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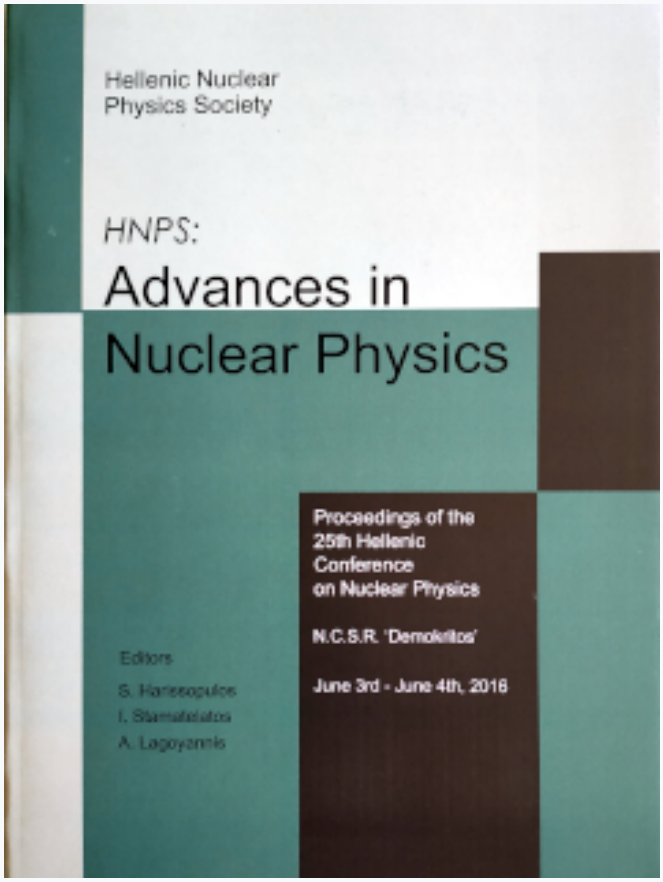

Aggregate abstracts-only section (multiple authors)

Abstracts only no papers submitted

Speed of Sound Effects on the Upper Bound of Neutron Star Mass

C. Margaritis[1], T. Gaitanos[1], G.A. Lalazissis[1], Ch.C. Moustakidis[1]
[1]Department of Theoretical Physics, Aristotle University of Thessaloniki, Thessaloniki 54124, Greece

The estimation of the maximum mass of a neutron star is one of the most important problems in Astrophysics. Observational identification of black holes requires the knowledge of the upper limit on the gravitational mass of a neutron star. The determination of an accurate maximum neutron star mass strongly depends on the employed nuclear equation of state (EoS) up to very high density. In order to derive upper bounds to the maximum allowed mass a few minimal general assumptions have been considered that is: 1) the matter is a perfect fluid described by a one parameter equation of state which relates the pressure P to the energy density ε, 2) the density is positive (ρ>0), 3) the matter is microscopically stable (dP/dε> 0) and 4) the pressure is always positive (P>0). Any further principle which restricts the EoS will leads to improvement in the bounds. Such kind of restriction is the condition that the hydrodynamic phase velocity of sound is less that the speed of light, that is v_s=(dP/dε)^(1/2)< c$. However, it has been conjectured that the speed of sound v_s in any medium is v_s< c/3^(1/2). The above statement imposes strong constraints on the EoS and leads to a significant lowering of the predicted maximum mass limit from 3M_solar to less than 2M_solar. The existence of neutron stars with masses around two solar masses combined with the knowledge of the EoS of hadronic matter is in contradiction with this bound. In the present work we study the depends of the maximum neutron star mass on the upper bound of the speed of sound by employing various set of modern EoS's. We display the dramatic effects of speed of sound bounds on the EoS and consequently on the upper limit of a neutron star mass. Finally, we study and present some preliminary results concerning the nuclear symmetry energy effects on the estimation of the maximum neutron star mass.

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Nuclear reaction studies for the νp-process *

Panagiotis Gastis[1,8], George Perdikakis[1,4,8], Carla Frohlich[3,8], Fernando Montes[4,8], Artemisia Spyrou[2,4,8], Mihai Horoi[1], Sean Liddick[2,4,8], Antonios Kontos[5], Antonio Carlos Camargo Villari[10], Daniel Alt[2,4], Kathrin Wimmer[6], Remco Zegers[2,4,8], Matthew Redshaw[1,4], Roman Senkov[9], Thomas Redpath[2,4,8], Stylianos Nikas[1,8], Ling-Ying Lin[7]

[1]Department of physics, Central Michigan University, Mt. Pleasant, Michigan, USA
[2] Department of Physics, Michigan State University, East Lansing, Michigan, USA
[3] Department of Physics, North Carolina State University, Raleigh, North Carolina, USA
[4] National Superconducting Cyclotron Laboratory (NSCL), Michigan State University, East Lansing, Michigan, USA
[5] Kavli Institute for Astrophysics and Space Research, Massachusetts Institute of Technology (MIT), Cambridge, Massachusetts, USA
[6] Department of Physics, University of Tokyo, Tokyo, Japan
[7] Argonne National Laboratory, Lemont, Illinois, USA
[8] Joint Institute for Nuclear Astrophysics: CEE, Michigan State University, East Lansing, Michigan, USA
[9] Department of Natural Sciences, City University of New York's LaGuardia Community College, Long Island City, New York, USA
[10] Facility for Rare Isotope Beams (FRIB), Michigan State University, East Lansing, Michigan, USA

The details of nucleosynthesis in core collapse supernovae (CCSNe) are important in answering the question about the origin of elements. If the right proton-rich conditions are found νp-process could be contributing to the synthesis of heavy elements beyond iron in the neutrino driven winds of CCSNe. Nucleosynthesis in νp-process proceeds via a sequence of proton-capture reactions and (n,p) reactions. The small abundance of neutrons needed originates from anti-neutrino captures on free protons. The strength of the νp-process in nucleosynthesis strongly depends on key reactions like the ^{56}Ni(n,p)^{56}Co. Currently, the reaction rates of such crucial nuclear reactions have been only estimated via theoretical models since no experimental data exist. For this purpose, a cross section measurement of the ^{56}Co(p,n)^{56}Ni reaction in inverse kinematics, is going to take place in the new ReA3 facility at National Superconducting Cyclotron Laboratory at Michigan State University. The result will constrain the reaction rate of the ^{56}Ni(n,p)^{56}Co reaction (time-inverse reaction) and will provide significant information about the role of the νp-process in the synthesis of heavy elements. In this presentation, a summary of the νp-process mechanism from both astrophysical and nuclear physics points of view will be presented. Furthermore, a description of the experimental technique and status of preparations for the measurement of the ^{56}Co(p,n)^{56}Ni reaction will be shown.

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Periodicity analysis of long period gamma radiation measurements in Thessaloniki, Northern Greece*

A.Clouvas[1] , F. Leontaris[1] , S. Xanthos[2,1] , A. Maltezos[3] , C. Potiriadis[3]
[1] Department of Electrical and Computer Engineering , Aristotle University of Thessaloniki,GR-54124 Thessaloniki, Greece.
[2]Department of Automation, Alexander Technological Education Institute of Thessaloniki,GR-57400, Thessaloniki, Greece.
[3] Greek Atomic Energy Commission ,GR-15341 Agia Paraskevi, Greece

Gamma radiation measurements were performed during the last 27 years, starting from 1988, with a NaI(Tl)-based Xetex 501A radiation monitor located outside the Nuclear Technology Laboratory of the Aristotle University of Thessaloniki in Northern Greece and a time series was created. Measurements were also performed in the same place during 1995-1998 and 2013-2015 with portable HPGe detector. The total absorbed dose rate in air decreases exponentially with time. The total absorbed dose rate in air is the sum of the gamma dose rates due to 1) Uranium series 2) Thorium series 3) ^{40}K 4) ^{137}Cs (due to the Chernobyl accident). In addition, a small contribution due to cosmic radiation is measured by the radiation monitor. From the time dependence measurements with the HPGe detector it was found that the time dependence of the absorbed gamma dose rate in air due to 1) Uranium series 2) Thorium series 3) ^{40}K is quite constant. On the contrary, gamma dose rate due to ^{137}Cs, decreases exponentially with an effective half-life ($t_{½}$) of about 13.5 years, stronger than expected due to the natural decay of ^{137}Cs. Time series analysis of the mean monthly total absorbed dose rate in air was performed. Fourier analysis reveals several periodicities and applying Zhao Atlas Marks Transform unravels the time distribution of those periodicities. There are three main discernible periodicities: 12±0.2 months, 42.3±2.9 months, 53.2±3.2 months. One of them is of a seasonal character (annual cycle) and can be linked to seasonal atmospheric variations and is strongly visible from 1988-2002 and 2008-2014. The other two (42.3±2.9 months, 53.2±3.2 months) were found to be also related to meteorological parameters (air temperature) and they were very intense during the years 2002-2004 when the annual periodicity was weak. Apart the three main periodicities, there are also four others (14.7, 18.6, 21.3 and 27.3 months) with lower magnitudes, of which three agree well with literature data periodicities in solar activity .

In order to study the influence of solar activity to the dose rate measurements , we performed also periodicity analysis of the mean monthly total absorbed dose rate in air data measured by a Reuter Stokes Ionisation chamber belonging to the Greek early warning system network and operated by the Greek Atomic Energy Commission . The data cover the period from 2001-2015. The Reuter Stokes ionisation chamber is located inside the Aristotle University Campus . In comparison to NaI (Tl) and HPGe detectors ,the Reuter Stokes Ionisation chamber is sensible to cosmic radiation . The periodogram of the mean monthly total absorbed dose rate in air deduced by the Reuter Stokes Ionisation chamber measurements is presented and compared to the periodogram deduced by the NaI(Tl)-based Xetex 501A radiation monitor.

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Temporal variatios of ^{7}Be and its AMAD over "Demokritos GAW station"

E. Dalaka[1,2], M. Anagnostakis[2], and K. Eleftheriadis[1]

[1]Institute of Nuclear & Radiological Sciences & Technology, Energy & Safety,
National Centre of Scientific Research "Demokritos", 15310 Ag. Paraskevi, Attiki, Greece
Environmental Radioactivity Laboratory
[2]Nuclear Engineering Laboratory, National Technical University of Athens,
15780, Athens, Greece
Presenting author email: edalaka@ipta.demokritos.gr

^{7}Be is a relative short lived natural occurring radioactive nuclide ($t_{1/2}$=53.3d) of cosmogenic origin which is formed in the upper troposphere and lower atmosphere by spallation reactions of light atmospheric nuclei of nitrogen and oxygen with cosmic rays and its flux to the Earth's surface has a latitudinal dependence. The ^{7}Be produced in the stratosphere, comes into the troposphere by exange processes of air mass between the troposphere and the stratosphere due to variations in atmospheric conditions associated with a seasonal change. It then attaches to aerosol particles, which later deposit on the ground.

An atmospheric sampling program by means of High Volume samplers has been established since March 2011 and is still in process at Demokritos urban background station (GAW-DEM, 2007). In this study, ^{7}Be concentrations' time series were correlated with weather conditions for the last 4 years. The station lies in the ERL field site away from direct emission sources in a vegetated area (pine). Since 23/3/2011 until present, measurements were conducted using a six-stages high volume cascade impactor (nominal 50% cutoff sizes: 10.1, 4.2, 2.1, 1.4, 0.73, 0.41, 0.05 μm). Concentrations of radioisotopes were measured by weekly sampling. The filters used were paper filters by Watman, and were analyzed by Gamma-spectroscopy, as ^{7}Be emits photons at the energy of 477.59keV.

Figure 1 shows seasonal variation, which can be attributed to the stratosphere – to – troposphere exchange process. The amount of rainfall also controls the seasonal variation of the depositional fluxes (measurements after rainfall events have lower ^{7}Be concentrations). This study has provided evidence of strong temporal variability of 7Be atmospheric ground concentrations .^{7}Be maxima are observed during summer months, and minima during winter months. The negative correlation between precipitation and ^{7}Be activity plus the significant increase in activity under dry meteorological conditions were due to the non-scavenging of ambient air by rainfall (fig1).

The specific activity of ^{7}Be starts to increase from March to September. The highest activities in the summer months are caused by increased vertical transport of ^{7}Be activities from the upper troposphere due to decreased stability of the troposphere during the summer months. AMAD ranges from 0.28 to 0.38 μm (avg 0.25 μm).

In this study, there appears to exist positive correlation in ^{7}Be concentration and temperature, probably because higher temperatures trigger the penetration of air masses from the upper atmospheric layers, thus favoring the air exchange processes in air masses enriched with ^{7}Be (fig.1) [1]. This instability in the atmosphere has an impact on particles' residence time, dropping the AMAD [2] (fig2).

This study has proved negative correlation between relative humidity and the activity. This could be explained by an increase in the diameter of airborne particles caused by condensation process, which are more likely to be scavenged, thus reducing activity in the atmosphere [3].

Periods of high pressure in the wintertime associated with relatively high ^{7}Be concentrations during these periods may be due to lower removal rates.

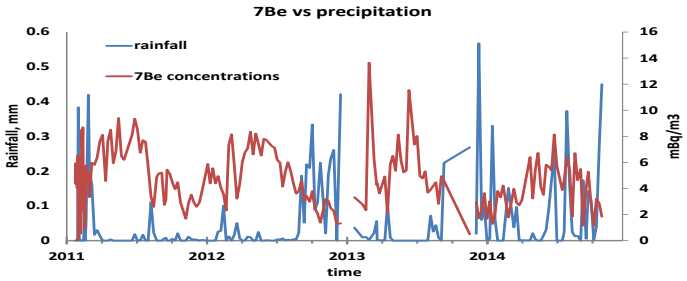

Figure 1. . 7Be concentrations in air with precipitation

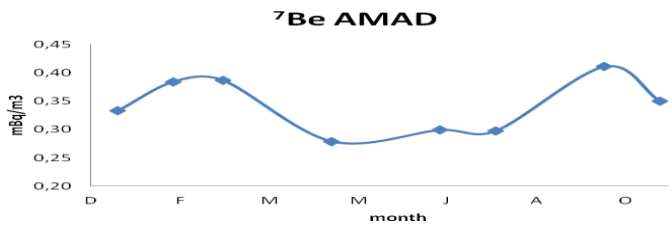

Figure 2. ^{7}Be AMAD in the year 2014

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Probing electromagnetic neutrino properties from neutrino-nucleus scattering

D.K. Papoulias[1], T.S. Kosmas[1]
[1]Theoretical Physics Section, University of Ioannina, GR-45110 Ioannina, Greece.

Majorana neutrino electromagnetic properties are studied through neutral-current coherent elastic neutrino-nucleus scattering (CENNS) [1]. We focus on the potential of the recently planned TEXONO [2] and COHERENT experiments [3] to probe exotic neutrino properties. Focusing on low threshold Germanium-based targets with kg-scale mass, we find a remarkable efficiency not only for detecting CENNS events due to the weak interaction, but also for probing novel electromagnetic neutrino interactions. The resulting sensitivities are determined on the basis of a analysis employing realistic nuclear structure calculations performed in the context of the QRPA. We find that they can improve existing limits on the neutrino magnetic moment by about half an order of magnitude [4]. In addition, we show that these experimental facilities allow for Standard Model precision tests in the low energy regime, with a competitive determination of the weak mixing angle. Finally, they also offer the capability to probe other electromagnetic neutrino properties, such as the neutrino charge-radius. This work, apart from realistic nuclear structure calculations takes into consideration the crucial quenching effect corrections [5]. Such a treatment, in conjunction with a simple statistical analysis, shows that the attainable sensitivities are improved by one order of magnitude as compared to those of previous studies. We illustrate our results for various choices of the experimental setup and the target material.

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Application of Synchrotrons radiation and fission track techniques to the characterization of U-bearing organic rich limestones of NW Greece.

Tzifas I. T. [1,2], Glasmacher U. A.[2], Misaelides P.[1], Godelitsas A.[3], Goettlicher J.[4], Steininger R.[4]

1. Department of Chemistry, Aristotle University of Thessaloniki, GR-54124 Thessaloniki, Greece.
2. Research Group Thermochronology and Archaeometry, Institute of Earth Sciences, University of Heidelberg, Postfach 103980, 69029 Heidelberg, Germany.
3. Department of Geology & Geoenvironment, University of Athens, Panepistimioupolis, 15784 Zographou, Greece.
4. Karlsruhe Institute of Technology, Institute for Synchrotron Radiation, Hermann-von Helmholtz-Platz 1, 76344 Eggenstein-Leopoldshafen, Germany.

Abstract

Synchrotron radiation (μ-XRF) was applied to the study of organic-rich phosphatized limestones of NW Greece (Epirus). The results revealed uranium accumulation in areas of the material containing, among others, carbonate apatite (francolite) and organic matter. Uranium-bearing francolite crystals were separated from the rock and characterized by Raman spectroscopy and microprobe analysis. The analysis of francolite crystals also indicated the presence of sodium and sulfur. The UL_{III}-edge of μ-XANES spectra showed that uranium is present in tetravalent form. The uranium presence in the crystals was also visualized, after neutron irradiation and etching, by the observation of the fission tracks.

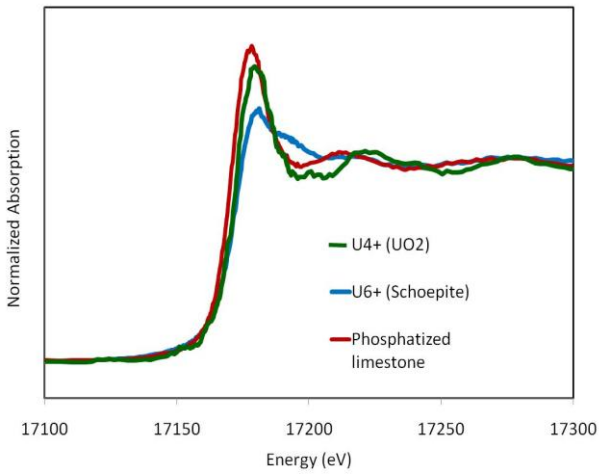

Figure: Preliminary UL_3-edge μ-XANES spectra.

γ-ray spectrometry practices in the deep ocean

C. Tsabaris[1], D. L. Patiris[1], E.G. Androulakaki[1,2], G. Eleftheriou[1,2], F.K. Pappa[1,2], S. Alexakis[1] and C.A. Kalfas[3]

[1] *Hellenic Centre for Marine Research, Institute of Oceanography, P.O. Box 712, GR-19013 Anavyssos, Greece*
[2] *National Technical University of Athens, Department of Physics, Zografou Campus, GR-15780 Athens, Greece*
3 National Centre for Scientific Research "Demokritos", Institute of Nuclear Physics, GR-15310 Agia Paraskevi, Greece

Keywords: in situ sensor, marine radioactivity, simulation, MDA, deep ocean

tsabaris@hcmr.gr

Abstract
In-situ radioactivity measurements in the deep marine environments are scarce since the in-situ sensors require special secifications for harsh deep ocean. The in-situ approach has been applied so far by installing the acquisition systems on large moored buoy networks [Tsabaris and Ballas, 2005; Tsabaris, 2008; Osvath et al., 2005]. The last years the KATERINA gamma-ray spectrometer has been developed to operate autonomously [Tsabaris et al., 2008] in depths up to 500m and to provide quantitative results [Bagatelas et al., 2010] for long term periods. In this work a theoretical and experimental study has been perfomed of a sub-sea radioactivity system for radioactivity in the deep oceans. The design of detection system consists of a scintillation crystal of NaI(Tl) 3x3 inches and a stainless steel watertight enclosure. A detaikled study has been perfomed by selecting other candidate enclosure materials for better efficiency in the high pressure. 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 first runs were dedicated to estaimte the effective radius (the distance where a photon ia fully absrorbed) along with gamma-ray energy for two different thickness of the enclosure (0.7 and 0.9 cm) using as material stainless steel and 0.9 cm using as material of the enclosure Titanium. The differences between the proposed system and the KATERINA system (Tsabaris et al., 2008) will be discussed in detailed. The marine efficiency of the system was estimated for stainless steel using two different enclosure thickness runing the MC simulations (0.9 and 0.7 cm). The data are compared with previous data using acetal (0.9 cm) for pressures of intermediate water mass. The selection is performed taking into account the maximum operational depth and the minimum absorption of the gamma-rays into the material. The results exhibited similar values for energies above 1000 keV while the differences below this energy values is significant between acetal and the other materials.

The sub-sea radioactivity detector is installed in the Rossette of the research Vessel Aegeao for providing spectra in the deep ocean. Furthermore, the Minimum Detectable Activity (MDA) was study for the harsh deep environments in a background marine area in South of Crete, The proposed in-situ detection system could be applied for detecting any anthropogenic radioactivity in deep marine compartments affected by nuclear activities (e.g. dumped nuclear wastes, oceanographic tracers such us ^{137}Cs appeared from previous tests and nuclear accidents).

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Utilization of the Monte Carlo code FLUKA for Applications in the Marine Environment

E. G. Androulakaki[1,2], G. Eleftheriou[4], E. Fatsea[1], M. Kokkoris[1], F.K. Pappa[1,2], D.L. Patiris[2], E. Skordis[3], C. Tsabaris[2], R. Vlastou[1]

[1] Department of Physics, National Technical University of Athens, Zografou Campus 157 80, Athens, Greece

[2]Hellenic Centre for Marine Research, Institute of Oceanography, P.O. Box 712, Anavyssos, Greece

[3]European Organization for Nuclear Research (CERN), Geneva, Switzerland

[4]Department of Monitoring and Research, Norwegian Radiation Protection Authority, Norway

Among the general purpose Monte Carlo (MC) codes, the FLUKA [1] code has been extensively utilized for problems that involve high-energy physics, while its utilization regarding environmental applications is limited, although it offers several advantageous capabilities (e.g. automatic consideration of TCS – True Coincidence Summing – effects, retrieval of ENDF radiation decay information etc). In this work FLUKA was implemented to simulate pulse-height spectra of a 3″×3″NaI(Tl) detector (underwater system KATERINA), considering radioactive sources of naturally occurring and artificial radionuclides, that may be present in the marine environment. Concerning problems that involve the radioactive decay of naturally occurring radionuclides, a user-defined routine was developed for the proper simulation of the emitted γ-rays and is readily available to the scientific community upon request. The simulated spectra were compared with the corresponding spectra obtained using the widely implemented and validated MC code MCNP-CP [2], yielding a quite satisfactory agreement.

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A survey on the radioactivity of mineral springs in Greece *

G. Kuburas, E. Tzempelikou, H. Florou
Environmental Radioactivity Laboratory, Institute of Nuclear and Radiological Sciences and Technology, Energy and Safety, NCSR "Demokritos", Patr. Grigoriou E΄& 27 Neapoleos St., P.O. Box 60037, GR-153 41, Aghia Paraskevi, Attica, Greece.

Radon is a natural radioactive gas that emanates from rocks and soils as a daughter radionuclide of its parent nucleus Ra-226. Other sources including building materials, springs and water extracted from wells are of importance in certain circumstances [1]. The natural springs supplied by underground aquifers contain radon which may be considered harmful due to the ionizing radiation of its short lived decay products [2]. In the case of springs, radon is not usually supported by its parent nucleus but it is released from the surrounding rocks and ores present in underground repositories. In Greece, there are several mineral springs, presumed to have therapeutical properties, playing in this way an important role in medical tourism. Nevertheless, the elevated activity concentration of Rn-222 in a number of them poses a radiological issue to be taken into consideration.

In compliance with the 17414/2009 Decision of the Greek Ministry of Tourism on the identification process of thermal natural resources [3], a study of the natural radioactivity in thermal springs waters in Greece has been in progress at the Environmental Radioactivity Laboratory. In total, 75 water samples coming from 60 springs located in 30 Regional Units of Greece have been surveyed so far. In compliance with the Ministry's Decision, the radiological reports include the activity concentrations of Rn-222, Ra-226 and U-238 in order to identify the radiological quality of waters for external human use (balneotherapy). In case that the activity of Rn-222 exceeds the value of 100 Bq/L, a resumptive water sampling must take place in the same hydrological year to cover both wet and dry periods.

Thermal springs water samples are collected in air tightly sealed beakers (3 samples per day in order to estimate the daily radon fluctuation) and they are measured by means of γ-spectrometry to evaluate the Rn-222 activity concentrations. After the first measurement the beakers are vented to let the radon gas escape. They are then sealed and re-measured after a 24 days' period when secular equilibrium between Ra-226 and Rn-222 has been reached. In this way the activity concentration of any inherently present Ra-226 in the sample can be estimated. At the same time a separate quantity of the spring water is being submitted to mild evaporation and the remaining sediment is examined for the presence of U-238.

Elevated Rn-222 and Ra-226 activity concentrations are mainly observed in Ikaria Island (Eastern Aegean Sea) while elevated Ra-226 activity concentrations characterize the springs situated in and around the city of Loutra Edipsou (northern part of Euboea Island). The U-238 concentrations do not exceed in Greece the value of 0.5 Bq/L.

* The authors acknowledge funding from the Greek General Secretariat for Research and Technology and the European Regional Development Fund under the Action "Development Grant for Research Institutions – KRIPIS" of OPCE II.

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The Use of Nuclear Methods and Techniques in Radioecology: Teaching Approaches in the Secondary Education

G. Trabidou[1,2] and H. Florou[2]

[1]1st Experimental Junior High School of Athens

[2]Environmental Radioactivity Laboratory, Institute of Nuclear & Radiological Sciences & Technology, Energy & Safety, NCSR "Demokritos"

The connection of the modern school with scientific research and development of new science, presents a lot of gaps in many field subjects, especially in innovative scientific domains. One of these fields is related to the nuclear physics and its applications in research, technology and development activities in various scientific fields, such as nuclear technology, radiobiology and radioecology, a science newly born after the extended use of nuclear energy for several purposes. Radioecology, as a multidisciplinary science, sums the research activities related to the behavior of radioactivity in the environment, considering all types of ecosystems i.e. pristine, natural, semi-natural, rural, urban, domestic.

In the post-Chernobyl situation, radioecology, considering R&D, has been highlighted by the real time observations of the vice versa relations between environment and radioactivity· thus these relations are much more closer to the reality and the findings more reliable. One can note that there is a lot of Lab experimental work on the issue. However, the real time measurements after the radiological events cannot be reproduced as nature shows ecosystem complexity among all living disciplines.

Therefore, to pass the knowledge from the high academic level to the secondary education, even it remains a challenge, it can be efficient by presenting methods and techniques used for real time measurements of environmental components from all levels of life organization and the respective radiological impact assessment for man and the environment. This is the first step towards the comprehension by the second grade students of the multidisciplinary science of Radioecology.

In the present study summarized theoretical projects, demonstration activities and experimental participations are shown in the frame of the education program and teaching approaches of the 1st Experimental Junior High School of Athens in collaboration with ERL/INRASTES under the auspices of the education office of NCRD "Demokritos".

Indicatively, the activities were: Short seminars and lectures on the scientific background supervised by the researchers of NCSRD"D", demonstration experiments by the students (Researcher's nights 2012, 2013 and Athens Science Festival 2016) and in situ radioactivity measurements and demonstration in the school environment. From the experience gained over the four years collaboration activities, some notes and conclusions of the first feedback are presented in this study.

Acknowledgements are due to the Education Office of NCSR"D" for the coordination of the collaboration program.

Evaluation of 1s2l2l′ $^4P/^2P$, $^2P_+/^2P_-$ and $^2D/^2P$ ratios from collisions of mixed state ($1s^2$, 1s2s ^3S) He-like ion beams with H_2 and He targets *

I. Madesis[1,2], A. Laoutaris[2], E. P. Benis[3], T. J. M. Zouros[1,2]

[1]Dept. of Physics, University of Crete, P.O. Box 2208, GR 71003 Heraklion, Greece.
[2]Tandem Accelerator Laboratory, Institute of Nuclear and Particle Physics,
NCSR Demokritos, GR 15310 Ag. Paraskevi, Greece.
[3]Dept. of Physics, University of Ioannina, GR 45110 Ioannina, Greece.

New results are presented on the ratio R of $^4P/^2P$ populations of Li-like 1s2s2p quartet and doublet P states formed in energetic ion-atom collisions by single 2p electron transfer to the metastable 1s2s ^3S component of a He-like ion beam. Using spin statistics, a value of R=2 is predicted, mostly in disagreement with reported measurements of R=3-10 [1-2]. A new technique is used in the evaluation of R which overcomes the need for the normalization of the measured cross sections and allows for the determination of the separate contributions of ground- and metastable-state beam components to the measured spectra. Applying to older spectra from 4.5 MeV B^{3+} [3] and 25.3 MeV F^{7+} [4] mixed state ($1s^2$ ^1S, 1s2s ^3S) ion collisions with H_2 target, we report values of R=3.5±0.4 for boron and R=1.8±0.3 for fluorine. In addition, also reported for the first time are the ratios of $^2D/^2P$ and $^2P_+/^2P_-$ populations generated by either capture and/or Transfer Excitation mechanisms, providing essential information on the active processes that can affect the overall intensities of the measured Auger spectra. They are evaluated applying the same technique and compared to previously reported results for carbon collisions on He [1].

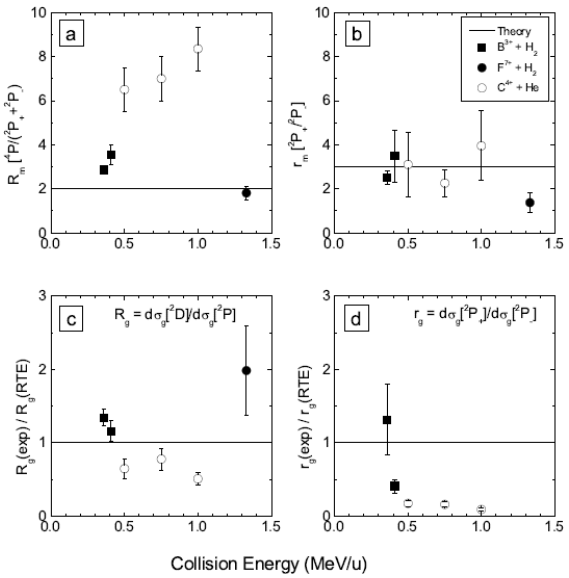

Figure 1: Theoretical and experimental ratios. The carbon on helium results are from [1].

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Assessment of gamma radiation exposure and distribution of natural radioactivity in beach sands close to plutonic rocks of Greece

Argyrios Papadopoulos[1], Antonios Koroneos[1], Georgios Christofides[1], Stylianos Stoulos[2]
[1]Department of Mineralogy, Petrology and Economic Geology, School of Geology, Aristotle University of Thessaloniki, 54124 Thessaloniki, Greece
[2]Laboratory of Nuclear Physics, Aristotle University of Thessaloniki, 54124 Thessaloniki, Greece

This study aims to evaluate the activity concentrations of ^{238}U, ^{226}Ra, ^{232}Th, ^{228}Th and ^{40}K along the beaches of Greece being adjacent to plutonic rocks. These ranged from 6-940, 1-2292, 5-10143, 5-9953 and 27-1319 Bq/kg respectively, some of them representing the highest values of natural radioactivity measured in sediments of Greece. The investigated beaches include Sithonia peninsula (Chalkidiki, N. Greece), some islands of the Aegean Sea (Mykonos, Paros, Naxos, Serifos, Ikaria) the area of Kavala (N. Greece), Samothraki island, NE Chalkidiki and Maronia (NE Greece). Several of these places are associated with high touristic activity such as Mykonos, Naxos, Paros, Serifos, Ikaria, Sithonia and Kavala. The (% wt.) heavy magnetic (HM) (allanite, amphibole, mica, clinopyroxene, magnetite and hematite) fraction, the heavy non-magnetic (HNM) (monazite, zircon, titanite and apatite) fraction and the total heavy fraction (TH), were correlated with the concentrations of the measured radionuclides in the bulk samples. The heavy fractions seem to control the activity concentrations of ^{238}U and ^{232}Th of all the samples, showing some local differences in the main ^{238}U and ^{232}Th mineral carrier. The measured radionuclides in the beach sands were normalized to the respective values measured in the granitic rocks, which are their most probable parental rocks, so as to provide data upon their enrichment or depletion. The highest values of the equivalent dose have been reported in Mykonos, Naxos, Kavala and Sithonia. The annual equivalent dose which should be limited to at least 1 mSv y^{-1}, varies between 0.003 and 0.759 mSv y^{-1} for tourists and from 0.012 to 3.164 mSv y^{-1} for local people working on the beach.

Towards the development of a radiological box model for Aegean Sea: considerations and perspectives*

G. Eleftheriou[1,2] and M. Iosjpe[1]

[1]Department of Monitoring and Research, Norwegian Radiation Protection Authority, 1332 Østerås, Norway

[2]Institute of Oceanography, Hellenic Centre for Marine Research, 19013 Anavyssos, Greece

Environmental modelling is proved to be an effective tool for the management and the protection of all kind of ecosystems. As a part of this effort, the prediction of dispersion after the release of radionuclides into the marine environment and the radiological consequences to the biota are of great concern. Marine radiomodelling owe to integrate different aspects like the contamination of the water and bottom sediments, the bioaccumulation of radionuclides in biota and the dose assessments to marine organism and human populations. Due to the extent and complexity of sea environments, box models are suitable for marine radiomodelling since they can cover large distances and long time scales.

In this work, the development steps of a radiological box model of Aegean Sea are presented. The applied methodology combines all the available and necessary site specific information concerning oceanographic, meteorological, topological, biological, hydrological, radiological and sociological data [1]. The modelling approach includes terms describing the radionuclide dispersion into oceanic space with time (non-instantaneous mixing), while the model's algorithms cover whole processes such as dispersion of radionuclides in oceanic space, transfer of radioactivity between seawater and sediments, within different sediment layers, uptake of radionuclides by biota and, finally, dose calculations for man and biota [2]. The model includes 50 marine and sediment boxes and is been optimised based on the experimental radionuclides measurements. The process is expected to reveal the key parameters controlling the radionuclides' fate as well as their effect on the model prediction.

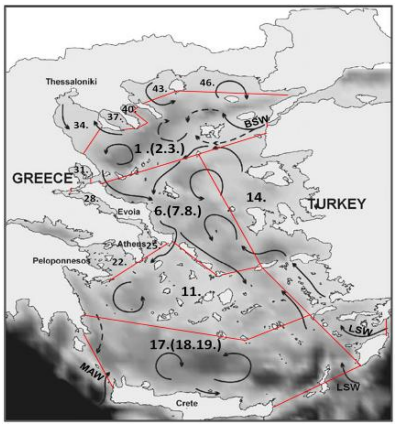

Figure 1: Boxes of Aegean Sea model and generalized pattern of surface water circulation (BSW: Black Sea Water; LSW: Levantine Surface Water; MAW: Middle Atlantic Water) [3].

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Engineering, Design Integration & the Integration Test Stand in the Engineering Resources Group (ERG)

N. Gazis, D. McGinnis, E. Tanke, S. Molloy, C.J. Hardh, D. Lundgren, M. Palsson

European Spallation Source ESS ERIC, Sweden

The mission of the Engineering Resources Group of the Accelerator Division is to provide services of design integration, mechanical engineering and system engineering to ESS Accelerator Systems (ACCSYS) that are applicable across work package boundaries. The roles of ERG are (i) system engineering management, (ii) Accelerator Tunnel (AT) and Klystron Gallery (KG) 3D-model documentation, (iii) Contact point for the communication of Accelerator Division (ESS-AD) to Conventional Facilities division (ESS-CF), (iv) Generation, maintenance and coordination of the Integration Test Stand, (v) Coordination of the AD Technical Laboratories, design and maintenance of the Repair Lab and of its functionalities, including mechanical and material properties experimentation and Non Destructive Testing for Accelerators (NDTA).

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The evolution of ^{137}Cs in the Greek marine environment and dose rate assessment in fish representing the three discrete exposure spaces

H. Florou, G. Trabidou, M. Sotiropoulou, G. Kuburas
Environmental Radioactivity Laboratory, Institute of Nuclear & Radiological Sciences & Technology, Energy & Safety, NCSR "Demokritos", Agia Paraskevi, 15310, Attiki, Greece
eflorou@ipta.demokritos.gr

Keywords: Cs-137 in seawater, Cs-137 in sediments, Cs-137 dose rates, Dose rates to Fish, Marine habitats

The time evolution of ^{137}Cs activity concentrations from 1984 to 2015 in seawater and sediments are reported in terms of cold and warm period, with the radiological impact to marine biota selected from the three habitats to be estimated before and after the Chernobyl NPP accident. Therefore, the 30-year retrospective synopsis of ^{137}Cs activity concentrations in abiotic components from the Aegean Sea is used to assess the external and internal dose rates to seven representative fish species according to their habitats. For this purpose, different exposure spaces as: a) infinitive for the sea water, b) infinitive for sediment layers and c) semi-infinitive for the seawater-sediment interface are contemplated for the external dose rate estimations to natural marine biota. The concentration factors, calculated on the basis of real measurements, are used to estimate the internal dose rates in terms of three distinct habitats of Fish characterized as: pelagic, demersal and demersal-pelagic. For the dose rate calculations in seawater, different layers from surface to 1000 m have been differentiated, whereas the coastal area to the isobath line of 250 m has been used for the dose rate calculations from sediments.

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