First IRENA-IANNA Workshop

Sunday 9 June 2024 - Tuesday 11 June 2024

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Book of Abstracts

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Experiments at the FRIB ReAccelerator

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The Facility for Rare Isotope Beams (FRIB) is a scientific user facility funded by the US Department of Energy Office of Science (DOE-SC) located at the Michigan State University. FRIB started operations in May 2022 and is ramping towards its designed 400 kW of driver beam power.

Within the FRIB laboratory, the ReAccelerator (ReA) is a superconducting LINAC aimed to reaccelerate stopped rare isotope beams produced via inflight fragmentation or fission from primary beams accelerated by the FRIB SC-LINAC. In addition, ReA can also accelerate stable and long lived radioactive isotopes from local sources. In 2021, ReA was upgraded and can provide beam energies from 300 keV/u up to 6 MeV/u for ions with charge over mass equal to 1/4. Those beam energies are of particular interest for nuclear astrophysics.

This contribution will briefly describe the ReAccelerator, its capabilities as well as the process towards conducting an experiment, including the support available at FRIB.

This material is based upon work supported by the U.S. Department of Energy, Office of Science, Office of Nuclear Physics and used resources of the Facility for Rare Isotope Beams (FRIB) operations, which is a DOE Office of Science User Facility under Award Number DE-SC0023633

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Nuclear Astrophysics Landscape in Portugal

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This year, Portugal celebrates the 50^{th} anniversary of the democratic revolution and the pacific start of democracy. Ever since, the Portuguese science landscape has evolved enormously, with many high quality scientists educated outside the Portuguese borders establishing their research groups in universities and research centers, and bringing Portugal into the international scientific scene. However, the number of national networks in specific fields is scarce and most contributions to science are done by individual scientists or small groups. In this the field of Nuclear Astrophysics is not an exception.
In this presentation, I will introduce some of the current activities and research infrastructures related to the field of Nuclear Astrophysics in Portugal. Strong focus will be devoted to the participation in international networks, in which Portuguese scientists are involved. Complementarily, I will present recent efforts done in low-energy nuclear physics, aiming to push the involvement of the Portuguese groups in explosive nucleosynthesis studies (some of them also presented in this workshop).

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Welcome

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The first IANNA-IReNA workshop on new reaction rates for Nuclear Astrophysics is being organized as a collaboration between IANNA (Ibero American Network of Nuclear Astrophysics) and IReNA (International Research Network for Nuclear Astrophysics), with main co-sponsorship from IReNA.

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58Ni(3He,t)58Cu Measurements to Constrain the Astrophysical Rate of 57Ni(p,γ)

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The 57Ni(p,γ)58Cu reaction rate significantly impacts nucleosynthesis in a variety of astrophysical sites. In core-collapse supernovae (CCSNe) this reaction impacts the production of 44Ti, a radioisotope whose observed gamma-ray emissions offer an important probe into CCSNe, providing a test of nucleosynthesis models. Furthermore, the 57Ni(p,γ)58Cu reaction rate has been shown to significantly impact vp-process nucleosynthesis in multiple astrophysical environments. Despite the importance of 57Ni(p,γ)58Cu, no experimental rates exist for this reaction. To experimentally constrain this rate, structure properties of 58Cu were measured via the 58Ni(3He,t)58Cu reaction using both GODDESS (GRETINA ORRUBA Dual Detectors for Experimental Structure Studies) at Argonne National Laboratory's ATLAS facility and the Enge split-pole spectrograph at the University of Notre Dame's Nuclear Science Laboratory. These measurements provide precise determination of 58Cu level energies. This precision is crucial, as the reaction rate depends exponentially on these level energies. The two measurements also provide additional, complimentary structure information that impacts the reaction rate, such as level spin, proton branching ratios, and gamma branching ratios. Experimental procedures and preliminary analysis will be presented.

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Welcome 2

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The first IANNA-IReNA workshop on new reaction rates for Nuclear Astrophysics is being organized as a collaboration between IANNA (Ibero American Network of Nuclear Astrophysics) and IReNA (International Research Network for Nuclear Astrophysics), with main co-sponsorship from IReNA.
For the opening of the conferences, we will have short explanations about IRENA (James deBoer) and IANNA (Luis Acosta).
Local Chair and Chair of the workshop, respectively.

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Systematic optical potentials for cluster-structured nuclei reactions

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Within the IANNA framework, we propose new instruments for nuclear reactions measurements, systematical data and theoretical analyses. In Seville (Spain), we have the National Accelerator Centre (CNA), where a permanent experimental setup is coupled to the 3MV tandem accelerator. Such a setup is based on MARS (Modular Apparatus for nuclear Reactions Spectrometry). With MARS, first exploratory measurements are being performed to the 6Li+12C system. Within the IANNA collaboration, experimental campaigns on 12,13C+119,120Sn (2023) and 12,13C+64Zn (2024) were recently carried out in the LAFN (São Paulo, Brazil). Data analyses are ongoing.
With these data, we propose to study the optical potential (OP) strengths, and their energy dependence, in reactions involving stable, tightly and weakly bound, and exotic nuclei projectiles on different targets, at energies around the respective Coulomb barriers.
Moreover, we analyze experimental elastic scattering angular distributions of 4,6He, 6,7Li, 9,10,11Be and 8B impinging on 64Zn and 120Sn targets. Within the data set, we report on optical model (OM) calculations and the determined OP, with the respective uncertainties quantification, based on the double-folding (DF) São Paulo potential (SPP). Within the SPP approach, the best-fit parameters, from OP study, correlate with projectile breakup process, at scattering energies around the Coulomb barrier. Thus, we propose optimum energies for which the projectile breakup shows to be favored, as a function of the projectile breakup Q-value and the Coulomb barrier of the system. The results show to be systematical, when analysing different weakly bound nuclei projectiles impinging on targets with different masses (and atomic numbers). The OP and their capability of predicting optimum projectile breakup yields, as a function of energy, represents important tools for other applications such as planning new experiments on weakly bound nuclei reactions or extrapolating it to Astrophysical systems/energies.

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Extending radiative transfer simulations in kilonovae towards non-equilibrium regimes

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The recent observations of several neutron-star merger events and associated electromagnetic transients, particularly AT2017gfo observation, provided robust indications that heavy r-process elements such as lanthanides and eventually actinides can be synthesised in these explosive environments [1]. Nonetheless, pinpointing particular features in the spectra, and linking them to the absorption and emission lines of distinct elements has presented a significant challenge [2,3,4].

One critical obstacle in the analysis is a severe lack of atomic data required to model the expansion's late epochs (> 4 days after the NSM). While it is reasonable to assume that the matter is in local thermodynamic equilibrium (LTE) and that atomic absorption processes dominate in the early hours (< 1 day after the NSM), LTE cannot be assumed for nebular epochs (non-LTE). During these late stages, significant processes include photoionization, ionisation and excitation by electronic impact, and electronic recombination, for which data is scarce.

In this work, we focus on performing large-scale atomic calculations on selected key elements, which are likely to have identifiable features in the spectra of the kilonova AT 2017gfo. Our approach, is therefore aimed at extending existing radiative transfer simulations to non-local thermodynamic equilibrium (NLTE) conditions. We try to overcome the limitations of current models, which often rely on approximations, leading to significant discrepancies in predicting spectral features. As highlighted by recent studies, conventional approaches, such as the Axelrod Van Regemorter treatments, can under- or overestimate effective collision strengths by orders of magnitude [5], impacting the accuracy of the simulated spectra and the intensity of line features.

The core of the calculations were done using the Flexible Atomic Code (FAC) [6] employing a configuration interaction approach, and a central potential that is optimised iteratively, making use of machine learning methods to better reproduce existing experimental data [7]. As to benchmark our calculations, we also use the general non-relativistic AUTOSTRUCTURE code, which has been extensively used and tested for opacity calculations in supernovae.[8]

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Isomers in nuclear astrophysics

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Nuclear isomers are metastable states with long half lives compared to typical nuclear excited states. Given that the nuclear properties of isomers are usually very different from those of the ground state, isomers that remain metastable in astrophysical environments can play an important role in nuclear astrophysics. Nuclear reactions on isomers affect the energy release, nucleosynthesis path, and the rate of reactions in a specific isotope. The development of high-quality isomeric beams opens the possibility to probe the influence of nuclear isomers in stellar scenarios and provide experimentally constrained parameters to astrophysical reaction rates. In this talk, I will discuss some recent experimental efforts with isomeric beams and their relevance in astrophysical scenarios.

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How can inclusive Coulomb break-up measurements help in determining astrophysical radiative capture reaction rates?

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A direct link between the Coulomb inclusive break-up probability and the radiative capture reaction rate for weakly bound systems can be established [1]. This link provides an indirect method to estimate reaction rates of astrophysical interest. This procedure can also assess the validity of different theoretical approaches that have been used to calculate reaction rates. In particular, this procedure is useful for systems in which the relevant reaction cross section cannot be measured directly, or it is experimentally unfeasible at present, such as three-body reactions [2] or short-lived initial nuclei [3].
Results will be presented for the three-body radiative capture reaction rates ^{4}He($2n,\gamma$)^{6}He and ^{9}Li($2n,\gamma$)^{11}Li, for which inclusive break-up experimental data exist [4-6] and theoretical three-body models are developed [6,7]. For ^{6}He case, the available experimental data provide a reaction rate that is considerably larger than the theoretical estimation. For that reason, a new experiment has been carried out recently at TRISOL facility (NSL, University of Notre Dame) for the reaction of ^{6}He$+^{208}$Pb at an energy around the Coulomb barrier (approx. 21 MeV), paying attention to the possible overestimation of alpha production at forward angles. The analysis of this experiment is still ongoing.
Other systems of interest for possible applications will be discussed.
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Continuum energy representation to study structure and reaction properties of loosely bound nuclei

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The study of the properties of loosely bound or unbound nuclei required the explicit consideration of the continuum spectrum of energy since the Fermi level is close to or even in the continuum. The continuum's single particle level density, with the Fermi gas subtracted, encodes information about its resonant structure. The Berggren representation explicitly isolates the resonant contribution so that one may incorporate them in the Shell Model. This talk presents the Berggren representation and the Gamow Shell Model in the context of few and many-body systems. We will illustrate its application for the calculation of the alpha-spectroscopic factor of 44Ti, the location of the drip line in the calcium isotopes, and its incorporation in couple channel calculation, with the hope this tool will be helpful for astrophysical applications where the continuum is relevant.

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Unveiling Stellar Secrets: Advancements in Alpha-Induced Reaction Studies with the Multi Sampling Ionization Chamber Detector (MUSIC)

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Several α-induced reactions on both stable and radioactive isotopes play a crucial role in nuclear astrophysics, significantly contributing to the nucleosynthesis of light elements in the rapid neutron-capture process (r-process) within neutrino-driven winds post core-collapse supernovae and in X-ray burst nucleosynthesis. However, direct measurements of these reactions at relevant astrophysical energies pose significant challenges due to small cross sections and the complexities of handling low-intensity radioactive beams.

In this talk, I will present the Multi Sampling Ionization Chamber (MUSIC) detector, a detector designed for precise measurements of ionization energy loss in nuclear reactions. We'll explore MUSIC's principles, its role in studying α-induced reactions, and recent experimental highlights. Additionally, we will introduce AMENA, a more advanced version of the MUSIC detector, featuring significant technological enhancements. These improvements, combined with advancements in experimental techniques and radioactive ion beam facilities, open new opportunities for exploring these critical reactions, paving the way for future research in nuclear astrophysics.

This material is based upon work supported by the U.S. Department of Energy, Office of Science, Office of Nuclear Physics, under contract number DE-AC02-06CH11357. This research used resources of ANL's ATLAS facility, which is a DOE Office of Science User Facility.

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New progress in the experimental studies of the ^{46}Mn β^{+} decay channel

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The ^{44}Ti nucleosynthesis takes place in Core Collapse Supernova (CCSN) explosions, the final process suffered by stars with initial mass greater than 8 $M_{\odot}$. This, alongside its characteristic gamma decay chain, turns the isotope into a good gamma tracer of Supernovae events. Besides, the comparison between observations and models of the synthesized ^{44}Ti in CCSN gives important constraints to the models in which reaction networks are used for modeling nucleosynthesis occurring in the last stages of those stars with thermonuclear reaction rates as its inputs [1,2,3].

Indirect methods, such as the β-delayed proton emission, may help us to approach narrow isolated resonances which are very difficult to study in a direct way by the current nuclear laboratories. This is the case of the ^{45}V(p,γ)^{46}Cr reaction, one of the candidates to be sensitive to the nucleosynthesis of ^{44}Ti in CCSN explosions [1,4,5].

In the current work, we present the advances achieved at analyzing the ^{45}V(p,γ)^{46}Cr reaction by means of the ^{46}Mn β^{+} decay channel. For that purpose and to study the excited states of his daughter nucleus ^{46}Cr, the ^{46}Mn was selected among other species in the cocktail beam delivered by LISE fragment separator at GANIL (Caen, France). As part of our results, we present the proton and gamma emission peaks related to the ^{46}Mn decay and compare them with the work from references [6,7]. Also, we present a p-γ coincidence study to identify the processes linked to the γ emission. Furthermore, we compare the intensities obtained from the γ peaks with those of previous works [6].

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Nuclear Astrophysics at the Notre Dame Nuclear Science Lab

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There is a distinguished history of nuclear astrophysics research at the Notre Dame Nuclear Science Lab (NSL). This has been fostered by University investment and strong support from the National Science Foundation. The NSL provides the research base for some 20 Notre Dame faculty members and approximately 35 graduate students as well as supporting the research programs of a number of external users. The laboratory hosts a number of unique facilities and instruments that help facilitate astrophysical research such as the St. George recoil separator coupled to the high-intensity 5U accelerator, the worlds-only triple solenoid in-flight radioactive beam facility, and one of only three operating Enge split-pole spectrometers in the U.S. The NSL maintains three on-site accelerators, which can operate simultaneously and continuously as well as the only underground nuclear accelerator in the U.S. at the SURF facility in South Dakota. The current research program at the NSL will be presented along with plans for future instrument upgrades and additions.

Research supported by the National Science Foundation grant NSF PHY-2011890 and the University of Notre Dame.

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Discussion

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Measurements of capture cross sections for the γ-process using HECTOR

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The γ-process is a nucleosynthesis scenario that occurs during an explosion of a supernova and produces the proton-rich isotopes of elements between Se and Hg. The γ-process involves series of (γ,n), (γ,p) and (γ,α) reactions on pre-existing s-process seed nuclei. The reactions relevant for the γ-process can be studied in the laboratory via the inverse ones: the capture of protons or α-particles. For these measurements, the High EffCiency TOtal Absorption SpectrometeR (HECTOR) was developed at the University of Notre Dame.
HECTOR is a NaI(Tl) summing detector comprised of 16 separate NaI(Tl) crystals, each read by 2 photomultipliers. The array is designed for precision cross section measurements for (p,γ) and (α,γ) reactions across the γ-process Gamow window. The summing efficiency is a function of the total γ-ray energy and the average γ-ray multiplicity: for the ^{60}Co, source it is 52.7(2.0)% and for typical cross section measurements it ranges between 20-30%.
Here, an overview of the recent results obtained with HECTOR for A˜100 mass region will be presented. The experimental data will be compared to the Hauser-Feshbach model calculations using the Talys code and will be used to constrain the inputs for Talys to best reproduce the experimental data in the A˜100 mass region.
This work is supported by the NSF under grants number: PHY-1614442, and PHY-2310059.

Session 4 / 47

Present Facilities and instrumentation for nuclear physics in Mexico: More than 70 years of nuclear studies

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Since the 1950s, the development of nuclear studies in Mexico has had a notable presence at an international level. The proximity of important North American institutions has been, without a doubt, a determining factor in the development of nuclear sciences in Mexico. Many researchers of great relevance in the development of Nuclear Physics in Mexico for the second part of the 20th century have had some type of training or established some close collaboration with North American institutions. In the area of nuclear astrophysics, particularly during the 80s and 90s, and since the beginning of the 21st century and to date, close collaborations have been maintained between the University of Notre Dame, ININ and IFUNAM. Presently, this old collaboration has been extended to Spanish, Portuguese, Greek and Italian Institutions. At the same time, Mexico has a relevant infrastructure for carrying out low-energy measurements, with up to 5 active accelerators and a research reactor, as well as an enormous, fairly recent development of instrumentation, which includes supersonic jet targets, high segmentation detectors and digitizing data acquisition systems. In this talk, we will give some details of all these elements for research in low-energy nuclear astrophysics and also about previous and recent research.

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Experimental study of ^{6}He Coulomb breakup as an indirect measurement of ^{4}He$(2n,\gamma)^6$He reaction rate for the astrophysical r-process

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Compact binary mergers as Binary Neutron Star Mergers (BNSM) have attracted a lot of attention in recent years as the most likely site for r-process (rapid neutron capture) nucleosynthesis [1] and for the emission of gravitational waves [2]. Recently there has been reported experimental evidence of r-process nucleosynthesis in a BNSM identified as the origin of the gravitational-wave source GW170817 [3]. The nuclear reactions that describe the evolution of such systems involve thousands of nuclides following a complex network of capture and decay processes. Here, the main parameter determining the feasibility of the astrophysical environment to produce heavy elements by the r-process is the neutron-to-seed ratio (existing nuclei in the onset of the r-process, like ^{12}C). In this context, the three-body capture reaction ^{4}He$(2n, \gamma)^{6}$He are expected to be important in producing ^{12}C, thus playing a relevant role [4].
As part of a possible path to synthesize ^{12}C, a low mass seed nucleus of the r process, the collaboration has proposed the measurement of the ^{4}He$(2n, \gamma)^{6}$He reaction rate at the TriSol facility of the NSL laboratory at the University of Notre Dame [6,7]. The experimental approach adopted consists of measuring the Coulomb breakup channel in collisions of the system ^{6}He$+^{208}$Pb, that is, the ^{6}He$(\gamma, 2n)^{4}$He reverse reaction, applying the theoretical framework described in [7], which was developed by members of the collaboration.
The experiment was performed in June 2013. The energy of the ^{6}He beam was 19.3 MeV. The detection system was composed of six silicon telescopes available at NSL placed at forward angles (11 ° < θ_{lab}< 25 °). A 1.7 mg/cm^2 thick self supported enriched target of ^{208}Pb, made by the collaboration at the target laboratory in the University of Lisbon-LIP, was used. More details about the experimental setup and preliminary results of the undergoing data analysis of the experiment will be presented in this talk.

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The 9,11Li+64Zn experiment within a systematical nuclear reactions program

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Exotic nuclei play a fundamental role in the stellar processes, such as the r-process in the stellar nucleosynthesis. Their study on Earth allows us to test the validity of models used with stable nuclei in these species, in order to better understand such processes. In this talk, we will discuss the experiment S1847, where the 9,11Li + 64Zn reactions were measured, for the first time. We will present the experimental set-up used for these measurements, as well as the data analysis and the main preliminary results. Results will be compared with previous ones obtained for 9,11Li + 208Pb. Furthermore, we will compare the experimental data with different theoretical calculations, based mainly on different optical model (OM) approaches, assuming the double folding (DF) São Paulo potential (SPP). Beyond the exotic nuclei, light weakly bound nuclei are involved in numerous interstellar reactions, at low energies. In this talk, we will show the new research line of nuclear reactions experiments with weakly bound projectiles colliding on light targets, at energies around the Coulomb barrier, carried out at the National Accelerators Center (CNA) in Seville, Spain. This research line is part of a wider systematical study developed for exotic and stable, tightly and weakly bound, nuclei reactions performed within the Ibero American Network of Nuclear Astrophysics (IANNA) collaboration.

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Investigation of cluster structure effects in light nuclei with elastic scattering

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The description of the elastic scattering cross-section is very sensitive not only to the interaction potential between the projectile and the target nuclei, but also on and their structure. Therefore, elastic scattering measurements have been used to extract information about the dynamics and structures of the involved nuclei [1]. In this contribution, we are going to present the results of two of these elastic scattering measurements aimed to investigate the clustering structure in ^{12}N and ^{13}C nuclei. The first measurement, ^{12}N on ^{197}Au target, was performed at Cyclotron Institute of Texas A&M University, USA. The ^{12}N is a weakly-bound proton-rich nucleus, which can be described as a valence proton bound to a ^{11}C core (S_p=0.601 MeV). The ^{12}N radioactive beam was produced with the recoil separator MARS [2], using the ^{3}He(^{10}B,^{12}N) reaction, with an intensity of 1×10^3 pps and 73.3 MeV of energy. The detection setup consisted of three Double Sided Silicon Strip detectors (DSSD) with 128 vertical and 128 horizontal fixed strips segmented with 16x16 connecting 8 strips. The measured angular distributions, ranged from 40 to 130 degrees at laboratory system, will be present. Optical model calculations have been performed, and large total cross section was observed for this projectile. To investigate the breakup effect in the elastic scattering, we also performed continuum discretized coupled-channels calculations (CDCC) and results will be present. The second measurement consisted in the elastic scattering of the ^{13}C nucleus on ^{208}Pb target, performed at Tandar Laboratory, Argentina. Full angular distributions for the elastic scattering, ranging from θ_{Lab} = 30 to 150 degrees, were obtained at three, close to the barrier, energies, i.e., E_{Lab} = 59.8, 63.8 and 65.8 MeV. Results of the analysis with Optical Model, CC and CRC calculations, using the code FRESCO [3], will be present.

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A Target Design Laboratory for Nuclear Astrophysics Experiments

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Nuclear astrophysics is at the frontier between nuclear physics and astrophysics aiming to understand the creation of the elements in the universe. Nuclear reaction networks require the input from nuclear cross sections, which have to be determined experimentally by mimicking conditions similar to the ones encountered in the stars that is experiments in the low energy spectrum (generally below 10 MeV).

Although not generally at the center of a nuclear reaction experiment, target properties and characteristics are crucial for the ultimate success of any cross section measurement. With the goal of interacting with the end-user, aiming at the best possible reaction target production, we created the Target Design Laboratory (TDL) at LIP-Lisbon in Portugal. We have specialised ourselves in the production and characterisation of thin films with thicknesses in the order of hundreds of micrograms cm^{-2}, which are very suitable for many low-energy cross-section measurements.

In this contribution, I will present the current equipment available for target production at the TDL group; introduce the various techniques we have in-house and close-by for thickness and homogeneity characterization, and will discuss some examples of targets produced in the recent years for low-energy reaction experiments, with strong focus on nuclear astrophysics studies.

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Discussion

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(α, n) reactions at the University of Notre Dame

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(α, n) reactions are needed to model a wide range of physical process ranging from the amount of neutrons available for the astrophysical s-process to the neutron energy spectrum emitted from radioactive fuel storage containers. Yet the cross sections of these reactions often have large, or worse yet uncharacterized, uncertainties that result in inconsistency between model and direct measurement. By evaluating past measurements and through the increased accuracy of modern neutron transport codes, errors in the efficiency determination of many past experiments have been realized. In addition, many applications require not only the total reaction cross section, but the partial cross section to different final states, which could not be determined with the thermalized neutron counters used for the majority of past measurements. To improve on these past measurements, we have developed an efficient measurement technique at the University of Notre Dame Nuclear Science Laboratory using the combination of a high current accelerator, deuterated liquid scintillators, and spectrum unfolding. This has enabled us to obtain partial differential cross sections for the ^{13}C$(\alpha, n)^{16}$O reaction, which extend from laboratory α-particle energies of 0.8 to 6.5˜MeV in approximately 10˜keV energy steps at 18 angles between 0 and 160°, resulting in over 700 distinct angular distributions. These measurements not only cover a wide energy range but are also the first to extend below 1˜MeV. To demonstrate one impact of these data, we use these differential data to augment the previous state-of-the-art R-matrix fit of the low energy ^{13}C$(\alpha, n)^{16}$O reaction and use Bayesian uncertainty estimation to demonstrate that the differential data decreases the uncertainty by a factor of two, from ≈10\% to ≈5\% over the energy region of astrophysical interest.

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Nuclear reactions with weakly bound nuclei at energies near to the coulomb barrier

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In this work the experimental and theoretical study of 6Li, 10C + 58Ni systems is presented. On one hand, 6Li is a stable weakly bound nucleus, its α + d break-up threshold is 1.47 MeV. On the other hand, 10C is an unstable nucleus with excess of protons and can break into three possible channels: 2p + 8Be, with binding energy of 3.820 MeV, 9B + p with binding energy of 4.006 MeV; and 6Be + α with binding energy of 5.101 MeV, respectively. Lithium-6 and 10C beams were delivered by the TWINSOL facility, to induce the 3He(6Li,n)8B and 3He(10B,10C)3H nuclear reactions at the University of Notre Dame. A test experiment was performed with natural Ni and 58Ni targets (1.36 mg/cm2 and 0.924 mg/cm2 respectively) using 36 and 38 MeV for the primary 6Li beam, 47 and 54 MeV for primary 10B beam. The fusion excitation function for the 6Li + 58Ni system was measured at energies near and below the Coulomb barrier.
The procedure to deduce the fusion cross sections from the angular distributions measured for the evaporated protons from the compound nucleus was based using the proton multiplicity predicted by the PACE, LILITA and CASCADE codes. So far, elastic scattering measurements have been performed for the 10C + 58Ni system, but fusion will also be measured by detecting the respective evaporation protons. Additionally, coupled channel (CC) calculations of elastic scattering cross sections for the systems above mentioned were made.

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Beyond the Barrier: Exploring α-Nuclear Potentials with Exotic Heavy Nuclei

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The poor knowledge of the α-nuclear potential in unstable nuclei still dominates the uncertainties associated to the production of the heavy p-nuclei [1,2]. Calculations of the elastic scattering cross section at energies close to the Coulomb barrier based on global α-nucleus potentials differ up to a factor of 2 when moving towards unstable nuclei with higher proton-to-neutron ratios. The lack of experimental data in the region around the heavy p-nuclei does not contribute to solve this issue.

In this talk I will present the first measurement of the elastic scattering of α-particles on exotic heavy nuclei, concentrating on the Sn isotopic chain. The experiment, performed at the HIE-ISOLDE facility at CERN, profited from the use of innovative thin silicon films with high amounts of He [3] and the high intensity beams for the isotopes 108, 109 and 110-Sn produced at ISOLDE. In addition to the astrophysical context of the measurement, I will present the main properties of the films, introduce the experimental setup considered for the measurement, and will show the current status of the analysis performed to the data obtained. The results from this benchmark measurement will open the door to the study of α-nuclear potentials in exotic proton-rich nuclei, contributing to the reduction of the uncertainties in network calculation studies.

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