ISINN-21

XXI International Seminar
on Interaction of Neutrons with Nuclei

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

Dubna, 2013

Abstracts

Joint Institute for Nuclear Research

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

XXI International Seminar on Interaction of Neutrons with Nuclei

Alushta, Ukraine, May 20–25, 2013

Abstracts of the Seminar

Dubna 2013

УДК 539. 125.5(042)
ББК 22.383.2я431+22.383.5я431+22.383.25я431
F97

The contributions are reproduced directly from the originals presented by the Organizing Committee.

F97 **Fundamental** Interactions & Neutrons, Nuclear Structure, Ultracold Neutrons, Related Topics: Abstracts of the XXI International Seminar on Interaction of Neutrons with Nuclei (Alushta, Ukraine, May 20–25, 2013). — Dubna: JINR, 2013. — 91 p.
ISBN 978-5-9530-0357-5

Фундаментальные взаимодействия и нейтроны, структура ядра, ультрахолодные нейтроны и связанные вопросы: Тезисы докладов XXI Международного семинара по взаимодействию нейтронов с ядрами (Алушта, Украина, 20–25 мая 2013 г.). — Дубна: ОИЯИ, 2013. — 91 с.
ISBN 978-5-9530-0357-5

ISBN 978-5-9530-0357-5

CONTENTS

ISINN-21 Agenda

May 20, Monday

17:00 – 19:00 Registration
19:00 Welcome party

May 21, Tuesday

8:00 – 8:30 Breakfast
8:30 – 9:00 Registration

Plenary session

Nuclear analytical methods in the life sciences, biology and medicine

	09:00 – 09:10	**Welcome/Introduction**
1.	**09:10 – 09:40**	**Steinnes E.** Milestones of Neutron Activation Analysis
2.	**09:40 – 10:10**	**Frontasyeva M.** The 50-th Anniversary of NAA at JINR
3.	**10:10 – 10:30**	**Wacławek W.** History of Discovery and Implementation of Radioactivity
4.	**10:30 – 10:50**	**Duliu O.** A Complex Investigation of the Costinesti, Southeastern Dobrudja (Romania) Loess Deposit
5.	**10:50 – 11:10**	**Fränzle S.** Muons Produced by Mobile Accelerators as a Powerful Means of Large-Scale Environmental Analysis also Providing Chemical Data on Oxidation State

11:10 – 11:30 Coffee break

Fission

6.	**11:30 – 12:00**	**Kamanin D.** Perspectives of the Study of Collinear Cluster Tri-Partition of Heavy Nuclei
7.	**12:00 – 12:30**	**Pyatkov Yu.** Light Shape Isomers in the CCT Channel?
8.	**12:30 – 12:50**	**Rovenskykh E.** Investigation of Isomeric Yields Ratios in Photofission Reactions (γ,f), (γ,nf) on ^{235}U

13:00 – 14:00 Lunch
15:45 – 16:00 Coffee

Plenary session

Nuclear structure & related topics

9.	**16:00 – 16:30**	**Urin M.** Fast Neutron Radiative Capture by Medium-Heavy Mass Spherical Nuclei: Semi-Microscopic Description
10.	**16:30 – 16:45**	**Gorbachenko O.** Nuclear Level Density within Modified Generalized Superfluid Model with Different Vibrational Enhancement
11.	**16:45 – 17:05**	**Gorbachenko O.** Test of Average Description of E1 Gamma Transitions in Atomic Nuclei
12.	**17:05 – 17:30**	**Sukhovoj A.** Possibility, Necessary Basis and Specificity for Development of Perspective Practical Model of Arbitrary Nucleus Compound State Decay
13.	**17:30 – 18:00**	**Lutostansky Yu.** Transfermium Neutron-Rich Nuclei Production in Pulsed Neutron Fluxes of Nuclear Explosions
14.	**18:00 – 18:20**	**Sukhoruchkin S.** Tuning Effect in Neutron/Nuclear Data for Z=5-30 Nuclei

19:00 Dinner

May 22, Wednesday

8:00 – 9:00 Breakfast

Plenary sessions

Fundamental symmetries

15.	**09:00 – 09:30**	**Crawford B.** Parity-Violating Neutron Spin Rotation Measurements at NIST
16.	**09:30 – 10:00**	**Crawford Ch.** New Results from the NPDGamma Parity Violation Experiment at the Spallation Neutron Source
17.	**10:00 – 10:25**	**Voronin V.** Abnormal Neutron Dispersion in Crystal Close to Bragg Reflex
18.	**10:25 – 10:55**	**Vesna V.** Measurement of the Left-Right Asymmetry in the Integrated Gamma Spectrum in the Interaction of the Nuclei with Polarized Thermal Neutrons
19.	**10:55 – 11:15**	**EL Sehly E.** CP Violation Effects on Chargino Decays of MMSM Charged Higgs Bosons

11:15– 11:25 Conference photo

11:25 – 11:40 Coffee break

11:40 – 13:00 **Poster session**

13:00 – 14:00 Lunch

15:45 – 16:00 Coffee

First parallel session

Nuclear analytical methods in the life sciences, biology and medicine

20.	**16:00 – 16:20**	**Gorelova S.** Nuclear and Related Analytical Techniques Used to Study Elemental Content of Some Exotic Woody Species under Intense Technogenic Pollution in Urban Ecosystem of Non-Chernozem Zone of Russia
21.	**16:20 – 16:50**	**Rumyantsev I.** Interspecies Comparison of Elemental Content in Moss from Ivanovo Region Determined by NAA and AAS
22.	**16:50 – 17:15**	**Cucu-Man S.** First Results On Atmospheric Trace Element Deposition In Republic Of Moldova Monitored By The Moss Hypnum Cupressiforme
23.	**17:15 – 17:35**	**Dunaev A.** Atmospheric Air Contamination Assessment in Ivanovo Region by Means of Combined Analysis of Snow and Mosses
24.	**17:35 – 17:55**	**Goryainova Z.** Bivalve Mussels Biomonitoring of the South African Atlantic Coastal Waters

Second parallel session

Fundamental properties of the neutron, UCN & related topics

25.	16:00 – 16:20	**Frank A.** On the Validity of the Potential -Like Dispersion Law for Neutrons in the Matter Moving with Giant Acceleration
26.	16:20 – 16:40	**Frank A.** The Goos - Hanchen Effect in Neutron Optics
27.	16:40 – 17:00	**Kulin G.** Status of New Experiment for Test of the Equivalence Principle with UCN
28.	17:00 – 17:20	**Vezhlev E.** Verification of the Weak Equivalence Principle with Laue Diffracting Neutrons. Current Status of the Experiment
29.	17:20 – 17:50	**Morris C.** Intersection of Proton Radiography and Basic Research in Los Alamos
30.	17:50 – 18:15	**Kuznetsov I.** Test and Improvement of the New method for Checking of the neutron Electroneutrality by Spin Interferometry Technique
31.	18:15 – 18:40	**Oprea A.** PV Effects in Neutron Reactions with Slow Neutrons on ^{204}Pb Nucleus

19:00 Dinner

May 23, Thursday

8:00 – 9:00 Breakfast

Plenary sessions

Fission

32.	09:00 – 09:25	**Gagarski A.** Angular Correlations of Light Charged Particles in Ternary Fission of ^{241}Pu by Polarized Cold Neutrons – New "Centrigugal" Effect in the Angular Distribution
33.	09:25 - 09:45	**Danilyan G.** Fissile Nucleus Rotational Effects in Prompt Fission Gamma-Rays and Neutrons in ^{233}U and ^{235}U Fission Induced by Cold Polarized Neutrons
34.	09:45 - 10:05	**Guseva I.** Comparative Analysis of Scission- Neutron Component Extraction
35.	10:05 - 10:25	**Carjan N.** Angular Distribution of the Scission Neutrons Predicted by the Dynamical Scission Model
36.	10:25 - 10:45	**Zeynalov Sh.** Novel Approach to Prompt Fission Neutron Investigation
37.	10:45 – 11:00	**Bunakov V.** P-odd, T-odd Asymmetries for Binary Fission of Oriented Nuclei by Cold Polarized Neutrons
38.	11:00 – 11:20	**Bunakov V.** T-Odd, P-Even Asymmetries for Reactions of Nuclear Fission by Cold Polarized Neutrons and T-Invariance

11:20 – 11:35 Coffee break

"Miscellany"

39.	11:35 – 12:05	**Shvetsov V.** Neutron- Derived Physical Properties of the Martian Soil
40.	12:05 – 12:30	**Ignatovich V.** EPR Paradox and a Neutron Experiment to Reject It
41.	12:30 – 13:00	**Nesvizhevsky V.** First Measurements at the GRANIT Facility

13:00 – 14:00 Lunch

15:45 – 16:00 Coffee

Third parallel session

Reactions with emission of light nuclei

42.	16:00 – 16:25	**Khryachkov V.** The $^{57}Fe(n,\alpha)^{54}Cr$ Reaction Cross-Section Investigation for Neutron with Energy Less than 7 MeV
43.	16:25 – 16:45	**Bondarenko I.** New Experimental Data for $^{36}Ar(n,\alpha_3)^{33}S$, $^{36}Ar(n,\alpha_{4+5})^{33}S$ and $^{40}Ar(n,\alpha_1)^{37}S$ Reaction Cross-Section
44.	16:45 – 17:10	**Hliustin D.** Neutron Cross Sections Structure and Integrated Characteristics Researches of Iron and Nickel Isotopes
45.	17:10 – 17:35	**Zhuravlev B.** Neutron Spectra from ^{57}Fe (p,n)^{57}Co, $^{56}Fe(d,n)^{57}Co$ Reactions and Level Density of ^{57}Co
46.	17:35 – 17:55	**Borzakov S.** Search for Quasistationary State of the Neutron and Proton System with Zero Total Momentum (Singlet Deuteron)
47.	17:55 – 18:10	**Zhang G.** $^{57}Fe(n,\alpha)$ Cross Sections in the MeV Region
48.	18:10 – 18:40	**Ratis Yu.** An Exotic Long-Live Particle "Neutroneum"

Fourth parallel session

Nuclear analytical methods in the life sciences, biology and medicine

49.	16:00 – 16:25	**Zaichick V.** EDXRF Determination of Trace Element Contents in Benign Prostatic Hypertrophic Tissue of Human Prostate
50.	16:25 – 16:45	**Pantelica A.** Neutron Activation Analysis at IFIN- HH Bucharest and JINR Dubna — Collaborative Studies
51.	16:45 – 17:10	**Kravtsova A.** Multielement Instrumental Activation Analysis of Macroalgae *Cystoseira* Used as Biomonitor of the Black Sea Coastal Waters in Sevastopol Region
52.	17:10 – 17:35	**Culicov O.** Investigation of Some Therapeutic Muds Collected at Different Sites in Romania: Preliminary Results
53.	17:35 – 17:55	**Zinicovscaia I.** Biotechnology of Metal Removal from Industrial Waste Water: Zinc Study
54.	17:55 – 18:15	**Vergel K.** Atmospheric Deposition Study in Tikhvin District, Leningradskaya Region

19:00 Dinner

May 25, Friday

8:00 – 9:00 Breakfast

Plenary sessions

Methodical aspects

55.	09:00 – 09:20	**Ahmadov F.** Development of the Next Generation of Gamma Ray Detector Based on Micro-Pixel Avalanche Photodiode
56.	09:20– 09:40	**Khromyleva T.** Digital Low Background Spectrometer for (n,α) Reaction Cross Section Measurement with Solid Target
57.	09:40 – 10:00	**Granja C.** Position-Sensitive Coincidence Detection of Two- and Three-Particle Nuclear Reactions
58.	10:00 – 10:20	**Skoy V.** Multicrystall Sctintillation Detector for Applied and Fundamental Neutron Research

10:20 – 10:50 Coffee break

Accelerator driven subcritical systems

59.	10:50 – 11:20	**Goverdovsky A.** Perspectives of ADS with Liquid Salt Active Core
60.	11:20 – 11:50	**Furman W. on the behalf of "Energy & Transmutation RAW" collaboration** Results of Experiments 2012-2013 with Massive Uranium Target Setup QUINTA at Nuclotron and Prospects for 2014 -2016
61.	11:50 – 12:10	**Voronko V.** Study of Neutron-Physical Characteristics of the Massive Uranium Target Irradiated by Deuterons with Energies of 1.32 - 8 GeV
62.	12:10 – 12:30	**Zavorka L.** Experimental Study of Reactions with Uranium and Transuranium Isotopes in the Neutron Field of the QUINTA Target
63.	12:30 – 12:50	**Adam J.** The investigations of reaction rates in Th interacted with neutrons in QUINTA subcritical assembly irradiated by 2, 4, and 6 GeV deuterons
64.	12:50 -13:00	**Closing of the Seminar**

13:00 – 14:00 Lunch

15:00 – 22:00 Picnic, shashlik, dancing etc.

List of posters

65.	**Ahmadov G.** Demonstration of the Time Coincidence Technique and the ΔE-E Method in the Timepix Pixel Detectors
66.	**Aleksiayenak Yu.** Moss Biomonitoring Technique, NAA and AAS Used to Study Atmospheric Pollution in Belarus
67.	**Bazhazhina N.** Determination of B Content in Composite Material by Neutron Spectroscopy
68.	**Berikov D.** The „KOLKHIDA" Setup Upgrade
69.	**Cherepanov E.** Formation of Nuclear Molecules in Cluster Radioactivity (on Interpretation of the Cluster Radioactivity Mechanism)
70.	**Cuprakov I.** Study of the Characteristics of an Ionization Chamber with gas CF4 for the Investigation of Fast Neutron Induced Reactions (n,α)
71.	**Dmitriev A.Yu.** NAA Database in Mass Neutron Activation Analysis at the IBR-2 Reactor of FLNP JINR
72.	**Ene A., Frontasyeva M.V. Strelkova L.P. and Pavlov S.S.** Occurrence of Heavy Metals and Other Trace Elements in Industrially Contaminated Soils Studied by Neutron Activation Analysis
73.	**Ene A.** Applications of INAA and X-ray Based Techniques for Trace Element Analysis in Materials and Environmental Sciences
74.	**Enik T.L., Mitsyna L.V., Popov A.B., Salamatin I.M., Sirotin A.P.** AURA Setup Testing at IREN Neutron Beam
75.	**Enik T.** Monitor for High-Intensity Neutron Beams
76.	**Goryunov S.** UCN Gas Detector with B(10) Converter for TOF Spectrometry
77.	**Grozdanov D.** Determination of Dead-Time Losses in a NaI(Tl) Gamma-ray Spectrometer
78.	**Hliustin D.** The Installation for Experimental Neutron Spectra Research in Reactor Materials Compositions
79.	**Kamanin D.V.,Pyatkov Yu.V.,Zhuchko V.E.,Kuznetsova E.A.,Strekalovsky A.O.** Time-of-Flight Spectrometry of Heavy Ions in the Wide Range of Energies and Masses. Data Processing
80.	**Khafizov R.U.** Particular Characteristics of Double and Triple Coincidences Spectra for Radiative Neutron Decay
81.	**Khryachkov V.A., Zhuravlev B.V, Talalaev V.A.** Photometry of Ionizing Radiations

82.	**Kustov D.** Interaction of Neutrons with Moving Barriers
83.	**Maňkovská B., Oszlányi J., Andráš P., Dubiel J., Florek M., Holý K., Frontasyeva M.V., Pavlov S.S.** Results of Cooperation between Slovakia and FLNP JINR in the Environmental Research (2000–2013)
84.	**Maňkovská B., Oszlányi J., Tučeková A., Izakovičová Z.** Temporal and Spatial Trends (1990- 2010) in Heavy Metal Accumulation in Mosses in Slovakia
85.	**Oprea A.** Cross Sections Analysis in (n,α) with Fast Neutrons Using Talys
86.	**Oprea A.** Cross Section of Nuclear Reactions Induced in Astrophysics
87.	**Oprea C.** Hauser – Feshbach Model Calculation of the (γ,n) Cross Sections for Some s-Process Nuclei
88.	**Sahar Ebeid Saad Mohamed Abo-Neima** Control of Staphylococcus Aureus Activity by Square Amplitude Modulated Waves at Resonance Frequency
89.	**Strekalovsky A.** Suppression of the Background in the Study of Specific CCT Modes
90.	**Salamatin I.M.** Development of Component System for Neutrons Spectrometry Automation Using Network Technologies
91.	**Sedysheva M.** Statistical Model Analysis of Averaged over the Fission Neutron Spectrum (n,α) and (n,p) Cross Sections
92.	**Stephenson S.** SPAGetty: the Gettysburg College 250 keV Proton Accelerator Program in Research and Teaching
93.	**Stihi C.** Moss Biomonitoring of Air Quality in Romania
94.	**Toksaba Zh.** Method to Determine the Elemental and Isotopic Composition of the Samples
95.	**Zahar N.** Study of Sapphire as Thermal Neutron Filter for the MA-R1 TRIGA Moroccan Reactor Beam Applications
96.	**Zaichick V.** Neutron Activation Analysis of Ca, Cl, Mg, Na, and P Contents in the Benign Giant cell Tumor of Bone
97.	**Zaichick V.** Relationship between Ca, Cl, K, Mg, Mn, Na, P, and Sr Contents in the Intact Trabecular Bone of Human Iliac Crest Investigated by Neutron Activation Analysis

DEMONSTRATION OF THE TIME COINCIDENCE TECHNIQUE AND THE ΔE-E METHOD WITH THE TIMEPIX PIXEL DETECTORS

Ahmadov G.S. [a,b], Ahmadov F.I. [a,b], Kopatch Yu.N.[a], Telezhnikov S.A.[a], Garibov A.A.[b], Granja C.[c], Pospisil S.[c]

[a] *Frank Laboratory of Neutron Physics, JINR, 141980 Dubna, Moscow reg, Russia*
[b] *Institute of Radiation Problems-ANAS,* B. Vaxabzade *9, AZ-1143 Baku, Azerbaijan*
[c] *Institute of Experimental and Applied Physics, Czech Technical University in Prague, Czech Republic*

Time of arrival mode in the Timepix pixel detector (300 μm thick silicon) allows applying the time coincidence technique to this type of detectors. Having special USB-based readout interface FITPix and due to limited speed of this readout system (about 1 *ms*), the Timepix detectors typically do not allow obtaining high time resolution in coincidence measurements with other detecting devices such as semiconductor detectors which signal is taken by ADC, digitizer and etc.

In our work the ΔE-E method was applied to the Timepix pixel detectors using a 12 μm thin silicon detector for ΔE measurement and cluster volumes from the Timepix detector (which are proportional to the deposited particle energy) for E measurement. In order to obtain best coincidence times, the time of arrival mode of the Timepix detector was used. The ΔE detector was read out using the 250 Mhz DT5720 CAEN digitizer. The internal timestamp of this digitizer allows to measure the time of arrival of the signal with accuracy of the order of 8 ns. Both, ΔE and Timepix detectors were read out independently using heir own acquisition systems (CAEN digitizer and FITPix, respectively), and the data were saved on the computer as two independent data streams, which could be analyzed off-line. In order to organize coincidence between these two data streams an external pulser was used, which served as external start for the FITPix interface and at the same time was fed into one of the channels of the CAEN digitizer, which was read synchronously with the ΔE channel. The frequency of the external pulser clock could be adjusted depending on the Timepix timer clock and the coincidence count rate. The ΔE-E method is demonstrated on the detection of alpha particles from different alpha radioactive sources (Pu239, Pu238 and U233) at different distances.

Control of *Staphylococcus Aureus* Activity by Square Amplitude Modulated Waves at Resonance Frequency

Fadel M.Ali[a], Sahar E.Abo-Neima[b], Soraya A.Sabry[c], Hussein A.Motaweh[b], Ahmed M.El-Khattib[d]

[a]Biophysics Department, Faculty of Science, Cairo University, Egypt.
[b]Physics Department, Faculty of Science, Damanhur University, Egypt.
[c]Botany&Microbiology Department, Faculty of Science, Alexandria University, Egypt.
[d]Physics Department, Faculty of Science, Alexandria University, Egypt.

The effect of extremely low frequency electromagnetic (ELF-EM) waves in the form of square amplitude modulated waves (QAMW) on the growth rate, morphology and antibiotic sensitivity patterns of the Gram-positive bacterium *Staphylococcus aureus* was studied to determine any morphological and metabolic changes that might have been caused by ELF-EM waves, in order to determine cell viability, number of colony-forming units (CFU) and growth rate (OD_{600}nm). The data confirmed that there was a resonance frequency only at 0.8 Hz. results showed highly significant inhibition effect occurred on the growth rate and the number of cells of *S.aureus*. Moreover, exposed cells became more sensitive to the tested antibiotics that inhibitors to DNA, proteins and cell wall compared to control. Significant ultra structural changes occurred as observed by TEM, also showed high significant difference in the dielectric parameters, RAPD-PCR revealed genetic fingerprinting variation as observed in the electrophoresis patterns between exposed and unexposed cells of *S.aureus*.

Key words: *Staphylococcus aureus*, ELF-EM waves- QAMW, bacterial growth rate, antibiotic sensitivity, morphological changes, TEM, RAPD.

ELEMENTAL CONTENT OF SOME MONGOLIAN MEDICINAL PLANTS DETERMINED BY EPITHERMAL NEUTRON ACTIVATION ANALYSIS

Baljinnyam N.[1], Jugder B[2]., Tsevegsuren N.[3]., Frontasyeva M.V.[1], Pavlov S.S.[1]

[1]*Frank Laboratory of Neutron Physics, JINR, Dubna, Russia*

[2]*Medical college "Monos", Ulaanbaatar, Mongolia*

[3]*Centre of Nuclear Research, NUM, Ulaanbaatar, Mongolia*

Many traditional healing herbs and plant parts have been shown to have medicinal value and to be used as forage for livestock, especially in desert regions of Mongolia. Among them *Sanguisorba officinalis, Granium pratense, Chamaenerion angustifolium (L)Scop., Euphorbia kozlovii* are used in Mongolian folk medicine for the treatment of poisonous ulcers, for fever caused by bacterial and viral infections, and for its diuretic and other properties. The plant species with soil were collected in the north-eastern and central Mongolia (Hangai, Douria, Kobodo, Mongolia-Altai Mountains). Mixed samples of branches, flowers and leaves of plants (~0.5 g) and soil samples (~0.2 g) were subject to multi-element instrumental epithermal neutron activation analysis at the IBR-2 reactor, FLNP, JINR, Dubna. A total of 39 elements were determined including trace elements. The results obtained considerably exceed the number of elements previously reported in literature. Possible links between pharmacological action of the plants and content of some elements are discussed.

NEW EXPERIMENTAL DATA FOR $^{36}Ar(n, \alpha_3)^{33}S$, $^{36}Ar(n, \alpha_{4+5})^{33}S$ AND $^{40}Ar(n, \alpha_1)^{37}S$ REACTION CROSS-SECTION

Bondarenko I.P., Khryachkov V.A., Ivanova T.A., Kuzminov B.D., Semenova N.N., Sergachev A.I.

Institute for Physics and Power Engineering
Russia, Obninsk, Bondarenko square, 1.

The $^{36}Ar(n,\alpha)^{33}S$ и $^{40}Ar(n,\alpha)^{37}S$ reaction cross-section measurement results are represented in this work. These investigations were carried out in 4–7 MeV neutron energy range using a low-background digital spectrometer along with great statistics. The Frisch grid ionization chamber filled with 90% Ar и 10% CH_4 gas mixture was used as a detector. Argon, as a component of working gas, was a target where investigated reactions took place. The registration of ^{238}U fission reaction products was used for neutron flux monitoring. The use of working gas as a target allowed us to increase number of target nuclei significantly. Such approach along with long term experiments helped us to storage great statistics, that allowed us to investigate reaction channels related to high excited states of residual nucleus, such as $^{36}Ar(n, \alpha_3)^{33}S$, $^{36}Ar(n, \alpha_{4+5})^{33}S$ and $^{40}Ar(n, \alpha_1)^{37}S$. Mentioned reaction channels cross-section data were obtained for the first time.

Search for quasistationary state of the neutron and proton system with zero total momentum (singlet deuteron)

S.B. Borzakov, N.A. Gundorin, Yu.N. Pokotilovski

FLNP JINR, Dubna, Russia

The investigations of nucleon-nucleon interaction are very important for understanding of the nuclear forces. The nucleon-nucleon interaction at low energy usually is described with help of effective range theory (ERT). The nucleon-nucleon interaction in the singlet state is described with help of virtual level. The physical sense f the virtual level is unclear. In our time another models to describe nucleon-nucleon interaction at low energy exist. One from these models is description of the scattering and the capture with help of a resonance with negative energy [1-2].

A number of theoretical works which based on quantum chromodynamics show that singlet metastable state of the *(n+p)* system exists. The mass of this state is little less than sum of masses for two nucleons [3, 4]. Their predictions support the representations about negative resonance. According to the work [4] the binding energy of the singlet deuteron is equal to the value of $B(^1S_0) = 79 \pm 12$ кэВ.

The calculations in quenched lattice QCD predict bound state of neutron-proton system with the zero angular momentum also [5].

R. Hackenburg from BNL has showed that the process with an emission of two gamma quanta must exist. First transition is from continuous state $^3S_1$ to the quasistationary level ($^1S_0$) and second transition is between "virtual" state and ground state of the deuteron ($^3S_1$). Every transition is M1 type. Energies of gamma quanta are equal to 66 and 2157 keV [6]. According to calculations made by Hackenburg the cross section for reaction is $\sigma(n_{th} + p \rightarrow d + \gamma_1 + \gamma_2) \approx 27$ μb. This transition is approximately in $1.3 \cdot 10^4$ times weaker than main transition. So the detector which has good resolution is needed for the searching for weak transition.

The experiment was carried out on the IBR-2M reactor with help of HpGe detector. The preliminary result of our measurements is $\sigma(n_{th} + p \rightarrow d + \gamma_1 + \gamma_2) \leq 13$ μb for gamma energy interval 2100 - 2200 keV.

1. Ma S.T. Rev. Mod. Phys., 25, p. 853, 1953.
2. Borzakov S.B., Physics of Atomic Nuclei, 57, p. 517, 1994.
3. Ivanov A.N. et al., e-ArXiv:nucl-th/0407079, 2004.
4. Maltman K., Isgur N., Phys. Rev., D29, No. 5, p. 952, 1984.
5. Yamazaki T., Kuramashi Y., Ukawa A., Phys. Rev., D84, 054506, 2011.
6. Hackenburg R. W., Report BNL 77483-2007-JA, 2007.

ANGULAR DISTRIBUTION OF THE SCISSION NEUTRONS PREDICTED BY THE DYNAMICAL SCISSION MODEL

Carjan N.[1,2], Rizea M.[1]

[1] Horia Hulubei – National Institute for Nuclear Physics and Engineering, P.O.Box MG-6, RO-77125, Bucharest, Romania
[2] CENBG, University of Bordeaux 1, BP 120, 33175 Gradignan Cedex, France

It is generally expected that the prompt neutrons emitted during nuclear fission have two main components: neutrons released during the scission process and neutrons evaporated from fully accelerated fragments. Although these two components are well separated in time [1], it has been difficult to identify them experimentally. The best observable that is supposed to make the distinction between the scission neutrons and the evaporated ones is the angular distribution with respect to the fission axis. This inference was based on the assumption that both components are emitted isotropically: one in the system of the scissioning nucleus and the other in the system of each of the fission fragments. While the second assumption is a good approximation, the first one is doubtful due to the proximity of the fission fragments at the moment of emission.

In this study we use a realistic time-dependent approach to the angular distribution of the scission neutrons based on a recently developed dynamical scission model [2]. It implies the numerical solution of the bi-dimensional time-dependent Schrödinger equation (TDSE) with time-dependent potential for the motion of a neutron inside a nucleus that undergoes fission. Axially symmetric extremely deformed nuclear shapes are described by modified Cassini ovals. The Hamiltonian is discretized on a bi-dimensional grid, using finite difference approximations of the derivatives. The solution of the TDSE is calculated by a Crank-Nicolson method associated with transparent conditions at numerical boundaries. The time evolution is calculated from the configuration with the minimum neck-radius ($\alpha = 0.985$), the start of the scission process, to the configuration of two just-separated fragments ($\alpha = 1.001$), the end of the scission process. The resulting time-dependent neutron wave-functions are then propagated further in time but with the configuration of the fissioning system frozen at $\alpha = 1.001$. We investigated the nucleus ^{236}U at three mass asymmetries defined by the light fragment mass A_L=70, 96 and 118. The numerical solutions at a given moment t are used to evaluate quantities like the spatial distribution of the emission points $S_{em}(r,\theta,t)$ as well as the current density $\mathbf{D}_{em}(r,\theta,t)$, a key quantity in the angular distribution calculation.

The number of neutrons that leave a sphere of radius R (equal to 40 fm in the present calculations) around the fissioning nucleus in a solid angle $d\Omega$ and in a time interval dt is

$$dv_{sc} = \mathbf{D}_{em}(R,\theta,t)\, \mathbf{n}(R,\theta,T)\, R^2\, dt\, d\Omega$$

The integration in time of this quantity from 0 to ∞ gives the angular distribution. In practice we can only reach $T=4\times10^{-21}$ sec, time at which however more than 75% the scission neutrons left the sphere. The scission-neutron emission is found to take place mainly along the fission axis with a small preference for the light fragment direction. A ratio v_L/v_H close to the experimental value (1.41) was obtained. In conclusion, the distinction between scission and evaporated neutrons, based on their angular distribution, is more challenging than expected.

[1] N. Carjan, M. Rizea, Phys. Rev. C82 (2010) 014617
[2] N. Carjan, M. Rizea, Int. J. Mod. Phys. E21 (2012) 1250031

Study of the Characteristics of an Ionization Chamber with gas CF_4 for the Investigation of Fast Neutron Induced (n,α) and (n,p) Reactions

I.A.Chuprakov, M. V. Sedysheva

Frank Laboratory of Neutron Physics, JINR, Dubna, Russia

This paper discusses the reactions with charged particles emission, (n,p) and (n,α). Such reactions are of great interest in the field of reactor construction, nuclear structure and astrophysics.

One of the problems is adequate description of reactions involving α- particles, in particular (n,α) reactions. For many isotopes data on (n,α) reactions in the energy range from 1 to 10 MeV are either absent or largely poor and inconsistent.

When ionization chamber (IC) was irradiated with fast neutrons we observe the additional problems related to the fact that the cross sections (n, p), (n,α) reactions at gas filling chamber large enough. Background reactions on nuclei of the gases entering the working gas mixture may complicate the selection α-particles from the reaction of interest. Therefore it is important to find new gases that enhance the measurement. As such we selected gas CF_4.

The technique of the study of (n,α) reactions based on the spectrometry of charged particles with an IC is investigated. The presented detector and method, from our point of view, are optimized for research of (n,α) reactions at energies 1-10 MeV and allow one to obtain both power spectra and angular distributions of reaction products.

PARITY-VIOLATING NEUTRON SPIN-ROTATION MEASUREMENTS AT NIST

B.E. Crawford[1], E. Anderson[2], L. Barrón-Palos[3], C.D. Bass[4], T.D. Bass[4], J. Fry[2], K. Gan[5], C. Haddock[2], B.R. Heckel[6], D. Luo[2], R.C. Malone[1], D.M. Markoff[7], A.M. Micherdzinska[8], H.P. Mumm[9], J.S. Nico[9], A.K. Opper[8], S. Penn[10], S. Santra[11], M. Sarsour[12], E. I. Sharapov[13], W.M. Snow[2], H.E. Swanson[6], S. Van Sciver[2], S.B. Walbridge[2], H. Yan[2], and V. Zhumabekova[14]

[1]*Gettysburg College, 300 North Washington Street,Gettysburg, PA17325, USA*
[2]*Indiana University/CEEM, 2401 Milo B.Sampson Lane, Bloomington, IN47408, USA*
[3]*Universidad Nacional Autónoma de M.exico ,C.P.04510 ,Mexico ,D.F*
[4]*Thomas Jefferson National Accelerator Facility ,12000 Jefferson Avenue ,Newport News,VA23606,USA*
[5]*University of Wimmipeg, 515 Portage Avenue, Winnipeg MB R3B 2E9 Canada*
[6]*University of Washington/CENPA, Box 354290, Seattle ,WA98195, USA*
[7]*North Carolina Central University/TUNL, 1801 Fayetteville Street, Durham, NC27707, USA*
[8]*The George Washington University ,2121 I Street N.W., Washington, D.C. 20052, USA*
[9]*National Institute of Standards and Technology, 100 Bureau Drive ,Gaithersburg, MD 20899 ,USA*
[10]*Hobart William Smith College ,Geneva, NY 14456, USA*
[11]*Bhabha Atomic Research Center, Trombay, Mumbai 400085, India*
[12]*Georgia State University, 29 Peachtree Center Avenue, Atlanta, GA 30303-4106, USA*
[13]*Joint Institute for Nuclear Research, Joliot-Curie 6, 141980 Dubna, Russia*
[14]*Al-Farabi Kazakh National University, Al-Farabi Ave. 71, 050038 Almaty, Kazakhstan*

In order to constrain weak coupling constants between nucleons, the Neutron Spin Rotation (NSR) collaboration has placed an experimental upper bound on the parity-violating spin rotation of transversely polarized neutrons transmitted through liquid helium. These measurements also place limits on the existence of possible long-range parity-odd forces [1]. Particular attention has been paid to reducing possible systematic errors below the statistical precision of the measurement. In addition, simulations of the beam transport and target interactions have been used to investigate systematic errors from small-angle scattering in the target and to help plan the next generation experiment. The recent experiment performed on the NG6 neutron beam at the NIST Center for Neutron Research (NCNR) yielded a statistically-limited rotation angle of $d\phi/dz = [+1.7 \pm 9.1(stat.) \pm 1.4(sys.)] \times 10^{-7}$ rad/m [2]. The NSR collaboration is currently upgrading the apparatus to accept the higher flux and increased phase-space of the new NGC beam at the NCNR.

This work was supported in part by NSFPHY-0457219, NSFPHY-0758018, DE-AI02-93ER40784, and DE-FG02-95ER40901.

[1] H.Yan, W.M. Snow, PRL **110**, 082003 (2013).
[2] W.M. Snow et al., PRC **83**, 022501(R) (2011).

FIRST RESULTS ON ATMOSPHERIC TRACE ELEMENT DEPOSITION IN REPUBLIC OF MOLDOVA MONITORED BY THE MOSS *HYPNUM CUPRESSIFORME*

Cucu-Man S.[1], Frontasyeva M.[2], Culicov O.[2,5], Mocanu R.[1], Tarcau D.[3], Steinnes E.[4]

[1]„Alexandru Ioan Cuza" University, Faculty of Chemistry, 11 Carol I Bd., 700506 Iasi, Romania
[2]Joint Institute for Nuclear Research, Frank Laboratory of Neutron Physics, 141980 Dubna, Moscow Region, Russia
[3]„Ion Ionescu de la Brad" University of Agricultural Sciences and Veterinary Medicine, Faculty of Agriculture, Aleea Mihail Sadoveanu 3, 700490 Iasi, Romania.
[4]Norwegian University of Science and Technology, Department of Chemistry, NO-7491 Trondheim, Norway
[5]National Institute for R&D in Electrical Engineering ICPE-CA, 313, Splaiul Unirii, 030138 Bucharest, Romania

The moss biomonitoring technique was used in order to assess the spatial distribution of elements in atmospheric deposition in Republic of Moldova, to create a database for future monitoring in Republic of Moldova and to investigate the existence of a possible atmospheric transport of pollutants from Eastern Romania (Moldavia province). It was the first time when biomonitoring with moss in 2001 was used in Republic of Moldova. The occurrence of mosses in the investigated area is limited. The most common species of moss there is the epiphytic *Hypnum cupressiforme* (as in eastern Romania), and the sampling sites were selected according to the distribution of this epiphytic species. The moss samples were collected from 13 locations in Republic of Moldova. V, Cr, Ni, Cu, Zn, As, Mo, Cd, In, Tl, Sn, Pb, and Bi were determined by ICP-MS and Na, Mg, Al, Cl, K, Sc, Ca, Ti, Cr, V, Mn, Ni, Fe, Co, Zn, Se, As, Br, Sr, Rb, Mo, Sb, I, Ba, Cs, La, Ce, Eu, Gd, Tb, Lu, Hf, Ta, W, Th, and U were determined by epithermal instrumental neutron activation analysis. Very high concentrations of most elements, were determined at two locations: cities of Chisinau and Ciobana. Principal component analysis was used to identify possible sources of metals in moss. Element concentrations in moss are lower than the mean values in Romania and do not support the existence of the transboundary pollution between the two countries.

INVESTIGATION OF SOME THERAPEUTIC MUDS COLLECTED AT DIFFERENT SITES IN ROMANIA: PRELIMINARY RESULTS

Culicov O.A[1,6], Setnescu T.[1,2], Bancuta I.[3], Setnescu R.[1,2], Bancuta R.[3], Chilian A.[3], Chelarescu E.D.[4,5], Frontasyeva M.[6], Bumbac M.[1]

[1]National R&D Institute for Electrical Engineering, Department for Advanced Materials, Bucharest, ROMANIA
[2]Valahia University of Târgovişte, Faculty of Science and Arts, Târgovişte, ROMANIA
[3]Valahia University of Târgovişte, Multidisciplinary Research Institute for Science and Technologies, Târgovişte, ROMANIA
[4]National R&D Institute for Physics and Engineering, Măgurele, ROMANIA
[5]University of Bucharest, Faculty of Physics - Doctoral school, Bucharest, ROMANIA
[6]Joint Institute for Nuclear Research, JINR, Dubna, RUSSIA

Romania has on old tradition of thermal treatments going back to Romans which used proper buildings called "balnea". Pelotherapy is the application of thermal muds ("peloids") for recovering muscle–bone–skin pathologies; more recently such old practice has received applications also for wellness and relax purposes. It is known that the peloid muds should possess suitable properties: hydric degree, consistency, adhesiveness, heat capacity, cooling rate, exchange capacity, ease of handling and pleasant sensation when applied to the skin. Nowadays, the extended pollution can influence the quality of therapeutic muds, therefore, their physico-chemical characterization is very important.

The elemental composition of several therapeutic muds collected at different sites in Romania has been determined by X-Ray Fluorescence (XRF) and Instrumental Neutron Activation Analysis (INAA). Attentuated total reflectance Fourier transform infrared (ATR-FTIR) spectroscopy was related to optical microscopy and differential scanning calorimetry (DSC) data for characterization the thermal behavior was used. To assess the organic content, a gravimetric analysis has been performed before and after the DSC measurement in air atmosphere up to 600 °C. The results indicate significant differences, depending on the region, between the samples in terms of both composition and structure.

NAA database in mass neutron activation analysis at the IBR-2 reactor of FLNP, JINR

Dmitriev A.Yu. and Pavlov S.S.

FLNP, JINR
ru-day@list.ru

The database used at the radioanalytical complex REGATA at the reactor IBR-2 of FLNP, JINR is a basis for automation of multielement mass neutron activation analysis (NAA) from registration of received samples to providing customers with the results obtained.

The necessity of developing such a database is caused by following tasks: transfer, storage, using in daily work and processing of a huge amount of information, as well traceability of the whole process.

The NAA database information includes data on

1) client provided samples for NAA;
2) provided samples;
3) standard samples used for calculation of concentrations;
4) neutron flux monitors;
5) preparation of samples, standard samples and neutron flux monitors;
6) journals of irradiations of short lived isotopes and long lived isotopes including names of files of gamma spectra of the induced activity for samples, standard samples and neutron flux monitors;
7) NAA results;
8) parameters of a physical environment.
9) results of procedures according to the requirements of QC/QA.

The NAA database is a network database. Access to the NAA database is possible from any computer of the sector of NAA of FLNP, JINR. All users of the NAA database may look through all information, however only authorized persons are able to change its content.

The NAA database allowed to supply the electronic document turnover. It allows automatic data exchange between the programs serving the process of NAA.

The NAA database has a convenient interface: it allows easy search and sort for the necessary information, to carry out the statistical analysis of the NAA results.

Implementation of the NAA database provided completely new scientific and technical level of the analysis and quality control of analytical measurements. Using of the NAA database is especially efficient when large sets of samples are analyzed.

A Complex Investigation of the Costinesti, South-Eastern Dobrudja (Romania) Loess Deposit

O.G. Duliu[1], A. Chirosca[1], L.C. Tugulan[1,2], Delia Dumitras[3], C. Costea[3], M.V. Frontasyeva[4], O.A. Culicov[4,5]

[1]*University of Bucharest, Department of Structure of Matter, Earth and Atmospheric Physics and Astrophysics, P.O. Box MG-11, 077125 Magurele (Ilfov), Romania*
[2]*Horia Hulubei National Institute for R&D in Physics and Nuclear Engineering, P.O. Box MG 06, 077125 Magurele (Ilfov) Romania*
[3]*Geological Institute of Romania, 1 Caransebes str., 012271 Bucharest, Romania*
[4]*Joint Institute of Nuclear Research, 6, Joliot Curie str. 141980 Dubna, Russian Federation*
[5]*National Institute for R&D in Electrical Engineering ICPE-CA, 313, Splaiul Unirii, 030138 Bucharest, Romania*

Loess deposit, which represents the most important remain of past glaciation, at present time occupies about 40% of Romanian territory, reaching in some places, such as Southern Dobruja thickness of 23-25 m. Ages grater than 50 ky and a quasi-absence of coeval volcanic rocks makes the absolute geochronology of loess deposits a difficult task. The only methods which gave in the past years confident results were those based on the accumulation of irradiation defects such as Thermoluminescence, (TL), Optically Stimulated Luminescence (OSL) and, at some extent the Electron Paramagnetic Resonance (EPR). All these methods could be used "in tandem" provided that there is a good description of both geochemistry and mineralogy of local deposits.

For this reason, a sequence of ten loess and paleosoil samples covering a vertical profile of 19 m collected from a freshly excavated loess rampart were simultaneously investigated by Epithermal neutron Activation Analysis (ENAA), High resolution Gamma-ray Spectrometry (HRGS), X-ray Diffraction (XRD), TL and Scanning Electron Microscopy (SEM).

Both ENAA and HRGS showed a relative uniform distribution of the major, rock forming, elements as well as the principal radioactive elements. A subsequent XRD analysis confirmed the presence not only of the dominant quartz phase, but also of the feldspars and other clay minerals as well as of minute amounts of calcium carbonates and iron oxides. At its turn SEM showed the typical pattern of eolian abrasion on both quartz and feldspar phases.

Based on these data it was possible to estimate at 2.49 to3.19 mGy/y the annual dose rate due to in situ radioactivity, value close to those reported in literature for Eastern European loess deposits.

All these facts were interpreted within a global model confirming the relative uniformity of supposed sources of a eolian dust which finally generated the Quaternary loess deposits.

ATMOSPHERIC AIR CONTAMINATION ASSESSMENT IN IVANOVO REGION BY MEANS OF COMBINED ANALYSIS OF SNOW AND MOSSES

Dunaev A.M.[1], Rumyantsev I.V.[1], Frontasyeva M.V.[2]

[1]Ivanovo State University of Chemistry and Technology, Ivanovo, Russia
[2]Joint Institute of Nuclear Research, Dubna, Russia

The assessment of air quality requires special equipment and long-term procedure of sampling. It makes the monitoring of the atmosphere very difficult. The solution may be found by application indirect methods such as biomonitoring and precipitation analysis. Mosses are one of the most appropriate indicator organisms to control air pollution, because they have a very developed surface, high cation exchange capacity and get nutrition elements only from air.

Ivanovo region situated at interfluve of the Volga and Klyaz'ma rivers was the object under study. The combined analysis of mosses and snow was applied for atmospheric air contamination assessment. The 25 samples of mosses *Pleurozium schreberi, Hylocomium splendens* и *Polytrihum Commune* were collected according to the ICP Vegetation monitoring manual. Metal extraction was made after digestion of mosses at 625°C by 1M HNO_3 treatment. Samples of snow were collected on March, melted and filtered. Concentrations of nine heavy metals (Cu, Zn, Pb, Cd, Co, Ni, Mn, Fe, Cr) were determined by flame atomic absorption spectrometry.

It was established that heavy metal content in mosses at the territory of Ivanovo region was very close to neighboring regions such as Yaroslavl, Tula and Udmurtia. In snow Cu, Zn, Mn and Fe were only found. The concentrations of these elements were sufficiently lower than at neighboring Nizhniy Novgorod region. The intensities of heavy metal depositions were calculated from metal content in bulk snow. After comparison with standard values it was established that air contamination level exceeded background level but was still permissible.

Factor analysis together with GIS methods was applied for identification of potential origins of metal arrival. The highest concentrations of observed metals were detected in Il'inskoe, Komsomolsk, Furmanov and Privolzhsk districts. All of them border on industrially developed Yaroslavl and Kostroma regions. Taking into account most frequent bearing of an apparent wind it may suppose that transboundary pollution is serious factor of air contamination level in Ivanovo region. At central part of Ivanovo region the asphalt plant was identified as most probable reason of air contamination near Rodniki city. Here the increasing concentrations of lead, zinc, copper, iron and chromium were found. The influence of motor transport might be dealt with the moss contamination in vicinity of Ivanovo city.

On the basis of these results it can be concluded that air contamination level in Ivanovo region is acceptable. However the transboundary air pollution was detected as well as different native sources.

APPLICATIONS OF INAA AND X-RAY BASED TECHNIQUES FOR TRACE ELEMENT ANALYSIS IN MATERIALS AND ENVIRONMENTAL SCIENCES

Ene Antoaneta[1], Frontasyeva M.V.[2], Popescu I.V.[3,4,5], Stihi C.[3,4], Ene Andreea[6], Drasovean R.[1], Chelarescu E.D.[5,7]

[1] Dunarea de Jos University of Galati, Department of Chemistry, Physics and Environment, Faculty of Sciences and Environment, 111 Domneasca St., 800201 Galati, Romania
[2] Joint Institute of Nuclear Research, Frank Laboratory of Neutron Physics, Dubna, Russia
[3] Valahia University of Targoviste, Faculty of Sciences and Arts, Sciences Department, 2 Carol I St., 130024, Targoviste, Romania
[4] Valahia University of Targoviste, Multidisciplinary Research Institute for Sciences and Technologies, 13 Sinaia St., 130004, Targoviste, Romania
[5] "Horia Hulubei" National Institute for Physics and Nuclear Engineering, 30 Reactorului St., P.O.BOX MG-6, Bucharest-Magurele, Romania
[6] Dunarea de Jos University of Galati, Faculty of Sciences and Environment, Environmental Monitoring and Management Master program, 111 Domneasca St., 800201 Galati, Romania
[7] University of Bucharest, Faculty of Physics, Doctoral School, P.O.BOX MG - 11, 077125 Bucharest-Magurele, Romania

Experience in applying non-destructive nuclear and related analytical techniques in materials science and environmental studies is reviewed. The employed techniques are: instrumental neutron activation analysis (INAA), energy-dispersive X-ray fluorescence (ED-XRF), particle-induced X-ray emission (PIXE) and scanning electron microscopy energy-dispersive X-ray analysis (SEM-EDX).

INAA was applied at "Horia Hulubei" Institute of Physics and Nuclear Engineering (IFIN-HH), Bucharest-Magurele, Romania and Frank Laboratory of Neutron Physics (FLNP) of Joint Institute of Nuclear Research (JINR) at Dubna, Russia, to investigate the elemental content of some iron- and steelmaking products (steels, slags) from the technological flux of Iron and Steel Works at Galati (Romania), soil samples collected in the vicinity of the industrial enterprise, and vegetation material. The INAA results for minor and trace elements in industrial and environmental materials are compared with those obtained by X-ray based techniques ED-XRF, SEM-EDX and PIXE using photon, electron and proton excitation, respectively, at "Dunarea de Jos" University of Galati, Valahia University of Targoviste and IFIN-HH, Romania, and their advantages and drawbacks are discussed in relation with each analyzed sample matrix.

The perspectives of applying INAA and SEM-EDX in the frame of a JINR-Romania bilateral project between FNLP and Dunarea de Jos University of Galati to the investigation of high purity materials such as lithium nitride and boron nitride in combination with their micro-structure characterization using SEM and X-ray Diffraction (XRD) are described.

OCCURRENCE OF HEAVY METALS AND OTHER TRACE ELEMENTS IN INDUSTRIALLY CONTAMINATED SOILS STUDIED BY NEUTRON ACTIVATION ANALYSIS

Ene A.[1], Frontasyeva M.V.[2], Strelkova L.P.[2], Pavlov S.S.[2]

[1] Dunarea de Jos University of Galati, Department of Chemistry, Physics and Environment, Faculty of Sciences and Environment, 111 Domneasca St., 800201 Galati, Romania
[2] Joint Institute of Nuclear Research, Frank Laboratory of Neutron Physics, 141980 Dubna, Moscow Region, Russia

The elemental content and their depth distribution in soil samples collected in the vicinity of an industrial enterprise at Galati, Romania, was investigated by instrumental neutron activation analysis (INAA) at FLNP JINR, Dubna, Russia.

Nine sampling points were chosen in the industrial area of the iron–steel plant of Galati, one of the most important metallurgical complexes in the South–East of Europe, at three rural sites from Braila County and three rural, two suburban and one in an urban site from Galati County. Also, control samples were collected from two rural sites not affected by industrial activities: in a forested area (north of Galati County) and Lake Bugeac area (Constanta County). With the exception of one site, which is the closest point to the iron-steel complex (coking and sinter plant and blast furnaces), all the rural sites are agricultural or pasture lands for the domestic animals, located near cultivated areas or gardens, and some sites are close to natural protected areas in Romania. Soils were randomly taken in each location from three depths (0-5; 5-20, and 20-30 cm) in 20 x 20 m plots as 5–8 subsamples, which were mixed to form a composite sample.

INAA carried out in two irradiation steps allowed determination of 40 elements (Na, Mg, Al, K, Ca, Ti, V, Cr, Mn, Fe, Ni, Co, Zn, As, Br, Rb, Sr, Zr, Mo, Sb, I, Cs, Ba, La, Ce, Nd, Sm, Eu, Tb, Dy, Tm, Yb, Hf, Ta, W, Au, Hg, Th, and U) in soil samples. Correlation coefficients matrix indicates very strong correlation ($r>0.90$) of Co with Ni and Ba, as well as high correlation ($0.70<r<0.89$) for the following heavy metals: Al with V; Cr with Fe, Ni, Co, As, Sb, Ba and W; Mn with Zn; Fe with Ni, Co, Zn, Sb, Ba and W; Ni with W; Co with As; Zn with Sb; As with Ba and W, Ba with V and W; Sb with W, suggesting common origin. Also, very high correlation was found for most lithogenic elements. A discussion is made regarding the correlation of selected metals concentration with soil pH and total organic carbon (TOC).

INAA results for minor and trace elements in industrially contaminated soils are compared with those previously obtained by energy-dispersive X-ray fluorescence (ED-XRF) at "Dunarea de Jos" University of Galati (UDJG) Romania. The elemental content of the soil sample collected in the vicinity of the slag dump of the iron and steel enterprise was compared with the slag composition. The influence of steel plant activity on occurrence of heavy metals in surrounding soils is discussed, in relation to location of the studied sites.

AURA setup testing at the IREN neutron beam

T.L.Enik, L.V.Mitsyna, A.B.Popov, I.M.Salamatin, A.P.Sirotin

Frank Laboratory of Neutron Physics,
Joint Institute for Nuclear Research, 141980, Dubna, Russia

Abstract

The AURA experimental setup constructed for an angular anisotropy investigation of elastically scattered neutrons was tested at the 15 m flight path of IREN beam. The setup consists of the turn-table with four ^{3}He-detectors and an investigating sample in the center. The turn-table is rotated by a stepper motor. Pulses from the detectors and two monitor counters enter the multi-channel time-coder. The software support of control PC executes the management of motor and accumulation of time-of-flight spectra and their primary analysis. The results of AURA complex testing are presented.

Muons produced by mobile accelerators as a powerful means of large-scale environmental analysis also providing chemical data on oxidation state

Stefan Fränzle

Deptm. of Bio- and Environmental Sciences, Group of Environmental and Theoretical Chemistry (Head)

International Graduate School Zittau (IHI)

Dresden Technical University

Markt 23, D-02763 Zittau, Germany

For a long time, it was known to be feasible – and actually applied in more recent times – to use charged or neutral particles from ambient sources like cosmic radiation or radionuclides for purposes of environmental analysis. This includes XFS excited by way of α or γ radiation or *bremsstrahlung* of the former, H backscattering of neutrons from cosmic radiation or local sources such as (α, n) reactions by ^{13}C, ^{18}O or heavy Mg isotopes and spontaneous fission of uranium. However, a common disadvantage of these methods is that the particles penetrate just a few cm into or through soil which is due to neutrons and α-particles being subject to strong interactions. Massive particles which do not "feel" this interaction, i.e., heavy leptons, will not suffer from this disadvantage. Indeed, muons which are abundant in cosmic radiation (and were discovered therein) are known to penetrate some 50 – 100 m of solid rock, allowing to look for cavities (like with Chufu's large pyramid before) or chemical anomalies throughout this range. Muons can also be produced by small if not table-top-sized accelerators now via production and decay of charged $\pi^{\pm}$ mesons.

It will be pointed out in the lecture that short-lived radionuclides are made by (μ^-,γ) and (μ^-,n) processes of nuclei capturing negative muons. When μ^- are directed along the surface of an area or parallel to crevasses, canyons or boreholes, areas of several 1,000 m^2 can be investigated simultaneously by γ detection from these radionuclides from one given spot of μ emission. Besides of high sensitivities for detection of both some abundant (like Ti, Fe) and rarer elements in topsoil μ^- activation of O, S, and N also allows to estimate organic content as well as average oxidation state of upper soil layers or those next to some hole or cliff. The range is far superior to those which can be achieved by using any other (charged) particles. For increased sensitivity and arbitrary beam direction, cosmic-radiation muons must be replaced with such ones produced in a mobile accelerator mounted on e.g. a lorry or some crane-based platform. Capture yields and thus detection sensitivities – provided nuclides with half-lives in the s-to-min range are formed after the muons lost kinetic energy down to some 50 eV – increase with $\approx Z^{1.15}$, muon-induced fission prevailing in $Z > 75$ targets giving characteristic products from e.g. Pb or Th. A larger part of a forest biosystem or a small island of > 100 m diameter can be investigated in terms of elemental analysis (including ore prospection), biochemical activity, air penetration into deeper layers and approximate mineral composition, organic content from a single borehole or depression, just scanning the surface around by a γ spectrometer. Total activation is short-lived and negligible, generally going to harm local biota less than classical sampling by means of digging. Data are available in the field already, much faster than with chemical analysis also. Detection limits are estimated in the talk also.

Goos – Haenchen Effect in Neutron Optics

A.I. Frank

I.M.Frank Laboratory of Neutron Optics, JINR, Dubna

Goos-Haenchen effect, the longitudinal shift of the wave beam at total inner reflection, is a very well-known optical phenomenon. It was discovered in 1947 and later many times was observed in light optics, as well as at reflection microwave and ultrasonic waves. Recently cognate effect was observed with neutrons and that induced some discussion concerning G.-Ch. effect at neutron reflection.

Elementary theory of the G.-Ch. effect in respect to reflection of the massive particle will be presented and relation of the effect with delay time at reflection will be demonstrated. It will be shown that giant positive and negative longitudinal shifts of neutron beam may occurs at neutron reflection from some specially manufactured planar system.

In the conclusion we shortly discuss the experimental possibilities for observation of neutron delay time and longitudinal shift at neutron reflection.

On the Validity of the Potential-Like Dispersion Law for Neutrons in the Matter Moving with Giant Acceleration

A.I. Frank

I.M.Frank Laboratory of Neutron Optics, JINR, Dubna

Interaction of neutron waves with the matter moving with acceleration was experimentally investigated recently [1,2]. In these experiment ultracold neutrons passed through the silicon sample which was moving with acceleration of the order 60-80 m/s^2. The experimental results were in a good agreement with theoretical prediction obtained under the assumption that dispersion law of neutron waves in accelerating matter does not differ from the same in the matter in rest.

In the present communication we will present arguments that this assumption is valid only for the acceleration which is not exceeding some critical value. The idea of the experiment for the test of the validity of the potential like dispersion law in matter for the case of giant acceleration will be discussed.

Results of experiments 2012-2013 with massive uranium target setup QUINTA at Nuclotron and prospects for 2014 -2016

Furman W.
on the behalf of "Energy & Transmutation RAW" collaboration

The project "Energy and Transmutation of RadioActive Waste" ("E & T - RAO"), executed in 2011 -2013, aims to study nuclear physics aspects of the new scheme electronuclear method, based on the results of some pioneer work done in the last 50 years at JINR.

This scheme can be implemented for real electronuclear method of neutron production with its energy spectrum as hard thanks to deeply subcritical, quasi infinite (providing minimum leakage neutrons) active core based on natural (depleted) uranium or thorium bombarded powerful beam of relativistic particles. This neutron spectrum, in principle, allows the direct utilization of spent nuclear fuel (SNF) of nuclear power plants while producing energy.

The report discusses the key findings of the recent experiments on irradiation of the target assembly (TA) "KVINTA" with a mass of natural uranium ~ 512 kg by Nuclotron deuteron beams with energies Et = (1 ÷ 8) GeV (0,5 ÷ 4 GeV / nucleon) performed under the "E & T - RAO" project. Different methods were measured characteristics of neutron fields inside and outside the TA "KVINTA" as well as the spatial distribution of nuclear reaction densities induced by neutrons. It is shown that, in contrast to the predictions of a number of calculations similar electronuclear systems, integrated multiplicity of neutrons produced and, therefore, the total numbers of fission and radiative capture in TA "KVINTA" increase linearly with the energy of the incident deuterons up to Ed = 8 GeV. Beside that the neutron energy spectra become harder with the growth of incident energy.

Physical and methodological results obtained with TA "KVINTA" are the basis for the planning of the scientific program of the next phase of the project "E and T - RAO" with quasi infinite target assembly "BURAN" from depleted uranium weighing about 20 tons, available at JINR

The experiments of the current phase of the project as well as planned activity with TA BURAN for next three years are performed in the frame of broad international collaboration formed by interested experts from the JINR member states and other countries and participants from almost all of JINR laboratories. A goal of this phase of the project is to obtained set of experimental data required to test and improve the existing INC computer codes. In addition, analysis of the data will allow for the planning of further work aimed at study of the possibility and feasibility of creation of the prototype electronuclear installation of new type.

THE LONG PERIODICITY PHASE FORMATION IN MODEL MEMBRANES OF THE OUTERMOST SKIN LAYER (STRATUM CORNEUM)

Ermakova E.V.[1], Kiselev M.A.[1], Gruzinov A. Yu.[2], Zabelin A.B.[2]

[1] Frank Laboratory of Neutron Physics, Joint Institute for Nuclear Research, Dubna, Russia
[2] National Research Centre «Kurchatov Institute», Moscow, Russia

Model lipid membranes of stratum corneum (SC), created from the main components of the lipids of the outermost layer of the mammalian skin are used for the investigation of the general laws in the formation of nanostructure of the SC lipid matrix.

Model membrane of the outermost layer of the skin stratum corneum with composition ceramide 1/ ceramide 6/ cholesterol/ palmitic acid/ cholesterol sulfate and weight component ratio 30/30/20/15/5 was investigated via neutron and X-ray diffraction. It was revealed that membrane structure at pH=7.2 consist of two short periodicity phases with repeat distances d=47 Å and d=35.7 Å, and also the long periodicity phase with d=127 Å. Long periodicity phase is demolished at the increasing of pH to 9, but short periodicity phase is retained with d=48.3 Å.

ANGULAR CORRELATIONS OF LIGHT CHARGED PARTICLES IN TERNARY FISSION OF ^{241}Pu BY POLARIZED COLD NEUTRONS– NEW "CENTRIFUGAL" EFFECT IN THE ANGULAR DISTRIBUTION

A.Gagarski [a], F. Gönnenwein [b], I. Guseva [a], Yu. Kopatch [e], T. Kuzmina [f], M. Mutterer [c], G. Petrov [a], T. Soldner [g], G. Tiourine [f], W. Trzaska [d], T. Zavarukhina [a]

[a] *Petersburg Nuclear Physics Institute, Gatchina, Russia;*
[b] *University of Tübingen, Germany;*
[c] *Technical University, Darmstadt, Germany;*
[d] *University of Jyväskylä, Finland;*
[e] *Joint Institute for Nuclear Research, Dubna, Russia;*
[f] *Khlopin Radium Institute, St. Petersburg, Russia;*
[g] *Institute Laue-Langevin, Grenoble, France*

Since several years our collaboration has studied angular distributions of light charged particles (LCP) in ternary fission induced by polarized cold neutrons. For the fissile isotopes ^{233}U, ^{235}U and ^{239}Pu novel features of ternary fission termed ROT and TRI effects were discovered. In proposed semi-classical phenomenological models both effects are considered to be a result of oriented rotation of compound nucleus before nuclear rupture. They appeared to be very sensitive to the parameters of transition states above fission barrier and to the characteristics of nuclear configuration at scission [1-8].

Results of a recent experiment on study the LCPs angular correlations in ternary fission of ^{241}Pu are presented in the report. In this experiment integral values of TRI and ROT effects were measured as well as their dependences on LCP energy. In addition to already known TRI and ROT effects a new effect was discovered in ^{241}Pu(n, f), which was named "centrifugal" (CEF effect). The essence of the new effect is that the LCP has a slightly greater chance to be emitted in a plane perpendicular to the polarization axis than along this axis, corresponding value of the anisotropy is $+0.003 \pm 0.0002$. The new CEF effect is believed to be linked with oriented rotation of scissioning nucleus, which gives rise to additional centrifugal force acting onto LCPs in the rotating system in direction perpendicular to the rotation axis.

Study of the new CEF effect together with already known TRI and ROT correlations looks very promising for obtaining new information on fission process, namely, about the least studied stage of the process– rupture of a nuclear matter. Further perspectives of the studies are discussed in the report.

References

1. P. Jesinger et al., Nucl. Instr. Methods A440 (2000) 618.
2. P. Jesinger et al., Phys. At. Nucl. 65 (2002) 630.
3. F. Goennenwein et al., Phys.Lett. B 652 (2007) 13.
4. I. Guseva, Yu. Gusev, Bull. of the RAS: Physics 71 (2007) 367.
5. G. A. Petrov et al., Phys. At. Nucl. 71 (2008) 1149.
6. A. Gagarski et al., Proc. of 4-th Int. Workshop on Nuclear Fission and Fission Product Spectroscopy, Cadarache May 13-19 2009. AIP Conf. Proc. vol. 1175 (2009), p. 323.
7. A. M. Gagarskii et al., Crystallography reports 56 (2011) 1238.
8. A. M. Gagarski et al., Proc. of the 19-th Int. Seminar on Interaction of Neutrons with Nuclei (ISINN-19), Dubna May 25-28 2011. Dubna, 2012, p. 27.

$^{57}Fe(n,\alpha)^{54}Cr$ cross sections in the MeV region

Yu. M. Gledenov, M. V. Sedysheva, V.A.Stolupin
JINR, Dubna 141980, Russia

Guohui Zhang*, Jinhua Han, Xiang Liu, Xiao Fan, Jinxiang Chen
State Key Laboratory of Nuclear Physics and Technology, Institute of Heavy Ion Physics, Peking University, Beijing 100871, China

G. Khuukhenkhuu
Nuclear Research Centre, National University of Mongolia, Ulaanbaatar, Mongolia

P. J. Szalanski
University of Lodz, Institute of Physics, Lodz, Poland

Cross sections of the $^{57}Fe(n,\alpha)^{54}Cr$ reaction are measured for the first time. Measurements were carried out at neutron energies of 5.0, 5.5, 6.0 and 6.5 MeV using a double-section gridded ionization chamber and two back-to-back ^{57}Fe samples. Experiments were performed at the 4.5 MV Van de Graaff Accelerator of Peking University. Monoenergetic neutrons were produced through the $^{2}H(d,n)^{3}He$ reaction with a deuterium gas target. Foreground and background were measured in separate runs. A ^{238}U sample and a BF_3 long counter were utilized for absolute neutron flux calibration and for neutron flux normalization, respectively. Present results are compared existing evaluations. The present work was financially supported by the National Natural Science Foundation of China (11175005).

* Corresponding author: guohuizhang@pku.edu.cn

NUCLEAR LEVEL DENSITY WITHIN MODIFIED GENERALIZED SUPERFLUID MODEL WITH VIBRATIONAL ENHANCEMENT

Gorbachenko O. M.[1], Plujko V. A.[1,2], Bondar B. M.[1], Rovenskykh E. P.[1,2]

[1] *Taras Shevchenko National University, Kyiv, Ukraine*
[2] *Institute for Nuclear Research, NAS of Ukraine, Kyiv, Ukraine*
oleksandr.gorbachenko@gmail.com

A new variant[1] of enhanced generalized superfluid(MEGS) model [2,3] with different collective state enhancement factors[4-6] is considered. An effect of collective states on forming the temperature is taken into account. The ready-to-use tables for the asymptotic value of a-parameter of level density as well as for addition shift to excitation energy are prepared using the chi-square fit of the theoretical values of neutron resonance spacing and cumulative number of low-energy levels to experimental values. The systematics of these parameters as a function of mass number and neutron excess are obtained. For MEGS model, approximation of boson partition function with average occupation numbers [5,6] can be considered as the most appropriate approach for calculation of the vibrational enhancement factor.

The collective state effect on gamma-ray spectra and excitation functions of neutron-induced nuclear reactions is investigated by the use of EMPIRE 3.1 code [3] with modified enhanced generalized superfluid model for nuclear level density.

1. V.A. Plujko, O.M. Gorbachenko, B.M. Bondar, E.P. Rovenskykh, M.M. Zolko // Intern. Nucl. Data Conf. Science and Techn. ND2013, 03-08 March 2012,USA, NY, Book of Abstracts, P.303.
2. R. Capote, M. Herman, P. Oblozinsky, P.G. Young, S. Goriely, T. Belgya, A.V. Ignatyuk, A.J. Koning, S. Hilaire, V.A. Plujko, M. Avrigeanu, O. Bersillon, M.B. Chadwick, T. Fukahori, Zhigang Ge, Yinlu Han, S. Kailas, J. Kopecky, V.M. Maslov, G. Reffo, M. Sin, E.Sh. Soukhovitskii, P. Talou // Nucl. Data Sheets. 2009. V.110. P.3107.
3. M. Herman, R. Capote, B.V. Carlson, P. Oblozinsky, M. Sin, A. Trkov, H. Winkle, V. Zerkin // Nucl.Data Sheets. 2007. V.108. P.2655.
4. A.V. Ignatyuk, J.L. Weil, S. Raman, S. Kahane // Phys. Rev. C. 1993. V.47. P.1504.
5. V.A. Plujko, O.M. Gorbachenko // Phys. Atom. Nucl. 2007. V.70. P.1643.
6. V.A.Plujko, O.M. Gorbachenko, I.M. Kadenko // Int. Journ. Mod. Phys. E. 2007. V.16. P.570.

NUCLEAR AND RELATED ANALYTICAL TECHNIQUES USED TO STUDY ELEMENTAL CONTENT OF SOME EXOTIC WOODY SPECIES UNDER INTENSE TECHNOGENIC POLLUTION IN URBAN ECOSYSTEM OF NON-CHERNOZEM ZONE OF RUSSIA

Gorelova S.V.[1], Gorbunov A.V.[2], Lyapunov S.M.[2], Okina O.I.[2], Frontasyeva M.V.[3]

[1]Department of Botany, Faculty of Natural Sciences, L.N. Tolstoy TSPU, Tula, Russia
[2]Laboratory of chemical and analytical reseaches, Geological Iinstitute of RAS, Moscow, Russia
[3]*FLNP JINR, Dubna, Russia*

Introducents represent more than half of the tree and shrub flora of green area of the urban ecosystems in non-chernozem zone of Russia. The study of the possibility of using exotic species in green areas and the their ability to accumulate toxic elements from the soil and air of large industrial cities is an important task for the environmental research.

Sampling was carried out in the city of Tula, a major industrial center of Russia, experiencing strong ecological stress, especially in the sanitary-protective zones of metallurgical enterprises. The sampling sites were Kosogorsky Metallurgical Works (production of high-purity pig, iron, and ferromanganese); JSC "Vanadium-Tulachermet" (production of iron and chrome, compounds of vanadium), as well as at sanitary-protective plantings along major city highways. Atomic absorption spectrometry (AAS) was used to study heavy metal content in organs of 8 species of shrubs under intense polymetalic contamination and instrumental neutron activation analysis (INAA) – in organs of 7 types of woody plants under impact of vehicle emissions along highways.

Studies has shown that the content of Pb in the leaves of exotic species ranges 0.5–17 mg/kg of dry weight under the impact of emissions from metallurgical enterprises; the content of Cd in the leaves – 0.04–1.81 mg/kg and maximum for *Spiraea japonica, Forsythia x intermedia and Syringa josikaea* (0.89–1.80 mg/kg) under impact of vehicle emissions along highways. Content of Cu in the shrubs leaves ranges from 4.6–12 mg/kg and was maximum for *Cotoneaster lucidus, Spiraea japonica, Forsythia x intermedia* which growing near highways (10–12 mg/kg). Mn content in leaves ranged from 30–335 mg/kg. The maximum content of Mn accumulated *Symphoricarpos albus* and *Cotoneaster lucidus* leaves (167–335 mg/kg) was observed in buffer zones of metallurgical enterprises. The content of Ni in the studied introductions plants on average was 1.2–5.5 mg/kg. Maximum amount of nickel accumulated in the leaves of *Cotoneaster lucidus*. Fe content was in the range of 210–7260 mg/kg. Maximum contents characterized *Karagana arborescens* and *Cotoneaster lucidus* leaves was observed in the area of industrial enterprises (6600–7250 mg/kg that is 2.5–6 times higher than in the leaves of synanthropic flora trees). Cr concentration in the leaves and shoots of exotic species growing along highways was within 0.2–1.7 mg/kg, *i.e.* 1.3% of its content in soil. Zn content in the leaves of introduced species ranged from 37–51 mg/kg, that is the average value for plants and is 80–100% of its content in soil. As accumulation in the leaves of exotic species was in the range of 0.05–0.31 mg/kg and the maximum content was observed for *Berberis thunbergii Atropurpurea*. Sb content varied in the range of 0.03–0.38 mg/kg that was 3–49% of its content in soil. The maximum absorption of Sb was revealed for *Syringa josikaea* and *Philadelphus coronarius*.

All investigated species were characterized by a better vitality than the synanthropic ones. Thus, the use of exotic species of wood as bioaccumulators of toxic elements from soil and air is promising to create green space in urboecosystems.

BIVALVE MUSSELS IN BIOMONITORING OF THE SOUTH AFRICAN ATLANTIC COASTAL WATERS

Z. Goryainova[1], J. Bezuidenhout[2], M.V. Frontasyeva[2], D. F. Pavlov[3], I. Zinikovskaia[1], Ntombizikhona Beaulah Ndlovu[4]

[1]Joint Institute for Nuclear Research, Dubna, Russia

[2] Physics Department, Faculty of Military Science, Stellenbosch University, Saldanha, South Africa

[3]I.D. Papanin Institute for the Biology of Inland Waters, Russian Academy of Sciences, Borok, Russia

[4]Department of Physics, Stellenbosch University, South Africa

To establish a system of aquatic biomonitoring in the Western Cape area of South Africa it was proposed to use bivalve mollusks as sentinel organisms. Sampling was carried out in two bays of the South African Atlantic coast: Saldanha and Danger bay. Two species of marine bivalve mollusks were sampled: artificially propagated and farmed in sea water Pacific oyster (*Crassostrea gigas*), as well as farmed and wild black mussels (*Mytilus galloprovincialis*). To study the element content in mollusks INAA was performed in the radioanalytical laboratory at the pulsed fast reactor IBR-2, FLNP JINR. A total of 38 elements (Na, Mg, Al, S, Cl, K, Ca, Sc, Ti, V, Cr, Mn, Fe, Co, Cu, Zn, As, Se, Br, Rb, Sr, Mo, Ag, Cd, In, Sb, I, Cs, Ba, La, Ce, Sm, Eu, Tm, Yb, Lu, Hf, Ta) were determined. The analysis of the obtained analytical results was performed as follows: comparison of the elemental content of black mussels (shells and soft tissues) from Saldanha Bay *versus* those from Danger Bay; comparison of the levels of elements in the same tissues of two studied species (oysters *versus* black mussels). The comparison revealed site-specific differences in the contents of determined elements in the tissues of black mussels from Danger and Saldanha bays as well as differences in elements accumulation between mussel species. It was shown that the bivalve mollusks are good biomonitors for tracing elemental content in the changing environmental conditions and they could be used for assessing the marine aquatic pollution.

Position-Sensitive Coincidence Detection of Two- and Three-Particle Nuclear Reactions

Carlos Granja[1], Valery Pugatch[2], Alexander Okrymenko[2], Vaclav Kraus[1], Stanislav Pospisil[1]

[1] *Institute of Experimental and Applied Physics, Czech Technical University in Prague, Czech Republic*

[2] *Institute for Nuclear Research KINR, Nat. Ac. of Sciences, Kiev, Ukraine Research carried out in frame of the Medipix Collaboration*

For studies of low-energy nuclear reactions knowledge of spectral and angular correlations of reaction products enables to determine angular cross sections, spectroscopic factors and partial reaction widths. For this purpose we assembled a multi-detector system based on the pixel semiconductor detector Timepix together with silicon diodes and dE detectors. The granularity and per-pixel energy/time sensitivity of Timepix allows performing spatial- and time-correlated detection of reaction products with high spatial and time resolution and enhanced signal-to-noise resolving power (see Fig.1). In this contribution we evaluate the response and resolving power of a modular coincidence system based of several pixel detectors Timepix which are operated with the FITPix readout interfaces together with a synchronizing DAQ module. Tests and preliminary measurements have been performed at the Tandem Van-de-Graaff accelerator of the KINR in Kiev using 2.65 MeV protons on CH_2 and ^{11}B targets.

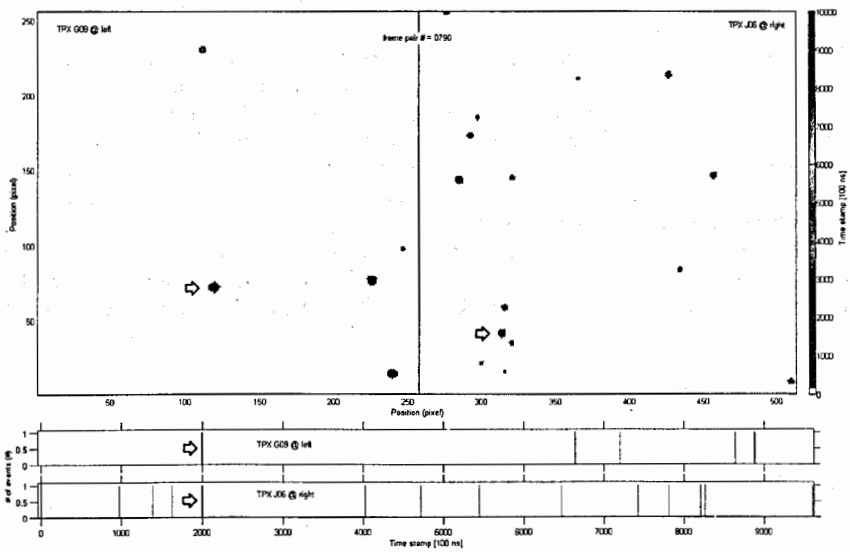

Fig. 1. *Spatial-and time-correlated detection of reaction products from a 2.65 MeV proton beam onto a CH_2 target. Single events are registered in two separate pixel detectors (top) which are operated in time-of-arrival mode (shown in color) providing their time stamp which can be plotted in time spectra (bottom). An elastically scattered pair of protons is indicated by the arrows. Frames shown collected in 1 ms exposure time. The spatial information, given by the 256 × 256 pixel matrix of each detector, is coupled to the time-correlated information given by the color scale shown in the range 0–1000 μs.*

Determination of dead-time losses in a NaI(Tl) gamma-ray spectrometer

D. Grozdanov[1,2], I. Ruskov[1,2]*, N. Janeva[1],

Yu.N. Kopach[2], S.I. Negovelov[2], Yu.D. Mareev[2]

[1]*Institute for Nuclear Research and Nuclear Energy (INRNE) of Bulgarian Academy of Science (BAS), Tzarigradsko chausse blvd, 1784 Sofia, Bulgaria*

[2]*Frank Laboratory of Neutron Physics (FLNP) of Joint Institute for Nuclear Research (JINR), Joliot Currie 6, 141980 Dubna, Moscow region, Russia*

**Corresponding author E-mail: ruskoiv@nf.jinr.ru*

The 12 NaI(Tl)-detector gamma-ray spectrometry system (GSS) "Romashka" is equipped with new computer controlled HVSys[LLC] power supply and AFI Electronics Digital signal processing (DSP) Data acquisition system (DAQ). In order to do some preliminary checks of the GSS chains' characteristics, a single channel gamma-spectrometry tract was commissioned. It consists of a single Romashka's section - NaI(Tl) crystal optically coupled with photo-multiplier tube FEU-110, POLON[TM] Active Filter Amplifier and EG&G ORTEC TRUMP[TM]-2k Multichannel Buffer (MCB) PC-compatible plug-in card with Maestro[TM] MCA Emulation and Analysis Software for Windows®, having real-time and life-time acquisition presets.

Two calibration sources method was applied for obtaining the effective dead-time (and dead-time losses) of a single spectrometry chain. It was used, also, to determine the dead-time of the chain when using a Parsek[LLC] desktop, with a USB powered 8k ADC interface, multichannel analyzer (MCA), having no live-time measured/indication possibility. The testing of the whole gamma-ray spectrometry system with the new HV power supply and DAQ has been recently accomplished.

It is planned to use the modernized "Romashka" GSS at JINR FLNP resonance neutron time-of-flight (TOF) spectrometer IREN, for the investigation of the neutron-induced capture and fission gamma-ray emission, using the multiplicity method, as before at the previous neutron sources IBR-30 (JINR) and IRT-2000 (INRNE).

COMPARATIVE ANALYSIS OF SCISSION-NEUTRON COMPONENT EXTRACTION

I.S. Guseva

B.P. Konstantinov Petersburg Nuclear Physics Institute

Gatchina, Leningrad District, 188300, Russia

It is known that both spontaneous and slow neutron induced fissions are accompanied by the emission of prompt neutrons. Well established that most of them are evaporated from the fragments fully accelerated due to Coulomb interaction. However, some neutrons can appear directly at scission of nucleus. There is a real difficulty to separate them experimentally from the post-acceleration component. Contrary to light-charged particles, scission neutrons are not focused by the Coulomb field of the nascent fragments. To distinguish them from the neutrons emitted after fully acceleration of fission fragments, the difference in the angular and energy distributions is normally used.

Unfortunately, various estimations of scission-neutron contribution do not coincide even for the same dividing nucleus, for example ^{252}Cf [1, 2]. They are very different depending on the experiment and its mode of treatment. This paper deals with a comparative analysis of different methods of this component extraction. It is shown that the method similar to that used C. Budtz-Jørgensen and H.-H. Knitter [1, 3] gives significantly understated value for scission-neutron part.

1. C. Budtz-Jørgensen and H.-H. Knitter, Nucl. Phys. A490 (1988) 307.
2. A. Gagarski, I. Guseva, G. Val'sky et al., ISINN-20, Alushta, Ukraine, May 21-26, 2012, Abstracts of the seminar, p. 42.
3. Sh. Zeynalov, O. Zeynalova, F.-J. Hambsch, S. Oberstedt, ISINN-19, Dubna, May 25-28, 2011, Proceedings of the Seminar, p. 82.

CP VIOLATION EFFECTS ON CHARGINO DECAYS OF MSSM CHARGED HIGGS BOSONS

T. Ibrahim[1], A. Bishara[2], H. Motaweh[3], Y. Keshk[4], E. El Sehly[5]

[1] Prof. of Particle Physics Theory, Faculty of Science, Alexandria University
[2] Prof. of cosmic ray Physics, Faculty of Science, Alexandria University
[3] Prof. of Physics, Faculty of Science, Damanhur University
[4] Dr. of Nuclear Physics, Faculty of Science, Damanhur University
[5] Assistant lecturer, Faculty of Science, Damanhur University

Abstract

We investigate the parameter space of extended N=1 supergravity which consists of nine parameters, $\tan\beta, |m_{1/2}|, m_0, |A_0|, \theta_\mu, \alpha_{A_0}, \xi_1, \xi_2, \xi_3$, that breaks supersymmetry[1]; and the effect of these parameters on the chargino decay into the lightest neutralino and the W-boson. Among these nine parameters, we focus on the roles played by five of them $\theta_\mu, \alpha_{A_0}, \xi_1, \xi_2$ and ξ_3 [2]. These are the CP violating phases in the supersymmetric breaking sector. Our calculations shows that the decay width of process $\chi^+_2 \rightarrow \chi^0_1 + W^+$ independent of the gaugino mass phase ξ_3. But the other four CP phases have small effect on the decay. The parameters m_0 and $m_{1/2}$ have the most effect on this decay among the other parameters of MSSM space. The decay $\chi^+_1 \rightarrow \chi^0_1 + W^+$, for the input parameters is closed channel at approximately $m_{1/2} \geq 200$(GeV), the decay width has a value, or the channel is opened. These results would affect the trileptonic signals in the charged Higgs decay and this should be taken into account for the precise experimental measurement at future colliders.

References:

[1] S. Weinberg; "The Quantum Theory of Field"; Volume 3: Supersymmetry, Cambridge University Press, Cambridge, 1999, ISBN 0-521-66000-9.

[2] T. Ibrahim, P. Nath, A. Psinas; "Effective Lagrangian for $\chi^+_i \chi^0_j H^-$ Interaction in the MSSM and Charged Higgs Decays"; Phys. Rev. D70 (2004) 035006.

PERSPECTIVES OF THE STUDY OF COLLINEAR CLUSTER TRI-PARTITION OF HEAVY NUCLEI

D.V. Kamanin[1], Yu.V. Pyatkov[1,2], A.A. Alexandrov[1], I.A. Alexandrova[1], N. Jacobs[3], N.A. Kondratyev[1], E.A. Kuznetsova[1], G.V. Mishinsky[1], V. Malaza[3], A.O. Strekalovsky[1], O.V. Strekalovsky[1], V.E. Zhuchko[1]

[1]Joint Institute for Nuclear Research, 141980 Dubna, Russia
[2]National Nuclear Research University "MEPHI", 115409 Moscow, Russia
[3]University of Stellenbosch, Faculty of Military Science, Military Academy, Saldanha 7395, South Africa

Our plans on further study of the CCT process are based on first results of quantitative treatment of the experimental data obtained so far [1]. We came to conclusion that quaternary decay channel is likely more probable compared to the ternary one due to more elongated prescission configuration provided substantial decreasing of coulomb interaction energy. In order to perform cinematically complete experiment i.e. with the direct registration of all (three and more) decay partners we have to develop new methodical approaches.

Digital image of the current impulses from the two CCT partners hit the same PIN-diode during registration gate can be obtained using fast flesh-ADC ("double-hit" technique). Both energy and time-reference linked with each impulse will be calculated event by event.

We have studied a possibility of an independent registration of all fragments from the collinear cluster decay using electrostatic guide system. Modeling of the ions trajectories showed that pair of the initially collinear unidirectional ions being different by the velocities or/and ionic charges can be detected separately in the final PIN diodes mosaic. The guide system is planning for realization at one of the channels of the IBR-2 reactor.

In the recent experiments at the COMETA setup we have find that one of the CCT partner being a di-nuclear system (shape-isomer) destroys due to inelastic scattering in the foil especially placed on the flight pass. Investigation of this new effect is also in our nearest plans.

References

1. D.V. Kamanin, Yu.V. Pyatkov, W. von Oertzen et al., Proc. ISINN-20, 21-26 May, Alushta, Ukraine, in press.

SUPPRESSION OF THE BACKGROUND IN THE STUDY OF SPECIFIC CCT MODES

D.V. Kamanin[1], Yu. V. Pyatkov[1,2], V. Malaza[3], A.A. Aleksandrov[1], I.A. Aleksandrova[1], N. Jacobs[3], N.A. Kondratyev[1], E.A. Kuznetsova[1], O.V. Strekalovsky[1], A.O. Strekalovsky[1], V.E. Zhuchko[1]

[1]Joint Institute for Nuclear Research, 141980 Dubna, Russia
[2]National Nuclear Research University "MEPHI", 115409 Moscow, Russia
[3]Faculty of Military Science, Military Academy, Saldanha 7395, South Africa

In our experiments devoted to study of a new ternary decay of low excited heavy nuclei called "collinear cluster tri-partition" (CCT) [1-3] a specific CCT mode based on the double magic ^{132}Sn cluster was observed by the "missing mass" method. Unfortunately, the data obtained suffer from low statistics. It was a reason to continue the measurements. The mass of one fragment is distributed in the range of (95-120) amu while the mass of another fragment is less than 40 amu. Events of this kind lie in the same area with scattered events to be a background. We have found an effective way to distinguish these two groups of events.

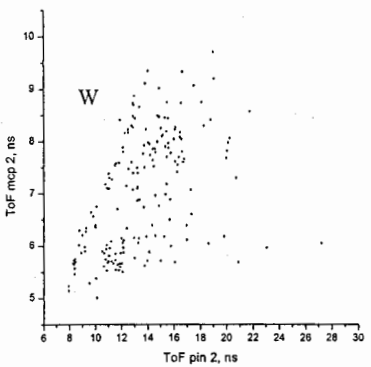

Fig.1. TOF_{pin} - TOF_{mcp} distribution for the mass region around Sn- based CCT mode. See text for details.

At the LIS setup the time-of –flight (TOF) of the fragment can be measured by two different ways using respectively PIN diode or micro-channel plates (MCP) based "stop" detector (TOF_{pin} and TOF_{mcp}). In any case another MCP based detector delivered "start" signal. As can be inferred from fig.1 there are two well separated loci in TOF_{pin} -TOF_{mcp} distribution. It appears to occur due to the difference in the plasma delay for heavy scattered fragments and those to be relatively light originated from the CCT channel (the locus marked by W letter in the figure). At the moment we continue to collect the data to be processed using the "cleaning" presented above.

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.
3. W.H. Trzaska, Yu.V. Pyatkov, D.V. Kamanin et al., Proc. Int. Seminar on Fission. Pont d'Oye V, 16 – 19 September 2003, Chateau du Pont D'Oye, Belgium, p. 102

TIME-OF-FLIGHT SPECTROMETRY OF HEAVY IONS IN THE WIDE RANGE OF ENERGIES AND MASSES. DATA PROCESSING

D.V. Kamanin[1], Yu.V. Pyatkov[1,2], V.E. Zhuchko[1], E.A. Kuznetsova[1], A.O. Strekalovsky[1]

[1]Joint Institute for Nuclear Research, 141980 Dubna, Russia
[2]National Nuclear Research University "MEPHI", 115409 Moscow, Russia

The use of the Si-semiconductor detectors in time-of-flight-energy (TOF-*E)* spectrometry of heavy ions or fission fragments (FFs) is known to have delicate methodological problems due to the "amplitude (pulse-height) defect" and "plasma delay" effects in the *E* and TOF channels, respectively. Correct accounting for both effects needs rather complicated procedure of the FF mass reconstruction. The task becomes extremely complicated if we deal with heavy ions in the wide range of energies and masses far from those typical for conventional binary fission. This is a case of the experiments dedicated to studying of the collinear cluster tri-partition of heavy nuclei [1, 2]. We present the modified algorithms and new methodical results compared to our previous publication [3].

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
3. D.V. Kamanin, Yu.V. Pyatkov, V.E. Zhuchko et al., Proc. ISINN-20, 21-26 May, Alushta, Ukraine, in press.

Particular Characteristics of Double and Triple Coincidences Spectra for Radiative Neutron Decay

Khafizov R. U. [a], Kolesnikov I.A. [a], Nikolenko M.B. [a], Tarnovitsky S.A. [a], Tolokonnikov S. V. [a], Torokhov V.D. [a], Trifonov G.M. [a], Solovei V.A. [a], Kolkhidashvili M.R. [a], Konorov I.V. [b]

[a] NRC «Kurchatov Institute», Russia
[b] Technical University of Munich, Munich, Germany

Annotation

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

Analysis of the Response of Different Scintillators for Use in Neutron Spectrometry and Dosimetry

Nafisah Khan, Rachid Machrafi

Faculty of Energy Systems and Nuclear Science

University of Ontario Institute of Technology

Oshawa, Canada

There has been a recent need to investigate sensors that can be used for neutron spectrometry and dosimetry. Neutrons are present in a wide range of energies in nuclear facilities and have different weight in terms of their contribution to the dose equivalent. Therefore, for an accurate dose measurement, the neutron energy spectra must be accurately measured. Since there is no single sensor that can serve to detect neutrons in a wide energy range due to the energy dependence and detection efficiency, multiple sensors have to be sought out. For thermal and low energy neutrons, detectors that are ^{6}Li, ^{10}B, ^{3}He based are typically employed. For fast neutrons, plastic scintillators are often employed using the dominant elastic scattering method to create recoil protons or by thermalizing and capturing these neutrons at low energies. However, these methods have drawbacks and challenges in deriving the energy spectrum due to the complexity of the unfolding techniques.

In this paper, three scintillators have been investigated for their response to neutron and gamma radiation. Both lithium iodide doped with europium and boron-loaded plastic scintillators have been chosen primarily for thermal and low energy neutrons, and a recently developed elpasolite scintillator has been chosen for fast neutrons. All reactions use a distinct peak in the response function from the charged particle energy deposition. The response of the different scintillators to neutron and gamma radiation has been simulated using Monte-Carlo N-Particle eXtended code (MCNPX). Experiments have been carried out using different facilities at the University of Ontario Institute of Technology, Canada. The results have been compared and analyzed in accordance to their application in neutron spectrometry/dosimetry.

DIGITAL LOW BACKGROUND SPECTROMETER FOR (n,α) REACTION CROSS-SECTION MEASUREMENT WITH SOLID TARGET

Khromyleva T.A., Bondarenko I.P., Kuzminov B.D.,
Semenova N.N., Sergachev A.I., Khryachkov V.A.
State Scientific center of the Russian Federation - Institute for Physics and Power Engineering,
1, Bondarenko square, Obninsk, Russia, 249033

Abstract.
To date the cross section of (n,α) reaction is poorly known for a number of the constructional elements. Because the cross section of (n,α) reaction is relatively little, the energy of the reaction is small and the events of the reaction is necessary to separate from the large background. In addition, it is impossible to prepare a gaseous target for these elements to use the effective method created in the IPPE earlier. Using the experience of digital processing stored in the IPPE the method was developed digital spectrometer with solid target. The created spectrometer as opposed to apply earlier has a number of constructional distinctions which allowed better use advantages of digital processing. Digital signals processing methods allowed not only measuring the energy of detected particles but to obtain its kind and the output angle relative to the axis of chamber. It was shown that the developed spectrometer has significantly lower background level. That is why it allows to measure the cross-section of studying reaction with solid target better.

THE $^{57}Fe(n,\alpha)^{54}Cr$ REACTION CROSS-SECTION INVESTIGATION FOR NEUTRONS WITH ENERGY LESS THAN 7 MeV

Khryachkov V.A., Bondarenko I.P., Gurbich A.F., Kuzminov B.D., Semenova N.N., Sergachev A.I., Khromyleva T.A.

All nuclear reactions taking place on iron isotopes are very important for nuclear engineering. For some of them there is only limited experimental information available. For example, we could find the $^{57}Fe(n,\alpha)^{54}Cr$ reaction cross-section information only for 14 MeV. But many applications are in need of information for MeV neutron energy region. For this region ratio of estimations given by ENDF B VII and JENDL 4 libraries can reach factor more than 2.

In this experiment ionization chamber with Frisch grid and waveform digitizer were used. The digital signal possessing application allows us to suppress background coming from parasitic reaction significantly. The thin self-supported ^{57}Fe foil was used as a target. Number of ^{57}Fe nuclei was determined by ion beam analysis method. Monoenergetic neutrons were generated in $d(d,n)^3He$ reaction on the solid titanium target. Neutron flux was measured by ^{238}U fission fragments registration. The $^{57}Fe(n,\alpha)^{54}Cr$ reaction cross-section for the neutron energy range 5-7 MeV is given.

PHOTOMETRY OF IONIZING RADIATIONS

Khryachkov V.A., Zhuravlev B.V., Talalaev V.A.

State Scientific Center of Russia Federation – Institute for Physics and Power Engineering, 249033 Obninsk, Kaluga Region, Russia.

In work is investigated and realized the opportunity of creation of system, in which the ionizing radiation in contact with air and other samples makes some of photons, and the special detector providing registration of the photons going from a given direction is capable to determine on distance a light stream from the fixed points of the controllable space. The range length of light radiation in an atmosphere considerably exceeds the range of ionizing radiations that allows to register a light signal on significant distances from a source.

Under action of neutrons in air there are protons and alpha - particles from nuclear reactions (n, α) and (n, p) on nucleus of nitrogen and oxygen and recoil nuclei, and. under action of γ - quanta – electrons. The moving charged particles (electrons, protons, alpha - particles, recoil nuclei) by their fields interact with atom electrons of air, causing their ionization and excitation. At recombination of ions and at returning of excited atoms in the ground state there will be photons of seen light. Moreover at pass of γ - rays in transparent optical dense surroundings (for example water, glass etc.) arises light radiation of Vavilov - Cherenkov.

In practice there are cases when the serious accidents arise with emission of a lot of radioactive pollutions. In this case there is a problem to locate in space a source of radiation and to carry out a tentative estimation of activity. The opportunity of realization of such remote monitoring essentially can lower risk of an irradiation for the personnel conducting works on the given accident district.

STATISTICAL MODEL ANALYSIS OF AVERAGED OVER THE FISSION NEUTRON SPECTRUM (n,α) AND (n,p) CROSS SECTIONS

G.Khuukhenkhuu[1], Yu.M.Gledenov[2], M.V.Sedysheva[2], M.Odsuren[1] and J.Munkhsaikhan[1]

[1]*Nuclear Research Center, National University of Mongolia, Ulaanbaatar, Mongolia*
[2]*Frank laboratory of Neutron Physics, JINR, Dubna, Russia*

Investigation of (n,α) and (n,p) cross sections averaged over the fission neutron spectrum is important to estimate radiation damage due to helium and hydrogen production, nuclear heating and transmutations in the reactor structural materials. On the other hand, systematical analysis of neutron cross sections is of interest to study nuclear reaction mechanisms. In addition, it is often necessary in practice to evaluate the neutron cross sections of the nuclides, for which no experimental data are available.

Analysis of the experimental (n,α) and (n,p) cross sections in the energy range of 14-15 MeV was carried out by Levkovsky [1,2] and a certain systematical dependence of the cross sections on the asymmetry parameter of neutron and proton numbers (N-Z)/A was observed which in literature is termed as the isotopic effect. We also have obtained a similar dependence for the (n,α) and (n,p) cross sections of 6 to 20 MeV [3] and for wide energy range suggested the statistical model [4-6] to explain the dependence of the (n,α) and (n,p) cross sections on the parameter (N–Z+0.5)/A and (N–Z+1)/A, respectively.

In this paper the statistical model based on the Weisskopf-Ewing theory is used for systematical analysis of known experimental (n,α) and (n,p) cross sections averaged over the fission neutron spectrum. A regular behavior in the fission neutron spectrum averaged (n,α) and (n,p) cross sections was observed. It was shown that the experimental data is satisfactorily described by the statistical model. In addition, the average effective neutron energy for (n,α) and (n,p) reactions induced by fission neutrons was found to be around 5 MeV.

References

1. V. N. Levkovsky. Journal of Experimental and Theoretical Physics. v.45, N8, 1963, p.305, (In Russian)
2. V. N. Levkovsky. Yadernaya Fizika, v.18, 1973, p.705, (In Russian)
3. G. Khuukhenkhuu, G. Unenbat, Yu. M. Gledenov, M. V. Sedysheva. Proceedings of the International Conference on Nuclear Data for Science and Technology (19-24 May 1997), Trieste, Italy, Bologna, Editors: G. Reffo, A. Ventura, C. Grandi, part 1, 1997, p.934.
4. G. Khuukhenkhuu, G. Unenbat. Scientific Transactions of the National University of Mongolia. №7(159), Ulaanbaatar, 2000, p.72.
5. G. Khuukhenkhuu, G. Unenbat, Yu. M. Gledenov, M. V. Sedysheva. Proceedings of the International Conference on Nuclear Data for Science and Technology, Oct. 7-12, 2001, Tsukuba, Journal of Nuclear Science and Technology, Supplement 2, v.1, 2002, p.782.
6. G. Khuukhenkhuu, G. Unenbat, M. Odsuren, Yu. M. Gledenov, M. V. Sedysheva, B. Bayarbadrakh. JINR Communication, E3-2007-25, Dubna, 2007.

WHAT CAN WE LEARN ABOUT THE LIPID VESICLE STRUCTURE FROM THE SMALL ANGLE NEUTRON SCATTERING EXPERIMENT?

M.A. Kiselev

Frank Laboratory of Neutron Physics, Joint Institute for Nuclear Research, Dubna

141980, Russia

E-mail: kiselev@nf.jinr.ru

Unilamellar vesicles with diameter about 50-100 nm are important objects which are used as drug delivery agents for transportation of water soluble and insoluble drugs. Neutron and X-ray small angle scattering are appropriate method for the characterization of the vesicle nanostructure. Method of separated form factors (SFF) was proposed to analyses the small angle scattering curve [1]. SFF method was successfully tested on the two populations of DMPC vesicles at different temperatures [2]. New unique information was obtained about properties of the curved DMPC membrane. Water distribution function across the lipid membrane of the unilamellar vesicles was calculated for the first time [3]. This result demonstrates the permeability of the DMPC membrane for the water molecules. The main statement of the SFF method and its possibilities are discussed. The first application of the SFF method for the characterization of the phospholipid transport nanosystem (FTNS) is presented.

References

[1] M.A. Kiselev, P. Lesieur, A.M. Kisselev, D. Lombardo, V.L. Aksenov. *Model of separated form factors for unilamellar vesicles.* Applied Physics A, 74 Suppl., S1654-S1656 (2002).

[2] M.A. Kiselev, E.V. Zemlyanaya, V.K. Aswal, R.H.H. Neubert. *What can we learn about the lipid vesicle structure from the small angle neutron scattering experiment?* European Biophys. J., 35, 477-493 (2006).

[3] M.A. Kiselev, E. V. Zemlyanaya, N.Y. Ryabova, T. Hauss, S. Dante, D. Lombardo. *Water distribution function across the curved lipid bilayer: SANS study.* Chemical Physics, 345, 185-190 (2008).

[4] M.A. Kiselev. *Methods for investigation of lipid nanostructures at neutron and synchrotron sources.* Particles&Nuclei, 42, 578-635 (2011).

MULTIELEMENT INSTRUMENTAL NEUTRON ACTIVATION ANALYSIS OF MACROALGAE *CYSTOSEIRA* USED AS BIOMONITOR OF THE BLACK SEA COASTAL WATERS IN SEVASTOPOL REGION

Kravtsova A.V.[1], Milchakova N.A.[1], Frontasyeva M.V.[2], Dmitriev A.Yu.[2]

[1] *Institute of Biology of the Southern Seas, 2, Nakhimov avenue, 99011 Sevastopol, Ukraine;*

[2] *Joint Institute for Nuclear Research, 6,* Joliot-Curie str., 141980 *Dubna, Russia*

Macroalgae can accumulate trace elements in concentrations that are orders of magnitude greater than their content in the environment. This ability allows using them for indication the level of pollution of coastal waters [1]. The data on the features of accumulation of trace elements by the Black Sea macroalgae are scarce, making it difficult to give recommendations for their use as biomonitors. In this paper we studied the features of macro- and trace elements accumulation by brown macroalgae *Cystoseira barbata* C. Ag. and *Cystoseira crinita* (Desf.) Bory depending on the season, age and morphostructural elements of the thalli. Algae sampling was carried out in spring and summer of 2012 at the five sites of Sevastopol water area with different anthropogenic load. For the first time for the studied area the concentrations of 26 elements (Al, Cl, Ca, V, Mg, Mn, I, Na, K, Sc, Fe, Co, Ni, Zn, As, Br, Rb, Sr, Sb, Cs, Ba, Sm, Nd, Ag, Au and U) in algae *Cystoseira* were determined by means of INAA performed at the pulsed fast reactor IBR-2, FLNP JINR [2]. It was shown that the average content of trace elements in *Cystoseira* evidences for the degree of contamination of the studied waters. The content of trace elements in the stems and branches of macroalgae from the same station differs by a factor of 2-7. In spring the concentration of the most elements in branches of plants is lower than in summer; for stems the reverse regularity was observed. The highest concentrations of trace elements were found in young plants under the age of 1 year at all stations, regardless of their pollution degree.

References

1. Burdin K.S., Zolotuhina E. Yu. Heavy metals in aquatic plants (Accumulation and toxicity), Moscow: Dialog MSU, 1998 – 202 p.
2. Frontasyeva M.V. Neutron activation analysis for the Life Sciences. A review. *Physics of Particles and Nuclei*, 2011, Vol. 42, No. 2, p. 332-378.

TEST AND IMPROVEMENT OF THE NEW METHOD FOR CHECKING OF THE NEUTRON ELECTRONEUTRALITY BY THE SPIN INTERFEROMETRY TECHNIQUE

I.A.Kuznetsov, V.V.Voronin

Petersburg Nuclear Physics Institute, 188300, Gatchina, Russia

In the frameworks of preparation for the experiment to check the neutron electroneutrality, the simple test of possibility to measure a small phase shift by the SESANS technique was done at the WWR-M reactor (PNPI, Gatchina). The good agreement of the theoretical and experimental dependencies was obtained.

Improvement of SESANS – like spin interferometry technique is proposed. It based on a well known effect of diffraction enhancement when a small variation of the incident neutron beam direction leads to a considerable deflection of a neutron trajectory inside a crystal. The prototype variant of setup is now under construction.

This work was supported by the Russian Foundation for Basic Research (project nos. 12-02-00441-a) and by the Ministry of Education and Science of the Russian Federation (project nos. 2012-1.2.1-12-000-1012-016).

TRANSFERMIUM NEUTRON-RICH NUCLEI PRODUCTION IN PULSED NEUTRON FLUXES OF NUCLEAR EXPLOSIONS

Lutostansky Yu.S.[1], Lyashuk V.I.[2, 1]

[1] National Research Center "Kurchatov Institute", Moscow, 123098 Russia
[2] Institute for Nuclear Research, Russian Academy of Science, Moscow, 117312 Russia

The model of transuranium isotopes production under condition of pulse explosive nucleosynthesis was developed in 1985 [1] – 1990 [2] years. Later on this model was extended by including effects connected with adiabatic expansion of matter and adopted for pulse conditions of very short in time ($t < 10^{-6}$c) nuclear explosion [3]. The model was also extended for binary starting target-isotopes compositions [4] – adiabatic binary model (ABM).

Half-life periods, probability of emission for one and two delayed neutrons, probability of delayed fission for unknown neutron-rich isotopes were calculated taking into account the β-strength function, which obtained from the finite-Fermi system theory [5]. These beta-delayed process, as well as α-decay and spontaneous fission, were taken into account by means of the "losing"-factor – $L(A)$, that allows to evaluate loss of concentrations in the isobar chains for produced isotopes. Namely this "losing-effect" allowed to explain the even-odd inversion in the observed yields for mass number $A > 250$.

Calculations of transuranium and transfermium nuclei production were made, using ABM model, for "Mike", "Par" and "Barbel" events, performed in 1952 - 1964 years in USA. In these "experimental" thermonuclear explosions the neutron flux on the ^{238}U-target was from $(1.2\text{-}1.8)\cdot10^{24}$ ("Mike") to ~ $6.6\cdot10^{24}$ ("Par", "Barbel") neutron/cm^2 [6]. The calculations of isotope yields for 3 thermonuclear explosions were realized for the single ^{238}U and for binary targets. The obtained results are in good agreement with the experimental data. The possible isotope yields up to $A = 290$ was calculated, using ABM, with start ^{238}U and ^{239}Pu isotopes and small admixture of ^{248}Cm or ^{251}Cf. It is shown that for nuclei with $A \geq 260$ adding small admixture of ^{248}Cm or ^{251}Cf isotopes in uranium target led to increasing yields of these nuclei up to 2 orders of degree. As our calculations for the "Par" experiment conditions shown, for nuclei with $A = 280 - 290$ the yields must be very small and the production of superheavy elements with $A \sim 290$ is only possible when using binary mixture of starting isotopes with the notable addition of heavy components, such as long-lived isotopes of curium, or californium.

The work is supported by the RFBR grants № 11-02-00882 and № 12-02-00955.

1. Yu.S. Lyutostanskii, et al., Yad. Fiz. 42, 215 (1985) [Sov. J.Nucl. Phys. 42, 136 (1985)].
2. Yu.S. Lutostansky, V.I. Lyashuk, I.V. Panov, Bull. Russ. Acad. Sci. Phys. 54, 2137 (1990).
3. V.I. Lyashuk, Bull. Russ. Acad. Sci. Phys. 76, no. 11 (2012).
4. Yu.S. Lutostansky, V.I. Lyashuk, I.V. Panov, Bull. Russ. Acad. Sci. Phys. 75, 533 (2011).
5. Yu.S. Lutostansky. Phys. At. Nucl. 74, 1176 (2011).
6. S.A. Becker, "Approximating the r-Process on Earth with Thermonuclear Explosions: Lessons Learned and Unanswered Questions", Carnegie Observatories astrophysics series. Vol. 4: Origin and Evolution of the Elements, 2004. Ed. A. McWilliam and M. Rauch (Pasadena: Carnegie Observatories, pp.1-10. 2004.

RESULTS OF COOPERATION BETWEEN SLOVAKIA AND FLNP JINR IN THE ENVIRONMENTAL RESEARCH (2000–2013)

B. Maňkovská, J. Oszlányi,
Institute of Landscape Ecology of the SAS, Bratislava, Slovak Republic
A. Tučeková,
NFC, Forest Research Institute, Zvolen, Slovak Republic
P. Andráš, J. Dubieľ,
Matej Bel University, Tajovského 40, 974 01 Banská Bystrica, Slovak Republic
M.V.Frontasyeva, S. S. Pavlov
Frank Laboratory of Neutron Physics, JINR, Dubna, Russian Federation
M. Florek, K. Holý, J.
Department of Nuclear Physics and Biophysics, Comenius University, Bratislava, Slovak Republic

During last years cooperation between Slovakia and FLNP JINR focused on the environmental studies. The moss (from 86 sampling sites located in Slovakia) was the objects of investigations. INAA at the IBR-2 reactor and flame AAS were applied in order to determine 44 elements in moss collected in 2000 and 2010. The concentrations of trace metals, rare earths, and actinides were evaluated in the vegetation organs of forest tree species, too (sites: aluminium plant; iron ore mines; contamination of mining territory by toxic elements at selected Cu-deposits and possibilities of their remediation). To the best of our knowledge, such a large association of elements has never been studied before in the environmental samples from Slovakia. Factor analysis was applied to determine possible sources of trace element deposition in the Slovakian moss. The transboundary contamination with Hg through dry and wet deposition from Czech Republic and Poland is evident in the bordering territory in the north-west part of Slovakia (The Second Black Triangle), known for metallurgical works, coal processing and chemical industries. Knowledge of the current contents of individual elements in the moss-biomonitors allowed us estimating their absolute atmospheric deposition levels ($mg \cdot m^{-2} year^{-1}$). Our data (only trace metals) were incorporated into the European programme "*Atmospheric heavy metal deposition in Europe – estimations based on moss analysis*". The full dataset was published in *"Mapping of Main Sources of Pollutants and their Transport in Visegrad Space"* (a printed publication+CD-edition), which was distributed among different environmental institutions of Slovakia in 2007.

Acknowledgements:
This article was realized due the financial support of grant APVV-0663-10, APVV-0889-11 and grant of Plenipotentiary of Slovakia at JINR in 2012.

TEMPORAL AND SPATIAL TRENDS (1990- 2010) OF HEAVY METAL ACCUMULATION IN MOSSES IN SLOVAKIA

Maňkovská, B., Oszlányi, J., Izakovičová, Z.,
Institute of Landscape Ecology, Slovak Academy of Sciences, Štefánikova str. 3, 814 99 Bratislava
Email: bmankov@stonline.sk, julius.oszlanyi@savba.sk, zita.izakovicova@savba.sk
Tučeková,A.,
NFC, Forest Research Institute, Zvolen, Slovak Republic

The use of mosses as biomonitors of atmospheric deposition of heavy metals in Slovakia started more than 30 years ago in connection with the problems of the forest dying in Slovakia. In 1990s, within the framework of UNECE ICP Vegetation programme, systematic studies using moss were carried out in Slovakia (net 16x16 km), and the results were presented in the European Atlas *Atmospheric Heavy Metal Deposition in Europe – Estimations Based on Moss Analysis*. It is assumed that in the Slovakia (SK) a large gradient of the atmospheric deposition load of elements exists because part of the SK territory belongs to the most polluted areas in central Europe known as the 'Black Triangle II'. In order to recognise the distribution of element deposition in the SK, the moss monitoring technique, also known as bryomonitoring, was applied to the whole territory in 1990, 1995, 1996, 1997, 2000, and 2005 (Maňkovská et al, 2008, Schröder, et al.,2008).

The moss samples of *Hylocomium splendens, Pleurozium schreberi* and *Dicranum* sp. were collected in the Slovakia. Separate we are evaluated in National parks, in Landscape protection area and industrial area. In comparison to the median northern Norway values of heavy metal contents in moss the Slovak atmospheric deposition loads of the elements were found to be the survey has been repeated and in this paper we report on the temporal trends in the concentration of Cd, Cr, Cu, Fe, Hg, Ni, Pb, V and Zn between 1990 and 2005. Metal- and sites -specific temporal trends were observed. In general, the concentration of Cd, Cr, Cu, Fe, Hg, Ni, Pb, V and Zn in mosses decreased between 1990 and 2005; the decline was higher for Pb than Cd. The observed temporal trends for the concentrations in mosses were similar to the trends reported for the modelled total deposition of cadmium, lead and mercury in Europe. The level of elements determined in bryophytes reflects the relative atmospheric deposition loads of the elements at the investigated sites. Factor analysis was applied to determine possible sources of trace element deposition in the Slovakian moss. In the industrial area of Central Spiš we found that levels for Al, As, Ca, Cd, Cl, Co, Fe, K, Mn, Sb, Sm, Sr, W, and Zn exceed the Norwegian maximal values (Central Norway is a relatively pristine region).

Keywords: air pollution, bryomonitoring, heavy metals.

Acknowledgements: This study realized due the financial support of grant APVV-0663-10 and APVV-0889-11.

Intersection of Proton Radiography and Basic Research in Los Alamos

C. L. Morris

LAMPF was an 800 MeV linear accelerator that was built in the 1970s as a pion factory. Nuclear physics funding was withdrawn in the 1990s and the focus of research with the accelerator changed to materials science and proton radiography. This talk will describe a new opportunity that came from the proton radiography research to build an Ultra-Cold Neutron (UCN) source that shares its beam with proton radiography. This history and the performance of the source will be presented.

Hauser – Feshbach model calculation of the (γ,n) cross sections for some s-process nuclei

C. Oprea[a], A. Oprea[a], A. Mihul[b]

[a]*Joint Institute for Nuclear Research (JINR), Joliot- Curie 6, Dubna 141980, Russia*
[b]*Dept. of Nuclear. Physics, University of Bucharest, 76900 Magurele, Romania*

The photoneutron cross section for some s-process nuclei using the Hauser - Feshbach formalism and Talys computer codes have been evaluated. The cross sections of (γ,n) reactions were evaluated with nuclear reaction computer codes Talys employing the default parameters such as nuclear potential, parameters of the levels and density levels. In a wide range of incident gamma quanta energies the contributions to the total cross section of (γ,n) reaction due to the charged particle channels like (γ,1n), (γ,2n), .., (γ,xn), (γ,pn) and others were analyzed.
The theoretical evaluations of the s- and p-process nuclei cross sections are part of the scientific program of isotopes production and they are used in the proposals for experiments to the IREN basic facility, the new neutron source from FLNP of JINR Dubna.

[1] P. Mohr, T. Shizuma, H. Ueda, S. Goko, Y. Makinaga, K. Y. Hara, H. Hayakawa, Y.-W. Lui, H. Ohgaki, H. Utsunomiya, Phys. Rev. 69, 032801, (2004).
[2] T. Shizuma, H. Utsunomiya, P. Mohr, T. Hayakawa, S. Goko, A. Makinaga, H. Akimune, T. Yamagata, M. Ohta, H. Ohgaki, Y.-W. Lui, H. Toyokawa, A. Uritani, S. Goriely, Phys. Rev. C 72, 025808 (2005).
[3] V. Hauser, W. Feshbach, Phys. Rev. 87, 2, 366, (1952).

Cross section of nuclear reactions induced by neutrons on ^{36}Cl applied in astrophysics

C. Oprea[1], I. A. Oprea[1], P. J. Szalanski[2], P. M. Potlog[3]

[1]*Frank Laboratory of Neutron Physics, JINR, Dubna 141980, Russia*
[2]*Dept. of Astrophysics, Faculty of Physics, Lodz University, Lodz, Poland*
[3]*Institute of Space Sciences, 077125 Magurele, Romania*

One of the important problems in astrophysics is the origin and the relative abundance of ^{36}Cl isotope and the production of this isotope during s-process of nucleosynthesis. A series of problems connecting with the uncertainties in the (n,p), (n,α) and (n,γ) reactions leading to the decreasing or increasing of the concentration of ^{36}Cl isotope should to be analyzed. For this reason the cross sections of mentioned reactions at the astrophysical relevant energies using Talys and Empire computer codes were evaluated. The theoretical calculations of cross sections for determination of isotopes astrophysical reaction rates were used and the results are compared with experimental results from literature. These data are required for better understanding of the origin of the rare neutron rich isotopes in the S-Cl-Ar region and for a discussion of the $^{40}K/^{40}Ar$ chronometer.

[1] P. E. Koehler, S. M. Graff, H. A. O'Brien, Yu. M. Gledenov, Yu. P. Popov, Phys. Rev. C, 47, 5, 2107 (1993).
[2] W. A. Fowler, G. R. Caughlan, B. A. Zimmerman, Annu. Rev. Astron. Astrophys., 5, 525 (1967)
[3] E. M. Burbidge, G. R. Burbidge, W. A. Fowler, F. Hoyle, Rev. Modern Physics, 29, 4, 547, (1957)
[4] K. Takahashi, K. Yokoi, Atomic Data and Nuclear Data Tables, 36, 375, (1987)

TEST OF AVERAGE DESCRIPTION OF E1 GAMMA TRANSITIONS IN ATOMIC NUCLEI

Plujko V. A.[1,2], Gorbachenko O. M.[1], Rovenskykh E. P.[1,2], Zheltonozhskii V.A.[2]

[1] *Taras Shevchenko National University, Kyiv, Ukraine*
[2] *Institute for Nuclear Research, NAS of Ukraine, Kyiv, Ukraine*
plujko@univ.kiev.ua

New version of a modified Lorentzian approach [1-3] for radiative strength function (RSF) is studied. It is based on nuclear response function with shape width that is dependent both on gamma-ray energy and on energy of the first collective quadrupole state. The overall comparison of the calculations within different simple models[3] and experimental data[4-9] are performed. It shows that the EGLO, GFL and MLO (SMLO) approaches[3] with non vanishing values of strength function at zero gamma-ray energy provide universal and rather reliable simple methods for estimation of the dipole RSF over a relatively wide energy interval ranging from zero to slightly above the giant dipole resonance peak. In generally, new version of MLO model (MLO4) leads to better description of the experimental data than previous ones as for gamma-decay and for photoexcitation functions.

The gamma-ray spectra and excitation functions of neutron-induced nuclear reactions are calculated by the use of EMPIRE 3.1 code [10] with different expressions for RSF. On the whole, the calculations within the RSF models with energy-dependent width are in better agreement with the experimental data for middle-weighted and heavy nuclei.

1. V.A. Plujko et al. // Intern. Nucl. Data Conf. Science and Techn. ND2013, 03-08 March 2012,USA, NY, Book of Abstracts, P.217.
2. V.A. Plujko et al. // Nuclear Physics and Atomic Energy.2012. V.13. 335.
3. R. Capote et al. // Nucl. Data Sheets. 2009. V.110. P.3107.
4. A.M. Sukhovoj et al. // in Proc. of the XV Int. Seminar on Interaction of Neutrons with Nuclei. (Dubna, May 2007)} 92
5. A.M. Sukhovoj et al. // Izvestiya RAN. Seriya Fiz. 2005 V.69. P.641.
6. E. Melby et al.// Phys. Rev.C. 2001. V.63. 044309.
7. U. Agvaanluvsan et al. // Phys. Rev. C. 2004. V. 70. 054611; http://ocl.uio.no/compilation/.
8. R. Schwengner et al. // Phys. Rev. C. 2010. V.81. 034319.
9. R. Schwengner et al. // Phys. Rev. C. 2008. V.78. 064314.
10. M. Herman et al.// Nucl.Data Sheets. 2007. V.108. P.2655.

MOSS BIOMONITORING OF AIR QUALITY IN ROMANIA

Popescu V.I.[1,6,8], Frontasyeva M.[2], Stihi C.[1,6], Ene A[3]., Cucu-Man S.[4], Todoran R.[5], Culicov O.[2], Zinicovscaia I.[2], My Trinh[2], Pavlov S.S.[2], Radulescu C.[1,6], Chilian A.[6,7], Gheboianu A.[6], Bancuta R.[7], Cimpoca Gh.V.[1,6], Bancuta I.[6], Dulama I.[6], Toma L.G.[6], Bucurica A.[6], Dima G.[1,6], Chelarescu E.D.[8,9], Drasovean R.[3], Sion A.[3], Condurache-Bota S.[3], Buhaceanu R.[4], Tarcau D.[4], Todoran D.[5]

[1] Valahia University of Targoviste, Faculty of Sciences and Arts, Sciences Department, 2 Carol I St., 130024, Targoviste, Romania

[2] Joint Institute for Nuclear Research, Frank Laboratory of Neutron Physics, 141980 Dubna, Moscow Region, Russia

[3] Dunarea de Jos University of Galati, Department of Chemistry, Physics and Environment, Faculty of Sciences and Environment, 111 Domneasca St., 800201 Galati, Romania

[4] Alexandru Ioan Cuza University, Faculty of Chemistry, 11 Carol I St., 700506, Iasi, Romania

[5] Technical University of Cluj-Napoca, North University Center, 62A Victor Babes St., 430083, Baia Mare, Romania

[6] Valahia University of Targoviste, Multidisciplinary Research Institute for Sciences and Technologies, 13 Sinaia St., 130004, Targoviste, Romania

[7] Valahia University of Targoviste, Doctoral School on Engineering Sciences, 35 Lt. Stancu Ion St., 130105, Targoviste, Romania

[8] "Horia Hulubei" National Institute for Physics and Nuclear Engineering, 30 Reactorului St., P.O.BOX MG-6, Bucharest-Magurele, Romania

[9] University of Bucharest, Faculty of Physics, Doctoral School, P.O.BOX MG - 11, 077125 Bucharest-Magurele, Romania

The aim of this study was to assess the air quality in Romania using terrestrial moss, to reveal highly polluted critical regions in the country in order to permanently survey the degree of atmospheric pollution and to contribute to the European moss survey 2010/11 conducted under the auspices of the UNECE ICP Vegetation covering some "white areas" in the map of atmospheric deposition of heavy metals in Europe. Within the bilateral project JINR-Romania, "Nuclear and related analytical techniques for Environmental and Life Sciences", moss samples were collected during the summer/autumn of 2010 at 303 sites in Romania: in the Carpathian Mountains, Transylvanian plateau, and Moldavia province, following internationally accepted guidelines. A total of 42 elements (Na, Mg, Al, Cl, K, Ca, Sc, Ti, V, Cr, Mn, Fe, Co, Ni, Zn, As, Se, Br, Rb, Sr, Zr, Mo, Ag, Cd, In, Sb, I, Cs, Ba, La, Ce, Sm, Eu, Tb, Hf, Ta, W, Au, Hg, Pb, Th, and U) were determined by epithermal instrumental neutron activation analysis at the pulsed fast reactor IBR-2, FLNP, JINR, complemented by AAS in the Valahia University of Targoviste, Romania. Principal component analysis (factor analysis) was used to classify the data and to identify possible sources of the elements. GIS technology (geographic information system) was used for constructing maps based on factor scores along with maps of the distribution of heavy metals and some other toxic elements expressed by these factors over the investigated territory. This study revealed several areas that are under particular environmental stress. A comparison with the results obtained in previous moss surveys in Romania was made.

LIGHT SHAPE ISOMERS IN THE CCT CHANNEL?

Yu.V. Pyatkov[1,2], D.V. Kamanin[1], A.A. Alexandrov[1], I.A. Alexandrova[1], N.A. Kondratyev[1], E.A. Kuznetsova[1], A.O. Strekalovsky[1], O.V. Strekalovsky[1], V.E. Zhuchko[1]

[1]Joint Institute for Nuclear Research, 141980 Dubna, Russia
[2]National Nuclear Research University "MEPHI", 115409 Moscow, Russia

In our previous pablications devoted to the collinear cluster tri-parttition of the low excited nuclei [1, 2] we have discussed the role of scattering medium in the registration of the CCT products. Briefly, even if initially two CCT partners fly in the same direction perfectly collinearly they get some angular divergence after passing the scattering medium on the flight pass due to the multiple scattering. Thanks to such effect they can be registered independently in the "stop" mosaic detector. Actually even thin backing of the radioactive source provides the observable effect. In order to increase it additional absorber (Ti foil of 2.2mkm thick) was introduced just after the source at the distance of approximately 1mm. We observe essential mass deficit in the total mass of the fission fragments detected in coincidence with Ti ions knocked out from the foil. It could be expected if the scattered fragment looks like a di-nuclear system destroying due to inelastic scattering on the Ti nucleus. A mean flight time between the Cf source and the foil does not exceed 0.1 ns. It can be regarded as a low limit for the life time of the di-nuclear system (shape-isomer). Verification of the preliminary result presented is in progress.

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.

An Exotic Long-Lived Particle "Neutroneum"

Yu.L. Ratis

Institute of power engineering for special applications, Samara, Russia

The possibility of the existence of the exotic neutral long-lived particle "neutroneum" is proved. This particle is the low-laying extremely narrow resonance in the elastic electron-proton scattering. This resonance is caused by the weak interaction and corresponds to the transition of the initial state of the system «electron + proton» into the virtual neutron-neutrino pair. Due to its small width and amplitude this resonance cannot be registered in the direct experiment on *ep* - scattering. The third particle at the collision of the electron and the atom of hydrogen results in a three-body effect in the expression for the cross-section of the creation of the neutroneum – the two-particle propagator of the electron and proton (excited hydrogen) is under the integral. Therefore the width of the resonance in the cross-section of the creation of the neutroneum at colliding of the electron with the atom of hydrogen is by eleven orders more than the width of a similar resonance in elastic *ep* - scattering, and its properties can be investigated experimentally.

If we consider only quantum number set of this particle, than we can characterize it as the quasi-stationary state of the quasi-bound neutrino in the neutron – an exotic neutrino atom. From the point of view of the Heisenberg uncertainty principle the exotic neutrino atom have the same status as the neutron, which has an opened channel of the decay into proton, electron and the electron antineutrino. However, the assertion that the neutron consists of the decay products is incorrect, since the Compton wavelength of the leptons in this case is much larger than the size of the neutron.

It is shown that the exotic atom "neutroneum" [1] – [4] is neutral nuclear-active particle, due to exotic low-energy nuclear reactions.

The lifetime of the neutroneum at the low energies when the decay channel $n_\nu \rightarrow p + e^-$ is open only, are about $\sim 10^{-6}$ seconds.

The mass of neutroneum is $m_{n\nu} >> m_p + m_e$.

The generation of the neutroneum $H(e,e')n_\nu$ in the gaseous hydrogen (protium) target has a threshold of order 100 – 1000 eV.

The cross section of the neutroneum generation in the reaction $H(e,e')n_\nu$ in the gaseous protium is approximately 1μb.

Based on the hypothesis of the existence of neutrino exotic atoms one could theoretically explain a) the prevalence of tritium in nature, and b) the ratio of the release tritium/neutron in the CF reactions ($T/n \sim 10^9$), etc.

References

1. 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
2. Ratis Yu.L., Controlled "thermonuclear" or cold fusion? The drama of the ideas. Samara. Issue SSC RAS, 2009. 93p.
3. Ratis Yu.L., Applied physics (rus), **1**, 21 (2010).

INTERSPECIES COMPARISON OF ELEMENTAL CONTENT IN MOSS FROM IVANOVO REGION DETERMINED BY NAA AND AAS

Rumyantsev I.V.[1], Dunaev A.M.[1], Frontasyeva M.V.[2], Ostrovnaya T.M.[2]

[1] Ivanovo State University of Chemistry and Technology, Ivanovo, Russia
[2] Joint Institute of Nuclear Research, Dubna, Russia

Among various techniques for environment contamination control the biomonitoring methods found recognition because they are simple, cheap and fast processing. Mosses as biomonitors of air pollution have an advantage expressed in developed surface, high cation exchange capacity and absence of covering tissues. However different moss species exhibit different ability to metal accumulation. Coefficients of metal accumulation for three moss species: *Hylocomium splendens, Pleurozium schreberi* и *Polytrichum commune* were calculated based on the results obtained by atomic absorption spectroscopy (AAS) in Ivanovo and neutron activation analysis (NAA) in Dubna. A total of 25 moss samples were collected in July, 2010 according to UNECE ICP Vegetation monitoring manual. Sampling grid on average was about 20 km. The determination uncertainties were about 30% and 10% for AAS (Pb, Cd, Cr, Co, Cu, Zn, Ni, Mn, Fe) and NAA (Na, K, Mg, Ca, Al, In, V, Mn, Cu, Cl, Br, I, Si), respectively.

AAS showed the presence of all elements under study except cobalt. The concentrations of Cu and Mn determined by NAA are on average 2 and 3 times, respectively, higher than the AAS data. It is explained by incomplete dissolution of Cu and Mn compounds while sample preparation for AAS using wet digestion and 1M HNO_3 extraction.

The interspecies comparison was made. It was revealed that *Pleurozium schreberi* has the highest ability for accumulation of elements, especially for In, Cu, Br, and I. It was found that the average ratio between concentrations in *Pleurozium schreberi* to *Polytrichum commune* was 1.32. The same results were obtained for *Pleurozium schreberi/Hylocomium splendens* ratio. Among three moss species under study *Pleurozium schreberi* showed itself as most suitable for biomonitoring purposes.

Development of Component System for Neutrons Spectrometry Automation Using Network Technologies

I.M. Salamatin, K.M. Salamatin

JINR, LNP
International University "Dubna"
str. University 17, Dubna, Moscow reg., 141980 Russia
del@tmpk.ru

Based on the analysis of modern network technologies and specificity of experiments automated systems (SAE) formulated the concept of the components-based SAE. Identified key tasks required for the construction of such a system are the development of a universal task preparation subsystem and distributed component interaction layer. The solution of these tasks is described. These results allow the reuse of components, increase their reliability, significantly reducing development time, modification of the SAE in accordance with the methodology of the experiment can be performed by users.

MILESTONES OF NEUTRON ACTIVATION ANALYSIS

Eiliv Steinnes

Department of Chemistry, Norwegian University of Science and Technology (NTNU), NO-7091 Trondheim, eiliv.steinnes@ntnu.no

Neutron activation analysis (NAA) was first demonstrated in 1936 but became of practical use only after the general access to nuclear reactors around 1950. The superb detection limits for many elements in NAA compared to other available analytical techniques stimulated to applications in many areas, particularly in the geosciences where NAA was used particularly during the extensive studies of extraterrestrial matter such as lunar samples from the Apollo missions. Another area where NAA led to considerable scientific improvement was the study of trace elements in biological material, where contamination problems had produced a lot of false data using conventional chemical techniques.

The access to solid-state detectors during the late 1960s facilitated determination of many elements directly and simultaneously avoiding time-consuming radiochemical separations prior to activity measurements. At the same time the use of epithermal neutrons was shown to offer some advantages relative to the whole reactor spectrum. Later developments in detection systems and spectrum resolution have gradually improved the conditions for instrumental NAA.

The peak of NAA was probably during the late 1970s when first-class research groups employing were active in universities and research centers in a large number of countries. This is also when it was first recognized that irradiation of standards for each element can be replaced by a single neutron flux monitor, provided that the decay scheme of the radionuclides employed and the detection efficiency of the detector is known as a function of gamma energy. This means that NAA can be considered as a "primary method of measurements".

After about 1980 new developments in NAA have been moderate. During the same period ICPMS has developed into a reliable analytical technique with superb detection limits for most elements. Moreover the access to nuclear research reactors has been substantially reduced worldwide, and the number of young professionals in nuclear science is more limited than before. NAA is therefore in a difficult situation internationally, and it is now important that some international centers of excellence are continuing and strengthening their activity for the benefit of science and for society in general.

SPAGetty: THE GETTYSBURG COLLEGE 250 keV PROTON ACCELERATOR PROGRAM IN RESEARCH AND TEACHING

S. L. Stephenson[1], B. E. Crawford[1], E. I. Sharapov[2]

[1]Gettysburg College, 300 N. Washington Street, Gettysburg PA 17325, USA
[2]Joint Institute for Nuclear Research, 141980 Dubna, Russia

Abstract

Even though today's low-energy accelerators are primarily used in medical and industrial applications, our understanding of nuclear physics owes a debt to decades of research with low-energy accelerators. Here we present characteristics of SPAGetty (Student Proton Accelerator at Gettysburg College), a 250 keV Van de Graaff accelerator at Gettysburg College in Gettysburg, Pennsylvania, USA. Our research and education agenda involves physicists, chemists and undergraduates students in an interdisciplinary program including nuclear physics, surface physics, nuclear chemistry, polymer science, atomic physics, and materials physics.

TUNING EFFECT IN NEUTRON/NUCLEAR DATA FOR Z=5-30 NUCLEI

Sukhoruchkin S. I., Soroko Z. N., Sukhoruchkin D. S.

Petersburg Nuclear Physics Institute 188300 Gatchina

In this work we study properties of excitations of light nuclei Z=5-30 in which many neutron resonance parameters are included in the spectrum. We investigate an influence of the nucleon structure on spectra of nuclear excitations and on binding energies [1] using collected in PNPI files of nuclear data (NRF, CRF, MDF) published in [3-5]).

In the region of Z=9-11 many hundreds of states are known from the neutron resonance spectroscopy (for example, about 300 out of 400 in ^{24}Na). The system of stable intervals 162 – 492 – 642 – 1289 – 1931 – 2577 keV observed earlier in the spectrum of ^{18}F and in levels of ^{odd}Sb (period 161 keV, n=1,3,4,8,12,16) was confirmed by the long range correlations of the stable intervals D=2594 keV and 3784 keV (n=16,24) in the total spectrum of ^{24}Na (the period of 1292 keV, n=8, close to δm_N=1293 keV – the nucleon mass splitting).

In nuclei around ^{24}Mg, ^{28}Si, ^{32}S (one valence neutron above the even-even core or the proton hole in it) stable intervals seen as maxima in spacing distributions which include many neutron resonances were found to be directly connected with the low-lying excitations of the core (also observed in total spacing distributions).

Stable excitations are considered together with the parameters of the residual nucleon interaction in light and heavy nuclei. Performed analysis confirms a suggestion about the common tuning effect in particle masses and in nuclear data. This effect includes correlations in masses of mesons, nucleons, constituent quarks and fundamental particles of the Standard Model [1].

REFERENCES

1. S.I. Sukhoruchkin: Nucl. Phys. B (Proc. Suppl.) 234C (2013) pp. 241-244; DOI:10.1016/j.nuclphysbps.2012.12.022.
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 vols. I/25A,B. Springer, 2012; vols. I/25C,D,E, 2013.

POSSIBILITY, NECESSARY BASIS AND SPECIFICITY FOR DEVELOPMENT OF PERSPECTIVE PRACTICAL MODEL OF ARBITRARY NUCLEUS COMPOUND STATE DECAY

A.M. Sukhovoj, V.A. Khitrov

Joint Institute for Nuclear Research, Dubna, 141980, Russia

The dynamics of change of super-fluid properties of heated nucleus can be studied only by analysis of reliable experimental data on density ρ of its levels and probabilities of their excitation/decay at thermodynamics temperature T below ~1 MeV. For the majority of nuclei there is region of excitations where is impossible to distinguish individual levels by means of any existing spectrometers {except narrow region of neutron resonances).
It is known that at small excitation energies level density of quasi-particle type is considerably larger than that of levels on phonon type. Id est, at weak fragmentation of vibration states of nucleus in the total level density must hold step-like structure, and its values must be less than level density of non-interacting Fermi-gas.

Therefore, for discovery and study of super-fluidity of heated nuclei is necessary:
a) to obtain gamma spectra in forms maximally depending on ρ and minimally on – Γ and
b) to solve the reversed task of mathematical analysis with maximum possible precision.
The existing methods for determination of ρ (from the spectra of evaporation neutrons or total gamma-spectra) do not satisfy the enumerated conditions absolutely.

The partial solution of the problem under consideration – measurement of the spectra of gamma cascades following radiative capture of neutrons (protons) in resonances, terminating by one or several low-lying levels. For the experimental data of this kind there was realized the method of model-less determination of an interval of random values of parameters from the systems of degenerated non-linear equations. Random functions ρ and Γ from these intervals reproduce intensity of two-step cascades with the equal precision. In spite of inevitable presence of false solutions, there was obtained that accounting of influence of super-fluid phase of nuclear mater on gamma decay of neutron resonance improves precision in description of this process. This is the most important result obtained in previous cascade data investigations. It points to absolute necessity:
a) development of level density and partial radiative widths of models for mixture of interacting fermion and boson states of nucleus matter and determination of form of connection between values ρ and Γ at any excitation energy of nucleus.
b) broadening of spectrum of the observed two-step cascades (regions of their final levels), minimum, up to $0.5B_n$ and
c) measurement of spectra of cascades from evaporation nucleon in coincidence with one or several following cascade gamma-quanta on beams of charged particles.
The models which describe parameters of interacting nuclear systems must be useful for practical approximation of the measured cascade spectra and reliable enough determination of the break-up threshold of the 2-5 Cooper pairs of nucleons, as a minimum.

The necessary information can be effectively obtained from the experiments on beams of neutrons or charged particles for dispersion of excitation energy of initial decaying compound stats ΔE not more than ~0.001–0.1 MeV.

THE PROBLEMS OF DETERMINATION OF VIBRATIONAL LEVEL DENSITY BELOW B_n IN THE FRAMEWORK OF THE EXISTING MODEL NOTIONS

A.M. Sukhovoj, V.A. Khitrov

Joint Institute for Nuclear Research, 141980, Dubna, Russia

Development of practical model of neutron resonance cascade gamma-decay for extraction of maximally reliable level density and determination of the available in this case values break-up thresholds of Cooper pairs from the data on the intensities of cascades from two successive gamma-transitions from resonances to final levels with energy E_f<0.5-1 MeV brings to the conclusion on absolute necessity in further development of model notions on a nucleus as a system interacting bosons and fermions up to the nucleon binding energy or higher.

The necessity in this activity is stipulated by:

a) absence level density models of phonon type excitations which includes as a parameter, break up thresholds of Cooper pairs;

b) the absolute absence of practical model of the strength function of the $M1$-transitions for $E_\gamma < B_n$;

c) and necessity of modification (or development) of the strength functions models for dipole gamma-radiation of both electric and magnetic types for decaying or excited vibration levels.

The total density of quasi-particle and phonon levels ρ_{exp} in analysis [1] was set as a product $\rho_{exp} = C_{coll}\,\rho_n$ for the phenomenological chosen coefficient C_{coll} of collective enhancement of quasi particle density ρ_n for excitation energy of nucleus E_{ex} and break up thresholds U_n of Cooper pairs number n:

$$C_{coll} = A_n \exp(\sqrt{(E_{ex}-U_n)/E_\mu} - (E_{ex}-U_n)/E_\lambda) + \beta$$

The best values of the parameters A_n, U_n, E_μ and E_λ determinate from approximation of cascade intensities. Very close criterions χ^2 of results of different variants of approximation did not allow us to get unambiguous conclusion on found parameters of nucleus. There is consequence of very large dispersion of the best values of A_n parameters owing to its strong correlation with E_λ. Some idea of its form can be obtained from analysis of difference of ρ_{exp}-ρ_n from the data, analogous to that presented in [1].

There was obtained that for the description of the experimental data is necessary to pass from idea C_{coll} to quite new level density model ρ_{vib} of only vibration level type. The model must obviously is depended on the parameters U_n and E_λ. And in the first approach it can use the obtained by such manner the experimental data for its verification.

[1]*Sukhovoj A. M., Khitrov V. A.*, Report on ISINN21.

The Kolkhida Setup Upgrade

M.I. Tsulaia[1,2], *I.M. Salamatin*[1], *A.P. Sirotin*[1], *T.L. Pikelner*[1], *Y.D. Mareev*[1], *D. Berikov*[1]

[1]Joint Institute for Nuclear Research, Dubna, Russia
[2]Andronikashvili Institute for Physics, Tbilisi, Georgia

We have upgraded the Kolkhida setup, which is designed to investigate interactions of polarized neutrons with polarized nuclei. We have changed the electronics and the software of the polarized neutron spectrometer, which is part of the Kolkhida setup. The control system uses step engines and angular sensors. The software consists of the spectrometer adjustment subsystem, the spectrum registration program and the setup control subsystem. We have completely updated the vacuum system of the polarized nuclear target by changing the vacuum pumps and the vacuum measurement system.

FAST NEUTRON RADIATIVE CAPTURE BY MEDIUM-HEAVY MASS SPHERICAL NUCLEI: SEMI-MIROSCOPIC DESCRIPTION

Tulupov B.A.[1], **Urin M.H.** [2]

[1] Institute for Nuclear Research, RAS, Moscow, Russia;
[2] National Research Nuclear University «MEPhI», Moscow, Russia

Recently developed particle-hole dispersive optical model (PHDOM) [1,2] is applied to description of fast neutron radiative capture accompanied by excitation of the isovector dipole and quadrupole giant resonances in medium-heavy mass spherical nuclei. Within the mentioned model (as well as within the "pole" limit of this model called as the semi-microscopic approach to the description of the giant resonance damping [1]) the main relaxation modes of the high-energy particle-hole-type nuclear excitations are commonly taken into account. These modes are: Landau damping, coupling to the single-particle (s.p) continuum and the spreading effect. The first two modes are described microscopically with the use of a partially self-consistent phenomenological mean field and Landau-Migdal particle-hole (p-h) interaction, while the spreading effect is treated phenomenologically in terms of the imaginary part of an effective s.p. optical-model potential. The latter is exploited in the basic PHDOM equations, which correspond to the extension of the continuum- RPA standard and non-standard versions [2].

Basic relationships for differential cross sections (and their derivative: anisotropy and asymmetry) of fast neutron radiative capture are given in Refs. [3] and [4]. In these Refs. the cross sections are described within the semi-microscopic approach and PHDOM, respectively, with the use also of separable isovector velocity-dependent forces. The unique feature of both models is the description of direct+ semi-direct one-nucleon reactions induced by an s.p. external field without the use of specific adjustable parameters. All the model parameters are taken from independent data and from the description of the experimentally studied proper strength function (in the considered case - from description of the photo-absorption cross section). In the present work we attempt to improve semi-microscopic description of photoabsorption (in particular, the integrated cross section) to get a new version of the semi-microscopic description of fast neutron radiative capture by ^{89}Y, ^{140}Ce, ^{208}Pb.

[1] M.G. Urin, Phys. At. Nucl. **74**, 1189 (2011).
[2] M.H. Urin, EPJ Web of Conferences **38**, 02002(2012); Phys.Rev.C (in press).
[3] B.A. Tulupov, M.G.Urin, Phys. At. Nucl.**75**, 1041(2012).
[4] B.A. Tulupov, M.H. Urin, EPJ Web of Conferences **38**, 17010(2012).

Measurement of the left-right asymmetry in the integrated γ-spectrum in the interaction of the nuclei with polarized thermal neutrons

V.A. Vesna[1], Yu.M. Gledenov[2], V.V. Nesvizhevsky[3], P.V. Sedyshev[2], E.V. Shulgina[1]

[1] *PNPI, Gatchina, Leningrad reg., 188300 Russia;* [2] *JINR, Dubna, Moskow reg., 141980 Russia;*
[3] *ILL, Grenoble, F-38042 France*

The expression for the cross section of (n, γ)-reaction, containing 17 correlations, was given in paper [1]. Usually, P-odd angular correlations were observed in the integrated spectrum of γ-rays, in particular correlation $(\vec{\sigma}_n \cdot \vec{p}_\gamma)$. Very rarely this correlation could be observed for a single γ-transition because of the difficulty in the selection of γ-transition and the smallness of effects. Observation of effects in the integrated spectrum of γ-rays leads to an effect's averaging and to reduction in the effect's magnitude but makes it possible to perform an experiment.

P-odd asymmetry of the form $(\vec{\sigma}_n \cdot \vec{p}_\gamma)$ and the left-right asymmetry $(\vec{\sigma}_n \cdot [\vec{p}_n \times \vec{p}_\gamma])$, according to [1] depend randomly from the final nuclear state and are suppressed by statistical manner to a value of $O(\varepsilon)$. Effects of the P-odd and the left-right asymmetries occur due to the interference of γ-transitions between nuclear states of different parity and are enhanced near p-resonances. In two-resonance approximation, these effects are related. In the calculations of [1] it was shown that the ratio of the coefficients P-odd and left-right asymmetries for monochromatic line should coincide with ratio of the coefficients for the integrated spectrum. On the example of ^{117}Sn we saw that in integrated spectrum of γ-ray the P-odd effects should be approximately equal to the effects of the left-right asymmetry [1].

At various times, we have measured the coefficients of left-right asymmetry for a number of nuclei, where the P-odd asymmetry was previously detected. Measurements were carried out in the integrated γ spectrum. For each nucleus physical state of matter and chemical compounds in the measurements of coefficients of the P-odd (a_{p-odd}) and the left-right (a_{lr}) asymmetries were identical, the measurements were performed on the same detectors.

The table shows the values of the coefficients of the P-odd asymmetry, taken from [2, 3] and preliminary results of measurements of the left-right asymmetry. E_p is p-resonance energy.

Nucleus	$a_{p-odd} \cdot 10^6$	$a_{lr} \cdot 10^6$	E_p, eV
^{nat}Cl	−27.6±4.9 [2]	−3.5±2.9*	398
^{nat}Br	−19.5±1.6 [2]	−6.5±1.7*	0.88
^{nat}La	−17.8±2.2 [2]	3.9±3.3*	0.75
^{nat}Fe	4.04±0.83 [3]	5.4±5.5*	11.47
^{117}Sn	2.4±1.6 [2]	0.9±4.1*	1.33
^{nat}Cd	1.64±0.36 [3]; 2.52±0.46**	–	7

* Measurements were carried out at the reactor of PNPI (Gatchina).
** Result was obtained on the reactor of ILL (Grenoble).

In all cases where in the measurements of the P-odd asymmetry it was observed a significant effect, the coefficient of the left-right asymmetry was smaller than the P-odd coefficient, though, it would seem, according to [1], these factors should be approximately equal for the integrated spectrum.

Since reliably left-right asymmetry is not found in any of the investigated nuclei, except bromine, in our view it is necessary to continue its study onto beams with high neutron flux.

[1] 0.P. Sushkov and V.V. Flambaum. Preprint INP 83-87, Novosibirsk, 1983.
[2] Vesna V.A. et al., JETP Letters 36(5) (1982) 209.
[3] Vesna V.A. et al., Yad.Fiz. 52, 3(9) (1990) 620.

VERIFICATION OF THE WEAK EQUIVALENCE PRINCIPLE WITH LAUE DIFFRACTING NEUTRONS. CURRENT STATUS OF THE EXPERIMENT

V.V. Voronin[1], V.V. Fedorov[1,2], I.A. Kuznetsov[1], S.Yu. Semenikhin[1], Yu.P. Braginetz[1], E.O. Vezhlev[1,2]

[1]*Petersburg Nuclear Physics Institute*
[2]*St. Petersburg State Polytechnical University*

We report the current status of the experiment aimed at testing weak equivalence principle (WEP) for the Laue diffracting neutron.

Our experiment is based on an essential magnification of an external affect on neutron diffracting by Laue for the Bragg angles close to the right one in couple with additional enhancement factor which exists due to the delay of the Laue diffracting neutron at such Bragg angles. The total diffraction enhancement factor may be as large as 10^9. This enhancement phenomena is proposed to be utilized for measuring the force which deviates from zero if WEP is violated.

Recently we made a series of test experiments on WWR-M reactor (PNPI, Gatchina) to analyze how dynamical diffraction theory predictions work in our experimental geometry and also to analyze the influence of external impacts (vibration, deformation of a working crystal under its own weight, temperature gradients etc.). Test experiments showed that the resolution of the experimental setup can reach the magnitude $\sim 5 \cdot 10^{-13}\, eV/cm$. This extremely high resolution provides us with the possible sensitivity to the external force on the level of $\sim 10^{-17}\, eV/cm$ for the available silicon crystal and cold neutron beam flux. In measuring of inertial to gravitational neutron mass ratio we plan to attain the accuracy $\sim 10^{-5}$. This is one order of magnitude superior to the best present-day value for neutron.

We show that available technical equipment allows us to fight against all of the external impacts that can decrease the sensitivity of the setup on acceptable level.

This work was supported by the Ministry of Education and Science of the Russian Federation (agreement No. 8419 dated 24.08.2012) and by the Russian Foundation for Basic Research (grant 11-02-00188).

ABNORMAL NEUTRON DISPERSION IN CRYSTAL CLOSE TO BRAGG REFLEX

V. V. Voronin, Yu. V. Borisov, A. V. Ivanyuta, I. A. Kuznetsov, S. Yu. Semenikhin, V.V. Fedorov

Petersburg Nuclear Physics Institute, 188300, Gatchina, Russia

The features of the propagation of a neutron through a crystal near Bragg "resonance" has been studied within the framework of the preparation of an experiment on the search for the electric dipole moment of a neutron by the crystal diffraction method. The time of passage of the neutron through the crystal has been studied as a function of the deviation from the Bragg condition. The anomalous behavior of the dispersion of the neutron, i.e. the energy dependence of its average velocity, has been observed. It has been shown that the derivative dv /dE for the diffracting neutron near Bragg energy can be three or four orders of magnitude larger than this derivative for a free neutron. This phenomenon should be taken into account for the neutron EDM search experiment and opens new possibilities in precision neutron spectroscopy.

For instance, method for measuring small changes in the energy of a neutron has been proposed. A high sensitivity of the method allows the observation of the acceleration of the neutron in the alternating magnetic field. It has been found that the small difference between the energies of two spin states of the neutron (parallel and anti-parallel to the magnetic field) leads to significant spatial splitting of wave packets and, correspondingly, to the depolarization of the neutron beam.

This work was supported by the Russian Foundation for Basic Research (project nos. 12-020-0446-a) and by the Ministry of Education and Science of the Russian Federation (project nos. 2012-1.2.1-12-000-1012-016).

HISTORY OF DISCOVERY AND IMPLEMENTATION OF RADIOACTIVITY

Wacławek W. and Wacławek M.

Opole University, Opole, Poland

In 1895 prof. Wilhelm Conrad Roentgen [1845–1923] discovered a strange radiation, that is thus quickly named "X-rays". 2.5 months later Henri Becquerel [1852-1908] during studies on X-rays properties detected radiation spontaneously emitted (without an external source of energy) by potassium uranyl sulfate. H. Becquerel had discovered radioactivity. The first use of the word "radioactivity" appeared in 1899 in the publication by the Curies. Marie Sklodowska-Curie [1867–1934] in her Ph D. thesis (1904) described the three kinds of rays (α, β and γ) - they have different trajectories in a magnetic field. Marie together with her husband Pierre Curie [1859-1906] and thanks to the quantitative approach to their study, they discovered in 1898 two new radioactive elements. There were: polonium (a million time more radioactive than uranium) and radium (2.5 millions times more radioactive than uranium). She found that the radiation of the radioactive substances causes chemical reactions. That was the beginning of the radiation chemistry.

In 1934, Irene Joliot-Curie [1897-1956] and Jean Frederic Joliot-Curie [1900-1958] discovered the artificial radioactivity, making a great step toward the use and the control of radioactivity.

In 1938 Otto Hahn [1879-1968] and Fritz Wilhelm Strassmann [1902-1980] demonstrated that the uranium atom had split into two lighter atoms. Lise Meitner [1878-1968] and Otto Frisch [1904-1979] explained the process, to which they gave the name nuclear fission. It was only small step to the explosion of the atomic bomb.

In the twentieth century, called the Nuclear Age, 57 Nobel Prizes honored the chemical and physical results achieved by people who can be rightly called nuclear scientists. This number alone proves that nuclear science must be recognised as one of the most powerful engines pushing science to new heights. It is interesting to note, that until the middle of the XX century the ratio of Nobel Prises that honored nuclear results was 2 : 1 for physics and chemistry. However, after 1950, majority of them (only 2 in chemistry and one in medicine) were awarded in the field of physics.
There are many signs that nuclear science will remain important in the future as well. Radiopharmaceutical chemistry is stimulating biomedical research and nuclear medicine (diagnosis and therapy). The development of particle physics keeps its dynamism as demonstrated by the Nobel Prises awarded in this century (2002, 2004 and 2008).

Study of sapphire as thermal neutron filter for the MA-R1 TRIGA Moroccan reactor beam applications

N.Zahar[a], D.Benchekroun[a], B.Belhorma[b], P.Hermet[c], C.Broeders[d]

a. RUPHE, Hassan II University, Casablanca, Morocco
b. National Center for Nuclear Energy, Science and Technology, Rabat, Morocco
c. Institut Charles Gerhardt, Equipe C2M, UMR CNRS 5253, Montpellier, France
d. Karlsruhe Institute of Technology, Germany

Abstract

In this contribution selected results of a research project in the Laboratory of High Energy Physics and Scientific Computing at Hassan II University in Casablanca, and the National Center for Nuclear Energy, Science and Technology in Rabat, Morocco, are presented. The objective of the PhD thesis of the first author concerns the simulation of neutron diffraction experiments with the GEANT4 software, well established in the High Energy Science community. The main task of the present work consists of the modeling of the diffractometer geometry, definition of the incident reactor neutron flux as given by the reactor team, determination of neutron energy, counts and position distribution after each diffractometer component like filter, collimator, monochromator etc. An important task is to determine the thickness of sapphire (Al2O3) material that gives the best filtering efficiency. Actually, sapphire is hugely used in the experiments around the research reactor because of its good thermal neutron transmission and fast neutron attenuation. Up to now the attenuation of fast neutrons has been determined as a fucntion of the filter thickness.The thermal neutron characteristics could not be analyzed because there is no data for thermal scatterring for sapphire in the GEANT4 database G4NDLfiles. Generally it was found that there is no data library with ENDFB format available for thermal scattering in Al2O3. A conference contribution to PHYSOR-2006 discussed the creation of such data, without giving access to cross section libraries. A further problem is that no accessible software is available for the creation of G4NDL-files. The extensive search for a solution to include thermal scattering data for sapphire in the GEANT4 database lead to the following procedure:

- Preparation of thermal scattering data for Al2O3 with the format of the MCNP Monte Carlo code. These so-called "ace-files" with ENDFB format can be created with the widely used cross section processing NJOY code.

- Reformatting the "ace-files" to G4NDL library data. This step is committed by the "GEANT4 collaboration group" with their proprietary software. In the present contribution, the creation of "ace-files" with thermal scattering data for the Al2O3 crystal is presented with a particular emphasis on the LEAPR module of the NJOY code. The phonon density-of-state, required by the LEAPR module, has been calculated using the ABINIT package within a variational formulation to the density functional perturbation theory and the generalized gradient approximation. The resulting calculated thermal scattering data are carefully validated, using available experimental information from the EXFOR database and from analytic fits reported in the literature. Generally, good agreement has been achieved. Currently, the thermal scattering data for sapphire is available as a complete set of ENDFB format files. The conversion to the G4NDL library format will be the last step to be performed to enable reliable GEANT4 simulations for sapphire experimental components.

EDXRF DETERMINATION OF TRACE ELEMENT CONTENTS IN BENIGN PROSTATIC HYPERTROPHIC TISSUE

S. Zaichick[1,2], V. Zaichick[1]

[1] *Medical Radiological Research Centre, Koroleva str., 4, Obninsk, 249036, Russia, e-mail: vezai@obninsk.com*

[2] *Current address: Northwestern University, Chicago, IL, 60611, USA*

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. 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 trace elements depend on tissue-specific need or tolerance, respectively. Excessive accumulation or an imbalance of the trace 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 Zn mass fraction in the prostate was observed. High intraprostatic zinc accumulation is probably one of the main factors acting in an overgrowth of the prostatic cells. A significant tendency of age-related increase in Zn/Fe, Zn/Rb, and Zn/Sr mass fraction ratios in the prostate was recently demonstrated by us using radionuclide-induced (^{109}Cd) energy dispersive X-ray fluorescent (EDXRF) analysis. Hence it is possible that besides Zn, such trace elements as Fe, Rb, and Sr also play a role in the pathophysiology of the prostate. To that end, we determined Br, Fe, Rb, Sr, and Zn content in normal (n=37) and BPH (n=43) tissues of the human prostate gland by EDXRF method. 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, Fe, Rb, Sr, and Zn ($mg \cdot kg^{-1}$ on dry weight basis) in the intact and morphologic normal prostate tissue were: 40.6±5.6, 118±8, 16.3±1.1, 2.5±0.4, and 1154±119, respectively. Mean values (M ± SEM) for Zn/Br, Zn/Fe, Zn/Rb, and Zn/Sr ratio of mass fraction were: 39.1±6.2, 11.2±1.3, 71.7±9.0, and 534±83, respectively. No changes of parameters investigated by us in BPH tissue were found with the exception of Zn/Br ratio. The Zn/Br ratio was significantly higher in BPH tissues than in normal tissues.

NEUTRON ACTIVATION ANALYSIS OF Ca, Cl, Mg, Na, and P CONTENTS IN THE BENIGN GIANT CELL TUMOR OF BONE

S. Zaichick[1,2], V. Zaichick[1]

[1] *Medical Radiological Research Centre, Koroleva str., 4, Obninsk, 249036, Russia, e-mail: vezai@obninsk.com*

[2] *Current address: Northwestern University, Chicago, IL, 60611, USA*

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 benign giant cell tumor (GCT) of bone (or benign osteoblastoclastoma) and intact bone tissue using instrumental neutron-activation analysis with high resolution spectrometry of short-lived radionuclides (INAA-SLR). Samples were obtained from 13 patients (4 females and 9 males from 7 to 47 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 tumor 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 benign GCT tissue were: 156±16, 4.85±0.80, 2.43±0.20, 6.74±0.54, and 79.1±7.3 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 (≤0,001), Cl (≤0,001), and P (≤0,01) content in benign GCT compared to healthy bone suggest potential of these elements as GCT 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 ILIAC CREST INVESTIGATED BY NEUTRON ACTIVATION ANALYSIS

S. Zaichick[1,2], V. Zaichick[1]

[1] *Medical Radiological Research Centre, Koroleva str., 4, Obninsk, 249036, Russia, e-mail: vezai@obninsk.com*

[2] *Current address: Northwestern University, Chicago, IL, 60611, USA*

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 iliac crest 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 iliac crest. 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 iliac crest.

NOVEL APPROACH TO PROMPT FISSION NEUTRON INVESTIGATION

Zeynalov Sh., Zeynalova O., Sedyshev P., Shvetsov V.

Joint Institute for Nuclear Research, Dubna, Russia

Nuclear fission model and prompt fission neutron emission (PFN) was first considered in classic paper of N. Bohr and J. Wheeler [1], where nuclei considered as a drop of charged liquid, which surface constantly distorted in competition between attractive nuclear and repulsive Coulomb forces. Rarely large distortion brought the nuclear into the configuration, where repulsion could not be compensated by nuclear force and the system split, sometimes after neutron emission. A convenient way to study of PFN emission in low excitation energy fission is to use a traditional twin back-to-back ionization chamber, with two chambers sharing a common cathode [2]. For binary fission events the two complementary FF are simultaneously detected in two independent chambers. The pulse height induced by fission fragment ionization in each chamber is proportional to corresponding FF kinetic energy release and the FF pulse shape conveys information on the FF angle (Θ) in respect to the electric field applied in the direction of the normal to the cathode plane. From the correlated energies obtained in the above double-energy (2E) experiment, FF masses and velocities may be found [3]. If the point fissile target located on the common cathode's centre and the fast neutron detector (ND) was positioned at the certain distance along the normal to the target, then the angle between FF and the PFN emission would be equal to Θ. The PFN velocity may be determined from the known flight path and the measured time delay between cathode and ND pulses. Measured FF and PFN velocity vectors then may be used to reconstruct the PFN emission kinematics. The PFN multiplicity distributions in respect to FF kinetic energy release and mass split may be reconstructed by comparison of two sets of FF measurements. In the first experiment fission fragment mass and kinetic energy release should be evaluated from the measurement independent from ND. In the second experiment FF mass and kinetic energy release should be evaluated for the FF coincided with ND. The obtained experimental results are of great demand for theoretical models of fission process development. However, the conventional chamber had limited suitability for investigations of nuclei with "zero thickness" or point sources like ^{252}Cf. The chamber of new design was developed mainly with intention to overcome that limitation and perform measurements with nuclei as ^{235}U, ^{239}Pu and other, which technically could not be made of point size. It should be pointed out that PFN emission data, evaluated from the kinematic parameters, provide information not only on FF shape and excitation energy just before scission, but also provide unique possibility for investigation of the energy exchange by two nuclei at different temperature connected by the neck [4].

1. N. Bohr, J.A. Wheeler, *Physical Review*, 56, pp. 426 (1939)
2. C. Budtz-Jørgensen and H.-H. Knitter , *Nucl. Phys.*, A490, 307 (1988).
3. C. Wagemans, The Nuclear Fission Process, Boca Raton: Boca Raton, 1991.
4. K.-H. Schmidt, B. Jurado, Phys. Rev. Lett 104, 212501 (2010).

INVESTIGATION OF ISOMERIC YIELDS RATIOS IN PHOTO-FISSION REACTIONS (γ, f), (γ, nf) ON ^{235}U

V. A. Zheltonozhsky[1], A. N. Savrasov[1], E. P. Rovenskykh[2], V. A. Plujko[2], O. M. Gorbachenko[2]

[1] *Institute for Nuclear Research, NAS of Ukraine, Kyiv, Ukraine*

[2] *Nuclear Physics Department, Taras Shevchenko National University, Kyiv, Ukraine*

The measurement of isomeric yield ratios in (γ, f)-, (γ, nf)-reactions was done by using the electron beams extracted from the M-30 microtron of the Laboratory of Photonuclear Reactions at IEP. These electron beams were sources of the bremmsstrahlung photons. A cooled tantalum disk, 2-mm thick, served as a bremmsstrahlung producing target for the both beams. Exposures to bremsstrahlung photons were performed for the end point energies about 17 MeV. The mean electron current was around 1,5 μA. Targets were made of metallic foil of Al and lay down on it ^{235}U of 99% enrichment. The data set was carried out through a system of two HPGe spectrometers. We compared the obtained results with recent experiments and foreign experimental results.

Isomeric yields ratio of $^{133}Sb^{m,g}$; $^{134}Te^{m,g}$; $^{135}I^{m,g}$ have been determined in the photofission of ^{239}Pu and ^{241}Am with 17-MeV bremsstrahlung using offline γ-ray spectrometric technique. Experimental values of isomeric yields ratio have been obtained with take into consideration of the contribution from the β-decay of the nuclei-isobar in the yields of the investigated nuclei. From the isomeric yields ratio the average angular momenta of the corresponding fission fragments have been deduced using a statistical deexcitation model. The influence of the nonstatistical effects has been observed for the certain nuclides.

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

B.V. Zhuravlev, A.A. Lychagin, N.N. Titarenko

State Scientific Center of Russia Federation – Institute for Physics and Power Engineering, 249033 Obninsk, Kaluga Region, Russia.

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.

BIOTECHNOLOGY OF METAL REMOVAL FROM INDUSTRIAL WASTEWATER: ZINC CASE STUDY

I. Zinicovscaia[1,3], L. Cepoi[2], T. Chiriac [2], Gh.Duca[1], T. Mitina[1], M.V. Frontasyeva[3], S.S. Pavlov[3], S.F. Gundorina[3]

[1]*The Institute of Chemistry of the Academy of Sciences of Moldova, 3, Academiei Str., 2028 Chisinau, R. Moldova*

[2]*Institute of Microbiology and Biotechnology of the Academy of Science of Moldova, 1, Academiei Str., 2028 Chisinau, R. Moldova*

[3]*Joint Institute for Nuclear Research, Joliot-Curie Str., 6, 1419890 Dubna, Russia*

Industrial activities lead to contamination of water resources and technological, water, in particular, with toxic metals. Biotechnology based on sorption of heavy metals by microorganisms offers a potential alternative to conventional techniques for water purification. The possibility of using blue-green microalgae *Spirulina platensis* from Institute of Microbiology and Biotechnology of the Academy of Science of Moldova for zinc removal from waste water of "Moldagrotehnica", the largest manufacturer of modern agricultural machinery in Republic of Moldova, was studied.

Zinc finds its way into water bodies through effluents from smelters, mining, galvanizing units, processing plants, paints and pigments. The temporary accumulation of Zn by *Spirulina* biomass studied in short-time experiment (1 hour) revealed that that maximum of sorption is achieved after 5 minutes. Atomic absorption spectrometry was used to determine concentration of Zn in waste water samples. The samples of dry *Spirulina* biomass after exposure to wastewater at given time intervals were subject to nondestructive instrumental neutron activation analysis. A total of 12 elements: As, Au, Br, Fe, K, Na, Nd, Np, Sb, Sm, W, and Zn were determined. Beside zinc removal *Spirulina platensis* showed a high capacity for the iron biosorption from wastewater. *Spirulina platensis* can be effectively used as an active biosorbent of heavy metals from aquatic systems.

New Results from the NPD Gamma Parity Violation Experiment at the Spallation Neutron Source

C.B.Crawford

Gettysburg College, 300 N. Washington Street, Gettysburg PA 17325, USA

The Hadronic Weak Interaction (HWI) is a complementary probe of nuclonic structure. Although this interaction is dominated by several orders of magnitude by the strong nuclear interaction, it can be isolated through parity violating observables. The HWI can be classified in chiral effective field theory in terms of the spin and isospin dependence of transition Amplitudes involving S and P waves. There is an active program to determine the EFT parameters by measuring hadronic PV using cold neutron beams at the Spallation Neutron Source (ORNL) and the NCNR reactor (NIST). These experiment use only few-body observables, for which nuclear wave functions are calculable. The NPDGamma experiment, currently running at the SNS, will measure the gamma asymmetry relative to the neutron spin in the reaction $n + p \rightarrow d + \gamma$. This asymmetry is only sensitive to the $3S1 \rightarrow 3P1$ isovector transition amplitude, usually modeled in terms of weak pion exchange. We will present preliminary first results from this experiment, and show how they will be used with existing data and future experiments to characterize the four major couplings of the HWI.

Научное издание

FUNDAMENTAL INTERACTIONS & NEUTRONS, NUCLEAR STRUCTURE, ULTRACOLD NEUTRONS, RELATED TOPICS
XXI International Seminar on Interaction of Neutrons with Nuclei
Abstracts of the Seminar

ФУНДАМЕНТАЛЬНЫЕ ВЗАИМОДЕЙСТВИЯ И НЕЙТРОНЫ, СТРУКТУРА ЯДРА, УЛЬТРАХОЛОДНЫЕ НЕЙТРОНЫ И СВЯЗАННЫЕ ВОПРОСЫ
XXI Международный семинар по взаимодействию нейтронов с ядрами
Тезисы докладов семинара

Ответственная за подготовку сборника к печати *Л. В. Мицына.*

Сборник отпечатан методом прямого репродуцирования с оригиналов, предоставленных оргкомитетом.

Е3-2013-40

Подписано в печать 22.04.2013.
Формат 60 × 90/16. Бумага офсетная. Печать офсетная.
Усл. печ. л. 5,63. Уч.-изд. л. 9,52. Тираж 145 экз. Заказ № 57963.

Издательский отдел Объединенного института ядерных исследований
141980, г. Дубна, Московская обл., ул. Жолио-Кюри, 6.

E-mail: publish@jinr.ru
www.jinr.ru/publish/