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Physics Department, Aristotle University of Thessaloniki

HINPw2

Book of Abstracts

- Nuclear Reactions
- Nuclear Structure & Dynamics
- Hadronic Physics
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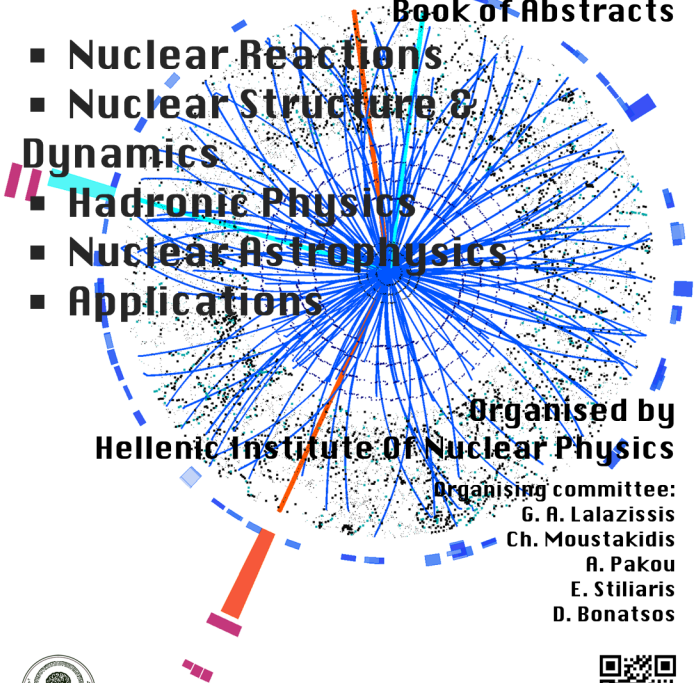

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Research Activities of the "Institute of Research into the Fundamental laws of the Universe"

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Abstract

I will present a general talk on the research activities of the "Institute of Research into the Fundamental laws of the Universe" (IRFU). The presentation will also provide an insight of the French scientific landscape in the domain of Nuclear Physics and its applications as well as general information about the French educations and research system.

Fast Neutron Spectroscopy With the Spherical Proportional Countert

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Abstract

A novel large volume spherical proportional counter has been developed, for neutron measurements. Gas mixtures of N_2 with C_2H_6 and pure N^2 have been studied for thermal and fast neutron detection, providing a new way for the neutron spectroscopy. The neutrons are detected via the ^{14}N(n,p), ^{14}C and ^{14}N(n,α) B11 reactions. In this presentation we have been studied the optimum gas mixture, gas pressure and also the optimum high voltage supply on the sensor of the detector, to achieve the maximum amplification and better resolution. The detector has been tested for thermal and fast neutrons with a ^{252}Cf and a ^{241}Am neutron source. The atmospheric neutrons have been successfully measured from thermal up to several MeV, well separated from the cosmic ray background. The result is promising and opens the way for contemporary neutron spectroscopy.

Elastic scattering measurements for the system ^{7}Be+^{28}Si at near barrier energies.

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Abstract

Elastic scattering angular distribution measurements for the system ^{7}Be+^{28}Si were performed at EXOTIC facility - Laboratori Nationali di Legnaro (LNL). The various ejectiles were collected in an angular distribution measurement using the detector array EXPADES (Exotic Particle Detection System). Preliminary results for the energy of 17.2MeV will be presented and discussed.

Acknowledgments

The research leading to these results has received funding from the European Union Seventh Framework Programme FP7/2007-2013 under the Grant Agreement no. 262010-ENSAR.

The first part of LIPMAGNEX experiment: Elastic scattering measurements at near barrier energies for ^{6}Li + p.

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Abstract

Elastic scattering measurements have been performed for the system ^{6}Li + p in inverse kinematics at the energies of 16, 20, 25 and 29 MeV. The heavy ejectile was detected by the large acceptance MAGNEX spectrometer at the Laboratori Nazionali del Sud (LNS) in Catania, Italy. Preliminary results will be presented and discussed.

Acknowledgments

The research leading to these results has received funding from the European Union Seventh Framework Programme FP7/2007-2013 under the Grant Agreement no. 262010-ENSAR.

Study of ^{nat}Mg(d,d_0) reaction at detector angles between 90° and 170°, for the energy range $E_{d,lab}$=1660-1990 keV

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Abstract

In the present work, the detailed study of the ^{nat}Mg(d,d_0) is presented for the energy range $E_{d,lab}$=1680-2000 keV (in steps of 5 keV) and for detector angles between 90° and 170°. Elastic scattering data for two forward angles (55° and 70°) were also obtained. The results of the present work are complementary to the recently published ^{24}Mg(d,$p_{0,1,2}$) reaction cross section data utilising the simultaneous depth profiling study of magnesium by d-NRA and EBS methods.

Enhanced proton-neutron interactions and emergent collectivity in nuclei

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Abstract

Enhanced proton-neutron interactions occur in heavy nuclei along a trajectory of approximately equal numbers of valence protons and neutrons. This is also closely aligned with the trajectory of the saturation of quadrupole deformation. The origin of these enhanced p-n interactions is discussed in terms of spatial overlaps of proton and neutron wave functions that are orbit-dependent. It is suggested for the first time that nuclear collectivity is driven by synchronized filling of protons and neutrons with orbitals having parallel spins, identical orbital and total angular momenta projections, belonging to adjacent major shells and differing by one quantum of excitation along the z-axis. These results may lead to a new approach to symmetry-based theoretical calculations for heavy nuclei.

Acknowledgments

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Quantum Phase Transitions and Conformality in nuclear structure

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Abstract

The $E(5)$ symmetry [1] and the 2nd order shape/phase transition [2] of the Interacting Boson Model [3] will be discussed after the appearance of conformality in the Bohr model [4, 5].

Acknowledgments

Many useful discussions with Piet Van Isacker, Dennis Bonatsos and Francesco Iachello are gratefully acknowledged.

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Transition from octupole deformation to octupole vibration in light actinides

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Abstract

The analytic quadrupole octupole axially symmetric model (AQOA) has successfully predicted that the light actinides ^{226}Ra and ^{226}Th lie at the border between the regions of octupole deformation and octupole vibrations. This collective model is applicable to a wider region of nuclei exhibiting octupole deformation, through the use of a Davidson potential, $\beta^2 + \beta_0^4/\beta^2$ (AQOA-D). Analytic expressions for energy spectra and B(E1), B(E2), B(E3) transition rates are derived. The spectra of $^{222-226}$Ra and ^{224,226}Th are described in terms of the two parameters ϕ_0 (expressing the relative amount of octupole vs. quadrupole deformation) and β_0 (the position of the minimum of the Davidson potential), while the recently determined B(EL) transition rates of ^{224}Ra, presenting stable octupole deformation, are successfully reproduced. A procedure for gradually determining the parameters appearing in the B(EL) transitions from a minimum set of data, thus increasing the predictive power of the model, is outlined.

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Exclusive muon capture rates

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Abstract

We evaluate exclusive rates of the ordinary muon capture on light- and medium-weight nuclear isotopes with state-by-state nuclear structure calculations. We employ a version of the proton-neutron quasi-particle random phase approximation which uses as realistic nuclear forces the Bonn C-D. We focus on the portion to the total μ^--capture rate of multipole transitions for specific low-spin multipolarities.

One of the main goals of this work is to provide reliable descriptions of the charged-current transition matrix elements entering similar semileptonic nuclear processes like the electron capture on nuclei, single $\beta^{\pm}$-decays and charged current netrino-nucleus reactions which play important role in currently interesting Astrophysical applications as the neutrino nucleosynthesis.

Acknowledgments

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Energy Recover from PileUp Events in Silicon Detectors

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Abstract

An experimental technique is described in the present work capable to identify pileup events and to reconstruct the hidden energy information. The procedure is based on the pulse shape analysis of digitized signals with the help of a high frequency, fast and sensitive flash ADC. The CAEN module V1729A, operating at a maximum sampling rate of 2 GHz has been successfully used in a recent experiment performed at the INFN-LNL EXOTIC facility, Padova, with an incident ^{8}B beam near barrier energies (E_L=25-40 MeV) on a three stage Si telescope. The nature of the unstable beam nucleus, which decays in ^{8}Be and consequently in two alphas, necessitates the usage of appropriate pileup rejection techniques. The proposed offline algorithmic approach has efficiently identified all the recorded pileup events and in most cases has successfully reconstructed the energy information of the overlapping signals. Details of the applied technique with energy reconstruction examples for normal and pileup events are discussed in the present work.

REC3D: An Accumulative Reconstruction Algorithm based on Volume Intersectional Information for PET

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Abstract

A new PET image reconstruction algorithm from raw data, based on analytical geometry relations and without *a priori* image information, is presented in the current study. The REC3D algorithm transforms the difficult mathematical problem of the PET image reconstruction in a simple geometrical one. The developed technique utilizes the accumulated ray density distribution in a predefined voxelized volume with appropriate dimensions which covers a given field of interest. The density distribution is the accumulation product of a geometrically weighted intersection of the annihilation line, as it is defined by the detected position of the two anti-diametrically emitted annihilation photons, with all the affected voxels. The final 3D tomographic image is created by properly interpreting the voxelized slices of the predefined volume. The algorithm is computationally optimized using an acceleration method, which scans only the affected voxels along the Line of Interest (LOR) in a continuous way. Following this technique for each pair of the detected annihilation photons, the computational time is reduced significantly. The efficiency of this method is evaluated with several phantoms simulated inside the GEANT4/GATE environment and the reconstruction results are compared with other widely used analytical and iterative algorithms.

Time Resolved Optical Tomographic Imaging
A Simulation Study

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Abstract

The Single Photon Emission Computed Tomography (SPECT) is unambiguously a powerful technique in modern physiological and functional Nuclear Imaging. Nevertheless, anatomical information of the surrounding tissue structure is basically limited by this modality. SPECT can therefore be supported by a non-ionizing, low cost and compact scheme such as a Time Resolved Optical Tomographic (TROT) modality. The current work focuses on the feasibility of a TROT system by utilizing the DETECT2000 software package, which is a Monte-Carlo simulator developed for the study of the optical light transportation inside the mater. Due to the highly diffusive nature of the near infrared radiation through tissue environment, commonly applied in this type of imaging, proper *"time-cuts"*, i.e. time resolving limits, must be applied on the detected rays in order to separate the diffused from the non-scattered photons. The non-scattered, time resolved photons, which are image baring photons, due to the non-divergent nature of their propagation can provide the correct planar information. This planar image is similar to a common X-ray image, but without any extra dosimetric load. In this study, an appropriate 3D geometrical phantom is examined and a total of 24 projections covering the full angle region ($0^o - 360^o$) is obtained. The time-filtered planar information is further analyzed to reconstruct the tomographic images using iterative algebraic algorithms (ART); all the tomograms are contour plotted creating a 3D image of the phantom under examination. Obtained results from the simulation are presented and the system's efficiency, regarding spatial and time resolution, is discussed.

Environmental radiochemistry of actinides: A short presentation of the recent activities at the Chemistry Department of the Aristotle University of Thessaloniki.

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Abstract

The presence of actinides in the environment is not only due to natural reasons but also to human activities closely related with the production and use of fertilizers, the nuclear and conventional energy production, the development and testing of nuclear weapons. The investigation of the environmental chemistry and behavior of the actinides are subjects of extreme scientific and technical interest, because of their strong radiotoxicity and their involvement in various geochemical and biogeochemical cycles. The transport of actinides in the biosphere mainly takes place through aquatic pathways and their mobility strongly depends on the geologic environment (site-specific minerals), the temperature and pressure profiles, the pH of the local waters, the redox potential (Eh) and concentration of inorganic (e.g. carbonates) or organic (e.g. humic acids) ligands. The interaction of their dissolved species with the highly sorptive geological materials also influences their migration behavior. Unfortunately, only few studies concerning the geochemical behavior of actinides can be performed in-situ and therefore laboratory experiments are necessary to elucidate their environmental behavior. Laboratory experiments are also necessary in order to evaluate the effectiveness of these materials to act as actinides decontamination agents, as backfill and sealing materials in nuclear repositories and as permeable reactive barriers for cleaning of waters. The chemical processes taking place include sorption through different mechanisms (e.g. adsorption/ surface sorption, absorption/ion exchange, surface precipitation), complexation (mainly with carbonate anions) as well as formation of colloidal- and pseudocolloidal systems. However, the hydrolysis of the actinides plays the determining role in the interaction processes. In general, the solid/liquid distribution coefficients (Rd) measured in a given solution /sorbent system, mostly not taking into account the underlying molecular reaction mechanism, the use of adsorption isotherms and their modelling using semiempirical equations as well as surface-complexation modelling are used for the quantification of the retention in performance assessment calculations. This contribution will present the recent research activities of the Radiochemical Laboratory of the Aristotle University in the field of the interaction of uranium, thorium and neptunium with a number of natural and synthetic inorganic sorbents (natural zeolites, clay minerals, power station fly ash, iron oxides, etc).

Long range transport of Fukushima radioactive plume to Europe

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Abstract

The data discussed in the present work includes the observations of Fukushima related radionuclides in Thessaloniki (40^oN), Greece and Milan (45^oN), Italy. This work gives the extent of contamination and an assessment of the radiation dose commitment at these European regions due to Fukushima fallout and interprets the measured activities at the site of investigation as these resulted from a complicated air mass transport. The ^{131}I concentration peaked on April 3-4, 2011, ($497\,mBq\,m^{-3}$). The ^{134}Cs/^{137}Cs activity ratio values in air were around 1, related to the burn-up history of the damaged nuclear fuel of the destroyed nuclear reactor. The high ^{131}I/^{137}Cs ratio, observed during the first days after the accident followed by lower values during the following days, reflects not only the initial release ratio but also the different volatility, attachment and removal of the two isotopes during transportation due to their different physico-chemical properties. The different maxima of airborne ^{131}I and ^{134,137}Cs were related to long-range air mass transport from Japan, across the Pacific and to Central Europe. Analysis of backward trajectories was applied for the interpretation of activity variations of measured radionuclides, which confirmed the westerly Japanese origin of the considered air masses. The estimated committed doses for population related to the contributions of Fukushima fallout due to different pathways were at least one order of magnitude less of the limit of $1\,mSv\,a^{-1}$, even if the calculations are made using high conservative assumptions. In conclusion, radioisotopes of caesium and iodine were found above their detection limits in all environmental samples, but well below levels of concern.

Vertical profile of ^{210}Pb, ^{137}Cs and ^{40}K in Algerian soil samples

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Abstract

The depth profiles of ^{210}Pb, ^{137}Cs and ^{40}K concentrations in two types of soil from different areas of Algeria were examined. The soil collection areas are near the location where the French nuclear tests took place at 1960-1961. The collection area of sample 1 is rocky with sand while the collection area of sample 2 is porous with stones and sand. The three radionuclides have different rhythm of diffusion and different transfer rate at the two different soils. The diffusion and transport of radionuclides in the two soils are different and depend on the natural soil composition. Sample 1 shows uniformity in the distribution of radionuclides, without a clear maximum (peak), while sample 2 shows a clear peak at 20 - 50 cm depth which is probably due to the different nature of the soil samples. The ^{210}Pb activity values ranged between 27 Bq kg^{-1} and 50 Bq kg^{-1} in sample 1 and between 37 Bq kg^{-1} and 75 Bq kg^{-1} in sample 2. The ^{137}Cs activity values ranged between 0.2 Bq kg^{-1} and 3 Bq kg^{-1} in sample 1 and between 4 Bq kg^{-1} and 6 Bq kg^{-1} in sample 2. And finally the ^{40}K activity values ranged between 75 Bq kg^{-1} and 90 Bq kg^{-1} in sample 1 and between 140 Bq kg^{-1} and 180 Bq kg^{-1} in sample 2. The vertical distribution of sample 2 refers more to the influence of the rate of sedimentation (movement of layers in soil) and less to the vertical diffusion and dispersion of the isotope. The observed activity concentrations of ^{137}Cs are smaller than concentrations observed in Europe. The similar behaviour of ^{137}Cs and ^{40}K at both soil samples is probably due to the similar chemical behaviour.

Post-Chernobyl ^{137}Cs released in the atmosphere due to biomass combustion

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Abstract

The background radiation level of ^{137}Cs at the urban atmosphere of Thessaloniki has been increased only due to Fukushima fallout during the recent decade. Since then no other signal of ^{137}Cs was observed until the winter period of 2013, when slightly elevated ^{137}Cs concentrations were measured at weekends, followed by non detectable activities in the next working days. The ^{137}Cs signals observed were up to $12\,\mu Bq\,m^{-3}$ one order of magnitude higher than the background measurements. Those episodes are a consequence of the financial crisis rose in the country since the majority of the inhabitants use wood products for residential heating releasing the ^{137}Cs absorbed by the trees after the Chernobyl accident. A preliminary survey of various wood products as well as of bottom ashes from different domestic burning devices has been implemented in order to study the contribution of biomass combustion. ^{137}Cs concentrations up to $11\,Bq\,kg^{-1}$ were measured in wood products and up to $500\,Bq\,kg^{-1}$ in ash samples. The release of ^{137}Cs estimated from 41% up to 79% of the wood concentrations. However, a more detailed study is necessary in order to validate the results presented.

Covariant Density Functional Theory: Nuclear Collective Motion

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Abstract

We will report some applications of the Covariant Density Functional Theory to the description of some nuclear collective phenomena.

Structure of transactinides with relativistic Energy Density Functionals

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Abstract

A fully microscopic theoretical framework based on nuclear relativistic energy density functionals (REDFs) [1] is applied to studies of shape evolution, excitation spectra and decay properties of heavy and superheavy nuclei. On the self-consistent mean-field level the microscopic approach is used in the description of rapid shape transitions, from spherical to axial and triaxial, in alpha-decay chains of superheavy nuclei [2, 3]. An especially interesting feature in this region of elements is the possible occurrence of shape-phase transitions and critical-point phenomena. A collective Hamiltonian model [4], based on microscopic REDFs is employed in studies of shape coexistence phenomena, complex excitation patterns and electromagnetic transition rates associated in Hs isotopes with the evolution of shell structures. Microscopic signatures of ground-state shape phase transitions are analyzed [5] using excitation spectra and collective wave functions obtained by diagonalization of a quadrupole collective Hamiltonian, with parameters fully determined by microscopic self-consistent mean-field calculations for triaxial shapes.

Acknowledgments

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Exotic neutrino physics issues and nuclear theory

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Abstract

Exotic processes in nuclei, predicted to occur within various new-physics models [1] are explored. We focus on the nuclear physics aspects [2] by using the quasi-particle RPA [3] and our main goal is to investigate the role of the ν-nucleus non-standard interactions (NSI) [4, 5, 6] in the leptonic sector. Specifically we are interested in: (i) the lepton flavour violating (LFV) processes involving the neutral particles ν_ℓ and $\tilde{\nu}_\ell$, $\ell = e, \mu, \tau$ and (ii) the charged lepton flavour violating (cLFV) processes involving the charged leptons ℓ^- or ℓ^+.

As concrete nuclear systems we have chosen the stopping targets of $\mu^- \to e^-$ conversion experiments, i.e. the ^{27}Al of the Mu2e at Fermilab [7] as well as of the COMET at J-PARC [8] and the ^{48}Ti nucleus of the PRIME/PRISM at J-PARC [9]. These experiments have been designed to reduce the single event sensitivity down to 10^{-16}–10^{-18} in searching for charged lepton mixing events. Our main purpose is, by taking advantage of our detailed nuclear structure calculations and employing the present limits or the sensitivity of the aforementioned exotic $\mu^- \to e^-$ experiments, to put severe constraints on the parameters of NSI Lagrangians.

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Symmetry energy effects on isovector properties of neutron rich nuclei with a density functional approach

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Abstract

We employ a variational method to study the effect of the symmetry energy on the neutron skin thickness and the symmetry energy coefficients of various neutron rich nuclei. We concentrate our interest on ^{208}Pb, ^{124}Sn, ^{90}Zr, and ^{48}Ca, although the method can be applied in the totality of medium and heavy neutron rich nuclei. Our approach has the advantage that the isospin asymmetry function $\alpha(r)$, which is the key quantity to calculate isovector properties of various nuclei, is directly related with the symmetry energy as a consequence of the variational principle. Moreover, the Coulomb interaction is included in a self-consistent way and its effects can be separated easily from the nucleon-nucleon interaction. We confirm, both qualitatively and quantitatively, the strong dependence of the symmetry energy on the various isovector properties for the relevant nuclei, using possible constraints between the slope and the value of the symmetry energy at the saturation density.