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Nuclear Physics

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NUCLEAR PHYSICS

Determination of Depleted Uranium in Environmental Samples From Albania (abstract)

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The question of environmental and health impacts originating from depleted uranium (DU) present in ammunition after several conflicts has become a much debated issue. The aim of this work was to search for possible DU contamination in environmental samples (soil, groundwater, and grass) from Albania using radiochemical procedures.

NATO confirmed in February 2000 the use of DU during the Kosovo conflict. In March 2001 the United Nations Environment Programme (UNEP) published its findings in the report *DU in Kosovo*. UNEP carried out three environmental assessments of DU in the Balkans. These studies confirm that the behavior of DU is a complex issue and that DU can be found in soil, vegetation, groundwater, and air under certain conditions many years after the event. For this reason, UNEP strongly encourages further studies in the areas where risks might be found. It is evident that most of the targeted sites with DU are very close to the Albania–Kosovo border, in northeastern Albania.

For the safety of the local population, it is essential to obtain straightforward and accurate information regarding the environmental situation and any possible related health risks. We therefore decided to collect environmental samples (soil, grass, and groundwater) from this part of Albania. The samples were analyzed for DU. The analysis was performed by isotope dilution alpha spectrometry using ^{232}U tracers. The sources for the alpha spectrometric analysis were prepared by electrodepositing on stainless steel disks. IAEA reference materials were analyzed together with the samples for the purpose of internal quality control. The evaluation of the alpha-spectrometric results was made only for the activity concentration data on ^{238}U and ^{234}U due to higher sensitivity of this method for these isotopes. In order to distinguish between natural and anthropogenic uranium, ^{234}U/^{238}U and ^{235}U/^{238}U activity ratios can be used. No DU contaminations were found in our samples. It was thus concluded that there could be a future risk of DU contamination of groundwater. Because the mechanism that governs the contamination of water in a given environment is not known in detail, it is recommended that water sampling and measurements should continue for several years.

Radon-Concentration Measurements in Houses of Oujda, Morocco (abstract)

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Exposure to radon and radon decay products in the home and at work constitutes one of the greatest risks of ionizing radiation. Radon is continually produced from uranium and thorium, which occur in most rocks and soils throughout the world.

No radon measurements were previously taken in northeast Morocco. In this study, measurements were taken in houses in different environments around the city of Oujda. We used the AlphaGUARD detector, which is an active detector. The time duration for each measurement in each house was at least three days.

Radon concentrations were also measured on different floors and in underground areas with very low ventilation and where doors and windows were kept closed. The results showed low radon concentration (it ranged between 2 and 27 Bq/m^3). We observed a correlation between the radon concentration and the humidity during the time of the measurements (2006–2010). The same results were observed in 2001 using Lucas cells.

Women in Physics
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Degeneracies Around the Alhassid-Whelan Arc of Regularity (abstract)

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More than a decade ago, Alhassid and Whelan carried out a study on the chaotic behavior in nuclei using a simple two-parameter IBA-1 Hamiltonian that spanned the entire range of structures from vibrator to axial rotor to gamma-soft rotor. Most nuclei, however, do not actually satisfy these stable limits of structure (placed at the vertices of a symmetry triangle, called the Casten triangle) but are rather placed in regions of changing character as a function of the nucleon (proton and/or neutron) number. They found that the level spectra are regular at and near the three dynamical symmetries U(5), SU(3), and O(6) of the model, and that chaotic behavior develops as one moves away from the symmetries. There were two exceptions. The first happens between U(5) and O(6) and is connected to the conserved O(5) symmetry. The second is a region of nearly regular behavior connecting SU(3) to U(5) centered on an arc in the triangle that could not be explained by a common subgroup. The fascinating theoretical curiosity was confirmed in subsequent years on theoretical grounds but was not understood in detail. Also, at the time, there were no identified nuclei corresponding to this new regular region.

Twelve atomic nuclei, spanning the whole range from well deformed to spherical, located close to the regular region of the Casten triangle noted by Alhassid and Whelan were recently identified. They exhibit an almost one-to-one correspondence between the near degeneracy of the gamma-band head (22+) and the K = 0 band head (02+). While the 22+/02+ degeneracy marks the regular region, the question then arises as to what features distinguish the nuclei that lie in the interior of the triangle from those near SU(3), since this near degeneracy is also a well-known signature of SU(3). Apparently along this trajectory there is some hidden symmetry, perhaps corresponding to the emergence of an unidentified conserved or partially conserved quantum number.

Most of the calculations involving the IBA are done in a U(5) basis. Wave functions of the nuclei on the arc of regularity are complicated when expressed in a U(5) basis. Since the 22+/02+ degeneracy is a well-known signature of SU(3), we decided to look at the wave functions expressed in the SU(3) basis. We performed calculations to describe and analyze energies and wave functions of nuclei on or close to the arc in the SU(3) basis to identify key observables that uniquely characterize this region of regularity. The calculations agree with the first example of an empirically manifested quasi-dynamical symmetry trajectory in the interior of the symmetry triangle of the interacting boson approximation model identified for large boson numbers.

Photoneutron Activation Analysis of a Few Grams of Samples Using a Low-Power Research Reactor: A Feasibility Study (abstract)

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A feasibility study of a large sample (samples ranging from 0.5 g to 5 g) of instrumental neutron activation analysis (INAA) using photoneutrons when GHARR-1 has been shut down is presented. Routine INAA employs neutrons from research reactors in operation rather than photoneutrons generated in the reactor after it has been shut down. Photoneutrons behave in a similar manner to delayed neutrons in their effect on the reactor kinetics. Thus, in addition to their contribution as a neutron start-up source in reactors, photoneutrons can also be employed as a neutron source in activation analysis. The photoneutron in GHARR-1 has a relatively low flux magnitude, in the order of 10^7 n/cm^2.s^1. Large-sample INAA lends itself to low flux irradiation; therefore, it makes the photoneutrons in GHARR-1 a very potential irradiation source. Large sample INAA complements and considerably extends the analytical tools available for qualitative and quantitative studies, providing unique applications of in-depth, non-destructive, multi-element analysis of materials too precious to damage for sampling purposes (whole objects analysis), representative sampling of heterogeneous materials, or analysis of samples of arbitrary shape. The gamma-ray detector efficiency for the voluminous large samples was determined. Corrections for gamma-ray self-attenuation and neutron self-shielding in the sample were performed via transmission experiments and neutron flux depression measurements, respectively. The results of this feasibility study provided the possibility for optimized utilization of the photoneutrons in GHARR-1 for large sample INAA.

Interaction of ^{12}C Ions With Enriched Tin Isotopes (abstract)

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The enriched tin isotopes ^{112,118,120,124}Sn were irradiated at the Nuclotron of the JINR (Joint Institute for Nuclear Research at Dubna) by a ^{12}C-ion beam with an energy of 2,2 A GeV. The induced-activity method used in the present work allows measurement of products in a mass range of A = 7 (^{7}Be) up to heavy products with masses close to the target. In this work, about 110 radioactive products of ^{12}C ion beam interaction with ^{112,118,120,124}Sn targets have been registered. However, measured cross sections are only a fraction of the total reaction cross section. In order to obtain the mass-yield curve and charge distribution curves unmeasured, cross sections have to be estimated. For this purpose, we used the equation proposed by Cumming et al. Using targets with different nucleonic compositions allowed us to observe a shift of the position of the maxima of the charge distribution Z_p toward more neutron-rich isotopes for more neutron-rich targets preserved in the whole nuclear-charge range.

The mass-yield curve obtained for p(8.1 GeV) + 118Sn, d(3.65 A GeV) + 118Sn, and 12C(2.2 A GeV) + 118Sn is discussed. Similarity of curves and shift on the certain factor may be considered as a conformation of factorization hypothesis (factorization hypothesis predicted that the ion cross sections be larger than proton cross sections by the ratio of respective total reaction cross sections). Comparison of experimental data with NC + SMM model calculations was made for these reactions.

Radionuclide Contamination of Edible Fish Species in the Oil-Producing Coastal Town of Ondo State, Nigeria (abstract)

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This study examined the radionuclide content of edible fish species in Igbobini, an oil-producing area of Ondo State. The activity concentration of selected radionuclide, potassium (^{40}K), uranium (^{238}U), and thorium (^{232}Th) in freshwater fish samples (catfish/*Clarias* and tilapia/*Channa obscura*) taken from River Oluwa, being the major source of fish consumed, was analyzed using gamma-ray spectroscopy. The results showed that tilapia did not have any trace of thorium (^{232}Th) activity. The calculated effective dose equivalent for tilapia samples for potassium (^{40}K) was 0.11308 mSv/y and 0.00642 mSv/y for uranium ^{238}U. For the catfish sample, potassium (^{40}K) was 0.1313 mSv/y, uranium (^{238}U) was 0.00209 mSv/), and thorium (^{232}Th) was 0.0313 mSv/y. These results show that the Derived Intervention Levels' recommendation of a dose of 5mSv per year was not exceeded.

Neutron Density Distributions of Nickel Isotopes Analyzed in Terms of Relativistic Impulse Approximation (abstract)

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The development of accelerator and experimental technology enables us to produce many unknown nuclei. They have either too much or too few neutrons; therefore, they are unstable. Knowing the nuclear size and distribution of protons and neutrons is very important because it provides us with information on the interaction between nucleons beyond the well-known stable region. The most convenient and usual method for such a purpose is proton-nucleus elastic scattering, where differential cross section and analyzing power are observed. On the other hand, recent relativistic mean-field calculations have provided nuclear distributions of many isotopes whose neutron numbers are much larger than their atomic numbers. In the present paper, the author calculates observables of proton elastic scattering from some of those unstable isotopes and discusses relations between observables and nuclear distributions of such unstable nuclei, especially nickel isotopes ^{58,60,62,64}Ni. The calculations are based on relativistic

impulse approximation (RIA) at incident proton energies from 300 through 500 MeV, where predictions of RIA have been shown to provide good agreement with experimental data.

Since experiments of unstable nuclei are not easy and rather difficult at present, in order to obtain information on nuclear density distributions of target unstable nuclei, the available experimental observables are restricted. The author demonstrates, as for unstable nuclei, that a model analysis in which the Woods-Saxon distribution is assumed for neutron density provides a prescription for determination of two parameters of assumed distribution in terms of two restricted observables: reaction cross section and the first dip position of the differential cross section. As already mentioned, calculations are based on the relativistic impulse approximation (RIA) and the relativistic mean-field theory (RFMT).

In the RIA analysis, observables are calculated according to the Dirac equation with optical potentials, and these optical potential are given by the nucleon-nucleon scattering amplitudes constructed in a relativistic framework, and by the target nuclear density provided from RMFT. RMFT, where the Lagrangian density is given in relativistic form, can provide density distributions not only of stable nuclei but also of unstable nuclei. For proton density, one can use distributions calculated from either RMFT or charge distribution given by the electron scattering. In either case, the proton distribution is fixed for a target nucleus. On the other hand, the assumed profile for neutron distribution has two parameters, according to the Woods-Saxon function: radius and diffuseness parameters.

Two contour maps for reaction cross section and the first dip position of differential cross section with respect to two parameters are presented for ^{64}Ni target nucleus at 300 MeV, and calculated two observables with RMFT density determine two parameters via these maps. Therefore, one can obtain the neutron distribution of unstable ^{64}Ni target nucleus. It is shown that the parameters determined with those observables given by RMFT density reproduce very well the profile of RMFT distribution, especially in the surface region.

Study of ^{12}Be Using the (^{7}Li, ^{7}Be) Charge-Exchange Reaction in Inverse Kinematics (abstract)

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In a nuclear charge-exchange reaction, a proton in the projectile nucleus is exchanged with a neutron in the target (or vice versa). These reactions have been used extensively in forward kinematics to probe the spin-isospin response of nuclei. They are particularly useful for studying Gamow-Teller (GT) transitions—characterized by zero angular momentum transfer and a total spin transfer of one—as they connect the same final and initial states as weak transitions like beta decay and electron capture but have access to a larger excitation energy window. A simple proportionality exists at intermediate energies between the differential cross section in the limit of vanishing momentum transfer and Gamow-Teller strength, B(GT). Exploiting this proportionality allows one to extract detailed structure information in a model-independent way and thus provides strict checks for nuclear structure models.

Until recently such use of charge-exchange reactions was limited to transitions from stable targets. The growing number of radioactive beam facilities, however, gives impetus to extend these studies to rare isotopes. In this spirit, the charge-exchange group at the National Superconducting Cyclotron Laboratory (NSCL) is pioneering the use of charge-exchange reactions in inverse kinematics for the study of exotic nuclei. In the (n,p) direction, a (^{7}Li, ^{7}Be) program has been developed, studying the B(GT) distribution excited from odd-odd nuclei near neutron shell closures.

The first successful application of this novel experiment technique was a study of the N = 20 nucleus ^{34}Si, located on the boundary of the island of inversion. The second and most recent application was to the lighter ^{12}Be system, in an attempt to elucidate the evolution of the N = 8 shell closure far from the valley of nuclear stability. The experimental technique, motivation for the study of ^{12}Be, and B(GT) distribution, will be presented.

Determination of Mean Glandular Dose in Mammography Procedure at Two Hospitals in Kumasi (abstract)

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The objective of this project was to determine the mean glandular dose (MGD) to the breast during diagnostic mammography. The study was conducted in 125 patients at the mammography unit of the Komfo Anokye Teaching Hospital and the Peace and Love Hospital, Oduom. Patients' data such as age, weight, height, bust size, compressed breast thickness, time of exposure, milliampere-second (mAs), kilovoltage peak (KVp), and half-value layer were recorded. MGD per film was estimated from recorded radiographic factors and the compressed breast thickness (CBT) using medical physics software. MGD per patient was calculated by adding up the MGDs for all films, averaging it over both breasts. The MGD per film was 1.15 mGy and 1.17 mGy for the craniocaudal (CC) and mediolateral oblique (MLO) views, respectively. The mean MGD per patient was 1.13 mGy. The only factors that were found to affect MGD were mAs and the compressed breast thickness. No significant relationships were noted between MGD per patient with respect to ethnicity, educational background, body mass index (BMI), equivalent diameter, or age. The dose values obtained fall within the internationally acceptable dose range of 1–3 mGy. This implies that the patients in the study were not overexposed during diagnostic mammography. This prompted us to rule out that, all other factors considered, they are not at risk of induced cancer from a mammography.

Measurement of the Beta Asymmetry in Neutron Decay Using Ultracold Neutrons (abstract)

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The axial-vector weak coupling constant, gA, plays an important role in our understanding of the nucleon spin and flavor structure. A comparison of the neutron lifetime and the beta asymmetry (the correlation between the neutron spin and the direction of the electron emitted in neutron beta decay) can be used to extract the value of gA. Such angular correlation measurements in neutron decay have been performed with thermal and cold neutron beams. The use of ultracold neutrons (UCNs) for these measurements provides a different and powerful approach to controlling key sources of systematic effects in measurements of polarized neutron decay: preparation of highly polarized neutron samples and reduction of the backgrounds intrinsic to the neutron decay sample.

UCNs are defined as neutrons with energies low enough that they undergo total external reflection from an effective potential barrier, EFermi, at some material surfaces and can thus be stored in material bottles. We produced UCN in a solid deuterium (SD2) converter coupled to a tungsten spallation target in the 800 MeV proton beam at the Los Alamos Neutron Science Center (LANSCE). UCNs were transported to the UCNA spectrometer, where their decay electrons were detected. In this poster, I will discuss our resulting measurements of the beta asymmetry and the resulting value of gA.

Ethiopia's Special Interest in Nuclear Radiation and Its Application (abstract)

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Different types of energy include, basically, tidal, hydroelectric, biomass, geothermal, solar, wind, wave, coal, petroleum, gas, and nuclear energy. Nuclear energy is the energy coming from different nuclear decays or reactions where finally there is the emission of different kinds of radiation. Intentionally or unintentionally, it is possible that humans have been exposed to excessive radiation, which could result in death. But if utilized wisely, radiation can be used in various applications.

Ethiopia's development policy focuses on poverty reduction, with a special transformation plan of five years that started in September 2010. This plan's priority areas are agriculture, rural development, industry, infrastructure, social development, and good governance. The agricultural sector is a leader in the growth of the economy, which has enabled the industrial sector to drive the development of the country. Ethiopia is naturally endowed with agricultural prosperity, with 85% of the population living and working in agriculture. We can broaden the application of nuclear radiation to the agricultural sector, but sectors such as health, security, and industry—which include Earth science, nuclear medicine, crime investigation, environmental protection, investigation of radioactive atoms in mining areas, access to clean water, archaeology, art, and oil and gas exploration—desperately need the application of nuclear radiation. There has been tremendous success as well, such as on Tsetse flies, cancer treatment, diagnostic nuclear medicine services, isotope hydrological analysis, and nondestructive quality testing.

Despite the fact that nuclear energy has many advantages in addition to various radiation applications, it has some disadvantages. First, if waste leaks it is dangerous. Second, earthquakes, flooding, and terrorists need to be considered when burying wastes, which could be costly because of these safety issues. Consequently, people are increasingly concerned about these threats—in the 1990s nuclear power was the fastest-growing source of power in much of the world. In 2005 it was the second slowest-growing. Surprisingly, this is not a problem for Ethiopia because huge nuclear reactors will not be established, and with important improvements on the waste disposal issue among others, serious consideration will be given even for the smallest application. Moreover, Ethiopia is focusing on peaceful applications of nuclear energy or radiation. It has more than 80 million people and an estimated 150,000 new cancer cases each year, but there are only two Cobalt-60 machines and a single SPECT gamma camera with a single radiotherapy center. There are many gaps to be filled, but Ethiopia is a developing country and does not have the resources to fill in the gaps. Hence it needs multifaceted support from different organizations.

The Role of Women in the Discovery of Isotopes (abstract)

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Ninety years after Soddy won the Nobel Prize in Chemistry for "his investigations into the origin and nature of isotopes," the quest to expand the nuclear horizon and discover new isotopes has regained momentum. After about 10 years of very little progress, the discovery rate has increased tremendously during the last few years. In 2010 more than 100 new isotopes were reported, which is the largest number of isotopes discovered in any one year. This increase is primarily due to the beginning of the operation of RIBF at RIKEN and to the technical advances to separate and identify heavy neutron-rich isotopes following uranium fragmentation at GSI.

We recently completed a project to document the discovery of all isotopes analyzing the more than 3,000 presently known isotopes. These data and some additional information are currently being published in a series of articles in *Atomic Data and Nuclear Data Tables*.

Women have played important roles in these discoveries. From Marie Curie, whom we credit with the discovery of one of the first isotopes, ^{210}Po, to Monique Bernas, who was the first author of two papers reporting the newest isotopes and second on the list of most isotopes discovered as first author with 110, behind only Frederick Aston. These data and other interesting facts, trends, and statistical data will be presented. In addition, the discovery criteria and some of the controversial cases will be discussed.

Small-Range Behavior of Meson Wave Function in a Relativistic Two-Body Model (abstract)

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Usually wave functions show singular behavior at small ranges. However, within Dirac's relativistic constraints, the relativistic wave functions do not show singularity even at small ranges as long as we treat the dynamics correctly. We applied the two-body Dirac equation (TBDE) to a qqbar system and obtained covariant nonperturbative bound states. In this process, we reduced the TBDE to the relativistic Schrödinger-type equation with effective potentials. When the bound state is spin-doublet, the Schrödinger-type equations are coupled equations between S- and D-waves. We used linear-plus-Coulomb-type potential, which reflected the confinement and asymptotic freedom. The solution of this relativistic Schrödinger-type equation behaves well even at small range with Coulomb-type interaction.