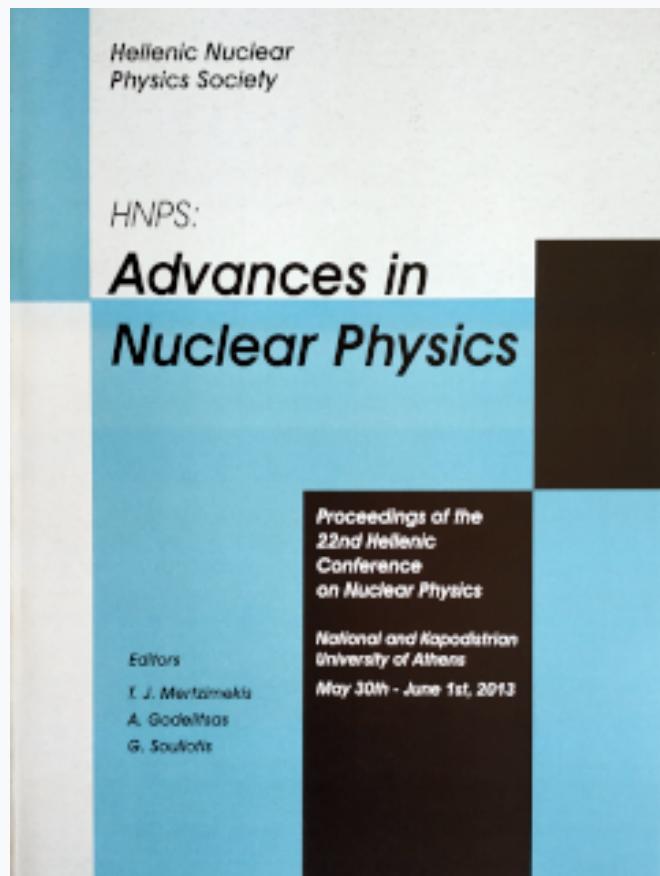


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Baryon Properties from Relativistic Constituent–Quark Models

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Abstract

I will give a review of the ground-state and excitation spectra of the nucleon, the Δ and all other baryons with flavors u, d, s, c, and b. In addition, I will address the electroweak form factors of the $SU(3)_F$ baryon ground states. For the nucleons I will furthermore discuss the flavor decompositions of the elastic electromagnetic form factors, vis-à-vis recent experimental data, as well as the axial, scalar, and gravitational form factors.

All results are consistently obtained from a relativistic constituent–quark model, whose dynamics include confinement –corresponding to the string tension of quantum chromodynamics– and the hyperfine dynamics derived from the spontaneous breaking of chiral symmetry of low-energy quantum chromodynamics; the latter consists in the formation of constituent quarks with dynamical masses and interacting by Goldstone–boson exchange.

It turns out that such a relativistic constituent–quark model relying on an invariant mass operator, which strictly respects Poincaré invariance, essentially succeeds in describing all known properties of baryons at low energies in agreement with phenomenology. In cases where experimental data are missing, the results compare reasonably well to available predictions from lattice quantum chromodynamics.

We conclude that the properties of low-energy baryons are essentially governed by spontaneous chiral symmetry breaking, and a strictly relativistic framework must be applied. Implications for nuclear systems, such as a microscopic description of the electroweak form nucleon factors will be indicated.

Search for critical fluctuations of the proton density in A+A collisions at maximum SPS energy*

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Abstract

Theoretical studies of QCD suggest the existence of a Critical End Point (CEP) in the QCD phase diagram, at the end of a line of first order transitions associated with the partial restoration of chiral symmetry. According to recent theoretical research, the net-proton density-density correlation function becomes singular at the CEP. Therefore, the net-proton density at the vicinity of the CEP is expected to carry the critical fluctuations of the chiral order parameter.

We use intermittency analysis to probe the transverse momentum phase space of protons produced around midrapidity in central A+A collisions in the NA49 experiment (SPS,CERN). In particular, we study C+C, Si+Si and Pb+Pb collisions at the maximum SPS energy of 158 AGeV. In the Si+Si and Pb+Pb systems, we find evidence of power-law density fluctuations, which is a signature of approaching criticality. The fitted power-law exponent (intermittency index) of the Si+Si system is consistent with the value expected for critical fluctuations. Thus, we conclude that the freeze-out of these systems is located close to the CEP in the QCD phase diagram

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Two-Nucleon Short-Range Correlations: An Update

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Abstract

Two-nucleon short-range correlations (2N-SRCs) arising mainly from the poorly known short-range repulsive core of the nucleon-nucleon interaction have been under intense investigation both theoretically and experimentally because they provide insight to the nuclear and nucleon structure [1, 2]. During the last years high-energy and high momentum transfer electron and hadron experiments have given direct evidence for their existence and steps towards their quantification have been taken. On the theory side significant achievements have been made regarding both the description of the reaction mechanisms involved and the calculation of different nuclear properties taking into consideration 2N-SRCs.

In this talk, I will first shortly review the latest knowledge obtained experimentally for the 2N-SRCs in nuclei and nuclear matter. Then, I will refer briefly to two particular calculations that reveal the role of the 2N-SRCs, namely to the calculation of the final state interactions in inclusive quasielastic (e, e) scattering off nuclear matter within a CBF-Glauber scheme [3] as well as to the calculation of the two-body momentum distribution of nucleons in the nucleus ${}^4\text{He}$ [4]. Finally, I will mention the perspectives for advancing the knowledge of 2N-SRCs including their non-nucleonic structure, with the planned new experiments and the required developments of theoretical methods

References

- [1] The Frontiers of Nuclear Science, A Long-Range Plan for the Next Decade, DOE/NSF Nuclear Science Advisory Committee, December 2007; NuPECC Long Range Plan 2010: Perspectives of Nuclear Physics in Europe, NuPECC , December 2010.
- [2] J. Arrington, D.W. Higinbotham, G. Rosner, M. Sargsian, *Prog. Part. Phys.* 67, 896 (2012); L. Frankfurt, M. Sargsian, M. Strikman, *Int. J. Mod. Phys. A*23, 2991 (2008).
- [3] M. Petraki et al., *Phys. Rev. C*67, 014605 (2003); O. Benhar, *Phys. Rev. C*87, 024606 (2013).
- [4] P. Papakonstantinou, E. Mavrommatis, T.S. Kosmas, *Nucl. Phys. A*713, 81 (2003); M. Alvioli, et al., *Phys. Rev. C*85, 021001 (2012).

Studying astrophysical neutrinos through the electron scattering data

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Abstract

As it is known, precise data on the magnetic dipole strength distributions for isotopes of the Fe group are dominated by isovector Gamow-Teller-like contributions [1]. Inelastic total and differential neutral-current neutrino-nucleus cross sections at supernova ν -energies can then be extracted from this electromagnetic information [2]. Knowledge about inelastic neutrino-nucleus scattering plays an important role in many astrophysical applications, including r-process nucleosynthesis, the synthesis of certain elements during a supernova explosion, the detection of supernova neutrinos, etc. Although inelastic neutrino-nucleus scattering is not yet extensively considered in supernova simulations, model studies have indicated that it might be relevant to several aspects of supernova physics [3].

In this work, as a concrete example we adopt the ν - ^{56}Fe reaction which plays important role in core collapse supernova. We study low-energy neutrino-nucleus interactions through the neutral Gamow-Teller strength $B(\text{GT0})$ by using electron scattering data of the M1 transitions. This strength is mainly concentrated on the resonance at around ~ 10 MeV. Within our quasi-particle RPA (QRPA) method, we may examine the changes in $B(\text{GT0})$ induced by non-zero values of the momentum transfer in astrophysical neutrino scattering on nuclei [5].

References

- [1] T. Kawabata, et al., Phys. Rev. C 70 (2004) 034318
- [2] K. Langanke, G. Martinez-Pinedo, P. von Neumann-Cosel, and A. Richter, Phys. Rev. Lett. 93 (2004) 202501.
- [3] Q. Zhi, K. Langanke, G. Martinez-Pinedo, et al., Nucl. Phys. A 859 (2011) 172
- [4] V. Tsakstara and T.S. Kosmas, Phys. Rev. C 83 (2011) 054612; Phys. Rev. C 84 (2011) 064620; Phys. Rev. C 86 (2012) 044618
- [5] V. Tsakstara and T.S. Kosmas, Proc. Symp. HNPS Demokritos, Athens, 2012, in press.

Size distributions of airborne radionuclides from the Fukushima nuclear accident in Athens, Greece

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Abstract

Segregation and radioactive analysis of aerosols according to their aerodynamic size were performed in Athens, after the arrival of contaminated air masses following the nuclear accident at the Fukushima Daiichi nuclear power plant in March 2011. Higher activity levels corresponded to the finest particle fraction sampled by High Volume Andersen impactors ($< 0.49 \mu\text{m}$). For the studied period the Activity Median Aerodynamic Diameter (AMAD) for ^{137}Cs ; ^{134}Cs and ^{131}I , was found in the accumulation mode of the aerosol size distribution. The Geometric Standard Deviation (GSD) appeared to be around 2 higher for iodine than for cesium isotopes; as a probable result of gaseous transfer on ambient particles of all sizes during transport. Natural origin ^7Be was also studied. Weathering conditions and gas-to-particle ^{131}I transfer can explain the size differences. The contribution from resuspension of old deposited ^{137}Cs can be assumed for the coarse particle fractions. The data agree well with general patterns observed across Europe (Masson et al, 2013)

References

- [1] Masson O., Ringer W., Malà H., Rulik P., Dlugosz-Lisiecka M., Eleftheriadis K., De Vismes A., Gensdarmes F. 2013, Size distributions of airborne radionuclides from the Fukushima nuclear accident at several places in Europe, submitted to Env. Sci. & Technology

A theoretical study for the development of a deep sub-sea radioactivity system

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Abstract

The paper contains a preliminary study for the development of a sub-sea radioactivity detection system for monitoring radioactive gases and detecting radioactive substances on deep marine environments. The design of detection system consists of a scintillation crystal of NaI(Tl) 3x3 inches and a stainless steel watertight enclosure. This material is selected for the robustness and tolerance at the high pressures of the deep water masses. The design of the system provides maximum operational depth of 4500 m in order to cover all potential deployments at the Mediterranean Sea.

A theoretical study was performed by means of Monte Carlo (MC) simulation using the MCNP5 code. The main difference between the proposed system and the KATERINA system [1], is the semi-spherical surface of the bottom of the system in order to reduce high pressures. The marine efficiency of the system was estimated for two different enclosure geometries using MC simulations. The selection of the enclosure geometries is performed taking into account the maximum operational depth and the minimum absorption of the gamma-rays into the material. MC results exhibited similar to previous efficiency estimations [2] for the gamma-ray produced at 1461 keV by ^{40}K decays. The marine efficiency of the proposed sub-sea detector is compared with the efficiency [2] of a commercial one from energy threshold till 2600 keV. The sensitivity of the detection system for ^{137}Cs measurement in the deep water masses is also discussed.

The sub-sea radioactivity detector could be installed in any existing deep observatory for gas monitoring (e.g. radon and thoron variation). Furthermore, the system could be applied for detecting any anthropogenic radioactivity in deep marine compartments affected by nuclear activities (e.g. dumped nuclear wastes).

References

- [1] C. Tsabarlis, et al., *Appl. Rad. Iso.* 66, 1419-1426 (2008).
- [2] C. Bagatelas, et al., *Env. Monit. Asses.* 165, 159-168 (2010).

Measurements and Modeling of ^{137}Cs distribution on ground due to the Chernobyl accident . A twenty seven years follow-up study in Thessaloniki in northern Greece

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Extended Abstract

Following the Chernobyl accident, an area of about 1000 m^2 in the University farm of the Aristotle University of Thessaloniki was considered as a test ground for radioecological measurements. The radio cesium deposition in this area, due to the Chernobyl accident, was 20 kBq m^{-2} . The profile of ^{137}Cs in the soil of this area was measured systematically since 1987. For the first years after the accident (1987-1994) it was found that ^{137}Cs remains practically fixed in the upper 30 cm of soil and approximately 80% of that is in the upper 10 cm. The profile appears as a sum of two exponentials. The ratio of the activities of ^{137}Cs and ^{134}Cs (backdated to May 1986) when the latter was measurable, was found to be approximately 2 in all layers. Taking into account, that the same ratio 2 was recorded in air filters immediately after the arrival in Greece of the radioactive plume and that ^{134}Cs in soil, is only due to the Chernobyl accident, we can suppose that practically all ^{137}Cs in soil is due to the Chernobyl accident, i.e. nuclear weapon tests fallout is negligible. Pure diffusion and diffusion-advection models of Cesium migration were investigated. It was found that the pure diffusion model could not reproduce the experimental profile, while the diffusion advection model could. An interesting result is that the form of the profile has changed over the years. During the 1987-2000 period the ^{137}Cs distribution was reproducible by a sum of two exponentials. However, at least since 2005 ^{137}Cs distribution can be successfully fitted by a single exponential function. The long time (about 27 years) evolution study of the ^{137}Cs distribution in soil permit us to extract the mean vertical migration velocity of ^{137}Cs . The ^{137}Cs activity concentration was measured in soil layers of 5 cm depth each up to a depth of 30 cm. Let $T(z)$ be the total activity of soil per unit area and per unit depth, at depth z . The measured activity $A(z)$ of the layer between $z-5 \text{ cm}$ and $z \text{ cm}$ is the integral:

$$A(z) = \int_{z-5}^z T(z) dz \quad (1)$$

The results presented here are expressed as the fractional contribution $R(z)$ of each layer to the total deposition, i.e.,

$$R(z) = \frac{\int_{z-5}^z T(z) dz}{\int_0^{30} T(z) dz} \quad (2)$$

In order to extract from the measured $R(z)$ time dependence the mean vertical ^{137}Cs migration velocity a simple compartment model was used. The first compartment corresponds to the depth 0-5 cm, the second correspond to the depth 5-10 cm etc. We assume the same net transfer rate λ per year between two consecutive compartments. In Figure 1 is shown the time dependence of $R(z = 5)$. The solution of the differential equation describing (in the framework of the compartment model) the time evolution of $R(z = 5)$ is:

$$R(z = 5) = R_o(z = 5) \cdot \exp(-\lambda t) \quad (3)$$

where t the years after the Chernobyl accident, $R_o(z = 5)$ is the $R(z = 5)$ in the year of the Chernobyl accident (1986) and is estimated about 0.71 from the first measurements performed in the site after the Chernobyl accident.

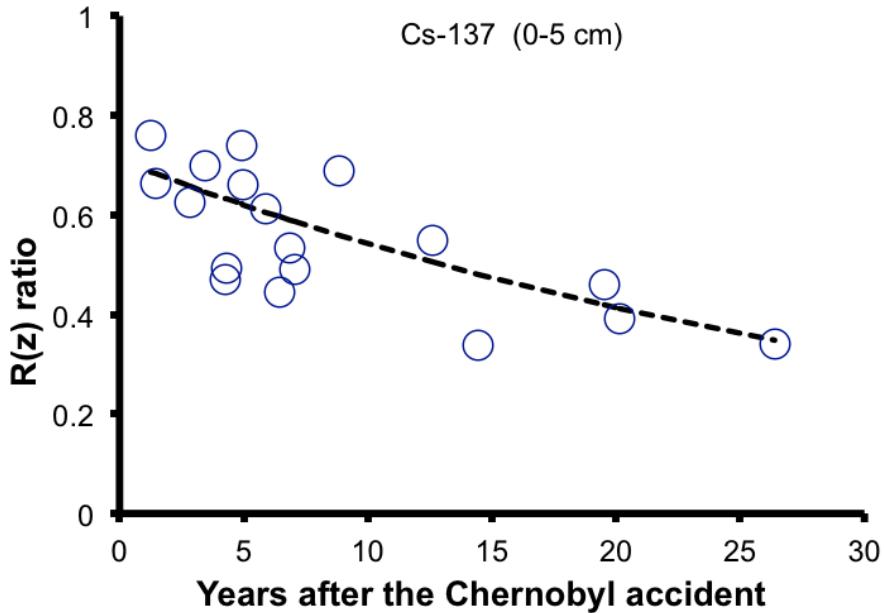


Figure 1: Time dependence of $R(z = 5)$. The dashed line is the best-fit exponential function (equation 3) passing through the data

From the exponential function passing through the data we can deduce the net transfer rate $\lambda = 0.027 y^{-1}$, the mean resident time of ^{137}Cs in the layer 0-5 cm (about 37 y), and from that we can estimate the mean vertical migration velocity about 0.14 cm per year. However, one has to bear in mind that this value corresponds to the mean “macroscopic” migration velocity. For the ^{137}Cs that is fixed in clay minerals, especially in illite, the migration velocity can be close to zero. On the other hand, for deposition by heavy rainfall, as it was the case in Greece during the Chernobyl accident, radionuclides percolate with rainwater and vertical migration can be very fast during the early stage. This is the reason that only a year after the Chernobyl accident ^{137}Cs could be found at even the depth of 30 cm.

The solution of the differential equation describing (in the framework of the compartment model) the time evolution of $R(z=10)$ is :

$$R(z = 10) = (\lambda \cdot R_o(z = 5) \cdot t + R_o(z = 10)) \exp(-\lambda t) \quad (4)$$

where $R_o(z = 10)$ is the $R(z = 10)$ in the year of the Chernobyl accident (1986) and is estimated about 0.1 from the first measurements performed in the site after the Chernobyl accident. In Figure 2 is shown the time dependence of $R(z = 10)$.

It is important to be noticed that the dashed line in Figure 2 is not a fit to the experimental values, but corresponds to the $R(z = 10)$ values calculated by equation 4. The relative good comparison between experimental and calculated values indicates that the simple compartment model used in the present work is realistic.

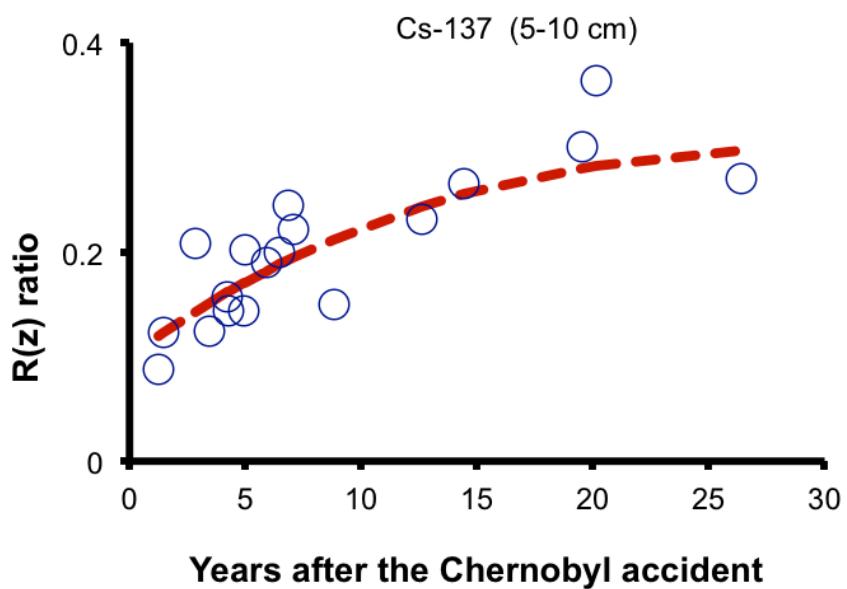


Figure 2: Time dependence of $R(z = 10)$. The dashed line corresponds to $R(z = 10)$ values calculated by equation 4

Natural radioactivity and radiation index of the major plutonic bodies in Greece

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Abstract

The natural radioactivity of the major plutonic bodies in Greece, as well as the assessment of any potential health hazard due to their usage as decorative building materials is studied. One hundred and twenty one samples from every major plutonic body in Greece, including various rock-types from gabbro to granite, have been measured for their natural radioactivity using γ -spectrometry methodology. According to the experimental results, the natural radioactivity levels were ranged up to 315 Bq kg^{-1} for ^{226}Ra , up to 376 Bq kg^{-1} for ^{232}Th and up to 1632 Bq kg^{-1} for ^{40}K , with arithmetic mean values and standard deviations of $74 (\pm 51)$, $85 (\pm 54)$ and $881 (\pm 331) \text{ Bq kg}^{-1}$ respectively, which are below the international representative mean values for granite stones. The excess on the effective dose received annually indoors due to granite tiles usage is estimated considering a standard room model where granite tiles with 1.5 cm in thickness cover only the floor of the room. The increment on the external γ -radiation effective dose rate shows a Gaussian distribution well dispersed below 0.3 mSv y^{-1} , presenting a mean value of $0.14 (\pm 0.06) \text{ mSv y}^{-1}$. In case of the internal α -radiation a log-normal distribution is appeared scattering below 0.5 mSv y^{-1} with a mean value $0.19 (\pm 0.13) \text{ mSv y}^{-1}$, for a well-ventilated living environment. In case of a poor-ventilated room the increment on internal effective dose rate is estimated with a mean value $0.27 (\pm 0.19) \text{ mSv y}^{-1}$ scattering below 0.8 mSv y^{-1} . The majority of the samples increase the external as well as the internal dose less than 30% of the maximum permitted limit of the effective dose rate. Therefore, at least from radiological point of view, the plutonic rocks of Greece could be safely used as decorative building materials.

Densities and energies of nuclei in dilute matter*

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Abstract

Nuclear matter at subsaturation densities, as encountered in astrophysical sites and in the aftermath of heavy-ion collisions, takes the form of nuclear droplets, or clusters, coexisting with a nucleon gas in statistical equilibrium. In this work we explore the ground-state properties of nuclear clusters embedded in a gas of nucleons with the help of Skyrme-Hartree-Fock microscopic calculations. Two alternative representations of clusters are introduced, namely coordinate-space and energy-space clusters. We parameterize their density profiles in spherical symmetry in terms of basic properties of the energy density functionals used and propose an analytical, Woods-Saxon density profile whose parameters depend, not only on the composition of the cluster, but also of the nucleon gas. We study the clusters' energies with the help of the local-density approximation, validated through our microscopic results. We find that the volume energies of coordinate-space clusters are determined by the saturation properties of matter, while the surface energies are strongly affected by the presence of the gas. We conclude that both the density profiles and the cluster energies are strongly affected by the gas and discuss implications for the nuclear equation of state and related perspectives.

Our study provides a simple, but microscopically motivated modeling of the energetics of clusterized matter at subsaturation densities, for direct use in consequential applications of astrophysical interest, in particular neutron stars and core-collapse supernova.

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Study of the $^{32}\text{S}(\text{p},\text{p}'\gamma)^{32}\text{S}$ reaction for resonant PIGE applications

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Abstract

Sulphurs quantification in various heavy element matrices is of great importance because of its use in numerous applications of technological interest. Moreover, its presence in various physicochemical processes directly connected with environmental studies, as for example corrosion of metals in polluted environments, demands an elaborate experimental technique capable of providing information about its depth profiling. Various Ion Beam Analysis (IBA) techniques have been proposed and used in some extent in the past in order to meet these goals. Among them, only the resonant particle gamma-ray emission (r-PIGE) can simultaneously provide accurate quantitative and depth profiling data. The most appropriate reaction for r-PIGE is $^{32}\text{S}(\text{p},\text{p}'\gamma)^{32}\text{S}$ as it has four well separated resonances in the energy range between 3.0 and 4.0 MeV. Especially the strongest one at 3379 keV (width ~ 1 keV) has been frequently applied for sulfurs depth profiling. However, the various studies performed at this energy region disagree upon the intrinsic features of these resonances, i.e. their exact energy, width and strength.

The aim of the present work is to disentangle between literatures discrepancies and provide enough information for the standard-less use of the technique. For that reason, the differential cross section as well as thick target yields of the reaction $^{32}\text{S}(\text{p},\text{p}'\gamma)^{32}\text{S}$ have been measured in 4 different angles at the energy range between 3.0 to 5.0 MeV with a variable energy step of 1–5 keV. Moreover, 4 additional angles were measured at the vicinity of the resonances enabling the extraction of the angular distribution of the emitted γ -ray. A comparison of the present results with the previous ones will be discussed.

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Proton-Neutron Interactions and Emergence of Collectivity

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Abstract

Double differences of binding energies, δV_{pn} , are used to measure the strength of the average proton-neutron interaction [1]. These double differences show maxima, hence enhanced proton-neutron interaction, in heavy nuclei, when the numbers of valence protons and neutrons are approximately equal. These maxima are also close to the line of the saturation of quadrupole deformation. Enhanced proton-neutron interactions are interpreted in terms of spatial overlaps of proton and neutron wave functions. It is suggested that highly overlapping pairs of proton and neutron orbitals which are filled synchronously, give a microscopic basis to the empirical phenomenon of nuclear collectivity and pave the way towards novel and simplified symmetry-based shell model calculations [2].

References

- [1] R. B. Cakirli, K. Blaum, and R. F. Casten, Phys. Rev. C 82, 061304(R) (2010).
- [2] D. Bonatsos, S. Karampagia, R. B. Cakirli, R.F. Casten, K. Blaum, L. Amon Susam, to be published.

Uranium - Plutonium Detection via the Neutron Emission

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Abstract

The detection of uranium and plutonium isotopes is very important for two reasons. The first is the possibility to explore for uranium minerals on the surface of the earth and the second is the control of the illicit trafficking or hidden of highly enriched uranium and plutonium.

Since the alpha and x-ray radiation emitted from uranium and plutonium isotopes can often be easily shielded, the only penetrating radiation comes from the neutrons of the spontaneous fission. Therefore a special high sensitivity and low cost neutron detector must be designed for commercial use.

At the present work is presented the investigation of a large volume spherical proportional counter as a neutron detector, with the use of ${}^3\text{He}$. The very low background and the high neutron sensitivity are the advantages of the detector, with minimum detectable thermal neutron flux $1.4 \times 10^{-6} \text{ n/cm}^2 \cdot \text{s}$

Benchmarking Experiments for the Proton Backscattering on ^{23}Na , ^{nat}Si , ^{31}P , and ^{nat}S up to 4 MeV

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Abstract

The application of IBA depth profiling techniques critically depends on the accuracy of the differential cross sections for the reactions involved. Unfortunately the existing experimentally determined differential cross-section datasets are in many cases quite scarce and discrepant, thus limiting the applicability of these techniques. The evaluated cross-section data, available through the online calculator SigmaCalc [1], are the most reliable data to be used in analytical studies. However, they are still relatively limited both in the total number of reactions, and in the energy range covered. A carefully designed benchmarking experimental procedure, i.e. the validation of microscopic differential cross-section data via thick target spectra, is thus mandatory. Benchmarking can also provide feedback necessary for the adjustment of the parameters of the nuclear model used in the evaluation process, and can help in assigning realistic uncertainties to the cross-sections; also, in the absence of evaluated cross-sections, can help in recommending specific experimental datasets.

The present work is a first step in an attempt to coherently benchmark all the cross-sections relevant to IBA. It also aims to facilitate the extension of the evaluations to higher energies. Spectra of elastically backscattered protons from ^{23}Na , ^{nat}Si , ^{31}P , and ^{32}S uniform thick targets were measured and simulated in the energy range 1-3.5 MeV, in selected steps of 250 keV, at 120.6° , 148.8° and 173.5° . The measurements were performed using the 2 MV Tandetron Accelerator of the Ion Beam Centre of the University of Surrey. The targets used were either highly pressurized tablets (e.g. NaBr, MoS₂) or polished crystalline wafers (Si, GaP). The whole experimental procedure involved the accurate calibration of the accelerator over a broad energy range, the minimization of target-related effects such as channelling, and the a posteriori treatment of surface roughness through a detailed mathematical model [2]. The DataFurnace code [3], capable of taking into account the cross-section fine structure, was used in the simulation. The results obtained and the discrepancies found are discussed.

References

- [1] www-nds.iaea.org/sigmacalc
- [2] S. L. Molodtsov, A. F. Gurbich and C. Jeynes, J. Phys. D: Applied Phys. 41 (2008) 205303.
- [3] N. P. Barradas and C. Jeynes, NIM B 266 (8) 2008, p. 1338-1342.

¹On leave from the Institute of Physics and Power Engineering, Obninsk, Russia.

Measurement, Evaluation and Benchmarking of Selected Differential Cross-Sections Suitable for EBS (Elastic Backscattering Spectroscopy) and NRA (Nuclear Reaction Analysis)

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Abstract

The recent creation of IBANDL (<http://www-nds.iaea.org/ibandl/>), an especially designed library supported by IAEA, which mainly contains experimental differential cross-sections suitable for IBA (Ion Beam Analysis) has been a milestone for the evolution of EBS (Elastic Backscattering Spectroscopy) and NRA (Nuclear Reaction Analysis). However, the most reliable differential cross-sections, suitable for widely used analytical programs, yielding high-accuracy light-element depth profile distributions, are the theoretically evaluated ones. The -so far- evaluated datasets are made available to the scientific community through the on-line calculator SigmaCalc (<http://www-nds.iaea.org/sigmacalc/>) and through IBANDL as well. Nonetheless, while there has been an enormous progress concerning EBS measurements and evaluations [1], in the case of NRA, the situation is far less satisfactory. It should be noted, that in many cases (e.g. dNRA), the evaluation presents strong and interesting theoretical challenges, such as the problem of taking into account the co-existence of two reaction mechanisms (direct and compound) with energy-dependent contributions, which seems to be critical for the correct interpretation of the results. Moreover, it is practically imperative to test the reliability of the obtained evaluated results, *a posteriori*, through a rigorous benchmarking process. The results of the benchmarking experiments can in turn provide the necessary feedback for the fine tuning of the optimal potential and resonance parameters.

In the current work the whole evaluation procedure is presented, including differential cross-section data measurements and assessments, theoretical calculations and tuning of the appropriate benchmarking results. The adopted nuclear theory models include different R-matrix approaches [2, 3] (for the analysis of resonances), along with DWBA (Distorted Wave Born Approximation) calculations (when there is a significant direct mechanism contribution). Specific examples of such evaluations are presented for the particular cases of the p+¹²C, d+¹²C, and d+d systems, which demonstrate the complexity of the process, as well as, the variety of problems which need to be addressed in order to achieve accuracies in the order of 4-7% (concerning the reproduction of experimental charged-particle spectra at steep backward detection angles).

References

- [1] D. Abriola et al., Nucl. Instr. and Meth. B269 (24), 2011, p. 2972-2978
- [2] A. M. Lane, R. G. Thomas, Rev. Mod. Phys., 30 (1958) 257.
- [3] C. H. Johnson, Phys. Rev. C, 7 (2) (1973) 561.

Core Analysis of the Thessaloniki Student Training Nuclear Reactor Using Stochastic and Deterministic Approaches*

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Abstract

The Student Training Nuclear Reactor, manufactured by the Nuclear Chicago Corporation and hosted by the Physics Department of the Aristotle University of Thessaloniki, has been put again in experimental use during 2012. The device is a subcritical assembly, fueled by natural uranium metal (U_3O_8) while light water (H_2O) serves both as moderator and reflector. The neutron source at the core is a ^{241}Am - 9Be source. In order to support the restart of the reactors experimental use, neutronic calculations, such as criticality and point-like neutron flux simulations were performed independently, using three neutronic codes, i.e. the stochastic codes TRIPOLI and MCNP as well as the deterministic code CITATION. A first measurement has been performed to validate the neutron flux computations and the obtained agreement is satisfactory.

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Dose rate estimations from ^{134}Cs , ^{137}Cs , ^{131}I in terrestrial Herbivores using the ERICA Tool

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Abstract

In this study, samples of organisms (grass and ruminants) were properly collected from grasslands in Greece and measured for gamma emitting artificial radionuclides (^{134}Cs , ^{137}Cs and ^{131}I) by gamma spectrometry. The results of the activity concentrations measurements were thereafter used to feed the ERICA software (Version 1.0, November 2012) for the internal dose rate assessments.

Comparative calculations have been performed, either by use of the default parameters of the ERICA Tool (i.e. Concentration Ratios among the various environmental components), and the direct measurements of the activity concentrations in grass and in the soft parts of the Herbivore bodies (flesh and viscera, as they are the critical tissues of the studied radionuclides). The consequent Dose Conversion Coefficients have been calculated by the model in terms of the reference and the real time data respectively.

The purpose of the study is to define the discrepancies in between the two procedures and to evaluate model effectiveness in calculating the internal dose rates in Herbivores indirectly from the activity concentration in grass.

Keywords: ERICA Tool, Radionuclides, ^{134}Cs , ^{137}Cs , ^{131}I , Dose Rate, Herbivores

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Evaluation of Dose Rates to Non-Human Biota in NORM and TENORM Areas

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Abstract

In the present study, the radiological impact on natural populations has been attempted in two selected areas of elevated natural background radioactivity as: a) the coastal environment of Ikaria island characterized as NORM area and b) two abandoned mining settling ponds in Poland named Rontok and Bojszowy, Upper Silesia, both characterized by the presence of high salinity levels and enhanced Radium concentrations, as typical TENORM areas. The dose rate calculations are based on the measured activity concentrations of natural radionuclides, theoretical relations and simple model application. Therefore, the study is integrated by: (a) data from the selected field components of the specific environments (b) measurements of the activity concentrations of ^{226}Ra , ^{228}Ra , ^{224}Ra and ^{40}K in soil, sediment and biota samples and (c) estimations of the absorbed dose rates of the natural gamma-emitters for selected wild terrestrial biota plants, trees and animals - and the respective dose risk assessment by use of conventional statistics and model application.

Keywords: NORM, TENORM, Natural Radionuclides, Dose to Non-Humans, Radionuclides and Model Application

Simulating a Time-Resolved Optical Tomographic Modality

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Abstract

Attenuation of photons by the tissue structure surrounding the radiating malignant cells affects the quantitative accuracy of the reconstructed image in tomographic emission modalities. In this work, we study the effect of the radiation absorption through different material structures by means of simulations in the Single Photon Emission Computed Tomography (SPECT). This study was performed by introducing a new projection matrix, which includes various cases of absorption in the simulated phantoms. In addition to the uniform absorption, two other cases of non-uniform attenuation are considered, by modeling the absorption strength in a linear or inverse-linear distance dependent way from a given center inside the phantom. Several multiple-source software phantoms with different characteristics (simple symmetrical, complex and center asymmetrical phantoms) are simulated and reconstructed following the methodology of the Algebraic Reconstruction Technique (ART). The improvement in the quality of the reconstructed images by taking into account the absorption effects for the variety of the simulated phantoms is discussed in this work.

Simulating a Time-Resolved Optical Tomographic Modality*

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Abstract

Ferritic/martensitic steels are currently considered as the most promising structural materials for the construction of the future Fusion Power Plants, due to their high radiation and corrosion resistance combined with good mechanical properties. However, these steels still suffer from irradiation hardening and embrittlement; further research is currently undertaken in order to understand and solve these issues. In view of this we study the radiation damage evolution in the binary Fe-Cr alloy system, which constitutes the base of ferritic/martensitic steels.

A series of high purity Fe-Cr alloys have been irradiated with 5 MeV protons at the TANDEM accelerator of NCSR-“Demokritos” at different dose level. The irradiations are carried out at cryogenic temperature (50 K), where the damage created by the irradiating particles remains frozen in the lattice. After the total dose is delivered to the sample, the temperature is gradually increased and the radiation induced damage is recovered by the thermal atomic movement. The rate of recovery is observed in-situ by measurements of the associated changes in the electrical resistivity of the sample. Recovery curves as a function of annealing temperature, initial dose and Cr concentration provide rich and important information on the behavior of this alloy under irradiation.

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Monte Carlo modelling of radiotherapy photon beams

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Abstract

Medical linear accelerators (linacs) are being routinely used for cancer treatment. Electron linacs accelerate high-energy electron beams to impinge on high Z targets producing high-energy gamma rays. The outgoing gamma rays are then shaped to conform the area under treatment, thus a beam of customized shape is produced and hits the patient's tumour. An essential requirement for successful radiation is to determine the sensitivity of the produced photon beam to the different parameters of the primary electron beam.

Although manufacturers do provide electron beam characteristics, they can only be considered as first estimates. In this study an accurate description of a Varian 2100 C accelerator operating at 18 MV is provided to GEANT4 simulation code. Several simulations are carried out to study the influence of the energy and spatial spread of the primary electron beam on the photon fluencies, energy and spatial distribution on the irradiation field. Different physics lists (Standard, Penelope, Livermore) have tested and the consistency of the results is verified. Results have shown an immense discrepancy in the old version of GEANT4, especially in the low energy region, whilst in the last version results are nearly the same. The major influence of the flattening filter on the beam and the meaning of building accurate models of the filter are also discussed.
