using a realistic triaxial Wood-Saxon (WS) Hamiltonian. Our study focuses on the nuclei ^{97}Tc, ^{120}Sn, ^{179}Au, and ^{208}Pb, where we compare our results with the available experimental data. Our findings show that, despite having fewer parameters than the macroscopic model, the microscopic model can reproduce the experimental trend in GDR width at lower temperatures in both the Sn and the Pb regions. Our results demonstrate the importance of considering quantal and thermal fluctuations and their interplay with the pairing interaction when studying the GDR at low temperatures. Future work in this field should focus on expanding the microscopic model to include other factors that influence the behavior of the nucleus, such as spin in hot and rotating nuclei.

Presenters: ABHISHEK, Abhishek (University of Surrey); TBA

Seniority isomers and their whereabouts

Tuesday, 13 June 2023 12:40 (5 minutes)

Nuclear isomers are long-lived excited states of nuclei that can be classified into several classes based on the hindrance mechanism to their respective decays. These classes include spin, seniority, K, shape, and fission isomers. Seniority isomers are a category related to Racah's seniority quantum number. These isomers from various valence spaces behave remarkably similarly to one another due to involved algebraic symmetry and can be explained using (generalized) seniority. Though the configuration mixing in these isomeric wave functions has also been important, the near goodness of generalized seniority can govern the evolution of their various spectroscopic features such as decay probabilities, excitation energies, and moments. Seniority isomers serve as a useful tool in determining the rigidity of spherical magic numbers, single-particle energies, and pairing interaction. These isomers in and around semi-magic nuclei can be used to address the boundary between the single-particle and collective motion of nucleons. Seniority isomers and their whereabouts in the full nuclear chart will be presented [Symmetry 14, 2680 (2022)]. Future possibilities will also be discussed.

Presenter: MAHESHWARI, Bhoomika (University of Zagreb, Croatia)

FARCOS detector in the CHIFAR experiment

Tuesday, 13 June 2023 12:45 (5 minutes)

The CHIFAR experiment was proposed to investigate the emission probability of Intermediate Mass Fragments (IMFs) in non-central collisions, focusing also on the role of the isospin degree of freedom of the colliding nuclei. The CHIMERA collaboration has investigated three nuclear reactions at the incident beam energy of 20A.MeV: 124Sn+64Ni, 112Sn+58Ni and 124Xe+64Zn.
For the first time the experimental setup was equipped with ten telescopes of FARCOS (Femtoscope ARray for COrrelation and Spectroscopy) correlator in its final configuration, coupled with the 4Ï CHIMERA multi-detector allowing to study correlations among IMFs produced in a nuclear reaction.
Each FARCOS telescope is composed of two Double Sided Silicon Strip Detectors (DSSSD), with 300 ÎŒm and 1500 ÎŒm of thickness respectively, and 4 CsI(Tl) crystals of 6 cm thickness. FARCOS is characterized with high energy and angular resolution.
The contribution will illustrate results of the energy calibration of the two DSSSDs, the evaluation of the energy resolution and the particles identification using the ÎE-E technique. Considering that FARCOS was placed between 13Â°-30Â° in the laboratory frame system, a good charge identification of fragments up to Zâ16 and an isotopic identification for IMFs with atomic number

up to Zâ9 are achieved.

Presenter: ZAGAMI, Cristina (Istituto Nazionale di Fisica Nucleare)

Latest results on NArCoS: a new correlator for neutrons and charged particles with high angular and energy resolution

Tuesday, 13 June 2023 12:50 (5 minutes)

The advent of new facilities for radioactive ion beams mainly rich in neutrons, SPES @ LNL, FRAISE @ LNS and FAIR @ GSI only to give some examples, imposes the joint detection and discrimination of neutrons and charged particles in Heavy radioactive Ion collisions, with high angular and energy resolutions. The construction of novel detection systems suitable for this experimental task is both a scientific and a technological challenge.
The contribution will illustrate the results of recent tests performed on a new plastic scintillator material, the EJ276, both in the “”green-shifted”” and in the base version, coupled with PMT and SiPM. This experimental activity pave the way for the construction of a workhouse of a detector for neutrons and charged particles with high energy and angular resolution, based on a 3D cluster of scintillation units, with the technical goal of high energy and angular resolution. This project is funded by the Italian Project PRIN ANCHISE (2020H8YFRE)

Presenter: PAGANO, Emanuele Vincenzo (Istituto Nazionale di Fisica Nucleare)

Systematic investigation of the Pygmy Dipole Resonance near the magic $N = 82$ shell closure

Tuesday, 13 June 2023 12:55 (5 minutes)

“The Pygmy Dipole Resonance (PDR) occurs as a concentration of electric dipole strength around and below the neutron separation energy and has been a research topic of great interest in theory and experiments for the last decades [1-3]. However, there are still several open questions concerning the PDR. Therefore, systematic studies are crucial to improve the knowledge of this excitation mode. Among others, such systematic studies have already been done along the magic $N = 82$ isotonic chain (^{136}Xe, ^{138}Ba, ^{140}Ce, ^{142}Nd and ^{144}Sm) using the Nuclear Resonance Fluorescence technique [4]. Furthermore, real photon-scattering experiments have been performed on the neighbouring even-even isotones ^{142}Ce and ^{144,146,150}Nd to evaluate the evolution of the PDR across the closed neutron shell. Due to the small angular momentum transfer, photons are a well-suited probe to investigate dipole excitations in general [5]. In this contribution, first results of these experiments on ^{144}Nd will be presented and compared to those of the other examined

nuclei in the $N = 82$ region.
This work is partly supported by the BMBF (05P21PKEN9).

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[4] D. Savran *et al.* Phys. Rev. C **84** (2011) 024326.
[5] A. Zilges *et al.*, Prog. Part. Nucl. Phys. **122** (2022) 103903."

Presenter: KLUWIG, Florian (University of Cologne)

Systematic investigation of E1 strength below S_n in the tin isotopic chain using the $(d, p\gamma)$ reaction

Tuesday, 13 June 2023 13:00 (5 minutes)

"While the general properties of the electric dipole strength below the neutron separation energy are well known, there are still open questions about its underlying structure [1]. For the investigation of this structure, experimental probes sensitive to different aspects of the nuclear response are crucial [2]. The $(d, p\gamma)$ reaction has already been shown to selectively excite one particle â one hole structures in ^{120}Sn [3]. In general, the tin isotopic chain is unique for this kind of investigation, since it has three stable isotopes which are available as targets for such experiments. Furthermore, all of those isotopes share the same ground state spin and thus enable comparisons among them. In all three isotopes, a dominant population of states was observed at lower energies while higher energies show no significant E1 response. The shape of this response is also reproduced by theoretical QPM calculations. This somewhat contrasts the historic interpretation of the Pygmy Dipole Resonance as a collective phenomenon and hints at structural origins of the observed intensities.

In this contribution, the analysis of $^{115,117,119}\mathrm{Sn}(d, p\gamma)$ measurements will be presented and first results will be compared to reference studies. Supported by the DFG (ZI 510/10-1).

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[2] D. Savran et al., Phys. Lett. B **786**, 16 (2018).
[3] M. Weinert et al., Phys. Rev. Lett. **127**, 242501 (2021)"

Presenter: MÃLLENMEISTER, M. (University of Cologne, Institute for Nuclear Physics, D-50937 Cologne, Germany)

Status of the ^{140}Ce$(n, n'\gamma)$ experiment at GANIL-SPIRAL2/NFS

Tuesday, 13 June 2023 13:05 (5 minutes)

"In September 2022, an experiment dedicated to the study of the pigmy dipole resonance (PDR) using neutron inelastic scattering was performed at GANIL, at the Neutrons For Science (NFS) facility. This facility, thanks to the high-intensity proton beams of the SPIRAL2 accelerator, delivers unique neutron beams in terms of intensity at neutron energies around 30 MeV. The use of this high-intensity neutron beam allows the study of the PDR using, for the very first time, a neutron probe.
The analysis has so far been focused on the calibration of PARIS detectors, a multi-detector used for the detection of gammas coming from the de-excitation of the PDR state. The calibration in both energy and efficiency has been performed and compared to previous works.

This abstract on the ongoing analysis is connected to the one proposed by Marine Vandebrouck who will present the general context of this experiment."

Presenter: MIRIOT-JAUBERT, PÃ©rine (CEA Saclay Irfu/DPhN)

Isobars A= 100 study within Cranked Nilsson-Strutinsky Model

Tuesday, 13 June 2023 13:10 (5 minutes)

The Cranked Nilsson Strutinsky (CNS) model is applied to study the isobars in A=100 region. Total energies are calculated and compared with the observed values. Divers configurations are assigned to interpret the different bands. The shape evolution is determined in function of deformation parameters (ϵ_2, γ) and of the kinematic ($\jmath^{(1)}$) and dynamic ($\jmath^{(2)}$) moments of inertia values. The nuclei of this region are deformed (ϵ_2 $\approx$0,2 - 0,3) and generally triaxial ($0^{o\circ}$ < γ < 60^o).

Key words: A=100 isobars, Cranked Nilsson Strutinsky (CNS), Deformation parameters (ϵ_2, γ), kinematic $\jmath^{(1)}$ and dynamic $\jmath^{(2)}$ moments of inertia.

Presenter: Samra Kaim (University Frères Montouri - Constantine)

Indirect methods: a bridge between nuclei and stars

Tuesday, 13 June 2023 14:45 (30 minutes)

Nuclear reactions in stars take place at energies well below 1 MeV so the Coulomb barrier, exponentially suppressing the cross section down to values as small as few nanobarns, makes it very difficult to provide accurate input data for astrophysics. Therefore, indirect methods have been introduced; in particular, in this presentation I will discuss about two approaches, the ANC and the THM, used to deduce the cross sections of reactions with photons and charged particles in the exit channel, respectively, with no need of extrapolation. I will present recent results of the application of the two methods: the 6Li(3He,d)7Be measurement used to deduced the ANC's of the 3He+4He->7Be and p+6Li->7Be channels and the corresponding radiative capture cross sections. Then, I will discuss about the THM measurement of the 27Al(p,a)24Mg cross section through the 2H(27Al,a24Mg)n reaction. In both cases, we were able to establish the cross section at astrophysical energies with unprecedented accuracy.

Presenter: LA COGNATA, Marco (Istituto Nazionale di Fisica Nucleare)

Nuclear structure constraints on nucleosynthesis

Tuesday, 13 June 2023 15:15 (20 minutes)

The production of the elements and the determination of their abundances is an active field of research in Nuclear Physics. Developments in ion separation, gamma detection, and time measurements, allowed to deal with very small cross sections, measure very short half lives and observe the spectrum of drip line nuclei. The extremes of stability were reached for many regions of the nuclear chart. This is quite relevant to the understanding of nucleosynthesis processes that evolve from reactions between elements very far from stability.
The path followed by the rapid proton capture rp-process that lead to the nucleosynthesis of medium heavy elements in explosive astrophysical scenarios, involves nuclei at the p drip line, and is constrained by its location. The path of these reactions depends on the energy spectrum and existence of specific resonances in proton rich nuclei. The existence of isomeric states, for example, might change the location of waiting points, that set a time scale by holding the process to proceed to higher masses [1]. Due to competition with beta decay over p capture, waiting points slow down the flow of the rp- process, and consequently decrease the production of heavier elements, strongly affecting the burst observables.
The rp- process has also been predicted to end up as a loop around neutron-deficient Sn-Sb-Te isotopes in the neighbourhood of 100Sn, which is a region of alpha emitters located at the verge of the proton drip-line. The knowledge how exactly the cycle proceeds, depends on the knowledge of the proton separation energies (Sp) of these isotopes, an important input in the network calculations [2].
The fact that the input to understand the trajectory, time scale and ending point of the rp- process requires the knowledge of the nuclear structure properties of nuclei at the extremes of stability, makes it a difficult problem, since these nuclei are extremely unstable to be used in direct experiments. One has to resort to indirect processes, that proton decay from dip line nuclei provides.
From the theoretical study of this phenomena [1,3], the interpretation of proton decay observables gives information on the quantum numbers and shape of the decaying nucleus, imposing constraints on Sp and thus providing an answer to open questions involving waiting points and end up cycle of the rp-process. It is the purpose of this talk to present these theoretical studies.
[1] H. Suzuki, L. Sinclair, P.A. SÃ¶derstrÃ¶m, G. Lorusso, P Davies, L.S. Ferreira,
E. Maglione, R. Wadsworth,J.Wu, Z.Y. Xu et al., Phys. Rev. Lett 119,192503 (2017)

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[3] P. Siwach, P. Arumugam, S. Modi, L.S. Ferreira, E. Maglione, Phys. Rev. C 103, L031303 (2021)

Presenter: FERREIRA, Lidia (CFIF/IST- Lisbon)

^{12}C+^{12}C moclecular resonances to enhance ^{12}C+^{12}C fusion reaction

Tuesday, 13 June 2023 15:35 (20 minutes)

^{12}C+^{12}C fusion reaction rate has significant uncertainties, although it is essential for the evolution of massive stars and explosive astrophysical phenomena. It is challenging to reproduce the stellar environment in accelerator experiments. Theoretically, it is also difficult to handle because it is a multi-nucleon rearrangement reaction.
We microscopically treat the dominant decay channels, $\alpha+^{20}$Ne and $p+^{23}$Na, in addition to the entrance ^{12}C+^{12}C channel, and show that ^{12}C+^{12}C molecular resonance states exist near the ^{12}C+^{12}C threshold. They increase the ^{12}C+^{12}C fusion reaction rate in the astrophysical environment. The density functional dependence of the fusion reaction rate is also discussed as an uncertainty of the theory.

Presenter: TANIGUCHI, Yasutaka (National Institute of Technology, Kagawa College)

From precision nuclear structure information to constraining statistical properties - methodical developments in photonuclear reactions

Tuesday, 13 June 2023 15:55 (30 minutes)

Photonnuclear reactions have been one of the working hourses in nuclear physics to determine properties of low-spin excited states of atomic nuclei [1]. One recently proven version for high-precision measurements of electromagnetic transition strenghts is the relative nuclear self-absorption (RSA) technique which so far was only used in experiments with bremsstrahlung [2,3]. Beside the advantage of providing model indepenent results the RSA technique is also independent of any normalization standard, which is usually used in standard nuclear resonance fluorescence experiments. In order to further improve the methode we have adapted it to monoenergetic photon beams produced via laser Compton backscattering (LCB) [4]. This combines the high precision of RSA with the high sensitivity of real-photon scattering with LCB. In addition the mono-energetic character of the LCB beam allows to extract nuclear level densities below the neutron separation

threshold. The method and first results of experiments performed at the High Intensity γ-ray source
will be presented.

[1] A. Zilges, D.L. Balabanski, J. Isaak and N. Pietralla, PPNP 122 (2022) 103903

[2] C. Romig et al., Phys. Lett. B 744 (2015) 369

[3] U. Friman-Gayer et al., Phys. Rev. Lett. 126 (2021) 102501

[4] D. Savran and J. Isaak, Nucl. Inst. and Meth. A 899 (2018) 28

Presenter: SAVRAN, Deniz

Theoretical description of the photon strength function and nuclear level densities

Tuesday, 13 June 2023 16:55 (30 minutes)

Reliable theoretical predictions of nuclear dipole excitations and level densities over the whole nuclear chart are of great interest for different applications, including in particular nuclear astrophysics. We present here axially-symmetric deformed QRPA calculations obtained with the finite-range D1M Gogny force. This so-called D1M+QRPA approach is used to estimate all intrinsic states with angular momentum projection up to Kmax= 9.
These calculations were used to estimate the E1 and M1 photoabsorption strength functions and are now applied to the calculation of the nuclear level density based on the boson expansion of QRPA excitations. The calculated nuclear level densities are shown to follow an energy-dependence close to a constant-temperature formula at energies above a few MeV, but present a spin distribution that is rather narrower than what is predicted by other models, especially for deformed nuclei. The parity distribution is also found to achieve equiparity at energies higher than what is obtained within the combinatorial approach.
For the few tens of even-even nuclei studied so far, a quite remarkable agreement with experimental s-wave resonance spacings and Oslo data is found, highlighting the relevance of the present approach. The impact of this new approach to nuclear level densities on the radiative neutron capture cross sections will also be illustrated.

Presenter: GORIELY, Stephane (Universite Libre de Bruxelles)

The Oslo Method With Inverse Kinematics

Tuesday, 13 June 2023 17:25 (20 minutes)

The Nuclear Level Density (NLD) and γ-ray Strength Function (γSF) are fundamental properties of the nuclei. These properties are important to understand the fundamental structures of excited nuclei ($E_x > 3-4$ MeV) as it becomes impractical or impossible to treat the excited levels discretely. They are especially important within the statistical model of nuclear reactions as they strongly affect the branching ratios for compound decay. In the case of low energy reactions such as neutron capture at astrophysical energies, the main contributor to theoretical errors will be the input NLD and γSF at energies up to and around the neutron separation energy [1]. This is also the energy region where models for these properties are the most uncertain as little experimental data existed prior to the development of the Oslo Method.

The Oslo Method [2] was developed to analyze particle-γ coincidences from compound reactions induced by light ion beams and is the only method that allows for the simultaneous measurement of both the NLD and γSF at energies below the particle threshold. The method has revealed unexpected features such as the Low Energy Enhancement (LEE) of the γSF [3] and provided important insights into the Scissors Mode Resonance (SR) [4]. To measure the γSF and NLD of more exotic nuclei or chemically challenging elements, the Oslo Method has been applied to particle-γ coincidences from inverse-kinematics experiments [5]. So far, the NLD and γSF of ^{85}Kr [6], ^{87}Kr [5], ^{133}Xe [7] and ^{67}Ni [8] has been measured with inverse kinematics and the Oslo Method and the results of these experiments will be presented.

[1] A. C. Larsen, A. Spyrou, S. N. Liddick, and M. Guttormsen, Prog. Part. Nucl. Phys. **107**, 69 (2019).

[2] A. Schiller *et al.*, Nucl. Instrum. Methods. Phys. Res. A **447**, 498 (2000).

[3] A. Voinov *et al.*, Phys. Rev. Lett. **93**, 142504 (2004).

[4] M. Guttormsen *et al.*, Phys. Rev. C **106**, 034314 (2022).

[5] V. W. Ingeberg *et al.*, EPJ A **56**, 68 (2020).

[6] T. K. Olafsen, *The γ-ray Strength Function and Nuclear Level Density in* ^{85}Kr, Master's thesis, University of Oslo (2022).

[7] H. C. Berg, *Solving the mysteries of* ^{133}Xe *with inverse kinematics*, Master's thesis, University of Oslo (2019).

[8] V. W. Ingeberg *et al.*, Nuclear level density and γ-ray Strength Function of ^{67}Ni and the Impact on the i-process (in prep.)

Presenter: WEGNER INGEBERG, Vetle

Statistical properties of well-deformed ^{153,155}Sm and the M1 scissors mode *

Tuesday, 13 June 2023 17:45 (15 minutes)

The rare-earth isotopic chain of samarium provides an excellent opportunity to systematically investigate the evolution of nuclear structure effects from the near-spherical (β_2=0.00) ^{144}Sm isotope to the well-deformed system (β_2=0.27) ^{154}Sm. As the nuclear shape changes, statistical properties such as the nuclear level density (NLD) and γ-strength function (γSF) are expected to be affected. In particular resonance modes, such as the Pygmy Dipole (PDR), Scissors Resonances (SR), and the recently discovered Low-Energy Enhancement (LEE) in the rare-earth region may reveal interesting features when their evolution is investigated across several nuclei in an isotopic chain. An experiment was performed at the Oslo Cyclotron Laboratory (OCL) where the NaI(Tl) γ-ray array and silicon particle telescopes were utilized to measure particle-γ coincidence events from which the NLDs and γSFs have been extracted below the neutron threshold, using the Oslo Method [Schiller2000]. The deuteron beam was used to populate excited states in ^{153,155}Sm through transfer reaction (d,pγ). Based on the results from these measurements, the extracted NLDs and γSFs have been used to investigate the evolution of nuclear structure effects, particularly the SR, in ^{153,155}Sm. Furthermore, the results are compared to the microscopic NLD calculations as well as the γSF QRPA calculations based on the D1M Gogny interaction.

In this presentation, the statistical properties of ^{153,155}Sm will be discussed and put into perspective with experimental results of neighboring isotopes.

A. Schiller \textit{et al.}, Nucl.\ Instrum.\ Methods Phys.\ Res.\ A {\bf 447} (2000) 498â511.

Presenter: MALATJI, Kgashane (SSC Laboratory, iThemba LABS)

The pygmy dipole resonance in Sn isotopes studied with the Oslo method *

Tuesday, 13 June 2023 18:00 (15 minutes)

M. Markova, A.-C. Larsen, F.L.B.Garrote1,
1 University of Oslo, Department of Physics, Nuclear Physics group, Oslo, Norway

The electric dipole response of neutron-rich nuclei below the neutron threshold often reveals presence of the pygmy dipole resonance (PDR), superimposed on the low-energy tail of the giant dipole resonance (GDR). As the PDR is commonly inter- preted in relation to the neutron excess, a multifaceted experimental and theoretical study of this feature may have a significant impact on studying the nuclear struc- ture properties in general as well as the astrophysical r and s processes of element production.
This work presents a systematic study of the dipole Î³-ray strength functions (GSF) below the neutron threshold in eleven Sn isotopes (111â113Sn,116â122Sn and 124Sn) with a primary goal of investigating the evolution of the pygmy dipole strength with an increasing neutron number in the Sn isotopic chain. The experimental GSFs have been extracted from particleâÎ³ coincidence data by applying the Oslo method [1], primarily used for a simultaneous extraction of statistical properties of nuclei, such as the GSF and nuclear level density. The most recent (p,pâ²Î³) experiments on 117,119,120,124Sn have been performed at the Oslo Cyclotron Laboratory with a new array of 30 LaBr3(Ce) scintillator detectors (OSCAR). The latter provides an improved energy resolution and timing conditions for selecting p â Î³ events as com- pared to the earlier experiments performed with the NaI detector array CACTUS. The previously published strengths in 116â119,121,122Sn [2] have been reanalyzed to provide a coherent analysis of the strengths in the studied nuclei.
All experimental strengths were compared to the GSFs extracted from relativistic Coulomb excitation in forward-angle inelastic proton scattering below the neutron separation energy [3] and were found to be in excellent agreement within the ex- perimental error bands in the regions where the data overlap. The Oslo method strengths below the neutron threshold, combined with the inelastic proton scatter- ing data above it provide an exhaustive picture of the nuclear response, covering the GDR, the PDR and the low-lying M1 strength. The evolution with an increasing neutron number of parameters characterizing the PDR as well as the fraction of the corresponding classical Thomas-

Reiche-Kuhn sum rule will be presented together with the study of the effect of the pygmy dipole strength on the radiative neutron capture cross-sections is these nuclei. The increasing number of neutrons was found to lead to the increasing low-lying dipole strength towards the heaviest studied 124Sn isotope. This trend may be expected to be the case for even heavier nuclei and play a noticeable role in various astrophysical scenarios.

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Presenter: MARKOVA, Maria

Tests of the Algebraic Cluster Model and Conjectured Hole States of the Cluster Shell Model

Wednesday, 14 June 2023 09:00 (30 minutes)

Bijker and Iachello's algebraic cluster model (ACM) [1,2] and its extension to the cluster shell model (CSM), provides a new theoretical platform for the study of alpha-clustering in light nuclei. We will review the basic tenants of the ACM and the discovery of a D3h symmetry in 12C [3] and 20Ne [4], with emphasize on the discovery in 12C of a new g.s. rotational band with the spin sequence of: 0+, 2+, 3-, 4+/- and 5-, including the predicted 4+/- parity doublet [3].

Applications of the CSM shell model to one particle molecular orbits in 9Be [5] and 13C (D3h' symmetry) [6], lead us to conjecture molecular hole states in 7Be and 19F. We observe in these nuclei the predicted phenomenological structure. And we further consider conjectured p-h states in 8Be with the predicted phenomenological p-h structure of rotational band at high excitations of approximately 20 MeV. A search for the conjectured p-h structure in 8Be is anticipated at ISOLDE [7].

The material presented here is based on work supported by the U.S. Department of Energy, Office of Science, Office of Nuclear Physics grants Number DE-FG02-94ER40870.
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Presenter: GAI, Moshe (University of Connecticut)

Disentangling clustering phenomena in ^{12}C and ^{16}O

Wednesday, 14 June 2023 09:30 (30 minutes)

^{12}C remains at the forefront of nuclear structure studies as it is the predicted site of a wide range of interesting phenomena and is also astrophysically significant. The challenge of understanding the structure of ^{12}C thus endures as a litmus test of our ability to not only theoretically model nuclei, but to also phenomenologically analyse/interpret data. This talk will present recent work which aims to disentangle broad, intertwined contributions to the excitation spectrum of ^{12}C, such as the predicted breathing-mode excitation of the Hoyle state, as well as a 4^+ state that has previously been obscured. Preliminary results on cluster states in ^{12}C will also be presented.

Presenter: LI, Kevin Ching Wei (University of Oslo)

^{10}Be clustering states investigation at LNS *

Wednesday, 14 June 2023 10:00 (15 minutes)

With the development of new facilities for the production of radioactive ion beams, interest in the investigation of clustering phenomena in neutron-rich isotopes has spread in the international scientific community. Clustering phenomena are in fact important in many fields, starting from the characterization of exotic states in radioactive nuclei, like the formation of Î± clustering structures with so-called valence neutrons, undergoing even large nucleus deformation, or of neutron halo around stable cores. This line of research of the CHIMERA collaboration has been active at INFN Laboratori Nazionali del Sud (LNS) for many years already, where, among the others, the CLIR (Clusters in Light Ion Reactions) experiment has been realized [1], aiming at the investigation of such cluster structures in light radioactive neutron-rich nuclei. This measurement has been performed by producing a radioactive ion beam by means of the FRIBs facility [2], containing different species of interest, such as ^{10}Be, ^{13}B, or ^{16}C. Identification of the beam components has been possible thanks to a tagging system, and the clusters, produced in break-up reactions on a polyethylene (proton) target, have been gathered by the CHIMERA multidetector [3], coupled to four FARCOS telescopes [4]. Calibration of the tagging system and FARCOS detectors has been performed, crucial for this analysis to determine the total kinetic energy of the fragments and thus allowing to reconstruct the excitation energy of the ions of interest by using the invariant mass method. Some results on the spectroscopy of ^{10}Be will be presented, for which the comparison with other measurement carried out in the past will be possible [5].

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Presenter: RISITANO, Fabio (Istituto Nazionale di Fisica Nucleare)

Accessing the Single-Particle Structure of the PDR

Wednesday, 14 June 2023 10:45 (30 minutes)

In atomic nuclei, the term âpygmy dipole resonance (PDR) has been commonly used for the electric dipole ($E1$) strength around and below the neutron-separation energy. It has been shown that the PDR strength strongly impacts neutron-capÂture rates in the s- and r-process, which synthesize the majority of heavy elements in our universe. A precise understanding of the PDRâs microscopic structure is essential to pin down how it conÂtributes to the gamma-ray strength function (γSF) often used to calculate the neutron-capÂture rates. In fact, the different responses to isovector and isoscalar probes highlighted the âcomplex structure of the PDR and emphasized that different underlying structures would indeed need to be disentangled experimentally if stringent comparisons to microscopic modÂels wanted to be made.

Featuring our recent study of ^{208}Pb [1], I will present how the neutron one-particle-one-hole structure of the PDR can be studied with high-resolution magnetic spectrographs. The data on \nuc{208}{Pb} were obtained from (d, p) one-neutron transfer and resonant proton scattering experiments performed at the Q3D spectrograph of the Maier-Leibnitz Laboratory in Garching, Germany. In this contribution, the new data will be compared to the large suite of complementary, experimental data available for \nuc{208}{Pb} highlighting how we established (d, p) as an additional, valuable, experimental probe to study the PDR and its collectivity. Besides the single-particle character of the states, different features of the strength distributions will be discussed and compared to Large-Scale-Shell-Model (LSSM) and energy-density functional (EDF) plus Quasiparticle-Phonon Model (QPM) theoretical approaches. The comparison clearly points out the importance of understanding both the population of the PDR in nuclear reactions and its γ-decay properties.

To highlight future possibilities, I will also present first results from a new experiÂmental program with the Super-Enge Split-Pole Spectrograph at Florida State University. Here, particle-γ coincidence capabilities have been recently added to study the PDR around the $N = 28$ shell closure, where the dipole-type neutron-skin mode is expected to develop.

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Presenter: SPIEKER, Mark-Christoph (Florida State University)

Probing the ^{11}Li low-lying dipole strength via ^{9}Li(t, p)

Wednesday, 14 June 2023 11:15 (30 minutes)

The differential cross section for Coulomb breakup for ^{11}Li exhibits a pronounced peak at very low relative energy $E_{rel} \approx 0.35$ MeV -corresponding to an excitation energy $E_x \approx 0.75$ MeV- with a very large cross section of almost 0.3 b/MeV. A low-lying $E1$ resonance in ^{11}Li was also observed in inelastic processes -(p, p') and (d, d')- with centroid $E_x \approx 1$ MeV, width $\Gamma \approx 0.5$ MeV and carrying a large ($\approx 8\%$) fraction of the TRK dipole energy weighted sum rule, which confirms the resonant character of the $E1$ transition strength observed in Coulomb excitation.

While much has been learned concerning the low-lying $E1$-resonance of ^{11}Li through Coulomb-excitation and inelastic scattering experiments, central questions regarding its microscopic structure remain open. More specifically, we will address here the role played in the structure of such an exotic mode by the interplay of particle-hole (ph) and particle-particle (pp) correlations, including the existence of multipolar Cooper pairs and the formation of quantum vortices.

We propose to probe the soft $E1$-mode through the reaction $^{9}\mathrm{Li}(t,p)^{11}\mathrm{Li}(1^-)$ as a quantitative aswer to this question, and we provide a prediction for the outcome of this experiment. The theoretical framework used consists in a unified combination of nuclear field theory (NFT) and second-order Distorted Wave Born Approximation (DWBA), which has been already succesfully applied to the description of structure and reactions observables in light nuclei around the $N = 6$ exotic shell closure. The validity and accuracy of our predictions are expected to be assessed in a dedicated experiment to be performed at the ISOLDE facility.

Presenter: POTEL AGUILAR, Gregory (Lawrence Livermore National Laboratory)

The Many Faces of the Pygmy Dipole Resonance in ^{120}Sn

Wednesday, 14 June 2023 11:45 (20 minutes)

A concentration of electric dipole strength below the neutron separation threshold, usually denoted as the Pygmy Dipole Resonance (PDR), is known to be common in medium to heavy mass nuclei and has been studied intensively in the past. A variety of complementary experiments uncovered intricate details of this strength accumulation in recent years. An isoscalar surface-mode character was identified in the lower-energy part of the PDR in ^{124}Sn based on the different responses observed in $(\alpha, \alpha'\gamma)$ or $(^{17}\mathrm{O},^{17}\mathrm{O}'\gamma)$ experiments compared to (γ, γ') data [1,2]. Conversely, the higher-energy part was attributed to a more isovector excitation taking place deeper inside the nucleus. This so-called *isospin splitting* is nowadays expected to be a common feature of medium to heavy mass nuclei exhibiting a neutron excess. In ^{120}Sn, access to more microscopic information was recently gained by comparing $^{119}\mathrm{Sn}(d, p\gamma)$ and $^{120}\mathrm{Sn}(\gamma, \gamma')$ reactions in both experiment and theory [3,4]. The strong population of, again, the lower group of states in the PDR region via the (d, p) transfer reaction was attributed to the dominant neutron single-particle character of these states in ^{120}Sn. Although visually similar to the case of $^{124}\mathrm{Sn}(\alpha, \alpha'\gamma)$, the $^{119}\mathrm{Sn}(d, p\gamma)$ experiment is sensitive to a very different type of nuclear structure information. To investigate the relation between the expected surface-mode character and the observed single-particle nature in ^{120}Sn, a complementary $^{120}\mathrm{Sn}(\alpha, \alpha'\gamma)$ experiment has been performed using the CAGRA+GR setup at the Research Center for Nuclear Physics in Osaka, Japan.

This contribution gives an overview of the current experimental knowledge on the low-energy electric dipole response in ^{120}Sn and discusses the structural comprehension based on Quasiparticle-Phonon-Model calculations. Combined with dedicated reaction theory for each population mechanism, consistent observables from experiments and theory are presented and the impact of the information gained in ^{120}Sn on the genuine low-energy E1 strength throughout the chart of nuclides is discussed.

Supported by the DFG (ZI 510/10-1).

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Presenter: WEINERT, Michael (University of Cologne)

One-nucleon transfer reactions as a tool to investigate the character of the PDR in ^{96}Mo *

Wednesday, 14 June 2023 12:05 (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 $^{97}\mathrm{Mo}(p,d)^{96}\mathrm{Mo}$ and its conjugate reaction $^{95}\mathrm{Mo}(d,p)^{96}\mathrm{Mo}$, were used to populate the nucleus of, $^{96}\mathrm{Mo}$. 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.

Presenter: KHUMALO, Thuthukile (iThemba Laboratory for Accelerator Based Sciences, Old Faure Road Faure, Somerset West PO Box 722, 7129 South Africa)

Study of the Ni-isotopic chain in real photon-scattering experiments *

Wednesday, 14 June 2023 12:20 (15 minutes)

In theoretical predictions regarding astrophysical processes for calculating the abundances in our universe, the photoabsorption cross section, i.e., the probability for absorbing photons with given energy, is an important input parameter. The low-lying dipole response of atomic nuclei consists of various dipole excitation modes occurring due to different nuclear phenomena, see, e.g., Refs.

[1-3] and references therein. To improve the models for describing astrophysical scenarios, the dipole excitation modes have to be well understood. Therefore, systematic studies of one isotope using different probes (multi-messenger studies [4]) as well as along isotopic and isotonic chains utilizing the same probe are essential.
One commonly-used approach for investigating the low-lying dipole response is real photon scattering, also denoted as Nuclear Resonance Fluorescence (NRF) [5,6]. By combining experiments with, on the one hand, an unpolarized, energetically continuous photon-flux distribution and on the other hand, a polarized, quasimonoenergetic Î³-ray beam, absolute photoabsorption cross sections can be extracted. Furthermore, spin and parity quantum numbers can model-independently be as-signed to the excited states in even-even nuclei.
This method has been used, for instance, on the nickel isotopic chain (Z = 28) which consists of four even-even, stable isotopes with N/Z ratios between 1.07 and 1.29. The dipole response of ^{58,60}Ni has already been studied [7-9] and NRF experiments on ^{62}Ni have been performed and are currently analyzed [10]. Hence, the missing stable, even-even nickel isotope to complete the sys-tematics is ^{64}Ni.
In this contribution, first results of the two complementary NRF experiments on ^{64}Ni performed at Î³ELBE [11] and HIÎ³S [12] will be presented and compared to existing results of 58,60,62Ni.
This work is partly supported by the BMBF (05P21PKEN9).

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Presenter: MÃSCHER, Miriam

Electric dipole strength of ^{52}Ca

Wednesday, 14 June 2023 12:35 (20 minutes)

The electric dipole strength of the neutron-rich nucleus 52Ca has been measured using Coulomb excitation at RIKEN RIBF. The giant dipole resonance and the low-lying strengths are observed.

The electric dipole response of neutron-rich nuclei has a low-lying electric dipole mode, sometimes called as pygmy dipole resonance (PDR), in addition to the well-known giant dipole resonance (GDR). While the PDR is often considered as an oscillation of the excess neutrons against the isospin saturated core, the origin and structure of PDR is still unclear. A recent theoretical work showed that the PDR strengths are rapidly enhanced at the neutron number N=28~34, and it is due to the occupation of low angular-momentum orbit by valence neutrons. In addition, the

electric dipole response of nuclei in this region is important for the symmetry energy of the nuclear equation of state. To investigate the PDR in N=28~34 region and to constrain the symmetry energy, the electric dipole strength of 52Ca has been measured by using the relativistic Coulomb excitation in inverse kinematics.
The experiment was performed at RIKEN RIBF. The secondary beam of 52Ca were produced via the fragmentation of 345 MeV/nucleon 70Zn primary beam, and impinged on a Pb and a C targets. The kinematically complete measurement was performed to reconstruct the excitation energy spectrum of 52Ca.

In this contribution, we will report on the electric dipole strength of 52Ca.

Presenter: TOGANO, Yasuhiro (RIKEN Nishina Center)

Clustering in nuclear systems: from finite to infinite

Thursday, 15 June 2023 09:00 (30 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 Î±-condensate states (e.g Hoyle state) and the 3-Î±-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,pÎ±) reaction with the high-resolution spectrometers of RCNP, Osaka University.

Presenter: YANG, Zaihong (Peking University, China)

Nuclear structure revealed in density profiles near the nuclear surface

Thursday, 15 June 2023 09:30 (30 minutes)

Various information on the nuclear structure is imprinted on the density profiles, especially, near the nuclear surface. In this talk, I will present how the nuclear structure is reflected in the density profiles by showing some examples from our recent works. Various density profiles are examined by using high-energy reaction theory, and then a direct comparison to reaction observables is made. Contents include the following topics:

(1) “”Nuclear deformation””
exhibits characteristic density profiles near the nuclear surface [1]. Some examples in the island of inversion near N=40 [2] will be presented.
(2) “”Core swelling phenomena [3]””
are found to be universal and can be understood by investigating the density profiles in both the internal and surface densities [2,3].
(3) “”Shell or cluster configurations?””
I will discuss the possibility of extracting the degree of nuclear clustering from the analysis of the density profiles [6,7] and propose a way to visualize the competition between cluster and shell structure in an intuitive and simple way.

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Presenter: HORIUCHI, Wataru (Osaka Metropolitan University)

Collective core effects and dineutron correlations in three-body nuclei

Thursday, 15 June 2023 10:00 (30 minutes)

Modern studies and advances in RIB physics allow us to explore the unusual properties and decay modes of exotic light nuclei at the limit of stability and beyond the driplines [1]. The case of two-neutron halo nuclei (such as ^{6}He, ^{11}Li or ^{14}Be), has attracted particular interest. These are Borromean systems, or three-body nuclei where possible binary subsystems are unbound. Their bound nature is therefore strongly linked to the correlations between the valence neutrons, which shape many of the properties of two-neutron halo nuclei [2]. It is also well known that a proper understanding of their structure requires solid constraints on the unbound subsystems (e.g., ^{5}He, ^{10}Li or ^{13}Be [3]). Here, the delicate interplay between pairing and tensor correlations [4], as well as the effect of Pauli blocking and the possible coupling to the core collective excitations [5], may be crucial to understand exotic phenomena such as parity inversion or shell gap quenching. Interestingly, the evolution of these correlations beyond the driplines gives rise to two-neutron emitters (e.g., ^{16}Be or ^{26}O [6]).

Since these nuclear systems show a marked core $+ n + n$ character, three-body models are a natural choice to describe their structure and reaction dynamics [7,8]. The role of collective core excitations, as well as dineutron correlations, will be discussed in the context of low-energy elastic scattering and breakup, intermediate-energy knockout reactions [9], and the decay properties of two-neutron emitters [10].

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Presenter: CASAL, JesÃºs (University of Seville)

Beyond mean field model for spin-isospin excitations and beta-decays

Thursday, 15 June 2023 11:00 (30 minutes)

I will discuss spin-isospin dependent collective motions in several doubly-closed shell nuclei by using a beyond mean field model, i.e., Subtracted Second Random-Phase Approximation (SSRPA) adopting the Skyrme energy density functional (EDF) with the tensor forces. Especially we study the quenching effect in Gamow-Teller transitions and also in beta-decay life time.

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Presenter: SAGAWA, Hiroyuki (RIKEN)

Gamow-Teller strengths and electron captures in stellar phenomema

Thursday, 15 June 2023 11:30 (30 minutes)

Transitions mediated by the weak nuclear force play an important role in astrophysical phenomena, but direct measurements of the transition strengths can only be performed for a subset of transitions due to Q-value limitations. Indirect measurements of Gamow-Teller strengths by using charge-exchange reactions at intermediate energies can provide much-needed information. (n,p)-type transitions are particularly important for estimating electron-capture rates of relevance for e.g., supernovae and neutron-star crustal processes. While a lot of progress has been made over the past 3 decades studying stable isotopes by using (n,p), (d,2He), and (t,3He) reactions, a good tool for studying (n,p)-type reactions on unstable nuclei, which is very important for nuclear astrophysics studies, has been lacking. Recently, the (d,2He) reaction in inverse kinematics was successfully developed for this purpose. The first experiment, 14O(d,2He), was focused on testing the ability of nuclear theories based on first principles to accurately describe the Gamow-Teller strength distribution without the use of a phenomenological quenching factor. Experiments for measurements of Gamow-Teller strengths from heavier unstable nuclei of interest for nuclear astrophysics are planned at FRIB.

Presenter: ZEGERS, Remco (Michigan State University/Facility for Rare Isotope Beams)

Recent studies within the Subtracted Second RPA

Thursday, 15 June 2023 12:00 (30 minutes)

We discuss recent applications of the subtracted second random-phase approximation, based on Skyrme functionals, to the study of nuclear excitations of different nature. First of all, the Gamow-Teller resonances are investigated in several nuclei located in various regions of the nuclear chart [1,2]. The amount of Gamow-Teller strength is much lower than in other energy-density-functional-based calculations, and it agrees better with experimental data. The inclusion of two-particle-two-hole configurations is responsible for this quenching, avoiding thus the use of any â��ad-hocâ�� quenching factors normally adopted in this kind of studies. This result may have implications for the computation of nuclear matrix elements in the same framework for neutrinoless double-beta decay. After that, the same model is used to investigate low-lying energy excitations in the dipole and monopole channels [3, 4]. Their differences and analogies are discussed in terms of isospin asymmetry, as well as their impact on the equation of state.

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Presenter: GAMBACURTA, Danilo (Istituto Nazionale di Fisica Nucleare)

Gamow-Teller Giant Resonance in ^{11}Li neutron drip line nucleus

Thursday, 15 June 2023 12:30 (20 minutes)

At the RIKEN Radioactive Isotope Beam Factory, the spin-isospin response of ^{11}Li was measured in charge- exchange (p, n) reaction at 182 MeV/nucleon beam energy. There is no available data for isovector spin-flip giant resonances in nuclei with large isospin asymmetry factors, where

(NâZ)/A>0.25 [1]. Our work aims to investigate this unexplored region up to (NâZ)/A=0.5.
The charge-exchange (p, n) reactions in inverse kinematics combined with the missing-mass technique are powerful tools to extract the B(GT) strengths of unstable isotopes up to high excitation energies, without Q-value limitation of the Î² decay [1]. In our previous work on ^{132}Sn [2], we demonstrated that accurate information about giant resonances can be obtained for unstable nuclei by using this probe. The combined setup [3] of PANDORA low-energy neutron spectrometer [4] and SAMURAI large-acceptance magnetic spectrometer [5] together with a thick liquid hydrogen target allowed us to perform the experiment with high luminosity. The recoil neutrons with kinetic energy of 0.1â10 MeV were identified with PANDORA, while the SAMURAI was used for tagging the decay channels of the reaction residues.
The Î² decay of ^{11}Li is complex. The ^{11}Li Î²-decay involves the largest number of decay channels ever detected [6] and experimental results have been reported for cases, when the daughter breaks into fragments, and emission of one, two, and three neutrons, Î± particles and ^{6}He, tritons, and deuterons has been observed in several Î²-decay studies [8,9]. However, the B(GT) values were not clearly deduced as these studies were effected by the Q value.
In this talk, the final results of our analysis will be presented. Deduced double differential cross section up to about 40 MeV, including the Gamow-Teller (GT) Giant Resonance region in ^{11}Li will be reported, as well as the comparison of the obtained B(GT) values with those from Î²-decay studies. We will discuss the nature of several newly identified decay channels of ^{11}Be also.
Our observation, that the GT peak occurs below the Isobaric Analog State in ^{11}Li, will be discussed in connection with the variation of residual spin-isospin interaction in exotic nuclei.

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Presenter: SASANO, Masaki

Impact of the isospin symmetry breaking on the neutron-skin thickness and the nuclear equation of state

Thursday, 15 June 2023 12:50 (20 minutes)

Isospin symmetry of atomic nuclei is broken due to the Coulomb interaction and the isospin symmetry breaking (ISB) terms of the nuclear interaction. Although the ISB terms are a tiny part of the whole, attention has been paid, for instance, to the mass difference of mirror nuclei and the isobaric analog states.

The ISB terms of the nuclear interaction are found to be indispensable in describing the neutron-skin thickness and the isobaric analog energy of 208Pb at the same time [1], where the neutron-skin thickness is correlated to the density dependence of the symmetry energy (L).

In this talk, the effect of the ISB terms on the estimation of the L parameter using the neutron-skin thickness and the charge radii difference of mirror nuclei will be discussed [2-4].

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Presenter: NAITO, Tomoya (RIKEN iTHEMS Program)

Present and future activities with the ELIGANT setups at ELI-NP

Thursday, 15 June 2023 14:30 (30 minutes)

The ELIGANT set of instruments are the dedicated tools being developed for studying high-energy collective nuclear excitations using the gamma beam at ELI-NP. The topics of interest in these studies range from fundamental nuclear structure properties of the Giant Dipole Resonance and the low-energy strength enhancement in the Pygmy Dipole Resonance region, as well as applications in p-process nucleosynthesis and propagation of Ultra-High Energy Cosmic Rays. The tools at our disposal consist of large-volume $LaBr_3$:Ce and $CeBr_3$ detectors for high-energy γ-rays, liquid scintillators and lithium glass scintillators for high- and low-energy neutron time-of-flight, and a proportional counter system of ^{3}He tubes for cross-section measurements. These instruments have been installed and comissioned both with sources and via in-beam measurements at the IFIN-HH Tandem accelerators with terminal voltages of 3MV and 9MV, in different configurations. Most notably, one of the in-beam campaigns performed was in collaboration with the Department of Nuclear Physics where the ELIGANT detectors were mounted in the ROSPHERE spectroscopic array at one of the 9MV beam-linesand a series of experiments were performed aiming for GDR and PDR properties via γ-ray studies, as well as high-energy γ-ray emission in light nuclei from states with very small γ-ray branching. In this presentation I will give an overview of the ELIGANT present and future activities.

Presenter: SÃDERSTRÃM, PÃ€r-Anders (Extreme Light Infrastructure - Nuclear Physics)

Status of ELIADE gamma-ray spectrometer at ELI-NP

Thursday, 15 June 2023 15:00 (15 minutes)

At The Extreme Light Infrastructure Nuclear Physics (ELI-NP, Romania), a Î³-ray beam will be delivered at a continous variable energy up to the maximum of â□Œ19.5 MeV and total flux of 10^{11} /s produced by the VEGA system [1]. The linear polarization of 95% and the average relative bandwidth of 0.5% will enhance the experimental horizon for experiments below and above the particle emission threshold in (stable) nuclei [2]. The response of a nucleus to injected electromagnetic radiation, below the particle separation threshold, will be studied using the ELIADE Î³-ray spectrometer [3]. It consists of 32 HPGe (High Purity Germanium) crystals arranged into 8 Clover detectors positioned at 90â□Š and 135 â□Š in respect to the beam direction. Each crystal is divided into 8 segments. Moreover, 4 scintillator detectors (CeBr) installed on ELIADE enhance its sensitivity to high-energy gamma-rays. The DELILA (Digital ELI-NP List-mode Acquisition), distributed data acquisition system, is used to acquire data from all the detectors. Data from each clover detector are processed by 4 CAEN digitizes (v1725) performing PHA waveform processing in FPGA mezzanines. The stored data is sorted by time stamp and is written in ROOT format. DELILA also provides a monitor web page by using ROOT libraries.
In the talk I will discuss the implementation of ELIADE and present results of characterization of the spectrometer performed using a set of standard gamma-ray sources and a custom made high energy gamma-ray source. Due to the fact that a typical gamma-ray energy in an NRF experiment can be of few MeV in order to establish well a response of ELIADE a dedicated high-energy gamma ray source (up to 9 MeV), developed and produced at ELI-NP, was used [4]. Different add-back schemes and Compton-rejections algorithms were verified and compared to the simulations. The ELIADE gamma-ray spectrometer is gradually getting on track and is practically awaiting for gamma beams to come.

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Presenter: TESTOV, Dmitry (ELI-NP)

Ground-breaking developments in ^{10}B with inelastic proton scattering

Thursday, 15 June 2023 15:15 (15 minutes)

A.KuÅ□oÄ□lu[1,2]

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Nuclear structure theory is pushing the accuracy level of its predictions using ab-initio determination of nuclear observables using realistic nucleon-nucleon interactions derived from chiral effective field theory. In particular, the ab-initio no-core shell model has been used for the derivation of the electromagnetic properties of light nuclei like ^{10}B [1, 2].

To help constrain the modelling of the fundamental nucleon-nucleon interaction, new and precise measurements on the transition probabilities of ^{10}B are necessary. In this work, we measured the relative intensities of γ-ray branching ratios of ^{10}B with inelastic proton scattering reaction using large-volume $LaBr_3$:Ce and $CeBr_3$ detectors [3] from several of the Extreme Light Infrastructure â Nuclear physics (ELI-NP) instrumental setups together with detectors and infrastructure from the ROSPHERE array [4] at the 9 MV Tandem facility at IFIN-HH [5].

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Acknowledgment: This work was carried out under the contract PN 23.21.01.06 sponsored by the Romanian Ministry of Research, Innovation, and Digitalization.

Presenter: KUSOGLU, Asli (ELI-NP/Istanbul University)

The emergence of multi-phonon giant resonances within a fully quantum TDDFT model

Friday, 16 June 2023 15:30 (15 minutes)

We show that collective multi-phonon states in atomic nuclei emerge spontaneously when quantum fluctuations are included beyond the independent particle approximation [1]. The quadrupole response of a nucleus is studied using a fully quantum extension of the nuclear time-dependent density functional theory (TDDFT) that mixes several many-body trajectories. While a single trajectory can account for the excitation of the first collective quantum, the higher quanta emerge due to the interference between trajectories. The collective spectrum of ^{40}Ca is nearly harmonic and agrees with the experimentally observed three quanta of the isoscalar giant quadrupole resonance. This study demonstrates the resistance of atomic nuclei to extremely high internal excitation and confirms the existence of multi-phonon giant resonances based on the state-of-the-art theory of nuclear dynamics.

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Presenter: MAREVIÄ, Petar (ENS Paris-Saclay)

New particle identification system for the MAGNEX magnetic spectrometer: the SiC-CsI telescope wall

Thursday, 15 June 2023 16:15 (15 minutes)

The physics of neutrinoless double beta ($0\nu\beta\beta$) decay has important implications on particle physics, cosmology and fundamental physics. In particular, it is the most promising process to access the effective neutrino mass. To determine quantitative information from the possible measurement of the $0\nu\beta\beta$ decay half-lives, the knowledge of the Nuclear Matrix Elements (NMEs) 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 main experimental tools for this project are the K800 Superconducting Cyclotron and the MAGNEX large acceptance magnetic spectrometer [2] at the INFN-LNS laboratory. The latter allows for high resolution measurements of the much suppressed DCE reactions and it is essential to obtain high resolution energy spectra and accurate cross sections at very forward angles, including zero degree. However, the tiny values of DCE cross-sections demand beam intensities much higher than those manageable with the present facility. The on-going upgrade of the INFN-LNS facilities promoted by the POTLNS project in this perspective is intimately connected to the NUMEN project. A radical upgrade of the detection systems used by the MAGNEX spectrometer is also in development. The solution proposed for the particle identification (PID) of the ejectiles of interest for NUMEN under extremely high beam intensities is a wall of 720 telescopes. State-of-the-art large area, 100 μm thick Silicon Carbide (SiC) detectors [3] will be used as the ΔE stage, whereas 5 mm thick Cesium Iodide (Tl doped) crystals will measure the residual energy E_r by means of silicon photodiodes. The PID capabilities, in terms of atomic number and mass resolution, and the radiation hardness of the proposed telescopes were tested, and the results will be discussed at the Conference.

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Presenter: CARBONE, Diana (Istituto Nazionale di Fisica Nucleare)

New developments in modeling Heavy Ion Double Charge Exchange reactions

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

The formalism underlying Heavy ion double charge exchange (HIDCE) nuclear reactions driven by meson exchange is discussed. Such kind of nuclear reactions represent a powerful and alternative tool to gain information on the Nuclear Matrix Element (NME) describing double beta decay processes. In particular, HIDCE reactions have been studied in terms of sequential meson-exchange, i.e. as a double single charge exchange (DSCE) reaction mechanism. The natural framework for describing the latter kind of processes is the second order DWBA, through which the DSCE reaction amplitudes can be expressed in terms of superpositions of distortion factors, accounting for initial and final state ion-ion elastic interactions, and nuclear matrix elements. It is also shown that the nuclear response tensors resemble the nuclear matrix elements of $2\nu\beta\beta$ decay in structure, even if characterized in general by a considerable more complex multipole and spin structure. Explicit expressions for NMEs are derived using QRPA theory. Reduction schemes for the DSCE transition form factors are also discussed, by investigating their momentum structure in closure approximation, in order to get a separate expression for projectile and target NMEs within DSCE cross section expression. As a first application, calculations are performed for the test reaction

^{40}Ca (^{18}O, ^{18}Ne) ^{40}Ar at 15.3 AMeV and results are compared to the data measured at LNS by the NUMEN Collaboration. Preliminary results of a more systematic analysis, including heavier systems, such as ^{76}Ge+^{20}Ne, will also be shown.

Presenter: BELLONE, Jessica Ilaria (UniversitÃ di Catania)

Multi-channel analysis of the ^{18}O + ^{48}Ti reaction at 275 MeV within the NUMEN project *

Thursday, 15 June 2023 16:45 (15 minutes)

In the last years, Double Charge Exchange (DCE) nuclear reactions have gained an increasing interest due to the close analogies to neutrinoless double beta ($0\nu\beta\beta$) decay [1]. On this ground, the NUMEN project [2] proposed an innovative method to deduce data-driven information on the nuclear many-body features for the candidate isotopes to $0\nu\beta\beta$ decay by measuring DCE cross sections. In this context, the $^{18}\mathrm{O} + {}^{48}\mathrm{Ti}$ collision at 275 MeV incident energy was studied for the first time, with ^{48}Ti being the daughter nucleus of ^{48}Ti in the $0\nu\beta\beta$ process [3]. The measurements were performed at the INFN - Laboratori Nazionali del Sud in Catania, using the MAGNEX magnetic spectrometer [4]. A full understanding of DCE reactions is a complex task since different reaction mechanisms can, in principle, contribute to the measured DCE cross section. For this reason, a multi-channel approach is adopted, where DCE reactions are examined not as stand-alone processes, but as a part of a network of nuclear transitions which includes elastic and inelastic scattering, one- and two-nucleon transfer and single charge exchange reactions [1,5]. The study of elastic and inelastic scattering gives access to the optical potential and nuclear deformations, respectively, which are key ingredients for the theoretical description of all the reaction channels. The analysis of one- [6] and two-nucleon transfer is fundamental to understand the degree of competition between the DCE process and successive nucleon transfer reactions. In this contribution, the status of the multi-channel study of the $^{18}\mathrm{O} + {}^{48}\mathrm{Ti}$ system will be presented.

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Presenter: BRISCHETTO, Giuseppe Antonio (INFN-LNS UniCt)

Experimental and theoretical analysis of ^{76}Se$(^{18}O,^{17}O)^{77}$Se and ^{76}Se$(^{18}O,^{19}F)^{75}$As transfer

reactions at 15 MeV/u in a multi-channel approach within the NUMEN project *

Thursday, 15 June 2023 17:00 (15 minutes)

A full-comprehensive study of heavy-ion induced nuclear transfer reactions is a powerful tool to characterize nuclear mean-field features as well as few-nucleon correlations in low-lying nuclear states. In this context, the ^{76}Se(^{18}O,^{17}O)^{77}Se and ^{76}Se(^{18}O,^{19}F)^{75}As one-nucleon transfer reactions give a quantitative access to the relevant single particle orbitals and core polarization transitions built on ^{76}Se. This is particularly relevant, since it provides data-driven information to constrain nuclear structure models for the ^{76}Se nucleus.
The excitation energy spectrum and the differential cross section angular distributions of these nucleon transfer reactions were measured at 275 MeV incident energy for the first time using the MAGNEX large acceptance magnetic spectrometer. The data are compared with theoretical calculations based on distorted wave Born approximation, coupled channel Born approximation and coupled reaction channels adopting spectroscopic amplitudes for the projectile and target overlaps derived by large-scale shell model calculations and interacting boson-fermion model. The experimental and theoretical analysis of one-nucleon transfer reactions populated in the collision ^{18}O + ^{76}Se were performed in a multi-channel approach to provide an accurate description of the complete network of nuclear reaction data, including charge-exchange reactions.
These reactions are studied in the frame of the NUMEN project. The NUMEN (NUclear Matrix Elements for Neutrinoless double beta decay) project was conceived at the Istituto Nazionale di Fisica Nucleareâ Laboratori Nazionali del Sud (INFN-LNS) in Catania, Italy, aiming at accessing information about the nuclear matrix elements (NME) of neutrinoless double beta decay (0ÎœÎ²Î²) through the study of the heavy-ion induced double charge exchange (DCE) reactions on various 0ÎœÎ²Î² decay candidate targets. Among these, the ^{76}Se nucleus is under investigation since it is the daughter nucleus of ^{76}Ge in the 0ÎœÎ²Î² decay process.

Presenter: CIRALDO, Irene (Istituto Nazionale di Fisica Nucleare)

Nuclear equation of state from nuclear collective excited state properties

Friday, 16 June 2023 09:00 (30 minutes)

This contribution reviews a personal selection of available constraints to the nuclear equation of state (EoS) around saturation density from nuclear structure calculations on collective excited state properties of atomic nuclei [1]. It concentrates on predictions based on self-consistent mean-field calculations, which can be considered as an approximate realization of an exact energy density functional (EDF). EDFs are derived from effective interactions commonly fitted to nuclear masses, charge radii and, in many cases, also to pseudo-data such as nuclear matter properties. Although in a model dependent way, EDFs constitute nowadays a unique tool to reliably and consistently access bulk ground state and collective excited state properties of atomic nuclei along the nuclear chart as well as the EoS.

Special emphasis will be made on the impact on the EoS of the new CREx [2] and PREx [3] measurements of the parity violating asymmetry (ground state observable) in 48Ca and 208Pb [4,5], respectively, and compared to previously presented results on the electric dipole polarizability [6,7] and the isobaric analog state [8].

Experimental and theoretical efforts in finding and measuring observables specially sensitive to the EoS properties are of paramount importance, not only for low-energy nuclear physics but also for nuclear astrophysics applications.

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Presenter: ROCA-MAZA, Javier (Istituto Nazionale di Fisica Nucleare)

Temperature evolution of the nucleon effective mass and symmetry energy coefficient in the $^{68-78}$Ni isotopic chain

Friday, 16 June 2023 09:30 (15 minutes)

The nucleon effective mass is an essential characteristic of nuclear matter and finite nuclei [1]. The temperature-dependent effective mass of a nucleon consists of k mass and ω mass [2]. As the k mass weakly depends on temperature, the temperature dependence of the effective mass predominantly originates from the ω mass, which is determined by the dynamical part of the self-energy. The temperature evolution of the effective mass plays a significant role in understanding the temperature evolution of the symmetry coefficient [3, 4].
In the present contribution, the single-(quasi)particle spectra for $^{68-78}$Ni isotopes at zero and finite temperature are obtained by solving the Dyson equation in the basis of Dirac spinors [5]. While the static part of the self-energy of the Dyson equation has its origin from a self-consistent mean field generated by the effective mesons, the dynamical part takes into account the coupling between (quasi)particles and phonons (vibrations). This (quasi)particle-vibration coupling mechanism is responsible for the fragmentation of single-(quasi)particle spectra. In this work, the calculated spectra of neutron-rich nickel isotopes are employed to extract the temperature-dependent ω mass within the $0-2$ MeV temperature interval, which is relevant for astrophysical modeling of the core-collapse supernova simulations. The impact of the temperature dependence of the effective mass on the symmetry energy coefficient in the $^{68-78}$Ni isotopic chain will be discussed.

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Presenter: WIBOWO, Herlik (School of Physics, Engineering and Technology, University of York, Heslington, York YO10 5DD, United Kingdom)

Nuclear energy density functionals constrained by collective nuclear excitations and parity violating electron scattering experiments

Friday, 16 June 2023 09:45 (20 minutes)

Recent measurements of dipole polarizability in nuclei and parity violating electron scattering experiments on ^{48}Ca (CREX) and ^{208}Pb (PREX-II) opened new perspectives to constrain nuclear energy density functionals, in particular their isovector channel that govern the properties of the symmetry energy and the size of the neutron skin in nuclei. A new relativistic energy density functional (EDF) has been constrained by the ground state properties of atomic nuclei along with the isoscalar giant monopole resonance energy and dipole polarizability in ^{208}Pb [1]. A unified framework of the relativistic Hartree-Bogoliubov model and quasiparticle random phase approximation based on the relativistic density-dependent point coupling interaction is established in order to constrain the parameters of the DD-PCX interaction [1,2]. It accurately describes the nuclear ground state properties including the neutron-skin thickness, as well as the isoscalar giant monopole resonance excitation energies, dipole polarizabilities [1], Gamow-Teller [3], and magnetic dipole transitions [4,5]. The implementation of the experimental data on nuclear excitations allows constraining the symmetry energy close to the saturation density, and the incompressibility of nuclear matter by using genuine observables on finite nuclei in the χ^2 minimization protocol, rather than using pseudo-observables on the nuclear matter, or by relying on the ground state properties only. Furthermore, by using the EDF framework, the implications of parity violating electron scattering CREX and PREX-II data on nuclear matter symmetry energy and isovector properties of finite nuclei have been investigated, in particular the neutron skin thickness and dipole polarizability [6]. The weak-charge form factors from the CREX and PREX-II experiments are employed directly in constraining the relativistic density-dependent point coupling EDFs [6]. The EDF established with the CREX data acquires considerably smaller values of the symmetry energy parameters, neutron skin thickness and dipole polarizability both for ^{48}Ca and ^{208}Pb, in comparison to the EDF obtained using the PREX-II data, and previously established EDFs.It has been shown that CREX and PREX-II experiments could not provide consistent constraints for the isovector sector of the EDFs, thus further theoretical and experimental studies are necessary.

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Presenter: PAAR, Nils (University of Zagreb)

Connecting low-lying dipole modes to nuclear structure properties and equation of state

Friday, 16 June 2023 10:05 (20 minutes)

A large amount of studies has been devoted in the last years to shed light on the properties of low-lying dipole modes in nuclei, particularly exploring how their features evolve with the isospin-asymmetry of the systems.
We perform Time Dependent Hartree-Fock and semi-classical Vlasov calculations, in the small-amplitude limit, to investigate dipole excitations in several nuclei. Employing Skyrme-like energy density functionals, we show how the relative weight of the excitations emerging in the low-energy region evolves with nuclear global features, such as density profile and neutron skin, which in turn reflect important properties of the nuclear effective interaction and equation of state. Moreover, these analyses better characterize the mixed isoscalar/isovector nature of the different modes and their surface/volume components, providing a novel interpretation of the debated nature of the so-called Pygmy Dipole Resonance and of its correlation with the neutron skin thickness in neutron-rich nuclei [1, 2].
On the other hand, a new class of energy density functionals, inspired by effective field theory and benchmarked on ab-initio calculations, was recently devised to improve the description of neutron matter in the dilute regime. Their recent application to finite systems has proven to also provide a more refined description of the nuclear surface [3]. Further developments are then envisaged to investigate the collective dipole excitations discussed above with these functionals.

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Presenter: BURRELLO, Stefano (Istituto Nazionale di Fisica Nucleare)

Gamma decay of ISGQR excited in ^{208}Pb by proton inelastic scattering

Friday, 16 June 2023 10:25 (20 minutes)

M. Kmiecik[1], B. Wasilewska[1], M. CiemaÅa[1], A. Maj[1], F.C.L. Crespi[2;3], A. Bracco[2;3], M.N. Harakeh[4], P. Bednarczyk[1], S. Bottoni[2;3], S. Brambilla[3], F. Camera[2;3], I. CiepaÅ[1], N. Cieplicka-OryÅczak[1], M. Csatlos[5], B. Fornal[1], V. Gaudilla[6], J. GrÄbosz[1], J. Isaak[7], Å.W. Iskra[1], M. JeÅŒabek[1], A.J.

Krasznahorkay[5], S. Kihel[8], M. Krzysiek[1], P. Lasko[1], S. Leoni[2;3], M. Lewitowicz[9], J. Åukasik[1], M. Matejska-Minda[1], K. Mazurek[1], P.J. Napiorkowski[10], W. Parol[1], P. PawÅowski[1], L.Q. Qi[11], M. Saxena[10], Ch. Schmitt[8], B. Sowicki[1], M. Stanoiu[12], A. Tamii[13], O. Wieland[3], and M. ZiÄbliÅski[1]

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An experimental campaign of measurements of the Î³ decay from states excited in nuclei using proton inelastic scattering reaction have been performed at CCB facility of IFJ PAN. The main goal of the experiments was to study the decay to the ground state of isoscalar giant quadrupole resonance (ISGQR) via Î³-ray emission. Previously such phenomenon was observed only once, in 1980s [1]. The reason for the lack of the experimental data is the fact the Î³ decay above the neutron threshold is hindered by the competing channel of neutron emission, which makes the measurement of ISGQR Î³ decay difficult requiring efficient setup.
The experiment was performed at Cyclotron Centre Bronowice (CCB) of IFJ PAN KrakÃ³w, Poland, a facility dedicated mainly to the proton radiotherapy. The experimental setup consisted of eight large-volume BaF_2 Î³ -ray detectors of the HECTOR (High Energy deteCTOR) array [2] and 16 triple telescopes of the KRATTA (KRAkÃ³w Triple Telescope Array) array [3] together with fast plastic scintillators for light charged particle identification and energy measurement. In the experiment the inelastic scattering of 85 MeV proton beam on ^{208}Pb target has been employed and the scattered protons were measured in coincidence with Î³ transitions.
As a result the measurement of the ISGQR Î³-decay has been confirmed and the branching ratio between ISGQR gamma decay to ground state and neutron emission was obtained [4].
During the talk I will present the experimental method, the used equipment as well as the obtained results. In addition, the outlook for the continuation of such studies will be discussed.

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Presenter: KMIECIK, Maria (IFJ PAN KrakÃ³w)

Electric dipole strength functions of Lambda hypernuclei obtained by the time-dependent mean-field calculation

Friday, 16 June 2023 10:45 (15 minutes)

In recent years, HIHR (High-Intensity High-Resolution) has been planned at J-PARC in Japan. The accuracy of nuclear structure on the Λ hypernucleus is expected to be significantly improved by the progress. Furthermore, it might expand to a broader nuclear mass number of regions. The research will also contribute to the properties of a high-density nuclear matter, like a neutron star. In the high-density nuclear matter, the hyperon degree of freedom should be considered, but it is difficult for the simple extension to realize the neutron star of the twice solar mass, known as the Hyperon puzzle.

The equation of state (EOS) for the nuclear matter is often studied by the mean-field model using the nuclear energy density functional (NEDF). The studies connect nuclear matter, and the structure of finite nuclei through the EOS parameters deduced from the NEDF. We present a time-dependent mean-field model that includes the Λ-hyperon degree of freedom into the NEDF to study the nuclear structure and matter properties simultaneously.

The theoretical model is the canonical-basis time-dependent Hartree-Fock-Bogoliubov theory (Cb-TDHFB) with Skyrme-type effective interaction. The initial state of Cb-TDHFB is prepared by the HF+BCS model represented in the three-dimensional Cartesian coordinate to treat nuclear deformation. Namely, our model fully self-consistently describes the nuclear dynamics, including nuclear pairing and deformation effects, although the pairing between Λ particles is excluded.

In our talk, we will show the linear response results of the electric dipole excitation and discuss the influences of Λ particle on the ground state and E1 excited states through several nuclear isotopes.

Presenter: EBATA, Shuichiro

Solving nuclear structure puzzles with the relativistic nuclear field theory

Friday, 16 June 2023 11:30 (30 minutes)

The nuclear many-body problem formulated in terms of the fermionic correlation functions (CFs), or propagators, will be discussed. Starting from the ab-initio Hamiltonian, the CFs are quantified within a systematic equation-of-motion (EOM) framework. Furthermore, the coupled one-fermion and two-fermion propagators, mostly relevant for the nuclear ground and excited states, can be decoupled from the rest of the CFs hierarchy by approximations with minimal truncations, which keep the leading effects of emergent collectivity.
The approach is implemented numerically for the nuclear single-particle states and nuclear response, on the basis of the relativistic effective meson-nucleon Lagrangian. It is shown that the coupling between the CFs of the single Bogoliubovâs quasiparticles (q) and their correlated pairs (phonons) improves systematically the description of the single-particle states, as compared to the Hartree-Fock-Bogoliubov approach, in both spherical and axially deformed nuclei. The 2qâphonon configurations beyond the standard (quasiparticle) random phase approximation help improve the description of the nuclear excitations, in both the gross and fine structure aspects, such as the centroids and widths of the giant resonances, and the low-energy strength distributions. It is shown that the higher-rank 2qâ2phonon configurations and backward-going 2qâphonon terms in the dynamical kernel of the response EOM may further refine the excitation spectra. Such nuclear structure phenomena as the giant dipole and monopole resonances, pygmy resonances, Gamow-Teller resonance and beta decay will be addressed within the self-consistent implementation based on the universal covariant parametrization across the nuclear chart.

Presenter: LITVINOVA, Elena (Western Michigan University)

The structure of low-lying 1â states in ^{90,94}Zr from (Î±,Î±â²Î³) and (p,pâ²Î³) reactions

Friday, 16 June 2023 12:00 (30 minutes)

The results of experiments aimed to study the low-lying dipole strength in the ^{90,94}Zr nuclei will be presented. The states of interest were populated via (p,pâ²Î³) at 80 MeV and (Î±,Î±â²Î³) at 130 MeV. The setup at the RCNP lab included the magnetic spectrometer Grand Raiden for the scattered particles detection and the array CAGRA with HPGe detectors for the Î³-decay. For ^{94}Zr these are the first data for both reactions and for ^{90}Zr these are the first data with (p,pâ²Î³) and the first ones at high energy resolution for (Î±,Î±â²Î³). The comparison of the present results for the two nuclei with existing (Î³,Î³â²) data shows that both nuclear probes produce a different excitation pattern. DWBA calculations were made using form factors deduced from transition densities, based on RPA calculations, characterized by a strong neutron component at the nuclear surface. A combined analysis of the two reactions was performed for the first time to investigate the isoscalar character of the 1â states in ^{90,94}Zr. The (p,pâ²Î³) cross section was calculated using values for the isoscalar electric dipole energy-weighted sum rule (E1 ISEWSR) obtained from the (Î±,Î±â²Î³) data. The isoscalar strength for ^{90}Zr was found to exhaust 20 Â± 2.5% of the EWSR in the energy range up to 12 MeV. In case of ^{94}Zr, a strength of 9 Â± 1.1% of the EWSR was found in the range up to 8.5 MeV. The fact that, although an overall general agreement was obtained in the studied energy intervals, not all proton cross sections were well reproduced using the isoscalar strength from (Î±,Î±â²Î³), might suggests the mixing of isoscalar and isovector components and that this mixing and the degree of collectivity are not the same for all the 1â states below the particle binding energy.

Presenter: CRESPI, Fabio (Istituto Nazionale di Fisica Nucleare)

Spurious states in ”beyond” RPA and multiphonon calculations

Friday, 16 June 2023 12:30 (20 minutes)

We scrutinize differences and analogies between the Equation of Motion Phonon method (EMPM), Second Tamm-Dancoff (STDA) and Second Random-Phase Approximations (SRPA) [1]. We investigate how these differences affect the nuclear response in some selected doubly-magic nuclei.
For this purpose, we perform self-consistent calculations within a space, including up to twoparticle-two-hole basis states using the UCOM potential and evaluate several multipole strength distributions. Special attention is paid to the impact of the center of mass motion (CM) and the tools each approach provides to remove the spurious admixtures induced by such a motion.
We show that states contaminated with spurious CM motion exist in SRPA(STDA), and no obvious prescription for their elimination is known. Consequently, strength distributions obtained in SRPA(STDA) of all multipolarities are affected by the spurious CM motion, which makes a com-

parison with experimental data somewhat problematic. As a possible solution to this problem, we propose the EMPM with an orthogonalization method based on singular value decomposition of the metric matrix, which allows for generating practically spurious-free states and strength functions. This feature is essential in the theoretical studies of low-energy dipole strength known as the pygmy resonance.

[1] F. Knapp, P. Papakonstantinou, P. VeselÃœ, G. De Gregorio, J. Herko, and N. Lo Iudice., Phys. Rev. C 107 (2023), 014305.

Presenter: KNAPP, Frantisek (Charles University, Prague)

Dipole excitations in open shell nuclides near the neutron threshold from (γ,γ') experiments : The case of Ge isotopes

Friday, 16 June 2023 12:50 (20 minutes)

N. Benouaret[1], R. Schwengner[2], R. Massarczyk[3], T. Shizuma[4,5], D. Bemmerer[2], R. Beyer[2], A.Junghans[2], A. Wagner[2]

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The enhancement of dipole strength near the neutron threshold, termed as Pygmy Dipole Resonance (PDR) is still the topic of many experimental and theoretical studies. Discovered in neutron shell closure nuclides [1], this extra strength of E1 character, increases significantly reaction rates in the r-process. The PDR excitation was described in most of microscopic approches as an oscillation of weakly-bound neutron skin against an inert symmetric N=Z proton-neutron core. Despite its correlation with the neutron excess, the corresponding collectivity is still not clear. Away from spherical nuclides, theoretical studies showed that the extra strength may be hindered by nuclear deformation [2]. First experimental results of (γ, γ') experiments, performed on the open shell ^{70}Ge using bremsstrahlung from the ELBE facility [3] will be presented. The results will complete the systematic study of the properties of the PDR in the Germanium isotopes [4],[5].
ACKNOWLEDGMENTS We would like to thank the operators group at the ELBE accelerator for the excellent electron beam during our NRF measurements. N. Benouaret is grateful to HZDR for providing the ^{70}Ge target.
References [1] D. Savran et al., Prog. Part. Nucl. Phys. 70 (2013) 210. [2] D. Pen~a Arteaga, Phys. Rev. C 79 (2009) 034311. [3] R. Schwengner et al., Nucl. Instrum. Methods A 555 (2005) 211. [4] R. Massarczyk et al., Phys. Rev. C 92 (2015) 044309. [5] R. Schwengner et al., Phys. Rev. C 105 (2022) 024303.

Presenter: BENOUARET, Nadia (University of Science and Technology Houari Boumediene)

Density dependence of pairing functionals for the rotational excitation in neutron-rich nuclei

Friday, 16 June 2023 14:40 (30 minutes)

Nuclear rotational motion is a typical example of collective excitation and occurs in response to the spontaneous breaking of rotational symmetry. By stepping away from the magic number, the first excited 2^+ state becomes lower in energy: The collective mode of excitation changes its character from vibrational to rotational as the deformation develops.

Recently, various spectroscopic studies have been carried out to explore unique structures in neutron-rich nuclei. The excitation energy of the 2_1^+ state, $E(2^+)$, is often among the first quantities accessible in experiments, and systematic measurements have revealed the evolution of the shell structure. In addition to the change of the shell structure associated with the onset of deformation, the $E(2^+)$ value may provide rich information about exotic nuclei.

The pair correlation is present in the ground state. It plays a decisive role in describing various phenomena, such as the energy gap in spectra of evenâeven nuclei and the oddÂ¬Â¬âeven staggering in binding energies. In addition, the pairing is indispensable for generating the collectivity of the low-frequency quadrupole vibration and a reduced value of the moment of inertia (MoI) for rotation compared with the values provided by the rigid-body estimation. Therefore, the $E(2^+)$ value should be scrutinized by considering not only the deformation but also the nuclear superfluidity.

I have investigated the rotational motion in neutron-rich nuclei, including drip-line nuclei, with an emphasis on pairing. Here, I studied the lowest spin stateâspecifically, the 2_1^+ stateâin evenâeven nonspherical nuclei. The MoI is evaluated microscopically by the self-consistent cranking model employing the Skyrme-type energy-density functional augmented with the pairing functional. The MoI is then found to increase significantly near the drip line when the pairing functional including the isovector-density dependence is adopted, whereas the deformation is not as strong as estimated by the empirical relation. The pairing functional including only the isoscalar density produces the enhanced pairing and reduced MoI relative to the rigid-body value. The currently used pairing functionals provide a fair description of the available experimental data of $E(2^+)$ with similar accuracy. However, they produce a considerable variation near the drip line. Future systematic measurement of $E(2^+)$ in neutron-rich nuclei puts a constraint on the density-dependence of the pairing.

Ref.: K. Yoshida, Phys. Lett. B834 (2022), 137458.

Presenter: YOSHIDA, Kenichi (RCNP, Osaka University)

Mo-100 monopole & quadrupole strength with triaxiality: A time-dependent density functional study

Friday, 16 June 2023 15:10 (20 minutes)

We use time-dependent density functional theory to calculate the monopole and quadrupole response of the Mo-100 nucleus, following recent experimental study. Using a combination of shape constraints in the initial state and the ground state configurations predicted by different Skyrme-type effective interactions, we compare the monopole and quadrupole strength functions for different beta and gamma deformations of the possible Mo-100 ground state, finding that finite triaxial deformation gives the closest reproduction of the observed giant resonance. The role of monopole-quadrupole coupling, which arises naturally from the time-dependent picture, is shown in the the multiple peak structure.

Reference
Yue Shi and P. D. Stevenson, Chinese Physics C 47, 034105 (2023)

Presenter: STEVENSON, Paul

On the measurement of ^{8}B+^{64}Zn to investigate the proton halo dynamics

Thursday, 15 June 2023 15:30 (15 minutes)

On the measurement of 8B+64Zn to investigate the proton halo dynamics

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T. Davinson[8], J. D. Ovejas[2], L.M. Fraile[9], D. Galaviz[1]0, B. Jonson[1]1, M. La Cognata[1], A. Perea[2], A. M. SÃ¡nchez-BenÃtez[4], N. SoiÄ[1]2, and S. ViÃ±als[2]

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9- Facultad de Ciencias FÃsicas, Madrid, SPAIN
10- Laboratory for Instrumentation and Experimental Particle Physics, Lisbon, Portugal
11- Department of Physics, Chalmers University of Technology, GÃ¶teborg, Sweden.
12- RuÄer BoÅ¡koviÄ Institute, Zagreb, Croatia

This presentation will report on proton halo effects in the 8B+64Zn reaction at an energy around 1.5 times the Coulomb barrier using, for the first time, the HIE-Isolde postaccelerated 8B beam. The effects observed in the elastic scattering angular distribution are at variance with what observed in the case of the one-neutron halo nucleus 11Be on the same target in a similar energy range. Only a modest suppression of the Coulomb-nuclear interference peak is observed, with no remarkable enhancement of the total reaction cross-section. Inclusive angular and energy distributions of 7Be produced in direct reaction processes have also been measured as well. Overall, the experimental data suggest a 8B collision dynamics at the barrier very different from the one of neutron halo nuclei, showing only modest effects of coupling to continuum [1].

[1] R. SpartÃ¡ et al. Phys. Lett. B. 820, 136477 (2021)

Presenter: SPARTA', Roberta (Istituto Nazionale di Fisica Nucleare)

Interplay Between Strong, Weak and Electromagnetic Interactions Revealed by Nuclear Decay Processes

Friday, 16 June 2023 15:45 (15 minutes)

The many facets of nuclear dynamics are relevant for our understanding of systems ranging from astrophysical bodies [1,2] all the way down to elementary particles and pursuits beyond the Standard Model [3]. This talk is mainly concerned with a beyond-the-mean-field theory of alpha decay, namely a solution to the alpha-decay problem through the use of the Hartree-Fock-Bogoliubov method together with a residual nucleon-nucleon Surface Gaussian Interaction, a generalization of the well-known Surface Delta Interaction. The method is used to give a systematic description of the alpha-particle formation amplitude in superfluid nuclei in terms of microscopic degrees of freedom, namely protons and neutrons, and to predict the decay properties of superheavy nuclei.

Further, a less-known interplay between the fundamental interactions is explored through decay processes, namely the the interplay betweenthe alpha-decay formation amplitude and electromagnetic observables or electron capture matrix elements calculated through long-range correlations in a deformed proton-neutron quasiparticle Random Phase Approximation.

Some of the relevant literature for this talk can be consulted in Refs. [4-7].

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[1] Light clusters in nuclei and nuclear matter: nuclear structure and decay, heavy ion collisions and astrophysics, ECT*, Trento, Italy, 2-6 September 2019.
[2] J. Tanaka et al., Science 371, 6526 (2015).
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[7] A. Dumitrescu and D.S. Delion, Cluster Mean Field Description of Alpha Emission, arxiv preprint: 2211.09452 (2022).

Presenter: DUMITRESCU, Alexandru (Horia Hulubei National Institute for R&D in Physics and Nuclear Engineering)