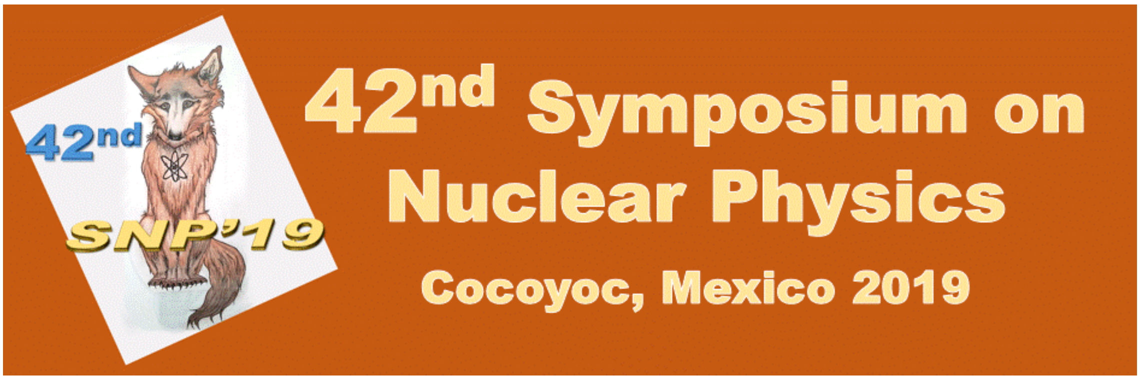

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Book of Abstracts

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TALKS

Recent results on heavy-ion induced reactions of interest for $0\nu\beta\beta$ decay

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Abstract
To determine quantitative information from the possible measurement of the $0\nu\beta\beta$ decay half-lives, the knowledge of the Nuclear Matrix Elements (NME) involved in the transition is mandatory. The NUMEN project proposes an innovative technique to access the NME using heavy-ion induced double charge exchange (DCE) reactions. The basic points are that the initial and final state wave functions in the two processes are the same and the transition operators are similar, including in both cases a superposition of Fermi, Gamow-Teller and rank-two tensor components. A key aspect of the project is the use at Laboratori Nazionali del Sud (LNS) of the Superconducting Cyclotron for the acceleration of the required high resolution and low emittance heavy-ion beams and of MAGNEX large acceptance magnetic spectrometer for the detection of the ejectiles. The concurrent measurement of the other relevant reaction channels allows to isolate the direct DCE mechanism from the competing multi-nucleon transfer processes. In the NUMEN framework, an experimental campaign has started at the INFN-LNS in Catania, using the MAGNEX spectrometer, focused on DCE reactions involving the nuclei of interest for $0\nu\beta\beta$ decay. New results obtained by the exploration of the (^{20}Ne,^{20}O) DCE reaction, measured for the first time using a ^{20}Ne 10+ cyclotron beam at 15 AMeV, on ^{116}Cd and ^{130}Te targets will be discussed.

Scalar current limits from the beta-neutrino correlation: the WISArD experiment

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2 CEN Bordeaux-Gradignan, France
3 LPC Caen, France
4 Rez, Czech Republic
5 Physics Institute, University of Giessen

Abstract

Beta-neutrino correlation measurements are key to research of physics beyond the Standard Model of particle physics. In pure Fermi beta transitions, the beta-neutrino correlation coefficient $a_{\beta\nu}$ is sensitive to the presence of scalar currents. Several experiments have been performed with this approach, with a measurement with ^{32}Ar β^{+} decay being one of the most precise case studies. An essential contribution to improve the constraints on scalar currents is being developed by the WISArD experiment at ISOLDE/CERN, where measurements of the energy shift of the β-delayed protons emitted from the isobaric analogue state of the ^{32}Ar ground state are performed. To enhance the sensitivity, protons and positrons are guided by a strong magnetic field and measured in coincidence with two different detectors located on both sides of a catcher foil in which the radioactive samples are implanted. Kinematic energy shifts of the protons in coincidence with positrons, in the same or opposite hemisphere of the catcher foil, will be more or less pronounced as a function of the possible scalar current component of the weak interaction. Details of the apparatus and preliminary results of the experiment will be presented.

Particle Decay of Astrophysically-Important Ne-19 States

D. Bardayan[1]

1 University of Notre Dame, USA

Abstract

The properties of excited Ne-19 states critically determine two astrophysically-important reaction rates: ^{15}O(α,γ)^{19}Ne and ^{18}F(p,α)^{15}O. The ^{15}O(α,γ)^{19}Ne rate strongly influences ignition conditions of the rapid-proton capture process in X-ray bursts while the ^{18}F(p,α)^{15}O reaction affects production of the radioisotope ^{18}F in novae. A better understanding of ^{19}Ne could therefore greatly aid in estimates of these two important astrophysical reactions. The relevant states in ^{19}Ne have been recently studied using the ^{20}Ne(p,d)^{19}Ne and ^{19}F(^{3}He,t)^{19}Ne reactions at Oak Ridge National Laboratory and Argonne National Laboratory, respectively. In the former case, α-decays have been detected in coincidence with reaction deuterons and particle-decay branching ratios can be extracted. In the latter case, decay γ-rays have been detected, which has greatly elucidated the level scheme. The experiments and initial results of the measurements will be presented.

Measurement of the Parity-odd γ-ray Asymmetry in the Capture of Polarized Neutrons on Hydrogen

L. Barrón-Palos[1]
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Abstract

NPDGamma is an experimental collaboration which for over 20 years has made an effort in research and development to measure the parity-violating gamma-ray asymmetry in the capture of polarized low-energy neutrons on hydrogen. This asymmetry is dominated by a $\Delta I = 1$ $^3S_1 - {}^3P_1$ parity-odd transition in the $n - p$ system. In the more traditional theoretical framework, the one-meson exchange model, developed in the 80's by Desplanques, Donoghue and Holstein (among others), this asymmetry is related to the weak pion-exchange coupling constant h^1_π, which characterizes the longest-range contribution in the Hadronic Weak Interaction (HWI). This system has the advantage of not being obscured by the lack of knowledge, to a sufficient precision, of nuclear wave functions; *ab initio* calculations are possible for the $n - p$ system. Additional scientific interest in this system comes from the fact that charged currents are suppressed in the $\Delta I = 1$ channel, so it constitutes one of the few systems available to study neutral currents at low energies. More modern theoretical approaches have implemented Effective Field Theories (EFT) in the study of the HWI. At low-energies, in the pion-less EFT, the weak interaction is characterized by five low-energy constants (LECs) related to the possible $S - P$ transitions, and in the expansion to infinite number of colors, N_c, applied to the HWI by Schindler, Springer and Vanasse, a hierarchization of the LECs has been achieved. Particularly, the LEC related to the

$^3S_1 - ^3P_1$ transition is expected to be suppressed. Testing large-N_c expectations is an important step towards a better understanding of the HWI. In this talk I will describe the different stages of the experiment and will present the final result achieved by the NPDGamma collaboration.

Odd-mass nuclei in the Cluster Shell Model

R. Bijker[1]
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Abstract

We present the Cluster Shell Model which is an analogue of the Nilsson model, but for cluster potentials. Special attention is paid to the consequences of the discrete symmetries of the geometric configuration of alpha particles for the cases of the dumbbell, triangle and tetrahedron. Each of these configurations is characterized by a special structure of the rotational bands which can be used as a fingerprint of the underlying geometric configuration. The model is applied to light odd-mass cluster nuclei.

State of the art measurements with TexAt - an active-target time projection chamber

J. Bishop[1], G. Rogachev[1], S. Ahn[1], E. Koshchiy[1], E. Pollacco[1], E. Uberseder[1], E. Aboud[1], M. Barbui[1], C. Hunt[1], J. Hooker[1], D. Jayatissa[1], S. Upadhyayula[1]

1 Cyclotron Institute, Texas A&M University, USA

Abstract

The TexAt detector, an active target time projection chamber has recently been commissioned at the Cyclotron Institute at Texas A&M University. The main purpose of this detector is for studying the structure of exotic nuclei as well as those pertinent to nuclear astrophysics. This talk will outline the functionality and capabilities of this detector, briefly discussing some novel uses to study fusion and beta-decay as well as more traditional thick target inverse kinematics experiments demonstrating the enormous flexibility of such a detector. Future plans and upgrades for this detector system will also be discussed.

Low energy accelerators in Mexico: Scientific programs and opportunities for collaboration.

E. Chávez[1]
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Abstract

Experiments in nuclear physics research have been conducted for quite long time in Mexico in two institutions: ININ (Instituto Nacional de Investigaciones Nucleares) and IFUNAM (Instituto de Fsica de la Universidad Nacional Autnoma de Mxico). ININ has the largest accelerator: an EN-Tandem (6 MV). IFUNAM has a CN-Van de Graaff (5.5 MV), a 3 MV Tandem and, most recently a 1 MV Tandem. Those laboratories will be described briefly, including their peripheral equipment: SUGAR (a supersonic gas jet target), an all-digital acquisition system (FEBEX), new Silicon Detection Arrays (DSSSDs) and others. The recent and current scientific programs in those facilities will be reviewed, with an emphasis on research related with nuclear science: Nuclear Astrophysics, Low-energy Fusion Reactions and Nuclear Structure.

Collective pairing effects and pair transfers between nuclei

O. Civitarese[1]
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Abstract

The treatment of pairing interactions in systems with a finite number of particles, like the atomic nucleus, was originally performed by applying the BCS transformations in the energy representation. An alternative method, formulated by de Gennes, introduces explicitly the radial dependence of the BCS-type solutions of the pairing force problem for superconductors. In this paper we explore the consequences of the use of de Gennes's formalism to calculate the pairing contribution to two-nucleon transfer amplitudes

Experimental Investigation of Helium Capture Reactions of Astrophysical Interest

M. Couder[1]
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Abstract

Helium capture reactions are taking place during various phases of stellar evolution, from the Helium burning phase of a star to the alpha-process during the thermonuclear runaway of an X-ray burst. In some environments, (α,n) reactions provide the neutrons needed for the s-process. The vanishingly small cross section of those reactions at relevant energies may be influenced by the presence of resonances close to, or below, the threshold. In this talk, we will focus on experimental methods to study radiative capture in inverse kinematics.

Pion induced Drell-Yan: the transverse momentum structure of the pion

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Abstract

We present a thorough analysis of unpolarized Drell-Yan (DY) pair production in pion-nucleus scattering. On the nucleus side, we use nuclear parton distributions along with parametrisations of the nucleon partonic transverse distribution available in the literature. Partonic longitudinal and transverse distributions of the pion are those obtained in a recent calculation in a Nambu-Jona Lasinio (NJL) framework, with Pauli-Villars regularization. The scale of the NJL model is determined with a minimisation procedure comparing NLO predictions based on NJL evolved pion distributions to rapidity differential DY cross sections data. The resulting distributions are then used to describe, up to next-to-leading logarithmic accuracy, the transverse momentum spectrum of dilepton pairs up to a transverse momentum of 2 GeV. With no additional parameters, fair agreement is found with available pion-nucleus data, confirming the virtues of the NJL description of pion parton structure. We find sizable evolution effects on the shape of the distributions and on the generated average transverse momentum of the dilepton pair. We furthermore discuss the possibility of gaining information about the behavior of the pion unpolarized transverse momentum dependent parton distribution from pion nucleus DY data.

Neutron Spectroscopy at the University of Notre Dame

R. J. deBoer[1], A. Boeltzig[1], M. Febbraro[2], K. L. Jones[3], K. T. Macon[1], and M. Wiescher[1]
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2 Oak Ridge National Laboratory, Tennessee, USA
3 University of Tennessee, Knoxville, USA

Abstract

The reactions ^{13}C(α,n)^{16}O and ^{22}Ne(α,n)^{25}Mg produce the neutrons for s-process nucleosynthesis during helium burning. The s-process proceeds by repeated neutron captures onto heavy seed nuclei already present in the stel- lar material. However, the amount of neutrons available is also determined by neutron capture reactions that occur on low mass nuclei that effectively poison the process. For example, the predominant poison is the ^{16}O(n,γ)^{17}O reaction. However, since these neutron captures are occurring in a helium rich environment, the ^{17}O may then undergo either the ^{17}O(α,n)^{20}Ne or ^{17}O(α,γ)^{21}Ne reaction. In the former case the neutrons get recycled back into the stellar environment, in the later case the poisoning remains effective. To study these types of (α,n) reactions in past experiments have often utilized high efficiency neutron counters. The drawback of such a detector is that no energy information is available. This has two main implications for the measurements. The first is that reactions on contaminants cannot be distinguished from those on the target material of interest. The second is that the cross section can not be accurately extracted if the reaction proceeds to multiple final states. This later difficulty is often the case for the reactions of interest as they usually have positive Q-values. To alleviate these issues, deuterated liquid scintillators have been utilized. These detectors

are sensitive to neutron energy, albeit with threshold and resolution limitations. In addition, a spectrum unfolding procedure is desired to more easily interpret the neutron yields. Complementing direct neutron spectroscopy, secondary γ-ray spectroscopy is also utilized when applicable. These techniques will be discussed and new measurements will be presented.

New experiment to constrain nuclear symmetry energy with heavy-ion collisions

D. Dell'Aquila[1] for the HiRA collaboration
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Abstract

Heavy-ion collisions (HICs) are unique tools to probe the properties of nuclear matter (i.e. its Equation of State, EoS) at supra-saturation and sub-saturation densities. The nuclear EoS is extremely relevant to several fields of physics including nuclear structure, nuclear dynamics and astrophysics. The density and momentum dependence of the isovector mean field (i.e. symmetry) potential of the EoS allows to connect properties of nuclear matter constrained in laboratory experiments to those of neutron stars. Observables related to collective emission properties of neutron and proton produced in HICs, such as kinetic energy and elliptic flow ratios, have been shown to be particularly sensitive to the EoS of asymmetric matter. Despite of its importance, the symmetry energy term is still poorly constrained away from the saturation density, demanding for new accurate experimental data. To place new constrains to density and momentum dependences of the isovector mean field potential of the symmetry energy, we have recently performed an experiment at the National Superconducting Cyclotron Laboratory (NSCL) of the Michigan State University (MSU) with the aim of studying differences in the collective emission of neutrons and protons produced in ^{40,48}Ca + ^{112,124}Sn and ^{40,48}Ca + ^{58,64}Ni collisions at 56 and 140 MeV/u. To enable the simultaneous detection of neutrons and light charged particles in a single experiment, we used a detection system involving the coupling of several detectors: the Washington University Microball to provide

impact parameter and reaction plane information, the upgraded high resolution array HiRA10 to detect light charged particles, the Large Area Neutron Wall (LANA) coupled with a charged particle veto wall to detect neutrons and an array of forward scintillators for neutron time of flight measurements. Details of the experiment and preliminary results of the analysis will be discussed in the talk.

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Nuclear Astrophysics deep underground and the LUNA experiment

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Abstract

The cross sections of nuclear reactions relevant for astrophysics are crucial ingredients to understand the energy generation inside stars and the synthesis of the elements. In stars, nuclear reactions take place at energies well below the Coulomb barrier. As a result, their cross sections are often too small to be measured in laboratories on the Earths surface, where the signal would be overwhelmed by the cosmic-ray induced background. An effective way to suppress the cosmic-ray induced background is to perform experiments in underground laboratories. LUNA is a unique facility located at Gran Sasso National Laboratories (Italy) and devoted to Nuclear Astrophysics. The extremely low background achieved at LUNA allows to measure nuclear cross sections directly at the energies of astrophysical interest. Over the years, many crucial reactions involved in stellar hydrogen burning as well as Big Bang Nucleosynthesis have been measured at LUNA. The presentation will provide an overview on underground Nuclear Astrophysics and discuss the latest results and future perspectives of the LUNA experiment.

The Interaction of Neutrons With ^{7}Be: Lack of Standard Nuclear Physics Solution to the "Primordial ^{7}Li Problem"

M. Gai[1]
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Abstract

The accurate measurement of the baryon density by WMAP renders Big Bang Nucleosynthesis (BBN) a parameter free theory with only inputs from measurements of the relevant (12 canonical) nuclear reactions. BBN predicts with high accuracy the measured abundance of deuterium, helion and helium relative to hydrogen, but it over-predicts the abundance of ^{7}Li relative to hydrogen by a factor of approximately three and more than three sigma difference from the observed value. This discrepancy was observed early on (approximately forty years ago) and has been dubbed the "Primordial ^{7}Li Problem". Several attempts to reconcile this discrepancy by destroying ^{7}Be with deuterons and helions or a conjectured d + ^{7}Be resonance were ruled out as solutions of the ^{7}Li problem. But the interaction of ^{7}Be with neutrons that are also prevailing during the epoch of BBN, was not directly measured thus far in the BBN window. Also, a hitherto unknown n + ^{7}Be narrow resonance in ^{8}Be at energies relevant for the BBN window was not yet ruled out. A worldwide effort for measuring indirectly [1] and directly the interaction of neutrons with ^{7}Be has evolved with measurements performed by the nTOF collaboration [2], and by measuring the time reverse process at Kyoto [3]. We discuss here a measurement of the Maxwell Averaged Cross Section (MACS) at the neutron facility at the Soreq Applied Research Accelerator Facility (SARAF) in Israel [4]. Only the SARAF measurement

covers the "BBN energy window" with T = 0.5 - 0.8 GK and kT = 43 - 72 keV. We deduced a significantly small upper limit on the ^{7}Be(n,α_0) reaction and the first measurement of the ^{7}Be(n,α_1)^{8}Be* (3.03 MeV) $\rightarrow \alpha + \alpha$ (E_α = 1.5 MeV). Our measurements allow us to re-evaluate the so designated "^{7}Be(n,α) reaction rate" first derived by Wagoner in 1969 and still used in BBN calculations. Measurement of gamma-decay of the 2- state ($\sim$ 10 keV above threshold) at 18.91 MeV in ^{8}Be reveal three almost identical strong E1 decays to the low lying 2+ states in ^{8}Be, indicating iso-spin allowed (T = 1) transitions.

Our measured MACS at the BBN window does not support the quoted extrapolated values [1-3] and in contrast we conclude an s-wave dominance of the interaction of neutrons with ^{7}Be. Our evaluated new rate demonstrates that the last possible avenue (of the n + ^{7}Be interaction) for a standard nuclear physics solution of the ^{7}Li problem does not solve the problem. We conclude on lack of standard nuclear physics solution to the "Primordial ^{7}Li problem".

*Work supported by the U.S.-Israel Bi National Science Foundation, Award Number 2012098, and the U.S. Department of Energy, Award Number DE-FG02-94ER40870.

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Neutrinoless-double-β-decay-Nuclear Matrix Elements via Heavy ion-β; Double Charge exchange

H. García-Tecocoatzi[1]
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Abstract

A Theory for Heavy ion-β; Double Charge exchange has never been developed. Recently, we have developed this theory [1] and in this contribution we give the explicit formulas in the low-momentum-transfer limit for the diffential crossection In this limit, i.e, at very forward angle, -for the first time- we show that the differential crossection can be factoried into a reaction part and a part that depends on the nuclear part, and -for the first time- that the nuclear transition matrix elements can be written as the sum of Double-β; Gamow-β; Teller (DGT) and Double Fermi (DF) type parts, and that they can both be further factorized in terms of target and projectile NMEs. Finally, we discuss the possibility of placing an upper limit on neutrinoless double-β;beta decay NMEs in terms of the DCE experimental.

Dark Particle Interpretation of the Neutron Decay Anomaly

B. Grinstein[1]

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Abstract

There is a long-standing discrepancy between the neutron lifetime measured in beam and bottle experiments. We propose to explain this anomaly by a dark decay channel for the neutron, involving a dark sector particle in the final state. If this particle is stable, it can be the dark matter. Its mass is close to the neutron mass, suggesting a connection between dark and baryonic matter. In the most interesting scenario a monochromatic photon with energy in the range 0.782 MeV - 1.664 MeV and branching fraction 1% is expected in the final state. We construct representative particle physics models consistent with all experimental constraints.

The nuclei ^{12}C, ^{16}O and thge role of the Pauli Exlcusion Principle

P. O. Hess, J. R. M. Berriel-Aguayo and L. J. Chávez-Nuñez[1]
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Abstract

We investigate the role of the Pauli Exclusion Principle (PEP) for light nuclei, at the examples of ^{12}C and ^{16}O. We show that ignoring the PEP does lead not only to a too dense spectrum at low energy but also to a wrong grouping into bands. Using a geometrical mapping, a triangular structure for ^{12}C and a tetrahedral structure in ^{16}O in the ground state is obtained by using the indistinguishably of the α-particles.

UCNτ: A New Approach for High Precision Determinations of the Free Neutron Lifetime

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Abstract

The neutron is an unstable but long-lived neutral baryon, characteristics that conspire to make it a versatile laboratory for testing the Standard Model at the precision frontier. Beta decay of the free neutron, for example, plays a central role in tests of symmetries that underlie fundamental particle interactions. The mean lifetime for free neutron decay is an interesting empirical target because it is an input to cosmological models, and in combination with other β-decay observables can provide sensitive tests for physical phenomena not currently included in the Standard Model. Theoretical uncertainties and uncertainties in astrophysical measurements make the interesting precision band for measurements of τ_n between 0.1% and 0.01%. Current experimental techniques have the capability to reach precisions in this range, but a clear application of the resulting measurements is hampered by a nearly four-sigma discrepancy between the two prevalent methods, called the "beam" and "bottle" techniques. The recent UCNτ result ($\tau_n = 877.7 \pm 0.7_{(\mathrm{stat})} + 0.4/-0.2_{(\mathrm{sys})}$) is of the latter type, and maintains the discrepancy between beam and bottle determinations despite using a large-volume magneto-gravitational trap which eliminates the dominant systematic effect in material bottle experiments and features new detection techniques that allow direct empirical characterization of residual systematic effects. This result has led to renewed interest in possible exotic explanations for the beam/bottle discrepancy. I

will describe the experimental developments leading to our new result, the current status of the UCNτ experiment, and our plans for future measurements.

Detector development for improving proton therapy outcomes

J. Holmes[1]
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Abstract

The challenge of any radiation-based treatment is to maximize the dose to the tumor while simultaneously minimizing the dose to everything else. Proton therapy is well suited to this challenge due to the way protons lose energy as they pass through matter. As the proton slows down, the amount of energy per unit path length that is deposited grows leading to a feature known as the Bragg peak. The protons stop inside the patient, focusing most of their energy deposition at the end of range. On paper, protons should be superior to the conventional method, x-ray therapy. However, due to the protons stopping inside the patient, uncertainty in exactly where the protons stop is introduced. This uncertainty causes doctors to take a very conservative approach in their treatment plans, thus reducing the advantages that protons have over x-rays. In order to retain the theoretical advantages proton therapy offers, new detectors are being developed to reduce the uncertainty in the range and fluence, which may ultimately improve patient outcomes. These detectors are being developed at Arizona State University in collaboration with the Mayo Clinic in Phoenix, AZ. Designs and results so far will be discussed.

Novae and supernovae investigation with the THM. Two case studies

M. La Cognata[1]
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Abstract

The Trojan Horse Method (THM) (see Ref. [1] for a review of the method) makes use of quasi-free reactions with three particles in the exit channel, a + A → c + C + s, to deduce the cross section of the reaction of astrophysical interest, a + x → c + C, under the hypothesis that A shows a strong x + s cluster structure. Thanks to the suppression of the a - x Coulomb barrier, the THM can be used to perform a full spectroscopic study of low-energy and sub-threshold resonances. In this presentation we will discuss the theory behind the method, to make clear its domain of applicability, the advantages and the drawbacks, and two experimental applications of this approach. In particular, we will focus on the latest stages of stellar evolution, leading to explosive scenarios. We will discuss the indirect investigation of the ^{18}F(p,α)^{15}O reaction, which is an important ^{18}F destruction channel in novae [2], and the ^{12}C + ^{12}C reaction, which plays a critical role in astrophysics to understand stellar burning scenarios in carbon-rich environments, including supernovae [3]. In the former case, we will show what changes are introduced by the Trojan Horse data in the ^{18}F(p,α)^{15}O astrophysical factor recommended in a recent R-matrix analysis [4], accounting for existing direct and indirect measurements [5]. We will particularly focus on the role of the THM experiment, since it allowed to cover the 0-1 MeV energy range with experimental data, with no need of extrapolation and with unprecedented accuracy (better than 20%). Also, the recent investigation of the ^{12}C

+ ^{12}C fusion reactions will be presented [5]. The THM was applied to the ^{12}C(^{14}N,α^{20}Ne)^{2}H and ^{12}C(^{14}N,p^{23}Na)^{2}H three-body processes at 30 MeV of beam energy in the quasi-free kinematical regime, where ^{2}H from the ^{14}N Trojan Horse nucleus is spectator to the ^{12}C + ^{12}C two-body processes. The ^{12}C(^{12}C,α)^{20}Ne and ^{12}C(^{12}C,p)^{23}Na cross sections at astrophysical energies were extracted, between 1 and 2 MeV center-of-mass energies, at odds with direct measurements stopping at 2.14 MeV, still at the beginning of the astrophysical region. A strong resonant behavior of the cross section associated to ^{24}Mg levels was observed causing a strong enhancement of the reaction at the relevant temperatures.

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^{8}B elastic scattering on ^{208}Pb at Coulomb barrier energies

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Abstract

The reaction dynamics induced by light weakly-bound Radioactive Ion Beams (RIBs) at Coulomb barrier energies has attracted the interest of the Nuclear Physics community for the last 25 years at least [1]. Compared to standard well-bound nuclei, breakup related effects largely enhance, especially at sub-barrier energies, the reaction probability for these RIBs and the investigation has moved towards understanding what processes are mainly responsible for the reaction cross section enhancement. Studies performed with n-halo nuclei indicated transfer channels as the most relevant reaction mechanisms at sub-barrier energies, while results for the interaction of the p-halo ^{8}B with ^{58}Ni showed an enhancement of the sub-barrier fusion cross section [2]. With the aim of shedding some light on this topic, we investigated for the first time the elastic scattering process for the reaction ^{8}B + ^{208}Pb at Coulomb barrier energies. The experiment was performed with the CRIB facility in Japan [3]. The study was integrated by the first measurement of the elastic scattering differential cross section for the system ^{7}Be + ^{208}Pb at three energies around the Coulomb barrier, being ^{7}Be the core nucleus of the weakly-bound p-halo nucleus ^{8}B (Sp = 0.1375 MeV). This second experiment was performed in Italy with the facility EXOTIC [4]. The collected data were analyzed within the framework of the optical model in order to extract the reaction cross sections. The comparison with the results obtained for reactions induced by other light weakly-bound nuclei indicates

an enhancement by a factor of 2 for the ^{8}B reaction cross section. Preliminary theoretical investigations suggest that this enhancement might be due to the breakup process $^{8}\mathrm{B} \rightarrow {}^{7}\mathrm{Be} + \mathrm{p}$.

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Analysis of states in ^{13}C and their cluster structure

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Abstract

Accurate studies on ^{13}C spectroscopy have great impact in the present understanding of the role played by extra-neutrons in stabilizing alpha-cluster structures formed in light nuclei. ^{13}C excited states are in fact the simplest systems that can be formed by adding a neutron to a triple-α molecular-like structure. Their spectroscopic properties are therefore a fundamental benchmark for theoretical models aiming at describing clustering in light nuclei. To improve our knowledge of ^{13}C structure, we performed a comprehensive R-matrix fit of α + ^{9}Be elastic and inelastic scattering data in the energy range $E_\alpha \approx$ 3.5-10 MeV at several angles. To carefully determine the partial decay widths of states above the α-decay threshold we included in the fit procedure also ^{9}Be(α,n$_0$)^{12}C and ^{9}Be(α,n$_1$)^{12}C cross section data taken from the literature. This analysis allows to improve the (poorly known) spectroscopy of excited states in ^{13}C in the $E_x \approx$ 12-17 MeV region, and tentatively suggests the presence of a large-deformation negative-parity molecular band.

On the nature of the Pygmy Dipole Resonance in ^{68}Ni

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Abstract

The Pygmy Dipole Resonance is an excitation mode connected to the neutron excess in nuclei, and its strength is more intense in nuclei far from the stability line with respect to the stable ones. The understanding of this mode is important also for the strong relation with the neutron skin and with the symmetry energy [1,2]. One of the major task of experimental and theoretical investigations is to determine a consistent density parametrization of the symmetry energy which can provide a unified picture of nuclear properties. Furthermore, the PDR might have an influence also on the astrophysical r-process [3]. In this framework, a better knowledge of the PDR properties could provide a link to understand the neutrons stars starting from the study of the neutron skin in nuclei, and it could provide information in the present multimessenger era. One of the most important feature of the PDR is the mixing of the isovector and isoscalar character, that allows to populate such mode by both isoscalar and isovector probes. The PDR has been investigated in a large number of stable nuclei and in few unstable

nuclei below the neutron emission threshold using both probes [1,4]. The comparison between these investigations reveals that only a group of states is excited by both isoscalar and isovector probes, whereas another group, at energies higher than the previous one, is populated only using the electromagnetic interaction. The investigation of the PDR in unstable nuclei was carried out in pioneering experiments performed at the GSI, using isovector probes [5-7]. In order to better understand the nature of the PDR and to verify if the isospin splitting is a common feature it is necessary to investigate the PDR using several probes, in different mass regions and in particular at energy above the neutron emission threshold. At LNS-INFN we performed an experiment aimed to study for the first time the pygmy decay in the ^{68}Ni at 28A MeV using an isoscalar target of ^{12}C. A ^{70}Zn primary beam was accelerated to an energy of 40A MeV, using the Superconducting Cyclotron (CS), and it impinged on a ^{9}Be target to produce the ^{68}Ni beam, delivered via the FRIBs@LNS facility [8]. The γ-decay channel of the PDR was studied using the CHIMERA multidetector [9], while the scattered ^{68}Ni ions were detected with the FARCOS array [10,11]. We report the results about the γ-decay channel of the PDR, recently published in [12]. Moreover, we present also some preliminary result about the neutron decay of the PDR.

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Probing explosive nucleosynthesis using direct reactions

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Abstract

The synthesis of heavy elements via the r-process involves extremely neutron-rich nuclei. Compared to light nuclei, our understanding of the properties of heavy, neutron-rich nuclei is sparse. The next generation radioactive ion beam facilities, like ARIEL (TRIUMF), FAIR (GSI) and FRIB (MSU) will offer unique possibilities to probe such nuclei. I will give a short overview about our current and future nuclear astrophysics program with reaccelerated beams at TRIUMF. The new TI-STAR silicon tracker detector, under development in an international collaboration at the University of Guelph and TRIUMF, is designed for experiments with heavy, exotic beams at the future ARIEL facility. TI-STAR coupled to the TIGRESS array of HPGe detectors and the new EMMA recoil separator will offer constraining neutron-capture rates in the A = 130 key region of r-process nucleosynthesis. In certain r-process scenarios, nuclear fission and fission-recycling influences the abundance distribution of elements in a major way. I will present our experimental program to study fission properties of A = 200 neutron-rich nuclei via quasi-free (p,2p) scattering using the R^3B experiment at FAIR.

Microscopically based energy density functionals for nuclei using the density matrix expansion

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Abstract

While ab-initio many body techniques have been able to successfully describe the properties of light and intermediate nuclei based on chiral effective field theory interactions, heavy neutron rich nuclei still remain out of reach for these methods. Conversely, self-consistent mean field approaches can be used to calculate heavy nuclei properties but rely on phenomenological interactions. In this work we present a usable form of the nuclear energy density functional that is rooted in the modern theory of nuclear forces. The first component of this functional is a non-local functional of the density and corresponds to the direct part (Hartree term) of the expectation value of local chiral potentials on a Slater determinant. A second component is a local functional of the density and is obtained by applying the density matrix expansion to the exchange part (Fock term) of the expectation value of the local chiral potential. We apply the UNEDF2 optimization protocol to determine the coupling constants of this energy functional. We obtain a set of microscopically-constrained functionals for local chiral potentials from leading-order up to next-to-next-to-leading order with and without three-body forces and contributions from Delta excitations. We also present validations of these functionals based on the calculation of nuclear and neutron matter, nuclear mass tables, single-particle shell structure in closed-shell nuclei and the fission barrier of ^{240}Pu.

^{19}F(α,p)^{22}Ne and ^{19}F(p,α)^{16}O Reaction Rate Measured via THM and Fluorine Nucleossynthesis

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Abstract

Cosmic origins of fluorine are still uncertain. Indeed its sole stable isotope, the ^{19}F, is produced in stars trough a very complicate network of reactions and it can be easily destroyed by both proton- and α-captures [1]. Asymptotic Giant Branch (AGB) stars have been proven to be sites of F production through spectroscopy observations by several authors ([2] and references therein). However, it is not clear whether these stars might account for fluorine abundance of the Galaxy and, in particular, of the solar neighborhood, for which the contribution from type-II supernovae has been definitively excluded by [3]. Very recently the two main channels for ^{19}F destruction in AGB stars, namely the ^{19}F(p,α)^{16}O and ^{19}F(α,p)^{16}O reactions, have been studied via the Trojan Horse Method [4,5,6,7] in the energy range of interest for astrophysics, not completely accessible by direct methods. In both cases experimental results have shown the presence of resonant structures below 500 keV never observed before, hinting to an enhancements in efficiency of fluorine destruction by stellar H- and He- burning. In particular the ^{19}F(p,α)^{16}O reaction rate at $T_9 \leqslant 0.2$ K turns out to be increased up to a factor of 1.7 while the ^{19}F(α,p)^{16}O is enhanced more than a factor of 4 at $0.1 \leqslant T_9 \leqslant 0.25$. We present here a re-analysis of the role of AGB stars as fluorine galactic source by comparing stellar observations with predictions of AGB nucleosynthesis (with masses from 1.5 to 5Mo) computed by employing in state-of-the-art models ([8,9] and references therein) the THM reaction rates

for ^{19}F destruction.

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Simulation study of the pbar p $\rightarrow$ Sigmabar Lambda channel at PANDA

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Abstract
The PANDA experiment will be part of the FAIR facility, currently under construction in Darmstadt, Germany. PANDA will be a fixed target experiment which will allow the study of non-perturbative phenomena of the strong inter- action, through antiproton-proton collisions in the momentum range of 1.5-15 GeV/c. Within the PANDA physics program, strangeness production will be addressed through pbar p $\rightarrow$ Hyperon Antihyperon processes. Measurements of the pbar p $\rightarrow$ Sigmabar Lambda channel for its comparison with the existing data of the Lambdabar Lambda channel are highly encouraged to study the role of isospin symmetry in hadron production dynamics. This work consists on a simulation study focusing on the feasibility of measuring the pbar p $\rightarrow$ Sigmabar Lambda channel at PANDA.

Underground Low-Energy Nuclear Astrophysics Studies

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Abstract

The drive of low-energy nuclear astrophysics laboratories is to study the reactions of importance to stellar burning processes and elemental production through stellar nucleosynthesis, over the energy range of astrophysical interest. As laboratory measurements approach the stellar burning window, the rapid drop off of cross-sections is a significant barrier and drives the need to lower background interference. This has highlighted the need for new approaches via higher intensity accelerators, more robust and isotopically enriched target material and lower background interference, to name a few. The natural background suppression of underground accelerator facilities enables the extension of current experimental data to the lower energies needed. New facilities around the world are coming on-line with a view to capitalizing on underground cosmic-ray suppression, each offering unique techniques and capabilities. This talk will highlight the advantages and challenges of such facilities.

Beta decay of Tz = -2 and Tz = -1 nuclei in the fp shell

B. Rubio[1]
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Abstract

I will present an overview of the physics case of the decay of even even Tz = -2 and Tz = -1 nuclei in the fp shell. The experiments started some years ago motivated by the idea of comparing these decays with the mirror charge-exchange reaction process on the mirror stable targets. Experiments have been carried out at GSI, GANIL and RIKEN. New results on the RIKEN experiments will be presented with particular emphasis on the decay of ^{64}Se, the heaviest Tz = -2 case where the decay still proceeds through a combination of beta-delayed γ-rays and β-delayed proton decay. This particular case presents a unique feature in the sense that the ground state of the daughter nucleus is the anti-analogue state of ^{64}Se, which is also reflected in the way it decays.

Search for gamma transitions from clustered states in ^{16}O*

P. Santa Rita[1], Tz. Kokalova[1], C. Wheldon[1], J. Bishop[1], N. Curtis[1], M. Freer[1], R. Smith[1], A. Turner[1], D. J. Parker[1], J. Walshe[1]
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Abstract

An overview of the ^{12}C(α,γ)^{16}O experiment at the University of Birmingham's MC40 cyclotron is presented in this work. The experimental set-up was a combination of the existing charged particle expertise and capability of the group and the ability to measure the emitted gamma rays using our new LaBr3 detector array. The motivation for this is to measure or put constraints on the B(E2)s for the ^{16}O nucleus. Such observations aid the assignment of rotational levels built on cluster configurations.

Heavy radioactive and Rare Earth elements in the geothermal microecology of the Los Azufres volcanic complex

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Abstract

Many of the fumaroles and hot springs of the Los Azufres geothermal complex situated in central Mexico, are characterized by high temperatures, high steam pressures, relatively high concentrations of noxious gases such as SO_x and H_2S, and very acidic waters (pH $\sim$ 2). Amongst higher organisms, only extremophilic primitive plants viz. mosses and ferns, have the capability to make such niches their habitats. The unspoiled amongst these microcosms mirror the plant-substrate landscape of the late Ordovician - early Devonian periods, $\sim$ 430 million years ago when these plants were the first land colonizers and were ubiquitous. Taking these microcosms as natural "laboratories" we have investigated the fractionation of heavy radioactive and rare earth elements between the plant tissue, the rhizospheric soil, the pure volcanic substrate and the hot-spring sediments, with the idea of understanding how biogeochemical processes versus the purely geochemical, contributed to pedogenesis and the biogeochemical recycling of these elements. The elemental analysis at trace (parts per million) level was carried out with the high sensitivity technique of Polarized Energy Dispersive X-ray Fluorescence (PEDXRF) spectrometry whilst for some elements instrumental Neutron Activation Analysis (NAA) was used. PEDXRF achieves near total cancellation of the background Bremmstrahlung continuum by double polarization of the primary X-ray beam through the

orthogonal optics between the X-ray source and the detector, leading to enhanced signal to noise ratios. We find that many of these elements are concentrated by these primitive plants in their tissue and rhizospheric soil at levels which even the aggressive chemistry of the harsh environment is not able to achieve. This suggests that biogeochemical processes were more important in the primitive geospheric surface than was previously believed and had shaped it to become a suitable crucible for the subsequent evolution of higher plants and animals. The details of this work will be presented at the 42^{nd} Symposium on Nuclear Physics at Cocoyoc, México.

Measurements of proton and alpha capture reactions for p-process nucleosynthesis using gamma-summing technique

A. Simon[1,3], C. Reingold[1,3], O. Gomez[1,2], A. Spyrou[2,3], F. Naqvi[1,3], A. Dombos[2,3], A. Palmisano[2,3] , T. Anderson[1,3], S. L. Henderson[1,3], S. Moylan[1,3], D. Robertson[1,3], C. Seymour[1,3], M. A. Skulski[1,3], M. K. Smith[1,2,3], E. Stech[1,3], S. Y. Strauss[1,3], B. Vande Kolk[1,3], W. P. Tan[1,3]

1 Department of Physics, University of Notre Dame, USA
2 National Superconducting Cyclotron Laboratory, Michigan State University, USA
3 Joint Institute for Nuclear Astrophysics-Center for the Evolution of the Elements, Michigan State University, USA

Abstract

The p-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 p-process involves series of (γ,n), (γ,p) and (γ,α) reactions on pre-existing s-process seed nuclei. The reactions relevant for the p-process can be studied in the laboratory via the inverse ones: the capture of protons or α-particles. For these measurements, the High EffiCiency 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 p-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%. The first measurements of the capture reactions on A $\approx$ 100 proton-rich isotopes will be presented in this talk. The results will be compared to the cross sections obtained with other techniques, when available, and to the Hauser-Feshbach model calculations us-

ing the Talys code.

This work is supported by the NSF under grants number: PHY-1614442 (Simon), PHY- 1713857 (NSL), PHY-1430152 (JINA-CEE).

A Study of Incomplete Fusion in Heavy Ion Reactions at Low Energies

B. P. Singh[1]
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Abstract

The reaction mechanism of heavy-ion interactions at low projectile energies is still not well understood. Both the complete as well as incomplete fusion of projectile have been observed at these energies. In the incomplete fusion (ICF), also referred to as the break-up fusion, a part of the incident ion fuses with the target nucleus while the remnant moves forward with the same velocity as that of projectile. Several models have been proposed, however, none of them could reproduce the data on ICF process at energies $\approx$ 4-7 MeV/n. In order to study the break-up fusion reactions and to study its influence on various entrance channel parameters, several experiments for the measurement of excitation functions, recoil range and spin distributions have been carried out using pelletron accelerator facility at the Inter University Accelerator Centre (IUAC), New Delhi, India. The analysis of data has indicated significant incomplete fusion contributions at these energies. Experimental data for a large number of projectile-target combinations has been used to develop systematics for incomplete fusion that may be useful for the development of a theoretical model for such reactions at low energies. The details will be presented.

Exploring nuclear structure and stellar helium burning with the HIgS Optical Time Projection Chamber

R. Smith[1]
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Abstract

Stellar helium burning results in the formation of carbon and oxygen [1]. However, the carbon-to-oxygen ratio at the end of helium burning is not well known, despite its importance in stellar evolution theory. The gamma-ray beam facility at HIgS (Duke University, USA) coupled with active target detectors, present an ideal opportunity for solving this problem, by allowing precise measurements of the cross sections for the ^{12}C(α,γ) reaction by measuring the reverse ^{16}O(γ,α) reaction. This talk will discuss the Optical Readout Time Projection Chamber (O-TPC) at HIgS [2] and the experiment that was performed to measure the photo-disassociation of ^{16}O. The experimental analysis so far will be discussed with a focus on the unique opportunity that this detector provides to precisely measure detailed angular distributions. Uncertainties in the current data and the extrapolation of the cross section to the astrophysical energy region will also be discussed.

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Neutron-induced reactions investigated via the Trojan Horse Method

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Abstract

The Trojan Horse Method has been applied to many neutron-induced reactions, using the deuteron as a virtual source of neutrons, to explore wide energy regions of interest for astrophysics and to investigate the suppression of the centrifugal barrier, that is one of the key advantages of this Method. The neutron-induced experimental campaign includes the ^{17}O(n,α)14C, ^{6}Li(n,α)^{3}H, ^{7}Be(n,p)^{7}Li and ^{7}Be(n,α)^{4}He, ^{14}N(n,p)^{14}C, while very recently ^{25}Mg(n,α)^{22}Ne and ^{27}Al(n,p)^{26}Mg, and others are planned to be measured soon, thus influencing different astrophysical scenarios. After mentioning the results from the experiments as above, I will concentrate on a new measurement regarding the ^{10}B(n,α)^{7}Li reaction, aimed to disentangle the ^{7}Li ground state contribution from its 1st excited state to the cross section.

Carbon burning in stars

W. Tan[1]
1 University of Notre Dame, USA

Abstract

Carbon and oxygen burning reactions, such as $^{12}C + {}^{12}C$, $^{12}C + {}^{16}O$, and $^{16}O + {}^{16}O$ are important for late stellar burning phases. The strength of these fusion reactions also determine the ignition, burning, and nucleosynthesis pattern in cataclysmic binary systems such as type Ia supernovae and x-ray superbursts. Various experimental work and developments related to measurement of these reaction rates have been carried out at University of Notre Dame. In particular, $^{12}C + {}^{12}C$ and $^{12}C + {}^{16}O$ fusion experiments with SAND (a silicon detector array) have been conducted using the high-intensity St. ANA accelerator and particle-gamma coincidence technique. New results on their cross sections at low energies relevant to nuclear astrophysics will be reported. Its impact on the carbon burning process under astrophysical scenarios will be discussed as well.

Constraining neutron-star equation of state using heavy-ion collisions.

B.Tsang[1]
1 NSCL/Michigan State University, USA

Abstract

The LIGO-Virgo collaboration's ground-breaking detection of the binary neutron-star merger event, GW170817, has intensified efforts towards the understanding of the equation of state (EoS) of nuclear matter. In this talk, I will show that the density-pressure constraint obtained from a recent analysis of the neutron-star merger event agree with the constraints obtained from heavy ion collision experiments published in 2002. To link nuclear physics to neutron star physics, we use a neutron star model that calculates properties of 1.4 solar-mass neutron stars using a large collection (> 200) of Skyrme density functionals that have been shown to describe properties of nuclei. Restricting this set of Skyrme equations of state to density functionals that describe nuclear masses, isobaric analog states, and low energy nuclear reactions (i.e. below saturation density) does not sufficiently restrict the predicted neutron-star radii and the tidal deformability. However, around twice saturation density ($2\text{x}2.74\text{x}10^{14}$ g/cm^3), which can be created in high energy nucleus-nucleus collisions, there is strong correlation between experimental measurements of pressure and the neutron-star radii and tidal deformabilities. I will discuss how new measurements of nucleus-nucleus collisions can improve these constraints on the EoS.

Selected topics and results of nuclear physics

K. Zuber[1]
1 Technische Universitat Dresden, Germany

Abstract

In this talk 3 topics will be tackeled:

1) The first part is providing new long-living half lives or alpha-, beta- and double beta decays together with an outlook.

2) The second part will describe some selected results from the Penning trap ISOLTRAP at CERN. This includes results from topic 1, nuclear structure and -astrophysics results.

3)Status of the Felsenkeller Underground accelerator for Nuclear Astrophysics.

POSTER SESSION

QCD at low energies using many body methods

G. A. Alcántara-Marín[1]
1 Instituto de Ciencias Nucleares, UNAM, México

Abstract

In this work, the meson spectrum at low energies obtained by applying RPA method to a QCD motivated effective Hamiltonian is presented and compared with experimental data, a resume of the model is described explaining its advantages respect to other models.

Semi-Microscopic Algebraic Cluster Model applied to ^{16}O

J. R. M. Berriel-Aguayo[1]
1 Instituto de Ciencias Nucleares, UNAM, México

Abstract
Used SACM to ^{16}O and used a system of 4α-clusters. It was obtained a microscopic model space for the 4α-clusters system, which observes the Pauli-Exclusion-Principle.

Influence of pairing forces on Gamow-Teller transitions for nuclei in the fp shell

A. Carranza-Melgarejo[1]
1 Instituto de Ciencias Nucleares, UNAM, México

Abstract

The influence of the isoescalar and isovectorial pairing forces in Gamow-Teller (GT) transition strength was analyzed, employing a schematic Hamiltonian that includes quadrupole-quadrupole, spin-orbit interaction and the two pairing forces. Extending previous results on the energy spectrum and B(E2) transition intensities (Y. Lei et al, Phys. Rev. C 84, 044318 (2011)), we assess the role of the various modes on GT transition strengths. The results show the great influence of the spin-orbit interaction for the fragmentation of the energy levels, the relevance of the isovectorial pairing on the intensities and the bounds on the isoescalar pairing contribution, which tend to close the energy gap between the ground state in the even-even nuclei and the first 1+ state in the odd-odd neighbor nuclei.

Carbon-12 within the Semimicroscopic Algebraic Cluster Model

L. J. Chávez-Nuñez[1]

1 Instituto de Ciencias Nucleares, UNAM, México

Abstract

The Semi-microscopic, Algebraic Cluster Model (SACM) is applied to ^{12}C as a system of three α clusters. A microscopic model space for the 3α cluster system is used , which observes the Pauli Exclusion Principle (PEP) and is symmetric under permutation of the 3α particles. A phenomenological Hamiltonian is used , justifying the name Semi. The experimental spectrum is well reproduced . The geometrical mapping is discussed and it is shown that the ground state corresponds approximately to a triangular structure, which is consistent with other microscopic calculations. The non-zero B(E2; 0 + 2 $\rightarrow$ 2 + 1) transition requires a mixing of SU(3) irreducible representations (irreps) whose consequences are discussed. The Hoyle state turns out to contain large shell excitations. The results are compared to another phenomenological model, which assumes a triangular structure and, using simple symmetry arguments, can reproduce the states observed up to now at low energy. This model does not observe the PEP and one objective of our contribution is to verify the extent of importance of the PEP

Development and characterization of plastic scintillators detector at iThemba LABS for β-decay studies

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2 University of the Western Cape, South Africa

Abstract

Nuclear β decay studies in experimental nuclear physics provide the essential knowledge of the unstable neutron rich nuclei. To obtain the parameters from β spectroscopy, various instrumental and software techniques for e.g., β-γ coincidence and β-γ angular correlation, etc [1, 2] were employed in the different laboratories. Present work consists of development, performance evaluation of the plastic scintillation detectors (anthracene) in order to obtain the experimental conditions for nuclear β decay studies. A set of radioactive β, γ sources (^{207}Bi, ^{133}Ba and ^{137}Cs) were used for energy calibration. The energy dependence of scintillation detector response and its limit sensibility for β radiation were compared with MCNPX code. By matching the Compton peak of the convoluted form of the calculated spectrum with the measured one, the actual position of the Compton edge will be determined. Light output characteristics of scintillator and calibrated are in good agreement with MCNP simulated spectra.

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Observation of fission modes in ^{225,227}Pa and ^{249}Bk nuclei

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Abstract

Fission properties of the heavy nuclei at low energies are always remain topic of research interest since discovery of first fission. Understanding of the measured fission variables are widely applicable and discussed in the various areas of science, technology, and medicine. Symmetric-asymmetric division of mass and total kinetic energy (TKE) are found to be one of the slient feature of the fission mechanism [1]. In the fission of nuclei mass A $\approx$ 226 (Z = 89-92) and other end of actinide chart in the same nuclei, sudden change in the nature of fission modes with the nucleon numbers are observed in their mass-TKE measurement. For e.g., TKE difference in the fission of isotope of ^{256,258}Fm are observed and linked to two different modes[2]. Fission of actinide nuclei produced through the fusion of heavy nuclei exhibit roughly cluster ^{132}Sn-like fragment and other one deformed fragment with mass number. In present work, we are attempted to measure the fragments velocity, total kinetic energy, mass yield for ^{225,227}Pa, ^{249}Bk around capture barrier energies by employing the time-of-flight techniques. These nuclei are produced with fusion of ^{19}F + ^{206,208}Pb, From the obtained results, the nature of fission modes in ^{249}Bk, ^{225,227}Pa nuclei almost under identical conditions matching their angular momenta and excitation energies and entrance channel dependences and ^{11}B+, ^{238}U $\rightarrow$ ^{249}Bk, ^{238}U has a static prolate deformation of β_2 [3] will

be investigated.

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Entropy and quantum coherence in the atomic nucleus

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Abstract

Entropy is a thermodynamic quantity related to the complexity of a system. Although the atomic nucleus is a system with very few particles, the concept of entropy does not lose generality if we study it in terms of quantum coherence. In this work we present both quantities: Entropy and quantum coherence of nuclear states corresponding to intermediate energy levels in the nucleus of ^{48}Ca. We can observe, as expected, that entropy has a reverse behaviour to the coherence of the nuclear states at the representation of the nuclear shell model.

Phase transitions within the Semi-Microscopic Algebraic Cluster Model

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Abstract

The catastrophe theory, an effective method for the description of phase transitions, is applied to the Semi-Microscopic Algebraic Cluster Model (SACM). The ground state and excited, rotational phase transitions for systems of two spherical clusters are investigated. The test case $^{16}\mathrm{O} + \alpha \rightarrow {}^{20}\mathrm{Ne}$ is considered.

Construction of the mechanical system for SIMAS array, a device for low energy spectroscopy

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Abstract

The main features of the mechanical SIMAS system are described, based on structures constructed in 3D printing and pieces machined with high precision systems. The first prototype of SIMAS is composed by 2 E-ΔE telescopes. The device allows the correct positioning of each detector, a comfortable and safe assembly, to be adapted to the signal redout system, based on high density and low noise wiring. Each SIMAS telescope have 32 + 1 signals, and consists of Double-Sided Silicon Strip Detectors of 16x16 strips (20 microns) and PAD detectors (135 microns), with 5x5 cm of active area. The main characteristics of the mechanical design are described on this work.

Electromagnetic Couplings of Heavy Baryons and Pentaquarks

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Abstract

In this work I present an extension of the conventional quark model to four flavors in order to classify the ground states of baryons with content qqb and pentaquarks with qqqc and anticharm. Additionally, the deformed quark model is implemented to explicitly consider the mass difference between the light and heavy quarks, for the excited states of baryons. Finally the electromagnetic couplings of interest are calculated for heavy baryons and pentaquarks.

A search for the ^{6}He fragmentation channel in ^{4}He at small angles around the Coulomb barrier

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Abstract

The ^{6}He is a nucleus that is characterized by having a halo of 2 neutrons sensibly separated from a core of ^{4}He. And in dispersion to energies around the Coulomb barrier, it presents serious changes when compared with its simile, the ^{6}Li. It is evident that the presence of the neutron halo strongly contributes to alterations in its dispersion, particularly at large angles. But also the behavior of breakup around the Coulomb barrier begins to be present at very small angles, demonstrating the weak bond of the neutrons of the halo. In this work, we present the first conjectures that were made for the search of the breakup channel for small angles around the Coulomb barrier. With these measures we sought to discern the experimental needs to make an exclusive measure of this channel.

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Characterization of the new hybrid low-energy accelerator facility in Mexico

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Abstract

In 2013, a new AMS facility was inaugurated in Mexico. Since then a good number of precise measurements of low concentrations of radioactive isotopes (^{14}C, ^{10}Be, ^{26}Al and Pu) have been made. This paper describes an extension to the isotope separator installed by the end of 2017. It takes advantage of the 1 MV High Voltage Engineering Europa (HVEE) tandem accelerator with the multi-cathode ion source (MCIS) and the fine-tuned injection system to deliver low energy beams into a multi-purpose scattering chamber. The MCIS allows for a very quick and smooth change of the ion species to be accelerated. The ability to automatically tune all the optics in the injection system produces an accelerator laboratory that can change the beam species, intensities and energies in seconds. The very careful and detailed study of the high energy analyzing magnet using well know proton resonances in ^{12}C and ^{28}Si, allowed us to calibrate the Terminal Voltage and the beam energy. Stable Ion beams with energies as low as 300 keV and as high as 8 MeV from H to Fe with intensities between 109-1015 particles per second were produced, as listed.

Observation of fission events in $^{14}N+^{181}Ta$ system at projectile energies ≈ 5-6 MeV/A

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Abstract

Measurement of production cross-sections of fission residues in heavy ion (HI) interactions, have been extensively carried out during the last few years. Reactions induced by HIs are important, because large input angular momentum is involved and, therefore, the composite system can be produced with relatively high spin. The resultant composite system formed via complete and/or incomplete fusion processes may attain thermodynamic equilibrium and at later stages the compound nucleus may de-excite via the emission of light nuclear particle(s), the characteristics γ-rays and/or may also undergo fission depending on the available excitation energy, angular momentum, entrance channel mass asymmetry, etc. [1, 2]. The development of future nuclear power reactors with applications of hybrid technologies using accelerator based incineration systems [3] require knowledge of precise experimental cross-sections of such nuclear reaction products in a wide range of energy and projectile-target combinations. In view of the above, experimental studies for ^{14}N + ^{181}Ta system have been performed at the Inter University Accelerator Centre (IUAC), New Delhi, India using the recoil-catcher technique followed by off-line γ-spectroscopy. In the present work, production cross-sections of ≈ 22 fission fragments produced in ^{14}N + ^{181}Ta interaction have been measured at four set of incident energies. The mass distribution of fission products is one of the important observables directly related to the collective dynamics of processes [4]. In the present work the

measured mass distribution of fission fragments have been found to be almost symmetric, as expected. Further, in some cases several isotopes of a given element have been found to be populated. The yield distribution are found to be of Gaussian shape. Furthermore, the variance ($\sigma 2$) of the isotopic yield distributions obtained in the present measurements agree closely to the literature values [5] for other fissioning systems. The present experiments at low energies ($\approx$ 5-6 MeV/A) indicate that apart from complete and incomplete fusion processes [6], fission of the excited composite system is also quite significant. As such, contribution of fission should also be taken into account while predicting the total reaction cross sections. Additional information on various observable of fusion-fission reaction dynamics may be obtained by measuring the angular distribution of the fission fragments. The details of the present measurements will be presented.

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Abstract

Spectra of ordered eigenvalues of finite random matrices are studied as a time series [1, 2, 3]. In particular, by applying the singular value decomposition (SVD) method directly to spectra of random matrices of standard Gaussian ensembles [1, 2], and also to nonstandard random-matrix ensembles such as the β-Hermite ensemble and the sparse matrix ensemble [3], a decomposition of each eigenspectrum, E(n), in trend and fluctuation modes (which can be considered as a generalization of the periodic modes of the Fourier analysis), i.e., a decomposition in a global and local part, E(n) = $\overline{E}$(n)+ $\widetilde{E}$(n), from GOE to Poisson statistics, based on the behavior of the fluctuation modes, which can be scale invariant and follow a power law, or exhibit a crossover between those two limits, is obtained in a direct way without performing the technical step known as unfolding.

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Beam current integration for charged particle accelerators using a beam profile monitor

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Abstract

Nuclear physics experiments in which cross sections are measured at energies lower than the Coulomb barrier become low-count experiments. Since counting time in such an experiment may become extremely long, it needs to be minimized. This period of counting is influenced by the beam, likewise the statistics. Thus, using an intense beam becomes crucial, so that the incidence rate of particles per unit area and per unit of time is optimized. Using backscattering as a method for current integration may not be the best option since detectors could be damaged by the continuous incidence of particles. We expose a method where a beam profile monitor (BPM) is used as current integrator, as it provides the facility of obtaining information of the beam's current by sweeping it 18 times per second and producing, as a result of the incidence of the beam on the BPM, a quantity of electrons proportional to the intensity of the beam.