ISINN-22

XXII International Seminar on Interaction of Neutrons with Nuclei

Fundamental Interactions & Neutrons, Nuclear Structure, Ultracold Neutrons, Related Topics

Dubna, 2014 **Absrtacts**

Joint Institute for Nuclear Research

FUNDAMENTAL INTERACTIONS & NEUTRONS, NUCLEAR STRUCTURE, ULTRACOLD NEUTRONS, RELATED TOPICS

XXII International Seminar on Interaction of Neutrons with Nuclei

Dubna, Russia, May 27–30, 2014

Abstracts of the Seminar

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May 26, Monday

18:00 – 20:00 Registration in DUBNA hotel

20:00 Welcome party in DUBNA hotel

May 27, Tuesday

8:30 – 9:00 Registration in International Conference Hall

UCN and fundamental interaction

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2.	**09:50 – 10:20**	**Golub R.** Random walks and the neutron electric dipole moment.
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4.	**10:50 – 11:20**	**Schmidt-Wellenburg Ph.** Status of the search for a neutron electric dipole moment - first results.

11:20 – 11:35 Coffee break

5.	**11:35 – 11:55**	**Kulin G.** Diffraction on moving grating and systematic effects in gravity experiment.
6.	**11:55 – 12:25**	**Korobkina E.** UCN source at PULSTAR reactor.
7.	**12:25 – 12:55**	**Lychagin E.V.,** Muzychka A.Yu, Nekhaev G.V., Nesvizhevsky V.V., Strelkov A.V. Helium UCN source at the extracted beam of thermal neutrons.

12:55 – 13:05 Conference photo

13:05 – 14:00 Lunch

8.	**14:00 – 14:25**	**Bunakov V.E.** Chaos as a result of symmetry breaking.
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15:20 – 15:35 Coffee break

Nuclear analytical methods in the life sciences, biology and medicine

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12.	**16:05 – 16:35**	**Frontasyeva M.V.** The moss biomonitoring, nuclear and related analytical techniques, and GIS technology used to study atmospheric deposition of trace elements and radionuclides in the areas under strong anthropogenic impact.
13.	**16:35 – 17:05**	**Duliu O.G.** The geochemistry of the Black Sea sediments belonging to the first and to the second stratigraphic units (I): the major elements vertical profile.
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17.	**09:30 – 09:50**	**Chietera A.** Neutron emission anisotropy in fission.
18.	**09:50 – 10:20**	**Carjan N.** Calculated scission-neutron properties in unexpected agreement with experimental data on prompt neutrons.
19.	**10:20 – 10:50**	**Kamanin D.V.** Searching for shape isomeric states leading to ternary decay of heavy nucleus.

10:50 – 11:05 Coffee break

20.	**11:05 – 11:35**	**Pyatkov Yu.** Study of shape isomeric states in fission fragments.
21.	**11:35 – 12:05**	**Barabanov A.L.** Interference of neutron resonances and T-odd angular correlations in ternary fission.
22.	**12:05 – 12:35**	**Kadmensky S.G.** Dynamical effects in the formation of anisotropies for angular distributions of products of binary and ternary fission of oriented nuclei targets by cold polarized neutrons.

12:35 – 14:00 Lunch

Second parallel session

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2.	**09:30 – 09:50**	**Pavlov D.F.** (Borok, Yaroslavl Oblast) Neutron activation analysis of chemical elemental composition of bivalve mollusks of the South African coast.
3.	**09:50 – 10:10**	**Nekhoroshkov P.** Neutron activation analysis of plankton from coastal zone of Crimea (Black Sea).
4.	**10:10 – 10:30**	**Ziembik Z.** (Opole University, Poland) Misinterpretation of correlation coefficients – false covariabilities in compositional data.
5.	**10:30 – 10:50**	**Ziembik Z.** Spatial patterns of element distributions in moss in the area of the Opole province (Poland).

10:50 – 11:05 Coffee break

6.	**11:05 – 11:30**	**Shakil Ahmad** (UK) Environmental projects in the Northern Africa.
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12:35 – 14:00 Lunch
14:00-15:45 Poster session
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Nuclear analytical methods in the Life Sciences

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12.	16:40 – 17:00	**Lazo P.** (Albania) Atmospheric deposition of trace elements in Albania by moss biomonitoring and NAA technique.
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Nuclear analytical methods in the Life Sciences

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11:00 – 11:15 Coffee break

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12:25 – 12:40 Coffee break

9.	12:40 – 13:00	**Zavorka L.** Investigation of the fission rates in ^{235}U, ^{238}U, and ^{209}Bi samples irradiated at the QUINTA target.
10.	13:00 – 13:20	**Kish Yu.** Measurement of the reaction rates in ^{232}Th samples irradiated by 4 GeV deuterons and secondary neutrons.
11.	13:20 – 13:40	**Khushvaktov J.** Study the interaction of secondary neutrons with nuclei Th-232, I-127, I-129 on the uranium assembly "QUINTA" Nuclotron JINR on deuterons beam with energy 2, 4, 8 GeV.

13:40 Lunch

16:00 Picnic

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11:00 – 11:15 Coffee break

Nuclear Structure, Photon strength functions

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13:05 – 14:00 Lunch

Nuclear Structure, Photon strength functions

21.	14:00 – 14:30	Achakovskiy O.I., Avdeenkov A.V., **Kamerdzhiev S.P.** On microscopic nature of photon strength function.
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STUDY OF THE INTERACTION OF SECONDARY NEUTRONS WITH NUCLEI ^{232}Th, ^{129}I, ^{127}I ON THE URANIUM ASSEMBLY "QUINTA" NUCLOTRON JINR ON DEUTERONS BEAM WITH ENERGY 2, 4, 8 GeV

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ABSTRACT

Target assembly "Quinta" with a mass of 512 kg of natural metallic uranium and surrounded with lead shield irradiated on three deuteron energies (2, 4 and 8 GeV) with the total number of deuterons on the target ~ 10^{13} at each energy. Samples ^{127}I, ^{129}I and ^{nat}Th were irradiated with secondary neutrons at lead shield. In results of experiment for ^{232}Th has been identified a large number of product nuclei (at 2 GeV – 19, at 4 GeV - 30 and at 8 GeV - 27) for three values of the deuteron energy. For each of these are obtained reaction rates. Thorium fission reaction rates for deuteron energies at 2 GeV is 0.58(6)E-27, at 4 GeV is 1.36(9)E-27 and at 8 GeV is 2.92(14)E-27. On samples ^{127}I has been identified (n,γ), (n,2n), (n,4n), (n,5n), (n,7n) and (n,8n) reactions and on^{129}I identified (n,γ), (n,4n), (n,6n) and (n,7n) reactions. Obtained results show that with increasing deuteron energy increases and the value of the reaction rates for almost all product nuclei. Obviously, this growth is due to the increased flux and energy of secondary neutrons with increasing energy deuterons. The experimental results were compared with Monte Carlo simulations perfomed with the MCNPX2.7 and MARS15 code. experimental and calculated rates of (n,γ), (n,xn) and (n,fission) reactions are in good agreement.

MEASUREMENT OF THE REACTION RATES IN ^{232}Th SAMPLES IRRADIATED BY 4 GeV DEUTERONS AND SECONDARY NEUTRONS

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The experiment was performed at the "*QUINTA*" (uranium target assembly, weight of 512 kg, consisting of 5 separate sections) on the deuteron beam (4 GeV) of the Nuclotron accelerator VBLHEP JINR. The total flux of deuterons on the target was 1.41E+13 particles during 1157 min. irradiation. The sample of ^{232}Th was placed inside the uranium assembly at the deuteron-beam axis in one of the six special gaps between sections 1 and 2. After irradiation, deuterons and secondary neutrons the sample was taken to the spectrometric complex YASNAPP-2 in the JINR DLNP, where the spectra of γ-radiation were measured using HPGe-detectors. The reaction rates with ^{232}Th(n,γ)^{233}Th→^{233}Pa, ^{232}Th(d,n)^{233}Pa, ^{232}Th[(d,t),(d,nd),(d,2np),(n,2n)]^{231}Th, ^{232}Th[(n,f),(d,spallation)]^{88}Kr and other were obtained.

A PROPOSAL FOR AN IRRADIATION OF THE «*QUINTA*» TARGET ASSEMBLY WITH THE PROTON BEAM OF THE DLNP JINR PHASOTRON ACCELERATOR

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The Accelerator Driven Systems (ADS) have been comprehensively investigated worldwide since the 1990s. The nuclear energy production and transmutation of spent nuclear fuel – a high-level long-lived radioactive material composed of actinides and fission products – are the main aims of both theoretical and experimental studies in the ADS field of research.

A spallation target *QUINTA* represents an experimental setup intended for performing such investigations. The massive spallation target is composed of natural uranium cylinders of the total mass of 512 kg. The whole target, assembled of five hexagonal sections, is located in 10 cm thick lead biological shielding. Since 2011, a series of comprehensive experimental studies have been performed at the JINR Nuclotron accelerator [1,2]. During the experimental sessions, the *QUINTA* target has been irradiated with the deuteron beams of energies from 0.5 AGeV up to 4 AGeV. The deuteron beam intensities reached the order of 10^9 particles per second which represents just a minimum value for achievement of sufficient statistics by means of gamma-spectrometry measurements of various experimental samples.

For this reason, an irradiation of the *QUINTA* target with the intense 660 MeV proton beam of JINR Phasotron has been proposed. The experiment will be carried out in the experimental hall of the *«GENERATOR»* facility (spallation lead target 330 mm long and of 80 mm in diameter). The number of three experimental performances has been already carried out at the mentioned lead target during the recent years. During the measurements, the total beam integral was about 10^{15} incident particles and the beam intensity reached up to 5×10^{11} protons per second which still represent only 1/100 of the total available beam intensity (it was reduced due to the radiation safety requirements). The proton beam energy can also be reduced to any demanded value by a set of carbon foils.

The following tasks are proposed to be performed: i) to determine the integral number of fissions of ^{235,238}U in the target, ii) to thoroughly investigate the fast neutron spectra inside the target with the use of activation threshold detectors, iii) to evaluate the neutron leakage from the target, and iv) to carry out measurements of transmutation rates of some minor actinide samples (^{237}Np, ^{238}Pu, ^{239}Pu) inside the target.

[1] Adam J.,*et al.* // JINR Preprint, P1-2012-147, Dubna, 2012.
[2] Chilap V.V., *et al.* // NNC RK Bulletin Journal, National Nuclear Center of the Republic of Kazakhstan, 2011, Vol. 48. № 4, p. 68-75.

ON MICROSCOPIC NATURE OF THE PHOTON STRENGTH FUNCTION

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The E1 photon strength functions (PSF) of many Ni and Sn even-even isotopes have been calculated microscopically within the self-consistent version of the Extended Theory of Finite Fermi Systems which includes the QRPA approach and, in addition, phonon coupling [1,2]. The calculations are fully self-consistent in the sense that the HFB mean field, effective interaction and phonons have been calculated using the Skyrme force Sly4 with the known parameters, details see in [3]. On the contrary to the usual phenomenological approaches, these PSF have structures, the most interesting ones being in the energy region of the pygmy-dipole resonance. These structures are caused both by the QRPA and by the phonon coupling effects. The microscopically obtained PSF have been used in the EMPIRE3.1 code to calculate the radiative neutron capture cross sections. Here, the contribution of phonon coupling turned out rather noticeable. A reasonable agreement with the available experimental data have been obtained, including the explanation of the PSF in ^{116}Sn [4] and of integral characteristics of the pygmy-dipole resonance in the unstable ^{68}Ni [5].

1. S. Kamerdzhiev, J. Speth, G. Tertychny, Phys. Rept. **393**, 1 (2004).
2. V. Tselyaev, Phys. Rev., C **75**, 024306 (2007).
3. A. Avdeenkov, S. Goriely, S. Kamerdzhiev, S. Krewald, Phys. Rev. C **83**, 064316 (2011).
4. H. K. Topf, A. C. Larsen, A. Buerger, *et al.*, Phys. Rev. C **83**, 044320 (2011).
5. O. Wieland, A. Bracco, F. Camera *et al.*, Phys. Rev. Lett. **102**, 092502 (2009).

IMPACT OF PHONON COUPLING ON THE CAPTURE GAMMA-RAY SPECTRA

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The E1 photon strength functions (PSF) of several Ni and Sn even-even isotopes have been calculated microscopically within the self-consistent version of the Extended Theory of Finite Fermi Systems, which includes the QRPA approach and, in addition, phonon coupling [1,2]. These microscopically obtained PSF's (see details in [3]) have been used in the EMPIRE3.1 code to calculate the capture gamma-ray spectra at the neutron energy of 100 keV. It has been shown that the phonon coupling contribution is rather important and increases the cross sections considered. As a rule, our final results with phonon coupling are in a better agreement with the known phenomenological variant EGLO [4] than with the QRPA values.

1. S. Kamerdzhiev, J. Speth, G. Tertychny, Phys. Rept. **393**, 1 (2004).
2. V. Tselyaev, Phys. Rev., C **75**, 024306 (2007).
3. O.I. Achakovskiy , A.V. Avdeenkov, S.P. Kamerdzhiev, this conference.
4. Handbook for calculations of nuclear reactions data-RIPL2, IAEA-TECDOC-1506, 2006.

Registration of ternary particles from ^{252}Cf spontaneous fission source with Timepix detector

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The light charge particles from ^{252}Cf spontaneous fission source have been studied with time-, position- and energy- sensitive hybryd silicon pixelated detector Timepix. Type of particles has been identified applying the method ΔE-E using an additional thin silicon ΔE detector. The Timepix detector has been used for rest energy measurements (E).

A TRANSPORTING AND A DEFLECTION OF THERMAL NEUTRONS USING POLYVINYL CHLORIDE TUBES COATED WITH FLUORINE POLYMER

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Experimental results on the transmission of thermal neutrons through flexible polyvinyl chloride (PVC) tubes with diameter of 8 mm and length up to 140 cm are presented. PVC tubes possess high reflectivity of the inner surface. The reflectivity grows when the tube internal surface is covered with a liquid layer of fluoride polymer, which have high limited velocity (4.56 m/s) and a low probability (~ 10^{-5}) losses of neutrons per a collision with the wall of the tube.

The neutron beam of reactor IR-8 (NRC "Kurchatov Institute") with an average velocity of 4400 m/s was used for measurements. It is shown that the tubes allow to deflect neutron beam at 1-2 tube diameter at that the output intensity equal to 3-5 percent of the input intensity. The deflection of the tube outlet on 1 diameter allows to bring out the neutron beam from a zone of the reactor hard gamma radiation with energies in range of (0.05-8.0) MeV

The transmission of neutrons with a velocity of less than 950 m/s by straight and curved tubes was investigated with using Bragg's filter in the form microcrystalline diamond powder. For measurements of the input and output neutron flux was used position-sensitive neutron detector (Image Plate), allowing one to obtain the image of the beam in the plane perpendicular to its axis. The measurements have shown that the output beam can be deflected using the PVC tube by 2.5 cm (more than 3 diameters) under maintaining of the output intensity at the level of 10 % from the input intensity.

The investigations which have been done for the first time showed that using PVC tubes with internal fluoride polymer coating possible the deflection and the formation of the reactor neutron beams of different energy composition and different admixture of fast neutrons and gamma rays. We also discuss the possibility using of PVC tubes for the purposes of neutron-capture therapy of cancerous tumors.

A MEASUREMENT OF THE NEUTRON LIFETIME USING THE METHOD OF STORAGE OF ULTRACOLD NEUTRONS AND DETECTION OF INELASTICALLY UP-SCATTERED NEUTRONS

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The neutron lifetime experiment using the method of storage of ultracold neutrons (UCN) in traps and detection of neutrons, which couldescape from the storage trap via their inelastic scattering on the trap walls, was performed in 2008-2010 at the high-flux neutron reactor of Institut Max von Laue – Paul Langevin (ILL, Grenoble, France).

Three independent neutron lifetime measurements under different experimental conditionswere performed. Each measurementis carried out in two geometries of the storage trap; these two options differ from each other by the frequency of UCN collisions with the trap walls arising due to different wall surface area open for UCN.

We present estimations and results of experimental studies of systematic effects in our experiment.

The reason for correction	Time [sec]		
	H_d = 55 cm, T = + 23° C	H_d = 75 cm, T = + 23° C	H_d = 75cm, T = - 26° C
Uncorrected τ_β-values	884.15±2.10$_{stat}$	884.30±0.95$_{stat}$	883.60±0.95$_{stat}$
Partial count rate loss in the UCN detector	- 1.28 ± 0.15	- 3.01 ± 0.18	- 3.82 ± 0.14
Scattering of UCN on residual gas	- 1.84 ± 0.31	- 0.43 ± 0.12	0.17 ± 0.10
Difference in ε_{ucn1} and ε_{ucn2}	- 0.61 ± 0.11	- 0.23 ± 0.06	- 0.24 ± 0.03
Difference in $\varepsilon^{(i)}_{ucn}$ and $\varepsilon^{(f)}_{ucn}$	-0.15 ±0.06	0. ±0.06	0. ±0.06
Difference in ε_{th1} and ε_{th2}	1.00 ±0.40	0.46 ±0.24	0.18 ±0.09
Difference in temperatures in the geometries 1 and 2	No correction	No correction	0.11 ± 0.06
Eventual leak through the trap UCN shutter	0 ± 0.05	0 ± 0.05	0 ± 0.05
The cross section ratios inequality	0 ± 0.03	0 ± 0.03	0 ± 0.01
Weak heating	-0.38 ±0.38	-0.52±0.52	-0.03 ±0.03
The total systematic correction	- 3.26 ± 1.49	- 3.73 ± 1.26	- 3.63 ± 0.57
τ_β-values with all systematic corrections	880.89 ± 3.59	880.57 ± 2.21	879.97 ± 1.52

Here H_d is the upper boundary of the UCN energy spectrum, ε_{ucn1} and ε_{ucn2} are the efficiencies of UCN detection for the geometries no.1 and no.2 respectively, ε_{th1} and ε_{th2} are analogous efficiencies of detection of neutrons inelastically scattered on the trap walls, $\varepsilon^{(i)}_{ucn}$and $\varepsilon^{(f)}_{ucn}$ are the efficiencies of UCN detection at the initial and final moments of the USN storage.

The result of measuring τ_β-value averaged over three independent results in the last line in Table is equal to τ_β= (880.2 ± 1.2) sec.

Activation cross-sections of (n, p) reactions for the selenium isotopes ^{78}Se and ^{80}Se over the neutron energy range 13.73 MeV to 14.77 MeV

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Abstract

The neutron-induced reactions which are important for some specific nuclear applications can be investigated by measuring the activities of the reaction products. Some reactions exhibit characteristics thresholds, cross-sections, emission radiations and decay half-lives which qualify them for use as monitors in fast neutron dosimetry. Neutron-induced cross section data are of importance both for the basic research, nuclear technologies and related developments.

Selenium is a non metallic mineral and is present in nature as six stable isotopes ^{74}Se, ^{76}Se, ^{77}Se, ^{78}Se, ^{80}Se, ^{82}Se isotopes. The selenium-79 isotope has half-life of 2.95 x 10^9 years and decays by beta emission namely present in the spent nuclear fuels and waste material obtained after reprocessing of the fuel. The selenium isotopes occur naturally as trace element in most soils, rocks, water and volcanic effluents. Selenium isotopes therefore present at trace levels in nuclear reactor installation. ^{77}Se and ^{78}Se are used for the production of therapeutic radioisotope ^{77}Br. ^{80}Se is used for the production of medical isotope ^{80}Br^{m}. Arsenic has over 33 different isotopes with mass number ranging from 60 to 92. Out of these isotopes, only ^{75}As is stable. Arsenic is one of the most toxic elements found in nature. Humans are exposed to arsenic through food, water and air.

Measurements of the activation cross-sections for different nuclear reactions have remained a field of interest for the past few decades. For fusion reactors, accurate values of the cross-sections for the (n, p) reaction are required for assessing and predicting the amount of hydrogen gas trapped in the surrounding materials. The total reaction cross-sections for the (n, p) reactions are also of interest in the study of damage in materials.

Activation cross-sections of (n, p) reactions for the two selenium isotopes ^{78}Se, ^{80}Se were measured at five neutron energies over the range 13.73 MeV to 14.77 MeV. The fast neutrons were produced by the ^{3}H(^{2}D, n)^{4}He reaction at the 200keV deuteron energy using the neutron generator laboratory of the University of Pune. Natural selenium samples were irradiated with neutrons along with Fe or F elements as moderators. The induced gamma-ray activities in each reaction were measured using a high resolution HPGE detector coupled to data storage system. The variation in the cross-sections for the ^{78}Se(n, p)^{78}As and ^{80}Se(n,p)^{80}As reactions with the neutron energies were studied. These results were compared with earlier measured cross-section values reported in the literature. The cross-sections were also theoretically estimated using statistical nuclear models EMPIRE-II and TALYS codes over neutron energies from 10 MeV to 20 MeV, covering the range of the presently used neutron energies.

INTERFERENCE OF NEUTRON RESONANCES AND T-ODD ANGULAR CORRELATIONS IN TERNARY FISSION

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T-odd angular correlations in the polarized-neutron-induced ternary fission of heavy nuclei are discussed (see, e.g., [1]). These correlations are caused by final-state interactions. Interest to T-odd correlations is due to the fact they can provide additional information on the mechanism of ternary fission.

General scheme for description of such angular correlations has been proposed in [2]. The method is based on the use in output three-body channel (two fission fragments and a third light particle, e.g., α particle) of the wave function expansion in terms of the hyperspherical harmonics. However, a proper account for input channel is of crucial importance to describe the angular correlations in fission of nuclei by slow (s-wave) polarized neutrons. The reason is in the following.

If the capture of a polarized neutron by a nucleus with spin I leads to the formation of compound resonance with a definite spin J, equal to $I-1/2$ or $I+1/2$, then the compound nucleus has the definite polarization $p(J)$. It is significant that T-odd angular correlations in ternary fission of the compound nucleus arise just due to the nuclear polarization. Notice, however, that the polarizations $p(J)$ for $I-1/2$ and $I+1/2$ differ not only in magnitude but also in sign (see, e.g., [3]).

In reality, excitation energies of the compound nuclei produced in the capture of slow neutrons by target nuclei usually lie in the region of overlap of neutron resonances with spins $I-1/2$ and $I+1/2$. Therefore, compound nucleus is in a state that is a superposition of neutron resonances. Consequently, the polarization of the compound nucleus is very sensitive to the structure of this superposition, i.e., to the interference of neutron resonances. It is clear that T-odd angular correlations in ternary fission have a similar high sensitivity to the interference of resonances. This work is devoted to the study of the influence of the interference of neutron resonances with spins $I-1/2$ and $I+1/2$ on the T-odd angular correlations in ternary fission.

1. A.L. Barabanov. Phys. Part. Nucl. Lett., 2013, v. 10, no. 4, p. 336.
2. G.A. Petrov et al. Phys. At. Nucl., 2008, v. 71, no. 7, p. 1149.
3. A.L. Barabanov. Symmetries and spin-angular correlations in reactions and decays. – Moscow, Fizmatlit, 2010 (in Russian).

AIR POLLUTION STUDY IN MACEDONIA BY USING MOSS BIOMONITORING TECHNIQUE, NAA, ICP-AES, AND AAS

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The third moss survey in Republic of Macedonia took place in August and September 2010 when 72 samples of the terrestrial mosses *Homalothecium lutescens* and *Hypnum cupressiforme* were collected over the whole territory of the country, using the same sampling network grid as for the previous surveys in 2002 and 2005. Using Neutron activation analysis (NAA), Inductively Coupled Plasma - Atomic Emission Spectrometry (ICP-AES) and Atomic Absorption Spectrometry (AAS), a total of 47 elements (Al, As, Au, Ba, Br, Ca, Cd, Ce, Cl, Co, Cr, Cs, Cu, Dy, Eu, Fe, Hf, Hg, I, In, K, La, Li, Mg, Mn, Mo, Na, Nd, Ni, P, Pb, Rb, Sb, Sc, Se, Sm, Sr, Ta, Tb, Th, Ti, U, V, W, Yb, Zn and Zr) were determined. Distributional maps were prepared to point out the regions most affected by pollution and related to known sources of contamination. To reveal hidden multivariate data structures and to identify and characterize different pollution sources Principal Component Analysis was used. Lower contents of some elements in the moss samples were observed in 2010 survey in comparison with the 2005 survey [1,2].

1. *L. Barandovski, M. V. Frontasyeva, T. Stafilov, R. Šajn, S. Pavlov, V. Enimiteva,* TRENDS OF ATMOSPHERIC DEPOSITION OF TRACE ELEMENTS IN MACEDONIA STUDIED BY THE MOSS BIOMONITORING TECHNIQUE, *Journal of Environmental Science and Health, Part A, 47(13), 2000-2015 (2012).*
2. *L. Barandovski, T. Stafilov, R. Šajn, M. V. Frontasyeva, K. Bačeva,* AIR POLLUTION STUDY IN MACEDONIA BY USING MOSS BIOMONITORING TECHNIQUE, ICP-AES AND AAS, *Macedonian Journal of Chemistry and Chemical Engineering, 32(1), (2013).*

Neutron stripping reaction $D_\nu(^{209}_{83}Bi, ^{210}_{83}Bi)n_\nu$ and experimentally observed α- particle emission at ultra-low energies

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A few years ago one of the authors of this abstract (D.S. Baranov) investigate the possibility of obtaining α- radioactive $^{210}_{84}Po$ isotope in the saturated water solution of $Bi(NO_3)_3 * 5H_2O$ during high voltage electrolysis. The probability of the reaction was reported earlier (see [1]).

The rough scheme of this investigation is the following. For every experiment Bi nitrate of $5-10\ mg$ was dissolved in $20-50\ mg$ of water. To provide electric interaction in the solution high voltage (of up to $30\ kV$) and low voltage (of up to $15\ V$) supply sources were applied. The details of the experiment see in [2]. Than the α- spectrum of all exposed samples were analyzed. It was found that α- count becomes more than 10 times as high as the background level. All of the discussed results were repeatedly reproduced by different ways and authors (see, for example, [2, 4]).

One of the possible explanations of such results were proposed by Yu.L. Ratis (see [5, 6] and references in this works).

The initiator of four steps sequence of the nuclear reactions is the long-living neutral exotic particle – dineutroneum. It was shown that the main mechanism of dineutroneum generation is the reaction $D(e,e')D_\nu$ (step 1, fig. 1). To interpret the diagrams fig. 1 see [5].

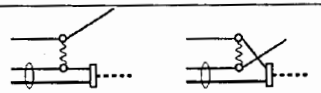

Fig. 1. Neutroneum electroproduction at the inelastic photon-hydrogen scattering

Step 2. Exotic reaction $D_\nu(^{209}_{83}Bi, ^{210}_{83}Bi)n_\nu$ *or* $D_\nu(^{209}_{83}Bi, ^{210}_{81}Po_\nu)n$.

Step 3. An exotic β- decay $^{210}_{83}Bi \rightarrow ^{210}_{84}Po + e^-$ *or* $^{210}_{81}Po_\nu \rightarrow ^{210}_{81}Po + e^-$.

Step 4. Usual α- decay $^{210}_{84}Po \rightarrow ^{206}_{82}Pb + \alpha$, $T_{1/2} \approx 138\ days$

The suggested mechanism explains the absence of the Coulomb barrier at extremely low energies. In the case of the analogous non-exotic reaction $d(^{209}_{83}Bi, ^{210}_{83}Bi)p$ deuteron can't penetrate the Coulomb barrier, and this reaction is forbidden.

References

1. A.G. Sytin. Poster. St.Petersburg, 1992. Conf. Nuclear Society Russia.
2. Baranov D.S., Baranova O.D. EXON-2009. AIP CONF. PROC. V. 1224 p.241-246.
3. D.S. Baranov, O.D. Baranova Proc. of Intern. Conf. (INIR-2011) Dubna. P.141-159.
4. Baranov D.S., Baranova O.D. EXON2012. Conf. P. p.209-212. http://exon2012.jinr.ru
5. Lipson A.G., Chernov I.P., Rusetsky A.S. *et al.*, Doklady RAS, **425**, №5, 1 (2009).
6. Ratis Yu.L., Proceedings of the XXI International Seminar on Interaction of Neutrons with Nuclei, Dubna: JINR, 2014.
7. Ratis Yu.L. The Old and New Concepts of Physics, Volume VI (2009), N 4, p.525-543 http://www.conceptsofphysics.net/VI_4/525.pdf

SEMI-EMPIRICAL SYSTEMATICS OF (n,np+d) REACTION CROSS SECTIONS AT 14 MeV NEUTRON ENERGY

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Abstract:

A study of new semi-empirical formulae for the calculation of the (n, d+n'p) reactions cross sections at 14.5 MeV neutron energy was carried out. The pre-equilibrium exciton and evaporation models allow to establish these new formulae by using the Droplet model of Myers and Swiatecki to express the reaction energy Q(n,d+n'p). The systematics behavior of the different terms of the Droplet model involved in the energy reaction expression was studied individually before choosing the pertinent terms that allow to setting up the formulae. Two systematics studies have been performed in this work; the first concerns the activation cross section of (n,n'p+d) reaction where we show the effect of neutron and proton separation energy on the behavior systematics of the reaction, and the second is devoted to systematize the direct measurement data of the (n,d) reaction cross section. Fitting these formulae to the existing cross section data, the adjustable parameters have been determined and the systematics of the (n,n'p+d) and (n,d) reactions have been studied. The predictions of these formulae are compared with those of the existing formulae and with the experimental data and give a better fit to the data than the previous comparable formulae.

Keywords: 14 MeV neutrons, semi-empirical cross sections, pre-equilibrium exciton model, evaporation model, (n,d) cross sections.

THE LEAKAGE NEUTRON SPECTRA FROM PbLi SPHERE WITH CENTRAL 14 MeV AND ^{252}Cf NEUTRON SOURCES AND VERIFICATION OF EVALUATED NEUTRON DATA

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The leakage neutron spectra from $Pb_{83}Li_{17}$ sphere with ^{252}Cf neutron source at its center have been measured by the time-of-flight method from 200 keV up to 10 MeV. Outer radius of sphere was 200 mm, inner - 60 mm. The new measurements was performed with use of a specially designed fast ionization chamber, supplied the stop pulses for the time-of-flight technique as well as total number of ^{252}Cf disintegrations during the experiment. The neutrons leaking from the outer surface of a sphere were detected with a scintillation counter composed of a paraterphenyl crystal of 5 cm in diameter and 5 cm long and FEU-143 photomultiplier tube. The similar measurements of leakage neutron spectrum from the same $Pb_{83}Li_{17}$ sphere were performed with 14 MeV neutron source using the same time-of-flight facility [1].

The measured data were compared with the MCNP-4 Monte-Carlo code calculations with nuclear data based on different data libraries (ENDF/B-VII.1, BROND-3 and ROSFOND). The results of comparison by the spectrum shape and the calculation/experiment values are presented. Some aspects of presented benchmarks are discussed in details including method of the measurement, influence of structure, smoothing of calculated spectra, energy resolution of spectrometer, methodology of calculation (1D- or 3D -dimensional problem).

1. S.P.Simakov, B.V.Devkin et al. Fusion Engineering and Design, v.46, (1999), p. 89-97.

CHAOS AS A RESULT OF SYMMETRY BREAKING

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The critical analysis is given of the present understanding of the quantum chaos as only the "trace" remaining in the quantum analogue of the classical chaotic system. Contrary to this approach it is suggested to look for the common source of both classical and quantum chaos. According to Liouville–Arnold theorem of classical mechanics the system is regular if the number N of its degrees of freedom equals the number M of its first integrals of motion which, in turn, are the results of the system's Hamiltonian symmetry. If the perturbation is introduced which breaks this symmetry and reduces the number M so that M<N, then the system becomes chaotic. It is suggested to generalize this definition of the chaotic system applying it to the quantum systems whose quantity M of the good quantum numbers is smaller than the number N of its degrees of freedom.

In order to introduce the quantitative measure of the quantum chaoticity it is suggested to use the experience of the nuclear theory in studying the properties of the compound nucleus states and resonances: strength function approach together with statistical and random matrix theories. It is shown (see e.g. [1]) that the quantum analogue of the classical Lyapunov exponent is the spreading width Γ_{spr} which characterizes the fragmentation of the "regular" single–particle state into the states of higher complexity caused by the residual two-body interactions destroying the symmetries of the single–particle average field and thus making the system chaotic. The dimensionless quantity measuring quantum chaoticity is the ratio $\kappa = \Gamma_{spr} / D_0$ where D_0 is the average single–particle level spacing. For $\kappa < 1$ we can still see the traces of the mean field symmetry and distinguish its original quantum numbers (case of weak chaos). For $\kappa > 1$ the residual interactions destroy all the traces of the original symmetry (strong chaos). Wigner's level repulsion which is the only "quantum signature of classical chaos" recognized in the present approaches, is easily explained as the removal of all the degeneracies in the many-body systems with very few quantum numbers (energy, spin and parity for compound resonances).

One should stress that our main aim is not to study chaos in nuclear systems but rather to show how the long nuclear theory experience of handling the quantum chaotic system of compound nucleus can be generalized and applied to other quantum chaotic systems.

1. V.Bunakov. Physics of Atomic Nuclei. 1999. V.62. P.1.

Neutron emission anisotropy in fission

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Abstract

Neutron experimental distributions are investigated in the spontaneous fission process of ^{252}Cf. It is well known that during the fission process the bulk of prompt neutrons is evaporated from the fully accelerated rotating fragments. Neutrons evaporation theory states that this emission is isotropic in the center of mass of the moving fragments (C.M.)[1], but if one compares experimental angular distributions with a pure isotropic evaporation, discrepancies appear in many different works.

To understand the origin of these deviations it was introduced a contribution to neutron angular distributions due to neutrons ejected at an early stage of the fission process, at the scission point[2]. But even by adding these scission neutrons and taking into account the anisotropy effect due to the kinematical focusing, an excess of neutrons observed at small laboratory angles around heavy and light fragment remains. So it was assumed that an anisotropy appears also in the C.M. of the two fragments and this effect reinforces the kinematical anisotropy in the laboratory system[3].

There are theoretical arguments and calculations that claim that this anisotropy exists, but there isn't any direct observation, because the contribution to the kinematical focusing due to the C.M. anisotropy is very weak. To show this effect a new method was developed by our collaboration. The CORA experiment was performed for this purpose. It consists in the measurement of triple coincidences between each fission fragment and two ejected neutrons. With this trick we can disentangle in the laboratory system the contribution to the anisotropy due to the kinematical focusing of the effect of the predicted C.M. anisotropy. The experiment is described and the new analysis method is presented.

[1] V. F. Weisskopf, Statistics and Nuclear Reaction, Phys. Rev., 52, 295-303, 1937
[2] H. R. Bowman et al, Phys. Rev., 126, 2120 (1962).
[3] V. Bunakov et al. Proc. "Int. Sem. ISINN-13" Dubna, Russia, 2005, p.175

NEUTRON ACTIVATION ANALYSIS OF ELEMENTAL CONTENT OF SUNFLOWER AND OLIVE OILS

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Assessment of the elemental content of edible oils is important from both toxicological and nutritional viewpoints. Neutron activation analysis was used to determine the chemical content of virgin sunflower oil, two types of refined sunflower oils commercially available in Romania, and virgin olive oil produced in Algeria. A total of 17 elements: Na, Al, Cl, K, Ca, Ti, V, Mn, Co, Zn, Cu, As, Br, Sr, Sb, I, and W were determined in the studied oils. In all samples the concentration of K, Ti, V, Co, Cu, As, Sr, and I were below the detection limit of their determination. The highest concentration of Br was detected in olive oil sample. The concentrations of heavy metals were found to be below the permissible limits for edible oils.

AUTOMATION SYSTEM FOR GAMMA SPECTRA MEASUREMENT IN NEUTRON ACTIVATION ANALYSIS AT THE IBR-2 REACTOR

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The automation system to measure gamma spectra of the induced activity of irradiated samples in the radioanalytical complex REGATA at the reactor IBR-2 of FLNP, JINR, was created. It consists of three spectrometers based on HPGe detectors and spectrometric electronics (Canberra). All spectrometers are equipped with sample changers. Each sample changer includes the 2-axis system (DriveSet) for horizontal and vertical movement of samples located on the disc with 45 cells. The position of 2-axis kinematics and disc is controlled by increment encoders, reference and end switches. Positioning precision can reach 0.1 mm. The developed software controls the automatic change of samples at each of the detectors and measurement of spectra. This software runs in a permanent interaction with the database of NAA at the IBR-2 reactor.

INTERCOMPARISON OF MOSS SPECIES USED TO STUDY ATMOSPHERIC DEPOSITION OF TRACE ELEMENTS IN CENTRAL VIETNAM

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Abstract

Intention of Vietnam to participate in the European-Asian Moss Survey in 2015 undertaken by the UNECE ICP Vegetation led to the necessity of choosing proper moss species abandon in the tropical and subtropical climate of Vietnam. It was shown in the pilot study of the authors in 2009-2010 (Nguyen Viet et al.) that such species as *Barbulaindica* can be successfully applied for the bio-monitoring purposes in the Northern Vietnam. The present study relates to the Central Vietnam where 20 samples of various moss species were collected in the areas of two cities, Dalat and Hue, and subjected to conventional and epithermal neutron activation analyses at the reactor IBR-2 in Dubna. The results on short-lived isotopes determined in April 2014, are reported. Further investigations are planned for the coming reactor cycles.

Reference

H. Nguyen Viet. M.V. Frontasyeva, T.M. Trinh Thi, D.Gilbert, N. Bernard. Atmospheric heavy metal deposition in Northern Vietnam: Hanoi and Thainguyen case study using the moss biomonitoring technique, INAA and AAS. Environmental Science and Pollution Research, Vol. 17, No, 5, 2010, p. 1045-1052.

COMPARATIVE ANALYSIS OF TRACE ELEMENT CONTENT IN IVANOVO REGION MOSSES AND SOILS

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The assessment of environmental quality based on analysis of trace element content of Ivanovo region mosses and soils has been performed. The 25 samples of mosses *Pleurozium schreberi, Hylocomium splendens* и *Polytrihum Commune* and 45 soil samples were respectively collected according to the ICP Vegetation monitoring manual and Methodological recommendation for heavy metals determination in soils. Metal extraction was made after digestion of mosses at 625°C by 1M HNO_3 treatment. Movable and gross forms of metals were extracted from soil samples by acetate-ammonia buffer with pH=4.8 and 1M HNO_3, respectively. Concentrations of some metals (Cu, Pb, Cd) were determined by the flame atomic absorption spectrometry (AAS) while others by the neutron activation analysis (NAA) in the Frank laboratory of neutron physics in Dubna. Determination uncertainties were about 10% for NAA and 30% for AAS.

The analysis of moss data pointed out a high level of air quality in Ivanovo region. Average concentrations of the most trace elements were lower than those in the neighboring regions. Nevertheless some areas with increased content of some industrial pollutants (Ni, Pb, Mo, As, Cr, Co) were detected. Firstly, they were districts situated at the Northern-West part of Ivanovo region influenced by the activity of Yaroslavl, Volgorechensk and Kostroma cities. Secondly, there are internal sources of the heavy metal emission such as Rodniki's asphalt plant.

The distribution of trace element content in soil well reproduced moss data. The soil as accumulating system has a very long period of the contaminant removal. Therefore it is easy to find the places characterized by the long term anthropogenic impact. In particular the territory near Volgorechensk power station had the worst soil quality among observed samples. The increased concentrations of Cr, Co, Cu, Fe, As, Ni, V and some other elements were fixed there. It was successfully agreed with results of moss monitoring. Unfortunately, the sample of soil near the town of Rodniki was absent and it is impossible to compare air and soil quality there. Also it was revealed another contaminated territory at the South of Ivanovo region. The moss data did not show any significant excess above the average level of trace elements content in this place. It was established that contamination of heavy metals was provided wastes from Kovrov plants during floodwater.

Comparative analysis of air and soil quality allowed to distinguish different sources of environmental pollution in Ivanovo region. Despite established high level of environmental quality of Ivanovo region several territories influenced by anthropogenic impact were revealed.

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The Angular Anisotropy of Slow Neutrons Scattering Measured at IREN Facility with Vanadium as a Sample

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For testing the AURA setup operation the angular anisotropy dependence on energy in the neutron elastic scattering by vanadium was measured using time-of-flight method in the energy interval 0.005 – 10 eV at the neutron source IREN. The results obtained are compared with ones available in literature.

Natural fission reactors other and older than Oklo, likelihood and isotopic data– a scenario from geo(photo)chemistry and chemical evolution

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Back in 1956, Paul Kuroda pointed out that ^{235}U, which unlike $^{238;234}U$ can undergo fission after capturing thermal neutrons, formerly had a larger share of uranium isotopic mixture (>> 0.72%) due to its half-life being shorter than that of ^{238}U. Hence, on early Earth natural fission reactors (NFRs) might possibly have operated given there is/was some geochemical process accumulating uranium in layers several cm to dm thick while removing neutron poisons and there is some neutron moderator, e.g. water or carbon. In 1972, such a NFR was first identified in Southern Gabon, near the village of Oklo. While there are some 20 more NFRs of similar age (some 1.8 bio. years) nearby, none were discovered so far anywhere else on Earth, not even in much older sediments which then had ^{235}U contents of up to about 8%. Carbon (^{12}C) and D are better moderators than H (common water, either liquid or bound to clays or salts or making a dense supercritical vapor [Oklo IX, several modern power reactor designs]), and carbon likely was present: either some organic matter or carbonato-ligands bound to U(VI) (i.e. $[(UO_2)(CO_3)_3]^{4-}$, in minerals like Ca salt liebigite). C_{org} could be either a product of chemical evolution or (later-on) formed by/in a kind of biogenic film. Pronounced heating of U- and C-containing phases will also alter their density and moderator availability (volume densities of H, ^{12}C), and even compact, purified UO_2 deposits can be produced from an uraniferous spring by photochemically oxidizing some of ambient organic matter.

What, then, happens during light impact or heating? Into which direction ("better" or less effective moderation, both shifting the minimum ^{235}U content required to sustain fission chains in a given NFR size and topology) will moderator densities change? While photochemical transformations of UO_2^{2+}/organic acid- or –lipid systems are shown to **increase** moderator density, that is, can start a NFR using neutrons from $^{13}C(\alpha,n)$ or cosmic radiation, UO_2 deposition, CO_2 loss and density changes from the above carbonatouranates(VI) cannot commence before a NFR does produce considerable heat itself (T > 150°C). Hence the latter kind of NFR would be intrinsically unstable whereas the former could operate in a controlled manner. This means there must have been some combination of U(VI) and organic matter directly exposed to light. Given data for redox potential and probable organics levels on young Earth, this was much more likely to occur **after** than before biogenesis. Hence a contribution by fissiogenic charged particles from NFRs to **chemical evolution** is unlikely while such surface-confined NFRs would probably be removed by erosion altogether. Nevertheless, the (small) extent of isotopic variations among samples of U and possibly fissiogenic isotopes $^{134;136}Xe$, $^{102;104}Ru$ and of Kr, Pd can constrain total U turnover by such older NFRs even if there are no geological traces left of them. Organisms like *Desulforudis audaxviator* detected in a South African gold mine (Mponeng) which "feed" on radiogenic chemicals (H_2) may give proof such sites were fairly common some 3 bio. years ago while the general conjecture by Kuroda concerning maximum ages of highly concentrated U ores probably is correct. The line of reasoning extends to our neighbor planets, excluding "stable" NFRs there.

THE MOSS BIOMONITORING, NUCLEAR AND RELATED ANALYTICAL TECHNIQUES, AND GIS TECHNOLOGY USED TO STUDY ATMOSPHERIC DEPOSITION OF TRACE ELEMENTS AND RADIONUCLIDES IN THE AREAS UNDER STRONG ANTHROPOGENIC IMPACT

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Experience in applying mosses as biomonitors of trace elements and radionuclides in some selected rural and urban areas affected by intense anthropogenic activity is reviewed. Among them the western part of the Kola Peninsula (NW Russia), the most heavily industrialized area in the entire Arctic; the South Urals (Karabash) counted among the most polluted areas in the worldwhere human impact on the environment is largely irreversible.The dominant groups of pollutants are heavy metals and long-lived radionuclides from full-scale activities and accidents at the radiochemical "Mayak" Production Association (PA).Moss was successfully used to study distribution of ^{137}Cs and ^{210}Pb in Belarus and Slovakia 20 years after the Chernobyl accident.A combination of analytical data (NAA and AAS in our case) with principle component analysis and GIS technologies allowed pollution source characterization and apportioning in the sampled areas around (1) copper mines in Karabash (RF), Bor (Serbia), South of Poland; (2) Zn-Pb smelters in Baia Mare (Romanai), Krdjali (Bulgaria) and Veles (Macedonia); (3) Fe-V plant in Tula (RF); (4) Fe-Cr industry in Tikhvin (RF) and Mo-i-Rana (Norway); (5) oil refinery industry in Yaroslavl (RF), and (6) thermal power plant in one of Moscow districts. Besides passive (terrestrial) moss biomonitoring, active moss biomonitoring (moss bags technique) showed itself efficient in accessing air pollution in large cities (street canyons of Belgrade and Moscow). The results obtained at local scale in the areas experiencing environmental stress can be used for establishing the emission levels of pollutants and to serve a source of information for health-related institutions.

INVESTIGATION OF INCINERATION RATE OF ^{241}AM, ^{243}AM, AND ^{237}NP SPALLATION TARGETS USING A PROTON ACCELERATOR DRIVEN SYSTEM USING MCNPX CODE

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Abstract

Whereas high level nuclear wastes consist of long half-life alpha emitter transuranic elements retain their radiotoxicity over natural level values up 10^6 year at disposal areas, their depleting via transmutation process during incineration using critical reactors or accelerator driven systems is seriously regarded recently. Before high cost trials, computational codes can provide acceptable information and feasibility study on nuclear waste neutronic behavior in critical reactors or accelerator driven systems. Hence, MCNPX 2.6.0 code has been used in this work to evaluate incineration possibility of ^{241}Am, ^{243}Am and ^{237}Np using proton accelerators via spallation process induction through these targets. Neutron yield leaked from the spallation targets, power density, neutron flux leaked from the spallation targets, residual nuclei production inside the investigated targets and some reaction rates has been calculated for the modeled targets. The neutronic calculations have been carried out using different proton energies of 0.4, 0.6, 0.8 and 1 GeV protons and 1 mA beam current. According to the computational data, ^{237}Np produces the most leaked neutron yield using all the investigated proton energies. ^{237}Np will be transmitted as 203.49 kg/y via (n, γ) reaction. It suffers the most heat deposition (6.83 kW/cm^3) and produces the most fission rates (61.2888 #/source particle). The incineration rate value is 62.96 kg/y for ^{241}Am and 27.72 kg/y for ^{243}Am.

Keywords: Transuranic transmutation, MCNPX 2.6.0 simulation, Accelerator driven system

BIOGEOCHEMICAL ACTIVITY OF SOME CONIFEROUS EXOTIC WOODY SPECIES IN URBAN ECOSYSTEMS

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Composition of woody vegetation in modern cities consists for more than a half of the species-introductions. Recently, much attention is paid not only to deciduous trees and shrubs, but also to conifers used in the landscaped groups of sanitary protection plantings. The study of their stability and biogeochemical activity in urban ecosystems is an important step in making decisions about further use of various species and types as for green landscaping streets as for neutralization of technogenic emissions.

Sampling was carried out in the city of Tula, one of major industrial centers of RF, experiencing strong ecological stress from metallurgical and other enterprises. The sampling sites were at sanitary-protective plantings along major city highways. Neutron activation analyses (INNA) was used to study elemental content in organs of 8 species and 5 varieties of exotic coniferous woody plants under intense polymetallic contamination impact of vehicle emissions along highways. The main elements pollutions the city soil are Fe, Cu, Zn, As, Pb.

The results obtained showed that all the studied exotic coniferous trees and shrubs can accumulate macro major elements a few times more than their content in soil and than indicated on average in the literature («Reference plant» Markert, 1992): potassium is 2-6 times higher (3710...16200 mg/kg; mean - 6760 mg/kg); calcium is 1.5-5 times higher than in the soil and 8-25 times higher than in the «Reference plant» (8600…20000; mean 16260 mg/kg). Potassium content is higher in immature organs and is lower in perennial ones. For calcium the backward tendency is observed: its content increases in perennial organs compared to immature ones. Coniferous of genus *Thuja* and some varieties of *Juniperus sabina* are able to accumulate Cl 6-12 times more than is given in the «Reference plant» (1370…5360; mean for coniferous is 1127 mg/kg). The content of Na and Mg in the needles and shoots of studied plants in opposite was less than in RP by factor of 2-3 (mean values are 92 and 157 mg/kg respectively).

The content of V in the *Thuja* and *Juniperus sabina* varieties is higher than in the «Reference plant» by factor 2-6 (1…2,8 mg/kg). The mean content of V in exotic coniferous is 1.3 mg/kg; Cr is 3-6 times higher than in the «Reference plant» and in exotic deciduous shrubs (4,8…10,6 mg/kg, mean is 6.4 mg/kg). The coniferous introducents can accumulate Fe on average 3 times more than is given for «Reference plant» (200…804; mean is 641 mg/kg). The coefficient of transfer TF of iron from the soil is 0.16.

Exotic coniferous trees and shrubs accumulate Ni and As 1.8 to 3 times more than the «Reference plant», but the content of Cu (5…11,7 mg/kg) and Zn (11…45 mg/kg) in them is less than on average in plants (mean 6.3 and 27 mg/kg, respectively).

In general, the content of Mn, Ni, Cu, and Zn in deciduous woody introdutcents is higher than in coniferious ones. However, conifers are the best accumulators of V, Cr, and As. The combination of deciduous and coniferous exotic woody species in landscape compositions is the optimal solution for the stabilization of urban environment.

The study was supported by the RFBR grant 'The study of adaptive characteristics and buffer role of woody exotic species in the migration of toxic elements in the urban ecosystems" (project No. r_center_a 13-05-97508).

Comparison of two NaI(Tl) multi-detector systems

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The main characteristics of particular detectors of two NaI(Tl) arrays were investigated. One of them is a gamma-ray spectrometer Romashka-1, which consists of 12 NaI(Tl) crystals of a total volume of about 16.6 *l*, grouped by 6 crystals in two identical Al shells. Each crystal is optically coupled to a FEU-110 photomultiplier tube (PMT). The outer diameter of the system is 30 cm, the central through hole's diameter is 4 cm. This way, a solid angle of ~ 4π can be "seen" by the sample when located in the center of the system. The second multi-detector gamma-ray spectrometer Romashka-2 consists of 24 hexagonal Amcrys-H NaI(Tl) crystals, optically coupled with Hamamatsu R1306 PMT. The detectors are grouped in 2 cylindrical rings of 12 NaI(Tl) each, with variable ring diameter and distance between both rings. The construction allows as many as 44 detectors to be arranged in 2 concentric rings of diameter of ~ 1 m.

In order to compare the main characteristics (energy resolution and gamma photo-peak efficiency) of the two NaI(Tl) multi-detector systems, a double channel gamma-spectrometry setup was commissioned – one per system. The both channels of the setup, used consequently, utilized a common electronic chain for the PMT pulse analyzing. The common chain consisted of a POLON active filter amplifier and an ORTEC 2k PC-compatible plug-in card, with Maestro multi-channel analyzer (MCA) emulation and analysis software, running under Windows operating system (OS).

Using point ^{137}Cs and ^{60}Co calibration sources, the energy resolution and efficiency of gamma-rays registration were determined and compared. The results obtained are reported.

Energy- and Time- resolution of gamma-ray detectors

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In Frank Laboratory of Neutron Physics (FLNP) of the Joint Institute for Nuclear Research (JINR) there is a long lasting tradition of studying the characteristics of the gamma-rays emission from neutron inelastic scattering, capture and fission reactions by the multiplicity method.

For this purpose a new multi-detector gamma-ray spectrometry system of daisy-type "Romashka" was build. The basic (test) configuration of this multi-parametric system consists of 24 NaI(Tl) hexagonal (200×78×90mm) crystals (Amcrys-H), equipped with modern photomultipliers (Hamamatsu R1306). A 32-channels computerized, digital readout system, utilizing two ADCM16-LTC, 16-channel, 14-bit, 100 MHz ADC boards from AFI Electronics, is used for signals digitizing and determining of their amplitude and timing characteristics from all the channels, simultaneously.

In order to assemble a detector with the needed amplitude and timing characteristics, some test measurements with different scintillators and photomultiplier tubes (PMT) were done. Point-size standard gamma-ray sources (^{137}Cs and ^{60}Co) were used for measurement of the energy and time resolution in different (source-detector) geometries and for different values of the PMT's high-voltage.

The obtained results are reported.

Evaluation of impact of human activities on landscape and its components

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Most human activities are associated with the production of detrimental substances in solid, liquid or gaseous form. At the landscape scale, they can release xenobiotic substances into the environment that contaminate the landscape and its components (air, water, soil, etc.) and disturb natural processes. As components of the landscape are interrelated, single xenobiotic elements can be transferred from one component to the other, thereby affecting the landscape as a whole. The consequences of this energy and material flow are compounded by phenomena such as climate change.

All these manifestations of human activities appear in the landscape as foreign, potentially harmful substances often referred to in the literature as 'stress factors'. Stress factors were first used in the medical field and referred to any kind of substances having a negative influence on living organisms. In this paper, we define stress factor from the point of view of landscape ecology whereby the landscape is seen as a geosystem (Selye, 1966; Charvát, 1969; Michal, 1992) and a stress factor is seen as any kind of substance that has a negative impact on the evolution of natural landscape ecosystems. As such, stress factors can be defined as any stimulus responsible for landscape stress, which can, in turn, lead to negative and, frequently irreversible, changes of the landscape system in the short or long term. Human activities act as stress factors in the landscape, either directly (as primary stress factors) or indirectly (as secondary stress factors) influencing the landscape negatively. Stress factor landscape loads are defined as material and nonmaterial influences, which negatively influence the landscape and cause various chemical, physical, bacteriological and other changes in the landscape.

The anthropogenic stress factors result primarily from socio-economic activities. Human activities manifest themselves in the landscape either by encroaching on natural ecosystems or by negatively impacting on single landscape elements. This means that even one human activity can have an effect at the landscape scale through the stress factors it generates.

The stress factors do not act in isolation but cumulatively and synergically on the territory and in a spatial projection they create a system of mutually connected integrating components (the territorial system of stress factors - TSSF), while acting as significant barriers within the territorial system of ecological stability. They are associated with decrease of natural ecosystems and degradation of natural resources and then the deterioration of quality of environment.

Landscape load evaluation can be critical in managing landscape-ecological problems, for example in the evaluation of potential optimal use of the landscape, in the evaluation of the quality of the environment including the assessment and management of threats, in the evaluation of impacts on the environment with the aim of preventing loading of the landscape above acceptable levels or thresholds, and in reaching sustainable development at the national scale.

The paper will present evaluation of the environmental problems arising from negative impact of human activities in the landscape. The assessment will be presented as an example of the Slovak landscape.

This work was supported by the Grant agency under contract GP VEGA: 2/0120/12 Evaluation of environmental quality of rural settlements.

UNIFICATION OF EXPERIMENT PROCEDURE CONTROL TOOLS FOR THE EXPERIMENT AUTOMATION SYSTEMS IN THE FIELD OF NEUTRON SPECTROMETRY USING NETWORK TECHNOLOGIES

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Abstract

One of the most serious obstacles to the painless development of experiments automation systems is the need to modify previously written and debugged source code. In distributed instrumental environments, the development of programs usually unthinkable without editing. There are fairly simple mechanisms for painless development of programs that can organically enter into traditional development environment, and as a result re- written parts of the program will only complement the existing sources, without requiring editing. This paper describes a standardized way of describing the experimental technique and program for control the sequence of operations in conditions of changing of this technique which does not require editing other system components.

DYNAMICAL EFFECTS IN THE FORMATION OF ANISOTROPIES FOR ANGULAR DISTRIBUTION OF PRODUCTS OF BINARY AND TERNARY FISSION OF ORIENTED NUCLEI – TARGETS CAUSED BY COLD POLARIZED NEUTRONS

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By using of the spin density matrix with different orientation orders for the compound fissile nucleus [1] formed in the reactions of fission of oriented nuclei – targets by cold polarized neutrons the dynamical effects in the formation of possible P – even, T – even; P – even, T – odd; P – odd, T – even and P – odd, T – odd asymmetries for angular distributions of fission fragments and prescission and evaporation third particles for named above reactions are investigated

It is demonstrated the important role for all asymmetries the interference of fission amplitudes of different neutron resonances excited in the fissile compound nucleus.

It is confirmed the necessity of parity violation nucleon – nucleon forces [2] for the formation of P – odd, T – even and P – odd, T – odd asymmetries.

It is emphasized the principal role of wriggling – vibrations [3] of compound fissile nucleus in the vicinity of its scission point for the formation of P – even, T – even asymmetries in fission fragments angular distributions focused along and against of the direction of the compound fissile nucleus symmetry axis and of fission fragments spin distributions connected with big values of these spins oriented perpendicularly to directions of fission fragments flights. It is marked that the last effect leads to P – even, T – odd anisotropies in the angular distributions of gamma -- quanta and neutrons evaporated from thermalizated fission fragments.

It is noted the necessity of taking into account the Coriolis interaction of the collective rotation of polarized compound fissile nucleus with orbital motions of fission fragments and of prescission third particles [4] for the formations of P – even, T – odd asymmetries for angular distributions of evaporation and prescission third particles correspondently.

1. Kadmensky S.G., Titova L.V., Bunakov V.E., Izv. Ros. Ak. Nauk, ser. fiz., 2008, V. 71, P. 909.
2. Sushkov O.P., Flambaum V.V., Uspekhi Fiz. Nauk, 1982, V. 136, P. 3
3. Kadmensky S.G., Lubashevsky D.E., Titova L.V., Bull. RAN, Ser. Phys. 2011, V. 75, P. 1052.
4. Kadmensky S.G., Bunakov V.E., Kadmensky S.S., Yad. Fiz. 2011, V. 74, P. 1735.

STUDY OF NUCLEAR LEVEL DENSITY IN THE CASE OF THE TIN NEUTRON-RICH ISOTOPES

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Properties of the nuclei at extreme conditions are important in various astrophysical scenarios such as in late stage of a supernova collapse and explosion. During this phenomenon, neutron-rich hot heavy nuclei can be produced. So, the study of properties of these exotic nuclei is essential for understanding processes in nuclear astrophysics. At finite temperature, very limited information exists on nuclear level density and thermodynamic properties particularly for such nuclei.

So, the purpose of the present paper is to perform the calculation of the nuclear level density of the Sn even-even neutron-rich isotopes. It is well known that the Sn isotopes are of particular importance. Lifetimes of these nuclei are very small and production rates are also very low, presenting challenges to spectroscopic studies. So, as a first step, our study will include the ordinary Sn isotopes, it will then be extended to the neutron-rich nuclei. This will be done in the framework of a microscopic model including both fluctuations: quantal and statistical ones. In this aim, we use the modified Lipkin-Nogami method (MLN)[1].

The obtained results are compared to the conventional FT-BCS results [2] and to the MBCS [3] predictions as well as to the experimental data when available [4]. The present study illustrates that the inclusion of statistical fluctuations affect the phenomenon of pairing phase transition. Moreover, the experimental data of this physical quantity are better reproduced when the MLN method is used.

[1] N. Dinh Dang, Phys. Rev. **C76** (2007) 064320.
[2] L.G.Moretto, Phys. Lett. **B40** (1972) 1.
[3] N. Dinh Dang , Nucl. Phys. **A784** (2007) 147.
[4] H. K. Toft. *et al.* , Phys . Rev . **C83**.(2011) 044320.

SEARCHING FOR SHAPE ISOMERIC STATES LEADING TO TERNARY DECAY OF HEAVY NUCLEUS

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Our program of studying of ternary decays of heavy nuclei dedicated basically to the collinear cluster tri-partition process [1] discovered by us earlier is extended due to the theoretical predictions presented in [2]. In the frame of a three-centre phenomenological model developed by the authors new minimum of a short-lived molecular state is revealed in the deformation energy at a separation distance very close to the touching point of the constituents of ternary chain-like configuration. The half-live of the quasimolecular state which could be formed in ^{12}C accompanied fission of ^{252}Cf is roughly estimated to be the order of 1 ms. We have planned to verify this prediction experimentally using COMETA-R spectrometer installed at the IBR-2 reactor. The experiment is in progress and first results obtained will be reported.

References

1. D.V. Kamanin, Yu. V. Pyatkov, "Clusters in Nuclei - Vol.3" ed. by C. Beck, Lecture Notes in Physics 875, pp. 183-246 (2013)
2. D N Poenaru, B Dobrescu et al., J. Phys. G: Nucl. Part. Phys. **26** (2000) L97–L102.

INVESTIGATION OF MINERAL CONTAMINATION FLOWS IN THE STRATEGICALLY IMPORTANT COASTAL REGION OF THE BLACK SEA (NEAR ANAPA)

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One of the most pressing problems of our time is the pollution of the ocean and its coastal zone. In Russia, the problem is most pronounced in the pollution of the Black Sea; one of the most unique and productive sea in the world. In order to study the flows of different pollutants in the coastal zone, we have chosen the model polygon, which includes the city dump at the top of the hill and all types of water bodies (Lake, River, Flowing) localized below the slope of the Hill (under the dump). These water objects form indivisible catchment flow like small rivers into the sea in the recreation zone of the city; the City Beach. The 43 samples of soil, sediments and aquatic plants (used as organisms for monitoring) were selected. All aquatic plants, on the one hand, are functioning as organisms cleaning the environment, and, on the other hand, serve as biomonitors of pollutants. The results of multi-element neutron activation analysis at the reactor IBR-2 allowed determination of the elements-pollutants and their distribution along the model polygon. To identify the pollution sources the factor analysis of the results obtained was applied.

Development of the Tagged Neutron Method for Elemental Analysis and Nuclear Reaction Studies – TANGRA Project

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The TANGRA (TAgged Neutrons & Gamma RAys) project is started at JINR in collaboration with several other institutes. The aim of the project is to continue the development of the tagged neutron method (TNM) and to use this method for experimental studies of neutron-induced nuclear reactions. The essence of the TNM is the registration of the characteristic prompt gamma-radiation emitted from a sample, irradiated by 14.1 MeV neutrons, produced in the d(t,α)n reaction, in coincidence with the α-particle from this reaction. Measurement of the time interval between the signals from α- and γ-detectors allows one to determine the distance from the point of the tagged neutron emission to the point where its interaction with the nucleus of the sample occurred. The use of the (α-γ)-coincidences reduces the background-to-signal ratio by more than 200 times, which significantly improves the quality of the measurements. An important advantage of the TNM for measuring the nuclear process characteristics (reaction yield, total and differential cross-sections) is the possibility of monitoring the flux of tagged neutrons incident on the target, with almost 100% efficiency.

It is planned to use a portable neutron generator ING-27, produced by the N.L. Dukhov All-Russia Research Institute of Automatics (VNIIA)*, equipped with a position sensitive silicon α-particle detector in combination with the multi detector gamma-ray spectrometery system "Romashka" and a number of fast neutron detectors, available at FLNP JINR. The planned pilot program of the project, as well as the results of the first test measurements will be presented.

*http://www.vniia.ru/eng/about/

Monte Carlo simulation of the neutron radiative decay experiment

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The report presents the results of Monte Carlo simulation of the experiment on radiative neutron decay. These calculations are needed to clarify the background conditions of the experiment, as well as to determine the geometric factors. To measure the main characteristics of radiative neutron decay, namely its relative intensity BR (branching ratio), it is necessary to measure the spectra of double coincidences between beta-electron and proton as well as the spectra of triple coincidences of electron, proton and radiative gamma-quantum. Analysis of double coincidences spectra requires one to distinguish events of ordinary neutron beta decay from the background; analysis of triple coincidences relies on distinguishing radiative neutron decay from background events. As demonstrated in our first experiment [1], these spectra presented a heterogeneous background that included response peaks related to the registration of electrons and protons by our electronic detection system. The NIST experimental group (emiT group) observed an analogous pattern on the spectrum of double coincidences [2]. The current report is dedicated to the analysis of this heterogeneous background. In particular, this report demonstrates that the use of response function methodology allows to clearly identify radiative neutron decay events and to distinguish them from the background. This methodology enabled us to become the first team to measure the relative intensity of radiative neutron decay B.R.=$(3.2\pm1.6)10^{-3}$ (where C.L.=99.7% and gamma quanta energy exceeds 35 kev) [1]. In addition, the report emphasizes that the background events on the spectrum of double coincidences are caused by ion registration, and demonstrates that one cannot ignore the ionic background, which is why experiment [3, 4] registered the ions and not recoil protons.

[1] R.U. Khafizov et al. JETP Letters, v. 83(1), 2006, p. 5
[2] L.J. Lising, et al., Phys. Rev. C. v.6, 2000, p. 055501
[3] J.S. Nico, et al., Nature v. 444, 2006, p.1059
[4] R.L. Cooper, et al., Phys. Rev. C v. 81, 2010, p.035503

Some Peculiarity of the Photon Activation Analysis by Bremsstrahlung Gamma-Ray

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A method of photon activation analysis by bremsstrahlung gamma-ray on the electron cyclic accelerator microtron MT-22 at the Nuclear Research Center, National University of Mongolia is described.

In the photon activation analysis by bremsstrahlung gamma-ray with continuum spectrum is usually used the same isotope for reference and element content determination purposes. However, for multielemental analysis, it is not easy to find suitable isotopes as the reference material. In connection with this reason, we consider a possibility to use different isotopes for reference and sample analysing.

A correction factor which takes into account a difference in the photo-nuclear reaction threshold energy for standard reference material and sample elements is introduced. The correction factor is determined by two methods of experimental and theoretical. In the case of the experimental correction factor, experimental data of the photo-nuclear reaction cross sections for the reference and sample isotopes are used. In this case we were forced to use the Schiff formula of the bremsstrahlung gamma-ray spectrum in connection with the difficulty of the exact measurement of flux for wide continuum energy spectrum gamma-rays. As for theoretical correction factor, the Lorentz formula for the giant resonance cross section and the Schiff formula for the bremsstrahlung gamma-ray spectrum are used.

It was shown that the contents of the sample isotopes of the natural metal foils determined by using the correction factors are satisfactorily in agreement with the real values.

SYSTEMATICAL ANALYSIS OF (n,α) REACTION CROSS SECTIONS FOR 4-6 MeV NEUTRONS

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For last years we have been analyzing known experimental (n,α) cross sections in the wide energy range of E_n=6-20 MeV and observed [1] some systematical regularity which in the literature is termed as the isotopic effect. The statistical model, based on the Weisskopf-Ewing evaporation model and constant nuclear temperature approximation, was suggested [1,2] to explain the isotopic effect.

In addition, the experimental study of the (n,α) reaction in the MeV neutron energy range for broad mass of target nuclei was carried out (see, for example [3,4]).

In this paper the results of the systematical analysis of our experimental (n,α) cross sections for new energy range of 4-6 MeV using the statistical model are described. In this energy range of neutrons the systematical dependence of the (n,α) cross sections on the relative neutron excess parameter (N-Z+0.5)/A for target nuclei was observed and explained by the statistical model.

References

1. G.Khuukhenkhuu, Yu.M.Gledenov, M.V.Sedysheva, M.Odsuren, J.Munkhsaikhan, T.Delgersaikhan
   In book: Neutron Spectroscopy, Nuclear Structure, Related Topics,
   ISINN-20, JINR, Dubna, 2013, p.173.
2. G.Khuukhenkhuu, G.Unenbat
   Scientific Transactions, National University of Mongolia, N7(159), 2000, Ulaanbaatar, p.72.
3. Yu.M.Gledenov, Guohui Zhang, P.E.Koehler, M.V.Sedysheva, Jiaguo Zhang, Hao Wu, Jiaming Liu, Jinxiang Chen, G.Khuukhenkhuu, P.J.Szalanski
   Journal of the Korean Physical Society, vol.59, N2, Part III, 2011, p.1693.
4. Guohui Zhang, Yu.M.Gledenov, Jiaguo Zhang, Hao Wu, Jiaming Liu, Jinxiang Chen, M.V.Sedysheva, G.Khuukhenkhuu, P.J.Szalanski
   Journal of the Korean Physical Society, vol.59, N2, Part III, 2011, p.1705.

MASS YIELD DISTRIBUTION IN THE PHOTON (BREMSSTRAHLUNG) INDUCED FISSION OF ACTINIDES (^{232}Th, ^{238}U) AND PRE-ACTINIDES (^{nat}Pb, ^{209}Bi)

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ABSTRACT

The yields of fission products in the photon (bremsstrahlung) induced fission of ^{232}Th and ^{238}U with end-point energy of 10 MeV as well as for ^{nat}Pb, ^{209}Bi and ^{232}Th with 45-80 MeV and 2.5 GeV have been determined by off-line γ-ray spectrometric technique using the electron linac of EBC, Kharghar and PAL, Pohang, Korea. The mass yield distributions were obtained from the fission yield data using charge distribution corrections. The peak to valley (P/V) ratio, average light mass ($<A_L>$) and heavy mass ($<A_H>$) at different excitation energy were obtained from the mass yield data of this work and literature data for the above fissioning systems. The value of P/V, $<A_L>$ and $<A_H>$ in the ^{232}Th(γ, f) and ^{238}U(γ, f) are compared with the similar data in ^{232}Th(n, f), and ^{238}U(n, f) to examine the role of excitation energy on nuclear structure effects. Similarly, the present data in the ^{nat}Pb(γ, f) and ^{209}Bi (γ, f) were compared with the literature data at other bremsstrahlung energies to examine the role of excitation energy on average mass (<A>) and P/V ratio.

Key words: **Photo-fission of ^{nat}Pb, ^{209}Bi, ^{232}Th and ^{238}U, E_γ =10, 45-80 and 2500 MeV, Offline γray spectrometric technique, Mass yield distribution.**

ACCUMULATION OF HEAVY METALS IN THE MOSS *PLEUROZIUM SCHREBERI* IN THE WEST OF RUSSIA (KALININGRAD REGION)

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The moss biomonitoring technique was applied to air pollution studies in the West region of Russia (Kaliningrad region). Samples of the terrestrial moss *Pleurozium schreberi* have been collected every 5 years, from 2000 in accordance with the sampling strategy of the European moss survey program.

Moss samples were collected on regular network of 10x10 km during the August – September in 2000, 2005, 2010. Metals such as Pb, Cd, Cr, Ni, Cu, Fe, Mn were determined by AAS technique (by flame – Mn, Fe; ETA – others).

In general, the concentration of Cd, Pb, Ni and Cu in mosses decreased between 2000 and 2010; the concentration of Cr increased in the same period.

Table 1 - Means of mediana in moss *Pleurozium shreberi* in Kaliningrad region in 2000 – 2010 year (mg/kg DW)

year	Cu	Ni	Pb	Cr	Cd	Mn	Fe
2000	5,3	4,11	13,2	0,14	0,14	256	192
2005	9,34	3,8	4,63	0,88	0,18	132	222
2010	2,84	1,21	1,91	1,41	0,05	245	168

The values of metals vary widely, but low values prevail. Highest concentrations were determined in the west part, lowest ones in the center of region.

Table 2 - Concentration of Heavy metals in moss *Pleurozium shreberi* in Kaliningrad region in 2010 year (mg/kg DW)

	Cu	Ni	Pb	Cr	Co	Ag	Cd	Mn	Fe
mean	4,46	1,20	2,51	2,16	0,119	0,044	0,11	346	217
min	1,68	0,36	0,39	0,69	0,038	0,007	0,006	73	113
max	19,7	2,54	9,33	12,1	0,245	0,235	1,12	960	700

Principal component factor analysis was used to identify and characterize different pollution sources and to point out the most polluted area. There were identified two factors of metals emission.

The maps of metals atmospheric deposition were created. Cartography analysis revealed spatial patterns of metals distribution. Probably highest levels of metals in moss in the west part of region (Sambia peninsula) and elevated levels in the North, North-East and South-West parts are indicating trans-boundary pollution.

Self-shielding and multiple scattering corrections to neutron capture yield in the Unresolved resonance region

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Abstract

New procedure for calculating the self-shielding and multiple scattering corrections to measured capture (absorption) yield has been proposed in the Unresolved Resonance Region (URR). The resonance Doppler broadening and resonance interference are accounted for in the applied numerical procedure, based on the periodical resonant cross sections structure and being modulated by multi-level Reich-Moore approximation of the Wigner's R- matrix theory. This procedure was developed and used in the evaluation task for nuclei with one open neutron channel under the threshold for neutron inelastic scattering.

Currently it is also applicable for nuclei with few open neutron and fission channels under the threshold of inelastic neutron scattering. Examples are given for nuclei ^{197}Au and ^{241}Pu.

Integral formulae for calculating the correction coefficients are also proposed. The coefficients are computed through the self-indication functions for neutron absorption, which functions give complete and comprehensive information for the neutron cross sections structure in the URR and reflect the physical phenomena in the sample.

Example is given for the correction coefficients, computed through experimentally derived self-indication functions for neutron capture of ^{238}U in the URR; (*Yu.V.Grigoriev et al., "Measurement and analysis of resonance structure for ^{238}U total and radiative capture cross section in energy range 0.465-200 keV", J,YK, 4 (1991) 26*).

This scheme enables a determination of the correction coefficients to neutron capture yield without using neutron resonance parameters; i.e. the evaluated nuclear data files.

NEUTRON ACTIVATION ANALYSIS OF MACROALGAE *CYSTOSEIRA* FROM COASTAL ZONE OF MARINE PROTECTED AREAS (THE BLACK SEA, CRIMEA)

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Marine macroalgae are proven indicators for the assessment of dissolved trace elements in the sea, because of their accumulation capacity [1]. The data on the content of trace elements in macroalgae from the coastal water areas of the Crimea, including marine protected areas (MPAs), are scarce. Since the majority of MPAs of the Crimea is under intense anthropogenic load, the aim of this study was to determine the level of 21 trace elements in macroalgae *Cystoseira* spp. collected during summer 2012 from 14 sites of the coastal zone of different MPAs of the Crimea. For the first time for the most chosen MPAs the concentrations of elements (Al, Sc, V, Mn, Fe, Ni, Co, Zn, As, Se, Br, Rb, Sr, Ag, Sb, I, Ba, Cs, Tb, Th and U) were determined in macroalgae by means of INAA performed at the pulsed fast reactor IBR-2, FLNP JINR [2]. The obtained results showed that the geological structure of the coastline, the level of anthropogenic pollution of water area and the type of analyzed morphostructure of the plant are most important factors that influence on accumulation of trace elements by *Cystoseira* spp. The highest concentrations of the majority of trace elements were found in *Cystoseira* spp. from the Coastal aquatic complex near cape Lukull (the Sevastopol region). High concentrations of Al, Sc, V, Cs, Fe and As and Sr were also determined in algae from Karadag Nature Reserve and Laspi-Sarych coastal aquatic complex, respectively.

1. Strezov A., Nonova T. Monitoring of Fe, Mn, Cu, Pb and Cd levels in two brown macroalgae from the Bulgarian Black Sea coast. *Intern. J. Environ. Anal. Chem.*, 2003, Vol. 83, No. 12, pp. 1045 – 1054.
2. Frontasyeva M.V. Neutron activation analysis for the Life Sciences. A review. *Physics of Particles and Nuclei*, 2011, Vol. 42, No. 2, pp. 332 – 378.

NEUTRON SOURCES FOR NEUTRINO INVESTIGATIONS

(AS ALTERNATIVE FOR NUCLEAR REACTORS)

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The (n,γ)-activation of ^{7}Li isotope lead to creation of short lived ^{8}Li, which in β^--decay ($T_{1/2}$ = 0.84s) emits hard spectrum $\widetilde{\nu}_e$ with E_{max} up to 13 MeV and mean energy of ~ 6 MeV. This idea is laid in the basis of lithium converter of neutron to antineutrino, i.e., installation for neutrino investigations with the main two parts: powerful neutron source for activation of the converter and lithium converter itself [1].

Different types of neutron sources can be utilized for lithium activation [1-6]. The most traditional and highly flux are nuclear reactors. It can be the high-flux nuclear reactors (in a stationary mode) enclosed by lithium converter (static regime of converter operation). In the static regime the advantages of ^{8}Li antineutrino spectrum can be utilize more fully if to realize the scheme with pulse reactors, when neutrino from β^--decay of fission isotopes will be separated in time from neutrino of ^{8}Li decay. For steady flux reactors the advantages of $\widetilde{\nu}_e$-spectum can be more fully utilized in the dynamic regime when an activated ^{7}Li is pumped in the close cycle through the reactor active zone and further - to the neutrino detector. It is discussed the geometry of the converter (essentially defined by neutron energy and spectrum), requirements to ^{7}Li isotope purification, possible matter for lithium converter [4]. For the discussed energy the neutrino-nuclear interaction cross section is proportional to E_ν^2. Along with advantages in fluxes, the reactors as neutrino sources have a serious disadvantage (in such a spectrum the detection efficiency of high-energy-threshold detectors rapidly decreases) compare to the well known and more hard $\widetilde{\nu}_e$-spectum of ^{8}Li decay. In addition the reactor antineutrino spectum of fission products it's not well defined and varies in reactor life-time.

Today the most perspective way to create a power neutrino source may be the tandem of lithium converter plus an accelerator and neutron generating target [3]. It was simulated neutron flux from W, Pb -targets in intermediate proton energy (hundreds of MeV's) and evaluated dimensions of the lithium converter for the "tandem"-scheme. It was calculated the expected efficiency of the lithium converter (number of ^{8}Li nuclei per neutron of the target). Today the proposed "tandem" scheme [3, 5] of the powerful neutrino source on the base of lithium converter is considered and proposed as neutrino project for construction [7].

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1. *Lyutostansky Yu.S., Lyashuk V.I.* // Nucl. Sci and Eng. - USA 1994. - Vol. 117. - P. 77.
2. *Lutostansky Yu.S., Lyashuk V.I.* // Phys. At. Nucl. - 2000. - Vol. 63. - P. 1288.
3. *Lutostansky Yu.S., Lyashuk V.I.* // Particles & Nucl. Lett. - 2005. - Vol. 2. - P. 60.
4. *Lyutostanskii Yu.S., Lyashuk V.I.* // Soviet Atomic Energy. - 1990. - Vol. 69. - P. 669; see also Atomnaya Energiya. -1990. - Vol. 69. - P. 120.
5. *Lutostansky Yu.S., Lyashuk V.I.* // Bull. Russ. Acad. Sci. Phys. -2011.- Vol. 75. - P. 468.
6. *Stavissky Yu. Ya.* // Physics-Uspekhi (UFN). – 2006. - Vol. 49. - P. 1253.
7. Bungau A., Adelmann A., Alonso J.R., et.al. \\ Phys. Rev. Lett. 109, 141802 (2012).

HELIUM UCN SOURCE AT THE EXTRACTED BEAM OF THERMAL NEUTRONS

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We propose a new method to largely increase ultracold neutron (UCN) density in superfluid ^{4}He source. The idea consists in placing a spherical (cylindrical) ^{4}He UCN source into a cavity in the cryogenic reflector/moderator from methane installed at the thermal neutron guide exit. The total flux of 8.9Å neutrons in the cavity largely increases compared to that in the incoming neutron guide due to cooling neutrons as well as multiple neutron reflection from the cavity walls. Thus the cavity becomes an "External" (at the extracted beam) cold neutron source. Conservative estimation of the resulting UCN density in an optimized UCN source of this kind ~10^5n/cm^3 and UCN production rate is about $3\cdot10^7$ s^{-1}.

One of the main advantages of the "External" cold neutron source method is relatively small thermo load from gamma rays and neutrons. Thus it does not need a too powerful and expansive cryogenics. The method looks very attractive for intensive neutron source like the ILL high flux reactor as well as the PIK reactor or ESS.

The results of experiment that was dedicated to investigation of cooling and accumulation of thermal neutrons in a vacuum cavity surrounded by solid methane at a temperature of 6 K will be reported. The experimental results confirm the correctness of the estimations.

Statistical modeling method for "Romashka"- type 4π detector system

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Abstract

At the Frank Laboratory of Neutron Physics (FLNP) of the Joint Institute of Nuclear Research (JINR), a new versatile multidetector "Romashka"-type gamma-ray spectrometer was built and tested. Up to 44 NaI(Tl) hexagonal detectors can be arranged in 2 cylindrical arrays with varying diameter and distance between them. This system is supposed to be used for the investigation of the neutron induced inelastic, capture and fission reactions in a number, important for fundamental physics and nuclear industry, nuclei.

The aim of the present work is to study the response function of the system to a cascade of gamma-rays, when the basic configuration, consisted of 24 NaI(Tl) detectors, is used.

This is done by the method of statistical modeling, which has already been successfully applied to 12 NaI (Tl) detector system.

In addition to the methodological importance of the obtained results, they stitch the mathematical model, describing the gamma-ray response of the detectors, to the simple, but interesting in Monte-Carlo treatment, model of mixing of the gamma-ray cascades, striking the multidetector system.

The detectors' gamma-sensitivity data are a good starting point for further phenomenological analysis of the measured, by such detector arrays, gamma-ray multiplicity and spectra from the neutron-nucleus radio-active capture and/or fission reactions, based on the statistical model of de-excitation of the formed compound nucleus.

MOSS BIOMONITORING OF TRACE ELEMENTS IN SLOVAK INDUSTRIAL AREAS, MINING COUNTRY, AND NATIONAL PARKS EXPERIENCING ENVIRONMENTAL STRESS

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The application of mosses as biomonitors of trace elements in selected Slovak industrial areas, mining country, and National parks affected by anthropogenic activity is reviewed. Moss was successfully used also to study temporal and spatial deposition of N and S. A combination of analytical data (NAA, and AAS in our case) with principle component analysis and correlation factor allowed pollution source characterization and apportioning in the sampled areas: Central Spiš (effect of heavy metalls); Aluminium plant ŽiarnadHronom; Thermal power plant Horná Nitra; Central Slovakia (mining area of StaréHory, Ľubietová, Španiadolina); Beskydy (north part of Slovakia- influence of Poland and Czech pollutants); High Tatra National Park (TANAP) and Low Tatra National Park (NAPANT).
The Slovakia moss survey has an important role in identifying spatial and temporal trends in atmospheric heavy metal pollution across Europe. This work is essential for monitoring future trends at a high spatial resolution and provides a useful tool for additional validation of modelled atmospheric deposition fluxes. Environmental monitoring programmes such as the moss survey are appropriate to regulatory bodies aiming to prevent the quality of the environment from deteriorating or ensure that its quality is improved.

Chemical and morphological characteristics of key tree species of mining country by toxic element at selected Cu- deposits

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ABSTRACT

Concentration of 31 elements in 1 year old needles of *P. abies, P. silvestris, A.alba* and leaves *B. pendula* from Staré Hory, Lubietová, Špania Dolina and control sites Čadca are discussed in a context of their limit values. S/N ratio was different from optimum in 90% of localities when compared with the European limit values. Likewise we found increase of Fe and Cu concentrations compared with their background levels in 100% of locations. Mn concentrations were increased in 76% of localities. Mn mobilization values indicate the disturbance of physiological balance leading to the change of the ratio with Fe. SEM-investigation of foliage waxes from all study sites in the Carpathian Mts. showed that there is a statistically significant difference in mean wax quality. Epistomatal waxes were damaged as indicated by increased development of net and amorphous waxes.

References

Maňkovská, B., Jeran, Z., Grodzinska, K., Alber, R., 2008: Metal accumulation in mosses across national boundaries: Uncovering and ranking causes of spatial variation. Environ. Pollut.,*151*: 377–388.

Majzlan, J., Chovan, M., Andráš, P., Newville, M., Wiedenbeck, M., 2010: The nanoparticulate nature of invisible gold in arsenopyrite from Pezinok (Slovakia). Mineralogical Magazine 1 ISSN 0077-7757: 1-9.

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ASSESSMENT OF SOIL CONTAMINATION WITH Pb AND Cu IN THE AREA AFFECTED BY KARDZHALI LEAD-ZINC SMELTER

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Abstract

The contents of Pb and Cu in 113 soil samples collected in the area of the lead-zinc smelter in the town of Kardzhali, Bulgaria, were determined. The sampled area was about 480 sq. km, ranging 12 km to the north and south and 10 km to the east and west from the factory chimney. The coordinates of the sampling sites were determined by GPS. Atomic absorption spectrometry was used as the analytical technique ("Varian SpektrAA 220", Australia). Sample preparation was performed in accordance with ISO 11464. Extractions were made with aqua regia in accordance with ISO 11466. The contents of heavy metals were determined in accordance with ISO 11047. The following wave-lengths were used: Pb – 217.0 nm and Cu – 324.8 nm. The results from the study show that the concentrations of Pb and Cu in the majority of the soil samples are within the norms defined by the judicial documentation for interventional and maximum acceptable concentrations. This means that for most of the sampled locations the measures for soil remediation are not necessary. Application of land improvement is needed in the polluted zones, where Pb and Cu concentrations exceed 90 mg/kg and 80 mg/kg respectively.

NEUTRON ACTIVATION ANALYSIS OF PLANKTON FROM COASTAL ZONE OF CRIMEA

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Accumulation of the trace elements by natural communities of phytoplankton inthe polluted coastal areas of the Crimeawasstudied by neutron activation analysis.The phytoplankton was collected from 26 sites of the coastal zone of Crimea near Sevastopol region during its active growth in summer-autumn of 2013. The Nansen and Juday nets with 35 μm and 50 μm mesh size were used for sampling. Concentrations of 46 elements were determined by means of epithermal instrumental NAA performed at the pulsed fast reactor IBR-2, FLNP JINR. Principal Component Analysis applied to the results obtained revealed 5 factors: factor 1 associated with *biophil*and *lithophil*elements which come to waters from the coastal areas or with atmospheric input (Mg, Al, S, Ca, Sc, V, Cr, Mn, Fe, Co, Cu, Zn, As, Br, Rb, Sr, Zr, I, Cs, Th, and rare earth elements); factor 2 marine elements (Na and Cl),factor 3 (K and Ba) associated with dissolved sea-salt particles,factors4 (Mo, Sb, Gd)and 5 (Sn) representing anthropogenic component, most probably associated with erosion of metal constructions like shore protection pilings, boats, ships, etc. The concentration of elements of factor 1 are higher in phytoplankton from the shallow water stations (less than 10 m of total depth), especially in the Sevastopol Bay than in the deep water stations.The gradient of concentrations with the distance from the shore and allocation of sampling sites is discussed.

PROSPECTS OF SUBCRITICAL MOLTEN SALT REACTOR FOR MINOR ACTINIDES INCINERATION IN CLOSED FUEL CYCLE

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Paper presents an attempt to carry out synthesis of the approaches based on use of subcritical reactors for minor actinides recycling and incineration, and gas-flourides methods of reprocessing of spent nuclear fuel.

The subcritical molten salt reactor (K_{eff}=0.95) with fuel composition based on molten FLiNaK salt and fluorides of minor actinides (separated from spent fuel VVER-1000 light water reactor) and external neutron source, based on 1 GeV proton accelerator with 6 mA protons current and molten salt cooled tungsten target is considered.

Paper presents the results of parametrical analysis of equilibrium isotopic composition of molten salt reactor with minor actinides feed in dependence of core dimensions, average neutron flux and external neutron source intensity.

KEYWORDS: long-lived radioactive wastes, transmutation, accelerator driven systems, subcritical molten salt reactor

RESEARCH OUTCOMES OF RECENT INTERACTION BETWEEN DUBNA AND UNIVERSITY OF THE WESTERN CAPE

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Research outcomes are overviewed of recent interaction between Joint Institute for Nuclear Research, Dubna, Russia and University of the Western Cape in the following research areas: (1) photocatalytic membrane reactor based on nanostructured semiconductors and track etched membranes for water treatment processes; (2) development of advanced composite materials based on track etched membrane and photovoltaic catalysts; (3) the study of uranium, thorium and their decay products in fly ash obtained by burning of fossil fuels by epithermal neutron activation analysis,(4) determining coal fly ash elemental composition and performing a comparative study with other analytical techniques.

EFFECT OF SHAPE OF NUCLEAR LEVEL DENSITY AND GAMMA-RAY STRENGTH ON GAMMA-RAY SPECTRA

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The effects of shapes of vibrational enhancement of nuclear level density (NLD) and E1 radiative strength function (RSF) on gamma-ray spectra and excitation functions of neutron-induced nuclear reactions are studied.

For the NLD, the modified variant [1] of enhanced generalized superfluid (MEGS) model [1,2] with different vibrational state enhancement factors [3-5] are used. The comparison of the experimental NLD [6-10] with the theoretical calculations is also presented for different vibrational enhancement. For MEGS model, approximation of boson partition function with average occupation numbers (BAN)[4,5] is found as the most appropriate approach for calculation of the vibrational enhancement factor.

For the RSF, a new version of a modified Lorentzian approach (MLO4)[11] is used. The overall comparison of the RSF calculations within different simple models [11,12] and experimental data [6-8,13] is performed. The MLO4 [11] looks like the best candidate for overall description of the RSF.

It is demonstrated that shape and values of the calculated excitation functions and gamma-ray spectra are sensitive for a choice of the NLD vibrational enhancement and the RSF description.

1. V.A. Plujko, O.M. Gorbachenko et al. // Intern. Nucl. Data Conf. Science and Techn. ND2013, 03-08 March 2013,USA, NY, Book of Abstracts, P.303.
2. M.Herman, R.Capote, B.V.Carlson et al.// Nucl.Data Sheets. 2007. V.108. P.2655.
3. A.V. Ignatyuk, J.L.Weil et al. // Phys. Rev. C. 1993. V.47. P.1504.
4. V.A. Plujko, O.M.Gorbachenko // Phys. Atom. Nucl. 2007. V.70. P.1643.
5. V.A. Plujko, O.M.Gorbachenko et al.//Int.Journ.Mod.Phys.E. 2007. V.16. P.570.
6. A.M. Sukhovoj et al. // Izvestiya RAN. Seriya Fiz. 2005 V.69. P.641.; Phys. Part. Nucl. 2005. V.36. P.359; Proc. Int. Conf. ISINN-21. 2014. (in press)
7. E. Melby et al.// Phys. Rev.C. 2001. V.63. 044309.
8. U. Agvaanluvsan et al. // Phys. Rev. C. 2004. V. 70. 054611; http://ocl.uio.no/compilation/.
9. R. Schwengner et al. // Phys. Rev. C. 2010. V.81. 034319.
10. R. Schwengner et al. // Phys. Rev. C. 2008. V.78. 064314.
11. V.A. Plujko et al. // Nuclear Physics and Atomic Energy.2012. V.13. 335.
12. R.Capote, M. Herman et al.// Nucl. Data Sheets. 2009. V.110. P.3107.
13. B.V. Zhuravlev // IAEA, INDC(NDS)-0554, Distr. G+NM (2009).

STUDY OF SHAPE ISOMERIC STATES IN FISSION FRAGMENTS

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In our previous pablications devoted to the collinear cluster tri-parttition (CCT) [1, 2] we have discussed the role of scattering medium in the registration of the CCT products. In order to increase the effect additional absorber (Ti, Ni or Cu foil) was introduced just after the Cf source. An essential mass deficit is observed in the total mass of the fission fragments detected in coincidence with the ions knocked out from the foil. It could be expected if the scattered fragment looks like a di-nuclear system (shape isomeric state) destroying due to inelastic scattering in the foil. Such process takes place in near head-on collisions only.

References

1. Yu. V. Pyatkov et al., Eur. Phys. J. A 45 (2010) 29.
2. Yu. V. Pyatkov et al., Eur. Phys. J. A 48 (2012) 94.

Method of the "dineutroneum" existence confirmation

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One of the main puzzle of the modern low-energy nuclear physics is repeatable effect of the neutronless tritium production ($t/n \sim 10^5 - 10^9$) at the heavy water electrolysis [1].

This effect one can explain in the framework of the "orthodox" nuclear physics on the base of hypothesis of the neutroneum and dineutroneum (bound state of the neutron and neutroneum) existence [2].

We can extremely clear verify this hypothesis in "experimentum crucis". The main idea of this experiment is follows. According to [2] the neutronless tritium production takes place in the reaction

$$D_\nu + d \rightarrow t + n_\nu \qquad (1)$$

In the previous works (see [3], for example) was shown that the main mechanism of the dineutroneum generation is the reaction $D(e,e')D_\nu$ (fig. 1). Analogous neutroneum (or dineutroneum) photoproduction processes corresponds to the reaction $D(\gamma,\gamma')D_\nu$ (fig. 2). Interpretation of diagrams fig. 1, 2 are given in [2].

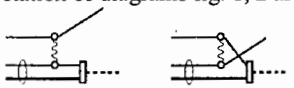

Fig. 1. Neutroneum electroproduction at the inelastic photon-hydrogen scattering

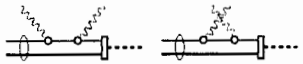

Fig. 2. Neutroneum photoproduction at the inelastic photon-hydrogen scattering

The easiest comparison analysis of the fig. 1 and fig. 2 gives us estimation

$$\sigma^{tot}_{D(\gamma,\gamma')D_\nu} \sim (v_e/c)\cdot\sigma^{max}_{D(e,e')D_\nu} \sim 10^{-4}\ mbarn \qquad (2)$$

in an accordance with the previous results $\sigma^{max}_{D(e,e')D_\nu} \equiv \max[\sigma^{tot}_{D(e,e')D_\nu}] \sim 10^{-2}\ mbarn$ [3], $v_e/c \sim 10^{-2}$, where σ^{tot} is the total cross-section of the corresponding reaction. This result brings us the scheme of the "experimentum crucis".

If we expose the X- ray transparent vessel contains gaseous deuterium ($V_{D_2} \sim 1\ l$) at the room temperature and high pressure $P \sim 10^7\ Pa$ at the γ- quanta beam with the energy $\varepsilon_\gamma \sim 50\,keV$ (total X- tube power $W_X \sim 0.5\ kW$), than the estimated rate of the tritium generation events will be approximately

$$\dot{N}_t \sim 10^6 \div 10^9\ event/s \qquad (3)$$

In all reasonable schemes of such kind experiments we can detect enormous quantity of tritium. That will be the clear signal of the dineutroneum existence.

References

1. Tsarev V.A., Uspekhi Fizicheskikh Nauk (Sov.Phys.- Uspekhi), **162**, №10, 63 (1992)
2. Ratis Yu.L., Proceedings of the XXI International Seminar on Interaction of Neutrons with Nuclei, Dubna: JINR, 2014.
3. Ratis Yu.L. The Old and New Concepts of Physics, Volume VI (2009), N 4, p.525-543 http://www.conceptsofphysics.net/VI_4/525.pdf

HUMAN HEALTH RISK ASSESSMENT IN IVANOVO REGION FROM SOIL CONTAMINATION

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Soil contamination is one of the possible sources of the heavy metal uptake by humans. Unfavorable quality of soil causes increasing of human health risks and loss in life expectancy (LLE). This work is concerned with the assessment of human health risk from soil contamination in Ivanovo region.

Ivanovo region situated at interfluve of the Volga and Klyaz'ma rivers. 45 samples of soil were collected according to the Methodological recommendation for heavy metals determination in soils. Sampling grid on average was about 20 km. Analysis of samples was carried out by atomic absorption spectroscopy (AAS) in Ivanovo and neutron activation analysis (NAA) in Dubna. The determination uncertainties were about 30% and 10% for AAS (Pb, Cd, Cu) and NAA, respectively.

The human health risks were calculated as probability of unfavorable events occurrence. The calculation was made for 4 groups: men, women, children and all adult population. Economic damage was also calculated from risks and average cost of living. LLE for each group of population was estimated on a basis of average life expectancy.

The results of calculation justified small human health risk values from the soil contamination. This fact is in a good agreement with environmental quality assessment results.

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Universal monitor of low intensity mixed neutron-gamma radiation fields utilizing the computer sound card as multi-channel pulse analyzer

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In Frank Laboratory of Neutron Physics (FLNP) an exploratory research on the development of a low-cost universal dual monitor of mixed neutron-gamma fields of low intensities is ongoing. As a monitor any, protected by a suitable (n,γ)-convertor, γ-sensitive detector can be used. The possibility of using of the computer sound card as a multichannel analog-to-digital converter (ADC) of the pulses from the monitor is discussed.

INTERACTION OF FAST NEUTRONS WITH HTc SUPERCONDUCTORS – CRITICAL CURRENT EFFECTS

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Investigations of the interaction of fast neutrons with the condensed matter bring new basic physical results on the atomic level. However important is also applied meaning of such interaction, which will be considered in the paper for the case of the influence of fast neutrons irradiation on the macroscopic properties of HTc superconductors, to which belong their critical current, pinning forces and current-voltage characteristics. This topic is especially important for the work of superconducting accelerators, as Nuclotron-NICA, in which just such neutrons irradiation occurs and influences the work of superconducting electromagnets.
In the paper is presented new model of the interaction of pancake type vortices appearing in HTc multilayered superconductors with nano-sized defects created just by the fast neutrons irradiation. The energy balance of the system of captured vortex and pinning nano-sized center has been considered for the case of shift of magnetic vortex from its initial equilibrium position under an influence of Lorentz force, induced by transport current flow. Energy barrier has been determined then. An enhancement in an elasticity energy of the vortices lattice disturbed by the vortex capturing has been taken into account too at current-voltage characteristics calculations. Finally from the electric field criterion the critical current was determined in the function of the dose of the fast neutrons irradiation of HTc superconductor versus static magnetic field and temperature. Some results of calculations are shown in Fig. 1.

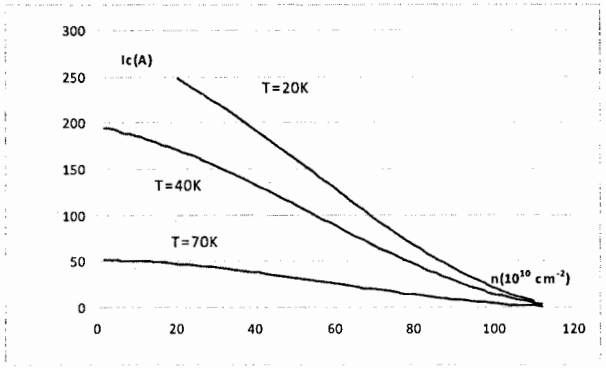

Fig.1. Calculated influence of the dose of irradiation by fast neutrons, creating nano-sized defects on the critical current of HTc superconductor, in the function of temperature for static magnetic induction equal to 2T.

Moreover obtained critical current magnetic field dependence of neutrons irradiated sample was used for determining the current-voltage characteristics in the dynamic case of linearly varying with time magnetic field. Then the new solution of the magnetic flux diffusion equation has been found, which predicts the appearance of the dynamic anomalies of these characteristics in HTc superconductors, in accordance with our previous experimental data.

THE APPLICATION OF AAS, ICP-AES AND ICP-MS IN ENVIRONMENTAL POLLUTION STUDIES

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The application of various spectrometric techniques: atomic absorption spectrometry (AAS), inductively coupled plasma – atomic emission spectrometry (ICP-AES) and inductively coupled plasma – mass spectrometry (ICP-MS) in environmental pollution studies is presented. The results from the surveys of the pollution of waters, air, soil and food with heavy metals in the Republic of Macedonia are reported. Air pollution was investigated by moss biomonitoring. The pollution with heavy metals in the particular regions was additionally investigated using moss, lichens, attic dust, soil, water and sediment samples. The results from the study of the pollution in the city of Veles (lead and zinc smelter plant), Kavadarci (ferronickel smelter plant), Radoviš (copper mine and flotation), Zletovo, Sasa and Toranica (lead and zinc mines and flotation plants) are presented. The spatial distribution maps for each specific element are prepared to give a proper interpretation of the obtained results.

NEW NUCLEAR DATA COMPILATIONS COLLECTED IN PNPI

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In this work we continue to study a few-nucleon aspect of the excitation properties in different nuclei including spectra of neutron resonances. Only the neutron spectroscopy data allows to explain the superfine structure in neutron resonances [1].

We collected in PNPI nuclear data compilations CRF-7 and CRF-8 (low-lying excitations) and NRF-4 (parameters of neutron resonances). Together with the compilations published earlier [2-4] they provide with the most recent data for a systematic study of few-nucleon effects connected with the most fundamental nucleon interaction - one-pion exchange (tensor force) interaction [5-7]. The empirical relations between the observed stable intervals in nuclear excitations and binding energies were considered earlier [1,8,9]. Together with the suggestion [10] on the role of QED radiative correction they were connected with the recent state of the Standard Model and its further development [11].

An important role of nuclear data - besides the fundamental origin of nucleon interaction at long distances - consists in the confirmation of the observed relations in particle masses called "the tuning effect". It includes the pion mass 140 MeV and its parameter f_π=130 MeV as well as constituent quark masses in NRCQM (Nonrelativistic Constituent Quark Model) and basic parameters of the Standard Model (masses of the scalar and vector fields). The direct confirmation of these values can be connected with the fundamental role of hadronic effect manifestating in QCD gluon-quark-dressing effect. It is confirmed with the observed correlations in nuclear binding energies.

The common tuning effect in particle masses and in nuclear data which includes correlations in masses of pion and ρ-mesons, nucleons and estimations of the constituent quark masses in NRCQM includes also the charged splitting of the particle masses (the nucleon mass difference δm_N-1293 keV, the pion mass splitting close to $9m_e$ and the value of m_e itself).

Analysis of the one-pion exchange dynamics in nucleon interaction allows an independent check of the common tuning effect parameters.

REFERENCES

1. S.I.Sukhoruchkin, Proc. Int. Conf. Stat. Prop. Nuclei, Albany, New York, 1971, p. 215. Pl. Press, 1972.
2. Landolt-Boernstein New Series vol. I/22A,B. Springer, 2009.
3. Landolt-Boernstein New Series vol. I/24. Springer, 2009.
4. Landolt-Boernstein New Series vol. I/25A,B. Springer, 2012; vol. I/25C,D,E, 2013.
5. T.Otsuka, Phys. Scr. T **152** (2013) 014007.
6. J.Schiffer *et al*, Phys. Rev. Lett. **92** (2004) 162501.
7. S.I.Sukhoruchkin, Proc. ISINN-6, Dubna, 1997. JINR **E2-97-213** p. 427.
8. S.I.Sukhoruchkin, J. Phys.: Conf. Ser. **381** (2012) 012076.
9. S.I. Sukhoruchkin, Nucl. Phys. B (Proc. Suppl.) 234C (2013) 241.
10. V.V. Belokurov, D.V. Shirkov, *The theory of Particle Interactions.* AIP, N.-Y., 1991.
11. Y.Nambu, Nucl. Phys. A **629** (1998) 3c.

NEW NUCLEAR DATA COMPILATIONS COLLECTED IN PNPI. II.

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We performed analysis of few-nucleon effects in the low-lying excitations of different light nuclei (Z=12-16) and non-statistical effects in the spectra of neutron resonances observed earlier as the superfine structure in spacing distributions for many nuclei [1-3]. A systematic study of few-nucleon effects explained with the one-pion exchange [4,5] could be connected with the recent state of the general theory of all interactions - Standard Model [6-7].

Spacing distributions in light nuclei show a stable character of intervals close to a half of the first excitation 1368 keV of the nucleus ^{24}Mg (two pairs of holes in $1d_{5/2}$ subshells). Together with the stable interval 492 keV directly observed in the spacing of the near-magic ^{18}F and tellurium isotopes (Z=52) these intervals are represented as parts of the system of stable intervals multiple to the parameters of the residual nucleon interaction 161 keV (tensor force parameter Δ^{TF}) and 170 keV observed in differences of nuclear binding energies and in excitations of near-magic heavy nuclei (Z=29,51; N,Z=83 etc.).

Stable interval 493 keV=2×161 keV+170 keV was found in neutron resonances of ^{41}Ca [8], in excitations 983 keV=2×492 keV of ^{19,20}F and stable low-lying excitations 1968 keV=4×492 keV in ^{33}S [3]. The exact integer relations in ^{41}Ca and ^{37,38}S (see Table, the period 644 keV=4×161 keV) support an important role of the one-pion exchange. An indirect support of the above mentioned few-nucleon fine structure effects was obtained in the analysis of neutron resonance spacing distributions. Super-fine structure interval 572 eV (corresponding to the fine structure D=492 keV) was found in positions and spacing of many nuclei. The ratio 572 eV/492 keV is close to QED radiative correction [1].

Table. Linear trend in energies E^* (in keV) of levels in N=21 nuclei; the excitations forming the slope 4×161 keV=4Δ^{TF} and rational to each other are boxed [3].

(Z-14)/2		3	2	1, ΔN=1	-1		0	1, ΔN=2	1 (ΔN=-4)
^{A}Z	^{41}Ca		^{39}Ar	^{37}S	^{33}Mg		^{32}Si	^{38}S	^{33}S
E^*, D	0.0	1943	0.0 1267	0	646	159	484	1942	1292	D=322
n(Δ^{TF})	0	1941	0 1293	0	646	161	483	1941	1293	322
n		12	8		4	(1)	3	12	8	2

REFERENCES

1. S.I.Sukhoruchkin, Stat. Prop. Nuclei, p. 215. Pl. Press, 1972.
2. Landolt-Boernstein New Series vol. I/24. Springer, 2009.
3. S.I.Sukhoruchkin, Soroko Z.N., Sukhoruchkin D.S., Proc. ISINN-21, JINR (2014).
4. T.Otsuka, Phys. Scr. T **152** (2013) 014007.
5. Landolt-Boernstein New Series vol. I/25A, Springer, 2012; vol. I/25E, Springer, 2013.
6. S.I. Sukhoruchkin, Izv. Acad. Nauk Ser. Fiz. **73** (2009) 824.
7. S.I. Sukhoruchkin, Izv. Acad. Nauk Ser. Fiz. (2014) (in press).
8. M.Ohkubo, Phys. Rev. C **87** (2013) 014608.

NEXT-GENERATION PRACTICAL MODEL OF CASCADE GAMMA DECAY OF NEUTRON RESONANCE. THE EXPECTED PARAMETER POINTS FOR ARBITRARY NUCLEUS

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To date the breaking threshold values of Cooper pairs, the phenomenological coefficients of vibrational increasing of the level density and radiation strength functions are received for 40 nuclei of masses 40 $\leq$A $\leq$200. Possible functional connections between these values and the mass of the stable target nuclei are proposed. The data obtained can be used for high precision calculations of gamma-spectra and cross-sections of neutron interactions.

NEXT-GENERATION PRACTICAL MODEL OF CASCADE GAMMA DECAY OF NEUTRON RESONANCE. FALSE MAXIMA OF THE LIKELIHOOD FUNCTION

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Approximation of two-step cascade intensities of neutron resonance gamma-decay, which occurs to a group of low-lying levels, is performed with the most possible accuracy of the model with taking into account the sequential gap of Cooper pairs and presences of collective levels within the phenomenological notion of factors of collective level density increasing. Strong correlations of parameters and exponential dependences of cascade intensity with the model parameters are the reason of false maxima of likelihood function existence. Examples of such cases and their influence on the level density and radiative strength functions cascade $E1$ and $M1$-transitions are presented.

ENERGY CALIBRATION OF TIMEPIX PIXELS BELOW 60 keV

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Abstract: Timepix detector is a position sensitive pixel detector, which consists of a semiconductor detector chip (usually 300 μm thick silicon) bump-bonded to a readout chip. The detector chip is equipped with a single common backside electrode and a front side matrix of electrodes (256 x 256 square pixels with pitch of 55 μm). Each element of the matrix (pixel) is connected to its respective preamplifier, discriminator and digital counter integrated on the readout chip. The response of each pixel is proportional to the energy/charge deposited in it.

Energy calibration of Timepix detector was made in energy region from 0 to 60 keV with x-rays. Only one-pixel events were used. A set of 12 OSGI sources was tested for obtaining x-ray transitions in the desired energy region. It was found that ^{60}Co and ^{137}Cs sources do not have transitions. Other sources have one or two transitions. Preliminary energy calibration of the detector was made using events from the whole area of it. Four sources ^{109}Cd, ^{133}Ba, ^{152}Eu and ^{241}Am were chosen for longtime measurements. Longtime measurements were provided using time from 19 to 263 hours. Determination of positions of 7 transitions was made in pixels of the detector. Not in all pixels this determination could be made. Hypothesis for function of calibration was invented which has six parameters. These parameters were found for the most number of pixels. Energy spectra of four sources were obtained from the whole area of the detector using the obtained matrix of parameters.

ANTINOMY OF PARALLEL DECAY IN BETA-DECAY OF NEUTRON

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Abstract

From the elementary notions of the set theory, the well-known data on the neutron beta-decay are considered. It is shown that the beta-asymmetry in the neutron beta-decay is figured out by existence of two subsets of neutrons, where the lifetimes are different. A cardinal estimation has been performed for those two values of neutron lifetime. The agreement of those values with the data on neutron lifetime measurements and asymmetry in electron emitting is discussed. Therefore, the author considers neutron beta-decay as two-channel process. Using the neutron beta-decay as an example the author proves the presence of an antinomy, embedded into the classical conception of the parallel decay. The proposed approach gives a chance of overcoming the traditionally developed antinomy in describing of the very wide circle of phenomena with the help of more precise study of the neutron decay. The author realizes now his own plan of a justification test for the mentioned estimation results by processing of the existing experimental data.

ISOMERIC YIELD RATIOS OF FISSION FRAGMENTS ^{131}Te, ^{132}Sb, ^{133}Te, ^{134}I, ^{135}Xe IN (γ, f), (γ, nf) REACTIONS ON ^{235}U, ^{237}Np, ^{239}Pu

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Isomeric yield ratios of fission fragments ^{131}Te, ^{132}Sb, ^{133}Te, ^{134}I, ^{135}Xe in (γ, f), (γ, nf), reactions on ^{235}U, ^{237}Np, ^{239}Pu were measured. The contributions to the isomeric yields from nuclei of isobaric chains due to β-decay were taken into consideration [1]. The samples were irradiated by bremsstrahlung of microtron M-30 (Institute of Electron Physics, Uzhgorod, Ukraine) with 18 MeV end point energy. The following results were obtained.

Nuclide	^{235}U	^{239}Pu	^{237}Np
Fission fragment	Y_h/Y_l		
^{131}Te	2.6 (5)	3.2 (6)	1.9 (3)
^{132}Sb	0,27 (2)	1.48 (16)	1.01 (12)
^{132}I	2.2 (4)	0.51 (6)	0.95 (15)
^{133}Te	4.3 (3)	5.3 (3)	9.0 (9)
^{134}I	0.58 (9)	1.26 (25)	-
^{135}Xe	0.056 (7)	0.066 (7)	0.041 (6)

The average angular momenta of the primary fragments were determined with the use of these data. The codes TALYS 1.4 [2] and EMPIRE 3.2 [3] were applied in the calculations. The effect of different expressions for the radiate strength functions [4] and nuclear level densities on average angular momenta was studied.

1. I.N. Vishnevskii, V.A. Zheltonozhskii, O.I. Davidovskaya et al. // Bull. Russian Acad. Sci. 2009. V.73, №6. P. 733.
2. A.J. Koning, S. Hilaire, M.C. Duijvestijn // Proc. of the Int. Conf. on Nuclear Data for Science and Technology. 22-27 May, Nice, France. 2007. P. 211; http://talys.eu/ .
3. M. Herman, R. Capote, B.V. Carlson et al. // Nuclear Data Sheets. 2007. V. 108. P.2655; http://nndc.bnl.gov/empire/.
4. V.A. Plujko, R. Capote, O.M. Gorbachenko // Atomic Data and Nuclear Data Tables. 2011. V.97. P.567.

INVESTIGATION OF THE REACTION RATES IN ^{235}U, ^{238}U, AND ^{209}Bi SAMPLES IRRADIATED AT THE *QUINTA* TARGET

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A set of experimental samples of both uranium and bismuthhave been irradiated in the fieldof secondary neutrons generated at the massive (~ 500 kg) spallation natural uranium target *QUINTA* [1]. The target was irradiated with the deuteron beams of energies E_d = 2 AGeV and 4 AGeV of the total beam intensities $2.12(3)\times10^{13}$ and $6.08(6)\times10^{12}$ deuterons, respectively, at the JINR Nuclotron accelerator. The experimental samples of natural and enriched uranium ($m \approx 1$ g, ^{235}U abundance 0.7% and 95.2%, respectively) were situated in different positions along the target axis (z = *254; 385; 516; 647* mm) and target radius (r = 0; 40; 80; 120 mm).So did the bismuth samples (m ≈1 g, ^{209}Bi abundance 100%).

Afterirradiation, the samples have been measured with HPGe detectors of 20% and 30% relative efficiency. The measurement of each sample was carried out at least six times in order to obtain the reaction rates (R, number of produced residual nuclei per one deuteron and one atom of the sample) with sufficient statistics for the isotopes of different half-lives $T_{1/2}$in the interval from 10^1 minutes up to 10^1 days.

As presented in **Fig. 1,** the cross sections of fission and inelastic reactions in Bi and U cover the wide range of incident neutron energies. Thus, for the different reaction thresholds and positions of the samples in the target, it is possible to determine how an increase in the incident deuteron beam energy affects the hardness of neutron spectrum inside the target.

The experimental results for the position z = 516 mm, r = 0 mmindicate hardly any difference in the neutron spectra below the energy E_n = 1 MeV since ^{235}U fission rate remains almost intact.On the other hand, there is a significant increase by 33(8)% in the production of ^{199}Tl, the decay productof the (n,11n) reaction in ^{209}Bi, which can in fact indicate a substantial increase in neutron production above the reaction threshold E_{th} = 79 MeV.

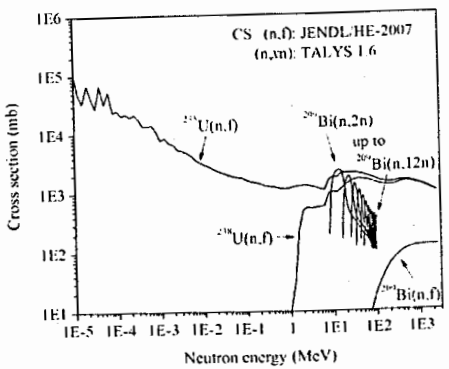

Fig.1 Cross sections for fission of ^{235}U, ^{238}U, and ^{209}Bi and (n,xn) reactions in ^{209}Bi.

[1]W.Furmanet *al.* // PoS (Baldin ISHEP XXI) 086, 2012.

NEUTRON ACTIVATION ANALYSIS OF Br, Ca, K, Mg, Mn, and Na CONTENTS IN BENIGN PROSTATIC HYPERTROPHIC TISSUE

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Benign prostatic hyperplasia (BPH) assigns most of men after the age of fifty and represents the most common urologic disease among elderly males. BPH is histologically defined as an overgrowth of the epithelial and stromal cells from the transition zone and peri-urethral area of prostate. Incidence of histological BPH could be over 70% at 60 years old and over 90% at 70 years old. To date, we still have no precise knowledge of the biochemical, cellular and molecular processes underlying the pathogenesis of BPH. Although the influence of androgens and estrogens has been demonstrated, hormonal factors alone may not fully explain BPH development. Main electrolytes and trace elements have essential physiological functions such as maintenance and regulation of cell function, gene regulation, activation or inhibition of enzymatic reactions, and regulation of membrane function. Essential or toxic (mutagenic, carcinogenic) properties of chemical elements depend on tissue-specific need or tolerance, respectively. Excessive accumulation or an imbalance of the chemical elements may disturb the cell functions and may result in cellular degeneration, death or, on the contrary, intensive proliferation.

In our previous study a significant positive correlation between age and Ca mass fraction in the prostate was observed. High intraprostatic Ca concentrations are probably one of the main factors acting in prostate cell proliferation. Moreover, a significant positive correlation was seen between the prostatic Ca and Na contents. Hence it is possible that besides Ca, some other elements also play a role in the pathophysiology of the prostate. To that end, we determined Br, Ca, K, Mg, Mn, and Na content in normal (n=37) and BPH (n=32) tissues of the human prostate gland by instrumental neutron activation analysis with high resolution spectrometry of short-lived radionuclides (INAA-SLR). All tissue samples were divided into two parts. One part was morphologically examined while chemical element contents of another one was estimated.

Mean values (M ± SEM) for mass fraction of Br, Ca, K, Mg, Mn, and Na (mg/kg, dry mass basis) in the intact and morphologic normal prostate tissue were: 32.9±3.6, 2280±178, 11211±414, 1118±76, 1.24±0.07, and 11100±408, respectively. Mean values (M ± SEM) for mass fraction of these chemical elements in BPH tissue were: 30.4±3.6, 2030±165, 14470±740, 1200±80, 1.19±0.09, and 11610±870, respectively. No changes of parameters investigated by us in BPH tissue were found with the exception of the K mass fraction. The K mass fraction was significantly higher ($p \leq 0.01$) in BPH tissues than in normal tissues.

NEUTRON ACTIVATION ANALYSIS OF Ca, Cl, Mg, Na, and P CONTENTS IN THE EWING'S SARCOMA TISSUE

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Bone tumors are a heterogeneous group of tumors that all arise from bone tissue, which consists of cartilaginous, osteoid and fibrous tissue, and bone marrow elements. Each tissue can give rise to benign or malignant spindle cell tumors. The differentiation of benign and malignant intraosseous lesions can often be accomplished by means of conventional roentgenology, CT, and MRI. All of these methods of visualization are very important, particularly for the assessment of tumor location, form, size, and infiltration of the adjacent tissue. However, the radiographic appearance of many lesions is indeterminate, and final diagnosis must be achieved using biopsy and histopathologic evaluation.

It is well known that tissues of human body differ greatly in their contents of chemical elements. Thus, it can be expected that bone tumors of a different origin would have specific elemental composition. *In vivo* neutron activation analysis (*in vivo* NAA) allows determination of some chemical element mass fractions in tumor tissue and has a potential to become a useful tool in oncology diagnostics.

To our knowledge, no data are available about the chemical element mass fractions of bone tumors with respect to different origin of disease. Therefore, we determined the Ca, Cl, Mg, Na, and P mass fractions in the Ewing's sarcoma tissue and intact bone tissue using instrumental neutron-activation analysis with high resolution spectrometry of short-lived radionuclides (INAA-SLR). Samples were obtained from 12 patients (2 females and 10 males from 4to 24 years old). All patients were hospitalized at the Medical Radiological Research Centre. In all cases the diagnosis has been confirmed by clinical and morphological data. The sarcoma samples for INAA-SLR were received from resected specimens. The control group consisted of 27 apparently healthy subjects (7 females and 20 males from 6 to 50 years old) who died an unexpected death. The intact bone samples were collected at the Department of Forensic Medicine, Obninsk City Hospital.

The summary of statistics, arithmetic mean, standard deviation, standard error of mean, minimum and maximum values, median, percentiles with 0,025 and 0,975 levels for mass fraction of all investigated chemical elements were determined. Mean values (M ± SEM) for mass fraction of Ca, Cl, Mg, Na, and P (g/kg, dry mass basis) in the Ewing's sarcoma tissue were: 81.3±5.5, 13.0±0.9, 2.38±0.15, 10.4±1.1, and 84.2±7.4 respectively. Mean values for mass fraction of these elements in intact cortical bone of femur and tibia were: 222±9, 1.52±0.30, 2.45±0.37, 6.40±0.36, and 112±6 respectively. The statistically significant differences of Ca ($\leq$0.01), Cl ($\leq$0.001), Na ($\leq$0.01), and P ($\leq$0.01) mass fractions in the Ewing's sarcoma tissue compared to healthy bone suggest potential of these elements and their ratios as the Ewing's sarcoma markers and validate NAA as detection method.

RELATIONSHIP BETWEEN Ca, Cl, K, Mg, Mn, Na, P, and Sr CONTENTS IN THE INTACT TRABECULAR BONE OF HUMAN FEMORAL NECK INVESTIGATED BY NEUTRON ACTIVATION ANALYSIS

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The bioaccumulation of chemical elements in human bone is rather a complex process. Factors that influence bioaccumulation include age, gender, genetic inheritance, dietary habits, environmental quality, and so on. Many chemical elements in human organism act antagonistically and/or synergistically. Some elements in the bone can be substituted by other elements and, as a result, change biochemical reactions in humans. Variations in relative content of chemical elements in the bone lead to modulation/dysfunction of bone metabolism.

To use chemical element composition as estimation of bone health in clinical, geographical, environmental and occupational medicine, paleoanthropology, and other directions, it is necessary to know normal levels and age- and gender-related changes of chemical element ratios.

This work had three aims. The first one was to determine the Ca, Cl, K, Mg, Mn, Na, P, and Sr mass fractions in the intact trabecular bone of human femoral neck by instrumental neutron activation analysis with high resolution spectrometry of short-lived radionuclides (INAA-SLR) and to calculate some statistical parameters of Cl/Ca, K/Ca, Mg/Ca, Mn/Ca, Na/Ca, P/Ca, Sr/Ca, Ca/P, Cl/P, K/P, Mg/P, Mn/P, Na/P, Sr/P, Ca/Mg, Cl/Mg, Mn/Mg, Na/Mg, P/Mg, Sr/Mg, Ca/Cl, K/Cl, Mg/Cl, Mn/Cl, Na/Cl, P/Cl, Sr/Cl, Ca/K, Cl/K, Mg/K, Mn/K, Na/K, P/K, Sr/K, Ca/Na, Cl/Na, K/Na, Mg/Na, Mn/Na, P/Na, and Sr/Na mass fraction ratios. The second aim was to evaluate the effect of age and gender on mean values of ratios of chemical element mass fractions in the intact trabecular bone of human femoral neck. The third aim was to estimate the inter correlations between Ca, Cl, K, Mg, Mn, Na, P, and Sr mass fractions in the intact trabecular bone of human femoral neck.

NEUTRON ACTIVATION CROSS SECTION OF ^{89}Y

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ABSTRACT

The cross sections for $^{89}Y(n,2n)^{88}Y$, $^{89}Y(n,3n)^{87}Y$ and $^{89}Y(n,4n)^{86}Y$reactions with the average neutron energies of 15 to 36 MeV were measured by activation and off-line γ-ray spectrometric techniques. The high energy neutron were produced from $^{9}Be(p,n)$ reaction using the MC-50 Cyclotron at Korea Institute of Radiological and Medical Sciences (KIRAMS) This work aims to study the neutron activation reaction cross sections using high energy neutron spectrum from the $^{9}Be(p,n)$ reaction. Monte Carlo Simulation Code MCNPX was used to generate high energy neutron spectrum for proton based neutron source from Be target. The neutron induced reaction cross sections of ^{89}Y for mono-energetic neutron as a function of neutron energy were calculated using theoretical model computer code TALYS 1.4. The present results for $^{89}Y(n, xn; x=2-4)$ reactions are compared with the literature data and those from the TALYS 1.4 code. The reaction cross sections of present work and from literature are found to be in good agreement with the calculated values of TALYS. It was observed that, the individual reaction cross section increases from reaction threshold to the energy where other reaction channel open-up, after that it remains constant for a while until next reaction channel reaches its maximum.

Key Words: **Spallation reactions, Neutron activation analysis, $^{89}Y(n, xn, x=2-4)$, Off-line γ-ray spectrometric technique.**

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RECENT EXPOSURES OF NUCLEAR TRACK EMULSION TO ^{8}He NUCLEI, FAST AND THERMAL NEUTRONS AND HEAVY IONS

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Abstract. Nuclear track emulsion (NTE) continues to be an effective and versatile technique for forefront researches. NTE of the known type BR-2 poured on a glass was recently produced by the Slavich enterprise [1]. In order to perform its quality tests and to compare low energy particle ranges with values calculated in the SRIM Model [2] samples of NTE have been exposed in JINR to ^{8}He nuclei [3, 4], thermal and fast neutrons [5, 6] and ions Kr and Xe [7].

Measurements performed for about 400 hammer-like decays of ^{8}He nuclei of energy of 7 MeV per nucleon stopped in NTE allow one to evaluate possibilities of a range α-spectrometry and to observe a thermal drift of ^{8}He atoms in matter [8].

Correlations of α-particles are studied on statistics of 400 events of splitting $n+^{12}C\rightarrow\alpha$ in NTE exposed to 14.1 MeV neutrons produced in the reaction $d + t \rightarrow n + \alpha$. Measurements of ranges and emission angles of the α-particles are performed. Distributions over energy of α-particle pairs and triples are obtained on a basis the SRIM model [2].

Samples of boron enriched NTE exposed to thermal neutrons allow one to extend range calibration for the ^{7}Li nucleus on a basis of 200 measured events $n_{th}+^{10}B \rightarrow {}^{7}Li +(\gamma)+\alpha$. Angular and energy correlations of products of the reaction induced by thermal neutrons are studied.

NTE samples without light protection paper are exposed to ions $^{86}Kr^{+17}$ and $^{132}Xe^{+26}$ of energy of about 1.2 MeV per nucleon. Measurements of 80 tracks of Kr and Xe ions stopped in NTE are in correspondence with the SRIM model [2]. Besides, 50 scatterings of Kr ions of degraded energy of around 300 keV with a visible recoil nucleus of NTE composition are completely measured.

Number of events manually analyzed in these pilot studies is a small part of available statistics. This limitation is defined by reasonable expenses of human time and labor. However, NTE provides a basis for the application of automated microscopy and image recognition software, allowing one to rely in perspective on unprecedented statistics of analyzed decays. Thus, a synergy of classical technique and modern technology can be achieved. The report is illustrated by macrophotographs and video of the discussed events [9].

REFERENCES

[1] TD Slavich, Pereslavl-Zalessky, Russia, www.slavich.ru.
[2] J. F. Ziegler, J. P. Biersack and M. D. Ziegler SRIM - The Stopping and Range of Ions in Matter 2008, ISBN 0-9654207-1-X, SRIM Co; http://srim.org/.
[3] A. M. Rodin et al. Nucl. Instr. & Meth. B 204, 114(2003).
[4] The ACCULINNA Project http://aculina.jinr.ru/.
[5] IBR-2 Pulsed Reactor http://np.jinr.ru/34/.
[6] V. M. Bystritsky et al. Phys. Part. Nucl. Lett. 6, 505(2009).
[7] IC-100 heavy ion cyclic implanter http://erovlab.jinr.ru/nr/ic-100.html.
[8] D. A. Artemenkov et al. Phys. Part. Nucl. Lett. 10, 415(2013); arXiv:1309.4808.
[9] The BECQUEREL Project http://becquerel.jinr.ru/.

NEUTRON SPECTRA FROM ^{57}Fe (p, n) ^{57}Co, ^{56}Fe (d, n) ^{57}Co REACTIONS AND LEVEL DENSITY OF ^{57}Co

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The basic statistical function of excited nuclei is the nuclear level density being very important for the creation of consistent theoretical description of excited nucleus statistical properties and in making nuclear reaction cross-section calculations in the framework of statistical model. One of the information sources on nuclear level density in a range between the discrete states and the neutron binding energy with accuracy comparable with neutron resonance data are the spectra of particles emitted in nuclear reactions. In the present work neutron spectra have been measured from ^{57}Fe (p, n) ^{57}Co reaction at proton energies between 8 and 11 MeV and from ^{56}Fe (d, n) ^{57}Co reaction at deuteron energies of 2.7 and 3.8 MeV. The measurements of neutron spectra were performed by time-of-flight fast neutron spectrometer on the pulsed tandem accelerator EGP-15 of IPPE. Analyses of the measured data have been carried out in the framework of statistical equilibrium and pre-equilibrium models of nuclear reactions. The calculations are done with use of the exact formalism of the statistical theory as given by Hauser-Feshbach with the generalized superfluid model of nucleus, the back-shifted Fermi-gas model and the composite formula of Gilbert-Cameron for nuclear level density. The nuclear level density of ^{57}Co and its energy dependence have been determined. The obtained results have been discussed in totality with existing experimental and model systematic data.

MISINTERPRETATION OF CORRELATION COEFFICIENTS - FALSE COVARIABILITIES IN COMPOSITIONAL DATA

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In a number of data analyses different types of variables are used. One of the most common is compositional type. These variables are calculated as a ratio of one component abundance in the total. Concentration is one of the compositional data example.

If values of at least two numerical variables were obtained in several repeated experiments, then the relationships between these parameters could be determined. One of the commonly used parameters in data analysis is Pearsons correlation coefficient, R. Its absolute value close to 1 is considered as an indicator of linear covariability between two variables in the data population. Though calculation of R is simple, its interpretation may lead to erroneous conclusions.

Influence of common denominator in concentrations on R distribution was described in literature and in this work it was demonstrated with numerical simulations. It was shown that the distribution of the correlation coefficient for expected R value $E(R)=0$ significantly changes, disabling credibility of commonly used statistical tests. Though this effect is known for over one hundred years, since Karl Pearson described it in 1897, up to now in many data analyses this problem is silently omitted.

For compositional data analysis the proper sample space has to be selected. In a number of publications was shown that simplex space fulfills appropriate requirements. To enable data analysis in commonly used Euclidean space, the compositional data can be transformed. Selection of transformation method is not unique and it should be chosen due to the problem studied. But it was demonstrated that analysis of neither crude data in simplex space, nor transformed data in Euclidean space, did not overcome the spurious correlation problem.

Other problem which appeared in analysis of correlations between concentrations was so called compositional incoherence. If the correlation matrix is calculated for concentration of different components then the results obtained depend strictly on the components selection. Significant correlation coefficient calculated for a pair of variables in a set of concentrations can be changed when some other concentrations were added or removed from data.

It is not possible to solve the problem of the spurious correlation in a simple way. Though for measuring of the two components covariability the variance of their logratio (logarithm of ratio) can be supposed, this approach allow to compare covariabilities only of the components in the certain data set.

Spurious correlation limits application of some methods of multivariate data analysis. Each method which uses correlation matrix in data structure determination will most likely lead to false statistical inferences. The results produced by methods in which the variance matrix is used could also be untrustworthy.

SPATIAL PATTERNS OF ELEMENT DISTRIBUTIONS IN MOSS IN THE AREA OF THE OPOLE PROVINCE (POLAND)

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Neutron activation analysis was used to determine the concentrations of 42 elements: Na, Mg, Al, Cl, K, Ca, Sc, V, Cr, Mn, Fe, Ni, Co, Zn, As, Se, Br, Rb, Sr, Zr, Nb, Mo, I, Ag, Cd, Sb, Ba, Cs, La, Ce, Nd, Sm, Eu, Tb, Yb, Hf, Ta, W, Au, Hg, Th, and U accumulated in mosses sampled in September-October 2011 in the Opole Province (Southern Poland). There are several sources of pollution in the province: urban areas, cement and limestone industry, steelworks, chemical, and coke industry. The province is surrounded by the Upper Silesian Industrial Region (in the south-east direction), Wrocław Industrial Region (in the west), Czestochowa Industrial Region (in the north-east), and the Ostrava-Karviná coal district (in the south). Moss samples were collected at 30 sites uniformly distributed in the area of the province. In data analysis the actual compositional character of variables was considered. The elemental concentrations in each sample determine position of a single point in the 42D space. Distances between the points (compositions) in simplex space was accepted as a measure of compositional similarity. The divisive, hierarchical clustering and fuzzy clustering methods were applied for the data analysis. Fuzzy clustering enables calculation of the certain cluster type contribution to each point. In computations the matrix of distances between the points was used. The computation results supposed existence of four non-unique clusters in the concentrations. Though the spatial data were not used directly in the cluster construction, the structures obtained tend to cover the continuous areas in the map of the region. The biggest contribution of the first cluster type can be observed in the north part of the province. Prevalence of the second cluster appeared in the north-eastern corner of the area. The third cluster dominates in the south-eastern region. The fourth cluster formed a belt in the center of province, starting from the west and fading in the east direction. The clusters can be distinguished by their main components. The main differences in compositions are shown in the table below. The following marks are used: "-" means that the concentration is lower than the others; "+" means that the concentration is higher than the others, and "0" means that the concentrations are similar.

Cluster	Mn	Ni	Mo	I	Ag	Cd	Nd	Eu	Au	Hg	U
1	+	-	+	+	-	-	0	0	+	0	0
2	0	0	0	0	+	0	-	0	0	0	0
3	0	0	0	0	+	+	0	+	0	+	+
4	-	0	0	0	-	0	0	0	0	0	0

Elemental composition of moss depends on composition of natural and anthropogenic components. Spatial structure of the main compositional clusters associates with the influence of the adjacent industrial regions on pollution of the province. Higher concentrations of some elements could be a result of intense fossil fuels combustion (U, Hg) or metallurgical industry activity (Cd). Regional differences in concentrations of other elements could a result of natural differences in soil compositions (Mn, Nd, Eu).

NEUTRON-GAMMA FIELD INTENSITY AND ABSORBED DOSES SIMULATION AT SOME POINTS OF ROMASHKA EXPERIMENTAL SETUP

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For investigation of the neutron-induced capture and fission reactions on a number of important for basics and applied physics nuclei using gamma-ray multiplicity method in Frank Laboratory of Neutron Physics (FLNP) a new experimental setup has been commissioned at beam line № 4 of IREN neutron time-of-flight spectrometer.

It consists of Pb-shielded "Romashka"-type gamma-ray spectrometry system (12 NaI(Tl) detectors in a nearly 4π geometry) and a shielding-collimator in the front of it.

Due to the neutron scattering and capture in the 120 cm long composite shielding-collimator, which narrows the neutron-gamma beam diameter from 16 cm to 4 cm, as well as in the floor and walls of the experimental hall, the detectors are additionally exposed by these neutrons and gamma-rays.

Because of the complexity of the setup, in order to estimate the neutron-gamma field intensities and absorbed doses, series of Monte-Carlo simulations, using FLUKA code, was carried out. Fluka is a general purpose tool for calculations of particle transport and interactions with matter and it is used for a large number of applications (shielding design, dosimetry, activation, etc.). It can simulate with high accuracy the interaction and propagation in matter of about 60 different particles with energies from 1 keV up to 20 TeV. Transport of neutrons with energies lower than 20 MeV is performed by multi-group algorithm, which is way faster than point-wise scheme, but lacks the energy resolution in the resolved resonance area due to group-averaged cross-sections.

The results of the simulations are reported. They are going to be used for optimizing the experiment's geometry.

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