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The objective of this workshop goes beyond my thesis in 180 sec!
It will provide the most important skills that are imperative when presenting your work as a young scientist.
In other words, the tips that can help you succeed.

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This workshop aims to provide guidance and tips on harnessing these resources to build a well-rounded CV and increase your chances of getting hired after your PhD for example.

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The effect of the energy functional on the pasta-phase properties of catalysed neutron stars

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Co-auteurs: Anthea Francesca FANTINA [2]; Francesca Gulminelli [3]

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Nuclear pasta, that is, an inhomogeneous distribution of nuclear matter characterised by non-spherical clustered structures, is expected to occur in a narrow spatial region at the bottom of the inner crust of neutron stars, but the width of the pasta layer is strongly model-dependent. In the framework of a compressible liquid-drop model, we use Bayesian inference to analyze the constraints on the sub-saturation energy functional and surface tension imposed by both ab-initio chiral perturbation theory calculations and experimental measurements of nuclear masses. The posterior models are used to obtain general predictions for the crust-pasta and pasta-core transition with controlled uncertainties. A correlation study allows extracting the most influential parameters for the calculation of the pasta phases. The important role of high-order empirical parameters and the surface tension is underlined.

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Understand 22Na cosmic abundance by measuring lifetimes in 23Mg*

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Simulations of novae explosive nucleosynthesis predict the production of the radionuclide ^{22}Na. Its half life of 2.6 yr makes it a very interesting astronomical observable by allowing space and time correlations with the astrophysical object. This radionuclide should bring constraints on nova models. It may also help to explain abnormal ^{22}Ne abundance observed in presolar grains and in cosmic rays. Its gamma-ray line at 1.275 MeV has not been observed yet by the gamma-ray space observatories. Hence accurate yields of ^{22}Na are required. Within the novae thermal range, the main destruction reaction ^{22}Na(p,γ)^{23}Mg has been found dominated by a resonance at E_R = 0.213 MeV corresponding to the Ex = 7.786 MeV excited state in ^{23}Mg. However the measured strengths of this resonance are in disagreement [1, 2].

An experiment was performed at GANIL facility to measure the lifetime of the key state at Ex = 7.786 MeV. The principle of the experiment is similar to the one used in [3]. With a beam energy of 4.6 MeV/u, the reaction ^{3}He(^{24}Mg,α)^{23}Mg* populated the state of interest. This reaction was tagged

with particle detectors (spectrometer VAMOS++, silicon detector SPIDER) and gamma tracking spectrometer AGATA. The state of interest decays either by gamma deexcitation or proton emission. The expected time resolution with AGATA high space and energy resolutions is 1~fs. Several Doppler based methods were used to analyse the lineshape of gamma peaks.

Preliminary results will be presented. Ejectiles, protons and ^{4}He, were identified with SPIDER and VAMOS in order to reconstruct the excitation energies in ^{23}Mg. Doppler shifted gamma-ray spectra from ^{23}Mg states were improved by imposing coincidences with the ^{4}He ejectile energies measured with VAMOS. It ensured to suppress feeding from higher states. Lifetimes in ^{23}Mg were measured with a new approach. Proton emitted from unbound levels in ^{23}Mg were also identified. With an higher precision on the lifetime of the Ex = 7.786 MeV state and the branching ratio measured in [4], a new value of ^{22}Na(p,γ)^{23}Mg resonance strength $\omega\gamma$ was obtained. The impact of the new thermonuclear ^{22}Na(p,γ)^{23}Mg rate on the predicted ^{22}Na production will be discussed.

References
[1] A.L. Sallaska *et al.*, Phys. Rev. Let. **105**, 152501 (2010).
[2] F. Stegmuller *et al.*, Nuc. Phy. A **601**, 168-180 (1996).
[3] O.S. Kirsebom *et al.*, Phys. Rev. C **93**, 025802 (2016).
[4] M. Friedman *et al.*, Phys. Rev. C **101**, 052802(R) (2020).

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Bogoliubov coupled cluster theory for open-shell nuclei

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The objective of the so-called ab initio approach to nuclear structure is to provide an accurate and universal description of nuclear systems from first principles [1]. In this context, solving the many-body Schrödinger equation requires systematically improvable many-body methods. Over the past 20 years, the development of novel expansion methods displaying a mild computational scaling with systems size have allowed access to mid-mass closed-shell nuclei. Such methods typically expand the exact ground-state wave-function around a reference/unperturbed Slater determinant and include correlations through elementary particle-hole excitations. This can be obtained from perturbative techniques [2] or from non-perturbative approaches such as coupled-cluster (CC) theory [3]. While closed-shell nuclei are well under control, the extension to open-shell nuclei remains a major challenge.

Only very recently, a novel many-body method coined as Bogoliubov coupled cluster (BCC) theory [4] has been formulated that extends the standard coupled cluster scheme to singly open-shell nuclei. This is achieved by breaking particle-number symmetry of the unperturbed state as a way to already incorporate crucial static correlations into it. In my talk I will present recent results obtained for the ground-state of oxygen isotopes based on nuclear interaction models derived from chiral effective field theory.

Once fully implemented, the non-perturbative (equation-of-motion) BCC method will allow for high-precision ab initio calculations of ground and excited states in medium-mass nuclei.

[1] H. Hergert, Front. Phys. 8, 379 (2020)
[2] A. Tichai, R. Roth, T. Duguet, Front Phys. 8, 164 (2020)
[3] G. Hagen, T. Papenbrock, M. Hjort-Jensen, D. J. Dean, Rep. Prog. Phys. 77, 9 (2014)
[4] A. Signoracci, T. Duguet, G. Hagen, G. Jansen, Phys. Rev. C 91, 064320 (2015)

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Nuclear structure studies at the FIPPS instrument at ILL

Auteurs: Giacomo Colombi[None]; Caterina Michelagnoli[1]; Jeremie Dudouet[2]; Joa Ljungvall[3]; Silvia Leoni[4]

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The FIssion Product Prompt gamma-ray spectrometer (FIPPS) is the new nuclear physics instrument at the *Institut Laue-Langevin* (ILL). FIPPS takes advantage of an intense pencil-like neutron beam (flux 10^8 n/s/cm^2) for inducing neutron capture and neutron induced fission reactions and study the nuclear structure via high resolution gamma-ray spectroscopy. The array is composed by 8 Compton suppressed HPGe clover detectors. Ancillary devices are possible, as $LaBr_3$ detectors for fast timing measurements or additional clover detectors (from the IFIN-HH collaboration) to increase efficiency and granularity.
After a general introduction on the main features of the instrument, recent developments to improve the energy resolution and the sensitivity of the instrument for fission studies will be reported. In particular, the procedure and effects of the correction for the cross-talk among the crystals in a same clover will be reported.
The setup and results from the first test of a diamond-base active target for neutron induced fission will be reported. These results will be shown with the ones from the well-established scintillator-based active target used at FIPPS in recent campaigns. The use of a fission tag allows for an identification of transitions from weak branches and/or isotopes produced with small fission yields.
Finally, the recently developed GEANT4 simulation code will be presented, with particular focus on the angular correlation analysis with hybrid gamma-ray arrays and on the first simulations for the development of a plunger device for lifetime measurements in fission fragments.

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Description of heavy nuclei within the Shell Model

Auteur: Duy Duc Dao[1]

Co-auteur: Frédéric Nowacki [1]

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The great challenge in the Shell Model framework is the diagonalization of the effective (generally two-body) Hamiltonian in the model space. Indeed, this is a huge task for open shell nuclei as the model space dimension grows combinatorially with the number of particles. I will present our recent development which allows to expand the applicability of the Shell Model into heavy nuclei by means of a generator coordinate method (GCM) based on constrained Hartree-Fock wave-functions after angular momentum projection. In particular, we have developed an efficient minimization technique that addresses the question of selecting relevant basis states in the GCM. Several applications in $N = Z$ heavy nuclei and in the Nobelium isotopes ($Z = 102$) will be presented.

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Ab-initio description of the monopole resonance in light- and medium-mass nuclei

Auteur: Andrea Porro[1]

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Giant monopole resonances have a long-standing theoretical importance in nuclear structure. The interest resides notably in the so-called breathing mode that has been established as a standard observable to constrain the nuclear incompressibility. The Random Phase Approximation (RPA) within the frame of phenomenological Energy Density Functionals (EDF) has become the standard tool to address (monopole) giant resonances and extensive studies, mostly in doubly-closed-shell systems, have been performed throughout the years, including via the use of so-called sum rules. A proper study of collective excitations in the ab-initio context is, however, missing.
In this perspective, the first systematic ab-initio predictions of (giant) monopole resonances will be presented. Ab-initio Quasiparticle-RPA (QRPA) and Projected Generator Coordinate Method (P-GCM) calculations of monopole resonances are compared in light- and mid-mass closed- and open-shell nuclei, which allows in particular to investigate the role of superfluidity from an ab-initio standpoint.
Sum rules are also employed within both many-body schemes to characterize the fragmentation of the monopole strength. The study further focuses on the dependence of the results on the starting nuclear Hamiltonian derived within the frame of chiral effective field theory.
Monopole resonance represents, thus, the first step towards the investigation of higher multipolarities. Eventually, the mid-term goal to establish P-GCM as a new method to study resonances in the light- and medium-mass region of the nuclide chart will be discussed: interpretation and analysis of resonance data in lighter nuclei is a very demanding task on which ab-initio P-GCM could shed new promising light.

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Nuclear Shell Model Effective Interactions from Many-Body Perturbation Theory

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The interacting shell model is a modern many-body method used in nuclear structure calculations. The basic idea of the model is that the eigenproblem for a microscopic Hamiltonian is solved by diagonalization of the Hamiltonian matrix in a spherically-symmetric many-body basis (for example, a harmonic oscillator basis). The basis dimension grows very rapidly with increasing atomic number A. For nuclei with A>18, only a few valence nucleons can be treated as active particles interacting with each other in a truncated Hilbert space, consisted of one or two oscillator shells outside a closed-shell core. The interaction between valence nucleons in such a model space is an effective interaction and not a bare nucleon-nucleon interaction as between free nucleons anymore. When phenomenological effective interactions are used, the shell model is known to provide excellent description of excitation spectra and transitions at low energies, while to derive accurate microscopic effective interactions from the bare nucleon-nucleon potential is still a challenge. In this work we discuss the microscopic sd shell effective interactions derived from many-body perturbation theory, as well as compare the results with empirical interactions.

23

Determining neutron-induced reaction cross sections through surrogate reactions at storage rings

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Co-auteurs: Beatriz Jurado [2]; Manfred Grieser [3]; Jérôme PIBERNAT [4]; Michele Sguazzin [5]; Jan Glorius [6]; Yuri Litvinov [6]; Bertrand Thomas [1]; Klaus Blaum [3]; Thierry Chiron [1]; Mathieu Roche [1]; Philippe Alfaurt [1]; Vincent Méot [7]; Olivier Roig [7]; René Reifarth [8]

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Investigating the interactions of neutrons with unstable nuclei is crucial to our understanding of nuclear astrophysics as it sheds light on the stellar nucleosynthesis of heavy elements. Obtaining accurate cross section data for neutron-induced reactions on these nuclei presents major experimental challenges since both beam and target are radioactive. The NECTAR (NuclEar reaCTions At storage Rings) project aims to solve this problem by using the surrogate-reaction method, where one may indirectly infer the neutron-induced cross sections of short-lived nuclei, in inverse kinematics. A heavy, radioactive nucleus in the beam is to interact with a light, stable nucleus in the target to produce the compound nucleus formed in the neutron-induced reaction of interest via an alternative or surrogate reaction such as transfer or inelastic scattering. This compound nucleus may decay by fission, neutron or gamma-ray emission, and the probabilities for these modes of decay are to be measured as a function of the excitation energy of the compound nucleus. This information is used to constrain model parameters and to inform more accurate predictions of neutron-induced reaction cross sections [1].

The heavy-ion storage rings at GSI/FAIR in Germany present an ideal laboratory for the development of the surrogate reaction method, which still suffers from various target-related issues. The sustained high beam quality, along with the use of an ultra-thin gas-jet target, makes it possible to measure excitation energies and decay probabilities with an unrivalled accuracy.
A first Proof-of-Principle experiment is to be performed during the first half of 2022 at the ESR storage ring facility. The 208Pb(p,p') reaction will be investigated in inverse kinematics with an incident beam of 208Pb at 30 AMeV. Target residues will be measured with a detector telescope inside the reaction chamber, in coincidence with beam residues using DSSSD detectors downstream after a dipole magnet, thus providing decay probabilities for both neutron and gamma-ray emission. After this first pilot experiment, NECTAR will eventually move to the CRYRING facility at GSI/FAIR, where the detection setup will be supplemented with fission fragment detectors, thus enabling for fission, neutron and gamma-ray emission probabilities to be measured simultaneously for the first time at this facility.

This presentation will focus on the concept and technical development of NECTAR, as well as the preparation for these experiments at the storage rings of GSI/FAIR.

*This work has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (ERC-Advanced grant NECTAR, grant agreement No 884715).

[1] R. Pérez Sánchez, B. Jurado et al., Phys. Rev. Lett. 125 (2020) 122502.

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Continuum coupling correction in Gamow Shell Model

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Loosely bound nuclei are currently at the center of interest in nuclear physics in problems related to the limits of stability of nuclear matter and nucleosynthesis. Since nuclear properties are profoundly affected by environment of the many-body continuum representing scattering and decay channels, a simultaneous understanding of the structural and reaction aspects is crucial for understanding of short-lived nucleonic matter.

Attempts to reconcile the nuclear shell model with the reaction theory has led to the development of the shell model for open quantum systems, the Gamow Shell Model (GSM), which change the comprehension of many nuclear phenomena and offers new perspectives for nuclear structure and reaction studies. Recently, near threshold effects have been studied in the $\beta^{-}p^{+}$ decay of ^{11}Be using Shell Model Embedded in the Continuum (SMEC). The continuum-coupling induced collectivization of shell model eigenstates is also responsible for the appearance of clustering in near-threshold states.

In my presentation, I shall concentrate on the continuum-coupling energy correction calculated in GSM and, in particular, on its near-threshold behavior as a function of the angular momentum, charge, and number of valence nucleons.

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Response of solar cells to heavy ions at energies close to 10 AMeV

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Solar cells have been used for several decades to detect fission fragments up to 1 AMeV. In this energy range, they provide an energy resolution of 1-2%, a time resolution of a few ns and better radiation hardness than Si detectors. All these properties, together with their low cost and low sensitivity to light particles, make solar cells an appealing alternative to silicon detectors for the detection of heavy ions.
Since 2018 we have been investigating the possibility to use solar cells for the detection of heavy ions at energies above 1 AMeV. The first exploratory measurements were performed using ^{84}Kr and ^{129}Xe beams at 7-13 AMeV, and ^{238}U at 3.8 MeV at GANIL. These measurements provided us with interesting results in relation to both energy and time resolution, and they evidenced a stable response of the cells when irradiated with beam intensities up to thousands of pps for a few minutes. These results showed the great potential of solar cells to be used in radioactive ion beam facilities for experiments and beam monitoring [1].
In March 2021 we carried out another experiment at GANIL to further study the response of solar cells of different types and dimensions to a ^{84}Kr beam at 5, 10 and 15 AMeV. In this measurement it was possible to successfully study the evolution of the cell response as a function of the beam energy and perform long radiation resistance tests. Moreover, a Si detector was also irradiated under the same conditions, thus enabling for a direct comparison with the solar cells.

In this contribution we will present the experimental procedure and the main results of the conducted measurements.

References
[1] A. Henriques et al., Nucl. Instrum. Methods A 969 (2020) 163941.

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Shapes of heavy and super-heavy atomic nuclei with Skyrme Energy Density Functionals

Auteurs: Philippe Da costa[None]; Michael Bender[1]; Karim Bennaceur[2]; Jacques MEYER[2]

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The mean-field, or Energy Density Functional (EDF), methods allow for the study of energies and shapes of all nuclei, but the lightest ones, throughout the mass-table. These approach and their extensions such as the Random Phase Approximation (RPA) and Generator Coordinate Method (GCM)
give access to observables from ground state, excited states and large-amplitude collective motion of the
nuclei. Furthermore, the mean-field gives a natural interpretation of the nuclear configurations through
the shapes of the system in its intrinsic frame.
It is well established that a correct description of the ground states of deformed heavy nuclei, rotational
bands, isomeric states energies and fission barriers is strongly correlated with the value of the surface
energy coefficient a surf and also the surface symmetry energy coefficient a ssym.
A first step in the direction of a better description of shapes of heavy nuclei was recently achieved with the construction of the SLy5sX series of Skyrme-EDFs and more specifically with the SLy5s1 parameterisation. The systematically improved agreement for deformation properties of heavy nuclei
achieved with SLy5s1 compared to widely-used parameterisations such as SLy5, however, comes at the expense of a significant increase of mass residuals.
In this presentation, I will show that a slight modification of the fit protocol together with the inclusion of the often-neglected two-body contribution to the center-of-mass correction in functional
greatly improve the results for shapes, barriers heights and binding energies. I will present the details
of the fit protocol and show a set of selected results. It turns out that completely omitting the center-of-mass correction as sometimes done for parameterisations aiming at nuclear dynamics is similarly problematic as using the standard recipe where only the one-body part is kept. I will also discuss how
the statistical error bars on the parameters of the functional propagate on calculated quantities such as
fission barriers.

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Can we decipher the composition of the core of a neutron star?

Auteurs: Chiranjib Mondal[1]; Francesca Gulminelli[2]

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Recent development in multi-messenger astronomy through gravitational waves (LIGO/VIRGO) or X-ray spectra (NICER) provide new constraints to the theories of nuclear physics, where an absolute energy density functional from ab-initio modelling is still not available.
General relativity guarantees that there is a unique one-to-one correspondence between static observables of neutron stars such as mass-radius relation or tidal deformability and equation of state (EoS) of beta equilibrated matter. However, these static properties are not enough to predict the composition of the interiors of neutron stars. In a novel meta-model approach this problem is demonstrated through a simple analytical method, which is further reinforced by a Bayesian analysis. A possible remedy is also suggested which can be realized by information on symmetric matter at high densities.

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Universality in many-body systems

Auteur: Lorenzo Contessi[1]

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Systems that share common proprieties as critical exponents and the number and nature of quantum states are said to belong to the same universality class. However, systems in the same class may have very different typical sizes and energies. For example, some nuclear systems, cold atoms, and hadronic molecules can all be described by the same typology of theories. This allows transferring knowledge among systems belonging to the same class, with great benefit of the fields in which experimental results are scarce and more difficult to be obtained.

In this talk, I am going to describe how universality is related to effective field theories and how they can be applied from nucleons to hadrons, and atoms; what are their advantages and disadvantages; and the challenges that still remain to be solved in their future.

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Experimental Study of the 30Si(p,γ)31P via the 30Si(3He,d)31P transfer reaction for understanding elemental anomalies in Globular Clusters.

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Co-auteurs: B Bastin ; T Faestermann ; R Hertenberger ; M La cognata ; L Lamia ; A Meyer ; S Palmerini ; R. G Pizzone ; S Romano ; A Tumino ; H-F Wirth

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Globular clusters are key grounds for models of stellar evolution and early stages of the formation of galaxies. Abundance anomalies observed in the globular cluster NGC 2419, such as the enhancement of potassium and depletion of magnesium can be explained in terms of an earlier generation of stars polluting the presently observed stars. However, the nature and the properties of the polluting sites are still debated. The range of temperatures and densities of the polluting sites depends on

the strength of a number of critical thermonuclear reaction rates. The 30 Si(p,γ) 31 P reaction is one of the few reactions that have been identified to have an influence for elucidating the nature of polluting sites in NGC 2419. The current uncertainty on the 30 Si(p,γ) 31 P reaction rate has strong impact on the range of possible temperatures and densities of the polluter sites.
Hence, we investigated the 30 Si(p,γ) 31 P reaction with the aim to reduce the associated uncertainties by determining the strength of resonances of astrophysical interest. In this talk I will present the study of the reaction 30 Si(p,γ) 31 P that we performed via the one proton 30 Si(3 He,d) 31 P transfer reaction at the Maier-Leinbnitz-Laboratorium Tandem. With the high resolution Q3D magnetic spectrograph, we measured the angular distributions of the light reaction products. These angular distributions are interpreted in the DWBA (Distorted Wave
Born Approximation) framework to determine the proton spectroscopic factor information needed to determine the proton partial width of the states of interest. This information was used to calculate the 30 Si(p,γ) 31 P reaction rate. The uncertainties on the reaction rate have been significantly reduced and key remaining uncertainties have been identified.

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First trap-assisted decay spectroscopy of the ^{81}Ge ground state

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The ^{78}Ni ($Z = 28$, $N = 50$) region has been one of the main focus points in nuclear structure studies during the last decades. The recently measured 2_1^+ excitation energy of ^{78}Ni $E_x(2_1^+) = 2.6$ MeV has been interpreted as the proof of its doubly magic nature. Despite this remarkable result, the nuclear structure in the region is far from fully understood. Shape coexistence phenomena observed in the $N = 40$ region seems to extend to the $N = 50$ region and result in a new island of inversion. Coexisting shapes can also lead to isomeric states which complicate the studies of these nuclei.

In this work, we re-investigate the ^{81}As level scheme populated in the decay of ^{81}Ge in a systematic attempt to improve spectroscopy knowledge in the region of suspected shape coexistence. Up to now, the β-decay studies of the $N = 49$ isotones for $Z \leq 32$ have not been performed with an unambiguous ground state and isomer separation. In this work, we have utilized the JYFLTRAP Penning trap at IGISOL, Jyväskylä and selected the $(9/2^+)$ ground state of ^{81}Ge ($Z = 32$) for detailed studies at a post-trap decay spectroscopy setup. This is a clear improvement compared to the previous spectroscopy study of the decay of ^{81}Ge \cite{Hoff81} which utilized a mass-separated $A = 81$ beam consisting mainly of ^{81}Ga.

The intrinsic half-life of the ^{81}Ge ground state has been determined as $T_{1/2} = 6.4(2)$ s, which is significantly shorter than the literature value. A new level scheme of ^{81}As has been built and is compared to shell-model calculations.

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Gamma Spectroscopy in a Laser-perturbed Environment

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When high power lasers interact with matter, ions, electrons and their associated bremsstrahlung photons are the products. The protons can reach hundreds of MeVs and intensities of some kA within a few ns. Such high-intensity opens up new realms of nuclear physics like the study of shot-lived nuclei states in a plasma by gamma spectroscopy [1].
It is common to use a LaBr3 scintillator coupled to a Photomultiplier Tube (PMT) for gamma spectroscopy. However, high-energy depositions in the detector due to huge amount of soft X-rays from the laser interaction trigger delayed emissions in the form of afterglows within the scintillator making the PMT blind for a few ms after the laser shot. Fortunately, with a LaBr3 and a Hybrid Photo Diode (HPD) the duration of the afterglow signal can decrease to some tens of µs [1]. Nonetheless, the amplitudes of signals near the region of the afterglow remain altered due to variations in the gain of the photodetector.
It is imperative to implement signal treatment procedures that take into account the role of the afterglow and the amplitude variations of signals in a laser-perturbed environment. In this work, I have done offline signal processing on experimental data acquired from a HPD coupled to a LaBr3. The experiment involved the use of laser-accelerated protons to induce nuclear excitations on a zirconium target. The outcome was the production of 90mNb nucleus, which emits several gamma rays including 122 keV and 257 keV with lifetimes of 63 µs and 6.19 ms, respectively. I will thus present the steps taken for the signal treatments and the obtained results.

[1] Scintillators in high-power laser-driven experiments; M.Tarisien, et al. ; IEEE Transactions on Nuclear Science, Vol 65, issue 8, p.2216-2219 (2018)

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Weak interaction studies with 32Ar

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Nuclear beta decay has represented for more than half a century a blooming testing ground for the Standard Model (SM), contributing particularly to the development of the theory of the electroweak interaction. The broad variety of nuclear states and beta transitions provide a highly remarkable tool to be competitive with high-energy physics experiments in searching for the possible presence of non-SM contributions to the firmly established vector - axial-vector (V-A) description of the weak interaction [1]. Particularly, the joined experimental determination of the beta-neutrino angular correlation coefficient ($a_{\beta\nu}$) and the correlated Fierz term (b_F) in pure Fermi and Gamow-Teller transitions tightly allows to set new stringent limits on the existence of scalar and tensor currents, respectively.

The most forthcoming way to retrieve $a_{\beta\nu}$ would be to measure the correlation between the leptons emitted in the decay; yet, as a direct measurement of the neutrino is almost impossible, the $a_{\beta\nu}$ coefficient can be determined from the recoil of the daughter nucleus, which can be measured either directly by means of trap measurements or via the kinematic shift it induces on the energy distribution of the β-delayed particles emitted in case of unstable daughter nuclei, as foreseen in the WISArD experiment at CERN.

The WISArD (Weak Interaction Studies with ^{32}Ar Decay) experiment [2] aims at a precise measurement of both the $a_{\beta\nu}$ and the b_F coefficients for both Fermi and Gamow-Teller transitions by using, differently from previous measurements [3], the kinematic energy shift of the β-delayed protons emitted in the same or the opposite direction to the β-particle from ^{32}Ar. A proof-of-principle experiment, though limited in statistics and performed via a still rudimental experimental set-up, has been successfully accomplished at ISOLDE in November 2018, already leading to the third best measurement of $a_{\beta\nu}$ for Fermi transitions [4]. After determining and estimating the systematic errors, a consistent upgrade of the experimental set-up has been commissioned and realized through the past two years, potentially permitting to reach the aimed precision of the permil level on the determination of both $a_{\beta\nu}$ and b_F. In this talk, the new experimental campaign conduced at ISOLDE in October 2021, along with the enhancements in the newly dedicated detection set-up, will be presented and the first preliminary results will be discussed.

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The double Penning trap mass spectrometer PIERADE for DESIR/SPIRAL2

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The DESIR (Désintégration, Excitation et Stockage d'Ions Radioactifs) hall is a part of the new extension of GANIL; the SPIRAL2 facility. This hall will be dedicated to the study of nuclear structure, astrophysics and weak interaction with low energy beams (30-60 keV). With the low-energy comes the advantage of working with good optical quality ion beams, allowing high-precision experiments. Various experimental apparatus will take place in the DESIR hall, divided into three main categories, β-decay spectroscopy, laser spectroscopy and mass spectrometry.

In the DESIR hall, ion beams coming from the upgraded SPIRAL1 facility and the Super Separator Spectrometer S3 will be available. SPIRAL1 is producing light exotic nuclei by ISOL-fragmentation and S3 a wide range of neutron deficient nuclei (including refractory elements) by in-flight fusion evaporation. SPIRAL1 and S3 will deliver unique ion beams to DESIR, but the production techniques are non-selective and, depending on the region of interest, can produce huge amounts of contaminants. To guarantee a high purity of the samples a HRS (High-Resolution Separator), composed mainly of two 90 degrees magnetic dipole and one multipole, is foreseen to be located in front of the DESIR hall. Its resolving power on the order of 10^4 will allow a purification of most isobars from the ion beam. Nevertheless, an even higher resolution is required to separate a few ions of interest from a large number of contaminants such as very close isobars or long-lived isomers.

For that purpose, at the entrance of the DESIR hall will be installed the GPIB (General Purpose Ion Buncher), a linear Paul trap for cooling and bunching continuous ion beam and the double Penning trap mass spectrometer PIPERADE (PIèges de PEnning pour les ions RAdionucléides à DESIR). The mass resolving power of PIPERADE is expected to be higher than 10^6 and will allow purification of close isobars and isomers. Besides purification purposes, PIPERADE will be used as a mass measurement apparatus on its own. The GPIB and PIPERADE are now fully assembled at CENBG and under commissioning before their transfer to GANIL in 2 or 3 years. Their status will be presented as well as recent achievements.

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Shape evolution in neutron-rich nuclei around mass 100 with the AGATA-VAMOS-OUPS setup

Auteurs: Giorgia Pasqualato[1]; Joa Ljungvall[1]

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