**ISINN-19**

**XIX International Seminar on Interaction of Neutrons with Nuclei**

# Neutron Spectroscopy, Nuclear Structure, Related Topics

**Dubna, 2011**

**Abstracts**

Joint Institute for Nuclear Research

# NEUTRON SPECTROSCOPY, NUCLEAR STRUCTURE, RELATED TOPICS



*XIX International Seminar*
*on Interaction of Neutrons with Nuclei*

Dubna, May 25–28, 2011

*Abstracts of the Seminar*

УДК 539.125.5(042)
ББК 22.383.2я431+22.383.5я431+22.383.25я431
N50



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

**Neutron** Spectroscopy, Nuclear Structure, Related Topics: Abstracts of the XIX
N50 International Seminar on Interaction of Neutrons with Nuclei (Dubna, May 25–28, 2011). — Dubna: JINR, 2011. — 81 p.
ISBN 978-5-9530-0281-3

**Нейтронная** спектроскопия, структура ядра и связанные вопросы: Тезисы докладов XIX Международного семинара по взаимодействию нейтронов с ядрами (Дубна, 25–28 мая 2011 г.). — Дубна: ОИЯИ, 2011. — 81 с.
ISBN 978-5-9530-0281-3

**УДК 539.125.5(042)**
**ББК 22.383.2я431+22.383.5я431+22.383.25я431**

**ISBN 978-5-9530-0281-3**



## CONTENTS

**Preliminary Program of ISINN-19** ..... 10

**Trace Element Atmospheric Deposition in Belarus – Estimations Based on Moss Biomonitoring Technique**
*Aleksiayenak Y.V., Frontasyeva M.V., Vermaercke P.* ..... 16

**On Perspectives of Use of the Complicated ("Flaky") Neutron-Optical Potential**
*Alexandrov Yu., Anikin G., Anikin V.* ..... 17

**Magnetic Shielding for the New Measurements of the Neutron EDM**
*Altarev I., Stuiber S.* ..... 18

**Active Biomonitoring of Trace Elements Atmospheric Deposition in Urban Area Using Moss**
*Aničić M., Tomašević M., Frontasyeva M.* ..... 19

**Discussion of Nuclear "Rotation Effect" in Ternary Fission and in Gamma Emission from Fission Fragments**
*Barabanov A.L.* ..... 20

**Gamma-Spectrum of (n,xγ) Reactions Induced by Interaction of 14 MeV Neutrons with Cadmium**
*Bondar B.M., Bondar V.M., Gorbachenko O.M., Kadenko I.M., Leshchenko B.Yu., Onishchuk Yu.M., Plujko V.A.* ..... 21

**Application of Neutron Spectroscopy Techniques to Determine the Isotopic Composition of Samples under Study at the IREN Facility**
*Borzakov S.B., Mareev Yu.D., Pikelner L.B., Sedyshev P.V., Shvetsov V.N.* ..... 22

**Quasi-Classical and Quantum Descriptions of the T-Odd Asymmetries in Ternary Fission**
*Bunakov V.E., Kadmensky S.G.* ..... 23

**T-Odd Angular Correlations in the Emission of Prompt Neutrons in $^{235}$U Fission Induced by Polarized Neutrons**
*Danilyan G.V., Klenke J., Krakhotin V.A., Kopatch Yu.N., Novitsky V.V., Pavlov V.S., Shatalov P.B.* ..... 24

**Interaction of Waves with Birefringent Medium Moving with Acceleration**
*Frank A.I.* ..... 25

**Biosynthesis of Silver and Gold Nanoparticles Using Microbial Biomass**
*Frontasyeva M.V., Pavlov S.S., Zinicovscaia I.I., Kalabegishvili T.L., Murusidze I.G., Pataraya D.T., Kirkesali E.I., Ginturi E.N.* ..... 26

**Microbial Biotechnology Studied by ENAA**
*Frontasyeva M.V., Pavlov S.S., Zinicovscaia I.I., Kalabegishvili T.L., Murusidze I.G., Pataraya D.T., Kirkesali E.I., Ginturi E.N.* ..... 27

**Marine Gradients of Halogens and Selenium in Moss and Soil Studied by ENAA**
*Frontasyeva M.V., Steinnes E., Barandovski L., Marinova S.* ..... 28

**Woody Plants in Passive Biomonitoring and Bioremediation of Urban Ecosystems. Aspects of Heavy Metals Accumulation**
*Gorelova S.V., Frontasyeva M.V., Gorbunov A.V., Lyapunov S.M., Okina O.I.* ..... 29

**Space Era of the XXI Century: to the 50th Anniversary of the Yuri Gagarin Flight**
*Gindilis L.M.* ..... 30

**Measurement of Parameters of Pulsed Neutron Sources RADEX and IN-06 at Moscow Meson Factory**
*Grigoriev Yu.V., Khlustin D.V., Mezentseva Zh.V., Vasiliev I.A., Ryabov Yu.V.* ..... 31

**Radioecological Research in the Construction of Belene NPP**
*Hristov H., Marinova S., Gustova M., Maslov O.* ..... 32

**Influence of Neutrons Inelastic Scattering on the Low Energy Part of the Background Gamma Spectra**
*Jovancevic N., Krmar M.* ..... 33

**The Nature of the T-Odd Asymmetries for the Prescission and Evaporation Third Particles in the Ternary Fission of Nuclei by Cold Polarized Neutrons**
*Kadmensky S.G., Bunakov V.E., Kadmensky S.S., Lubashevsky D.E.* ..... 34

**Studying of Some Rare Modes of Collinear Cluster Tri-Partition of $^{252}$Cf(sf)**
*Kamanin D.V., Pyatkov Yu.V., Malaza V., Aleksandrov A.A., Aleksandrova I.A., Jacobs N., Kondratyev N.A., Kuznetsova E.A., Strekalovsky O.V., Zhuchko V.E.* ..... 35



**Collinear Cluster Tri-Partition: Current Status of Studies**
*Kamanin D.V., Pyatkov Yu.V., Aleksandrov A.A., Aleksandrova I.A., Jakobs N., Kondratyev N.A., Kuznetsova E.A., Malaza V., Strekalovsky O.V., Zhuchko V.E.* ..... 36

**Measurement Methodology for the Main Characteristic of Radiative Neutron Decay**
*Khafizov R.U., Kolesnikov I.A., Nikolaenko M.V., Tarnovitsky S.A., Tolokonnikov S.V., Torokhov V.D., Solovei V.A., Kolhidashvili M.R., Konorov I.V., Plonka-Spehr C.* ..... 37

**Statistical Model Analysis of (n,α) Cross Sections Averaged over the Fission Neutron Spectrum**
*Khuukhenkhuu G., Gledenov Yu.M., Sedysheva M.V., Odsuren M.* ..... 38

**Status of Pulsed Neutron Facility in Korea**
*Kim G., Lee M., Kim K.S., Yang S., Cho M.-H., Namkung W.* ..... 39

***nd*-Breakup Reaction as a Tool for Studying Neutron-Neutron Interaction**
*Konobeevski E.S.* ..... 40

**Pine Needles as a Bioindicator of Atmospheric Pollution in Republic Karelia**
*Korokin A., Pankratova Yu.S., Frontasyeva M.V.* ..... 41

**A Multi-Section Frisch-Gridded Ionization Chamber for Studies of Neutron-Induced Fission at the GNEIS Facility**
*Kovalev N.V., Ryzhov I.V., Tutin G.A., Shcherbakov O.A., Vorobyev A.S., Vaishnene L.A.* ..... 42

**Coincidence System for Spectral- and Time-Correlated Multi-Particle Detection with Four Pixel Detectors Timepix**
*Kraus V., Granja C.* ..... 43

**Behaviour of Rare Earth Elements in Systems of Plants and Main Typical Soils of Northern Vietnam**
*Luu Viet Hung, Trinh Thi Thu My, Maslov O. D., Dang Duc Nhan, Frontasyeva M.V., Gustova M.V.* ..... 44

**Mixing of the s-Wave and p-Wave Resonances and P-Odd Asymmetry of γ Quantum Emission in the Radiative Capture of a Slow Polarized Neutron by a Spinless Nucleus**
*Lyuboshitz V.L., Lyuboshitz V.V.* ..... 45

**Determination of the Magnesium, Aluminum and Silicon Contents of Water Samples by IGAA and NAA**
*Maslov O.D., Gustova M.V., Belov A.G., Drobina T.P.* .....46

**Isomer Ratios for $^{241}$Am(n,γ) and $^{243}$Am(n,γ) Reactions**
*Maslov V.M., Pronyaev V.G., Tetereva N.A., Zolotarev K.I.* .....47

**On the Possibility to Increase a Neutron Beam Flux of IREN**
*Mitsyna L.V., Popov A.B., Song Zhaohui*.....48

**Calculation of Corrections for Precise Obtaining the n,e-Scattering Length from the Angle Anisotropy of Slow Neutrons Scattered by Noble Gases**
*Mitsyna L.V., Popov A.B.* .....49

**Photo-Neutron Cross-Sections for $^{208}$Pb and $^{209}$Bi Induced by Bremsstrahlung**
*Naik H., Singh S., Goswami A., Manchanda V.K., Kim G., Kim K.S., Lee M.-W., Rahman S., Raj D., Ganesan S., Suryanarayana S.V., Cho M.-H., Namkung W.* .....50

**INAA and PIXE Comparison on Some Vegetable Species (Cabbage, Tomato, Pepper and Parsnip)**
*Pantelica A., Culicov O.A., Frontasyeva M.V., Ene A., Ciortea C., Gugiu M.* .....51

**T-Odd Asymmetry Effects in Low Energy Fission**
*Petrov G.A., Gagarski A.M., Guseva I.S., Kopach Yu.N.* .....52

**Giant Dipole Resonance Parameters within Renewed Systematics**
*Plujko V.A., Gorbachenko O.M., Bondar V.M.* .....53

**Moss Biomonitoring in Romania in the Frame of JINR – Romania Collaboration**
*Popescu I.V., Ene A., Cucu-Man S., Todoran R., Frontasyeva M., Culicov O., Stihi C., Gheboianu A.* .....54

**New Physical Spectator of the Collinear Cluster Tri-Partition of $^{252}$Cf(sf)**
*Pyatkov Yu.V., Kamanin D.V., Aleksandrov A.A., Aleksandrova I.A., Kondratyev N.A., Kuznetsova E.A., Strekalovsky O.V., Zhuchko V.E.* .....55



**Parity-Violating Gamma Asymmetry in np-Capture**
*Sharapov E.I., Alarcon R., Balascuta S., Barrón-Palos L., Bowman J.D., Carlini R.D., Chen W., Chupp T.E., Crawford C., Covrig S., Dabaghyan M., Fomin N., Freedman S.J., Gentile T.R., Gericke M.T., Gillis R.C., Greene G.L., Hersman F.W., Ino T., Jones G.L., Lauss B., Leuschner M., Lozowski W.R., Mahurin R., Masuda Y., Mei J., Mitchell G.S., Muto S., Nann H., Page S.A., Penttilä S.I., Ramsay W.D., Salas-Bacci A., Santra S., Sharma M., Seo P.-N., Smith T.B., Snow W.M., Wilburn W.S., Yuan V.* .....56

**Neutron Beam at the Synchrocyclotron of the PNPI for Radiation Tests of Electronic Components**
*Shcherbakov O.A., Ivanov E.M., Ivanov N.A., Mikheev G.F., Mitin E.V., Pashuk V.V., Ryabov G.A., Tverskoy M.G., Vaishnene L.A., Vorobyev A.S.* .....57

**Comparative Analysis of the Pohang Neutron Facility and IREN Source. The Joint Program on Nuclear Data Measurements**
*Shvetsov V., Cho M.-H., Kim G., Lee M., Namkung W., Skoy V.* .....58

**Nuclear Structure Physics with MoNA–LISA**
*Stephenson S.L., Brown J.A., De Young P.A., Finck J.E., Frank N.H., Hinnefeld J.D., Kaye R.A., Luther B.A., Peaslee G.F., Meyer D.A., Rogers W.F.* .....59

**Study of Nonstatistical Effects due to Tensor Forces**
*Sukhoruchkin S.I., Sukhoruchkina M.S.* .....60

**Compilation of Nuclear Excited States CRF**
*Sukhoruchkin S.I., Soroko Z.N., Sukhoruchkin D.S.* .....61

**Compilation of Nuclear Binding Energies MDF**
*Sukhoruchkin S.I., Sukhoruchkin D.S.* .....62

**Modified Model of Neutron Resonances Width Distribution. Results of Neutron Reduced Widths Approximation for Mass Region 35 ≤A ≤249**
*Sukhovoj A.M., Khitrov V.A.* .....63

**Modified Model of Neutron Resonances Width Distribution. Estimation of the Quality of Results and Interpretation of Available Physics Information**
*Sukhovoj A.M., Furman W.I., Khitrov V.A.* .....64

**Modified Model of Neutron Resonances Width Distribution. Results of Total Gamma-Widths Approximation**
*Sukhovoj A.M., Khitrov V.A.* .....65

**Temporal Variations of $^{137}Cs$ in Surface Air in Bratislava, Slovakia, over 33 Years**
*Sukova I., Povinec P., Brestakova L., Florek M., Holý K., Masarik J., Frontasyeva M.V., Steinnes E.* ..... 66

**Exotic P-Noninvariant Correlations in Fission**
*Tchuvil'sky Yu.M.* ..... 67

**Semimicroscopic Description of the Fast Neutron Radiative Capture**
*Tulupov B.A., Urin M.H.* ..... 68

**Damping of High-Energy Particle-Hole-Type Excitations: a Semimicroscopic Model**
*Urin M.H.* ..... 69

**Measurement of the P-Odd Effect in Radiative Cross Section on Natural Lead**
*Vesna V.A., Gledenov Yu.M., Lazebnik I.M., Nesvizhevsky V.V., Sedyshev P.V., Shulgina E.V.* ..... 70

**Study of the Neutron Laue Diffraction in Large Silicon Crystals for the Bragg Angles Close to 90°**
*Voronin V.V., Fedorov V.V., Kusnetsov I.A., Semenikhin S.Yu., Vezhlev E.O., Chekmenev S.V.* ..... 71

**Neutron Activation Analysis of Ca, Cl, K, Mg, Mn, Na, P, and Sr Contents in the Human Osteogenic Sarcoma**
*Zaichick S., Zaichick V.* ..... 72

**Relationship between Ca, Cl, K, Mg, Mn, Na, P, and Sr Contents in the Human Rib Bone Investigated by Neutron Activation Analysis**
*Zaichick S., Zaichick V.* ..... 73

**The Effect of Age on the Zinc Content in Prostate of Healthy Men**
*Zaichick S., Zaichick V., Karandashev V., Nosenko C.* ..... 74

**PFN Data Analysis in Spontaneous Fission**
*Zeynalov Sh., Zeynalova O., Hambsch F.-J., Oberstedt S.* ..... 75



**Abstracts received after deadline**

**Investigations of the Neutron "Cross-Talk" Effect in DEMON Detectors**
*Telezhnikov S., Kopatch Yu., Mezentseva Zh., Stuttge L., Goennenwein F., Mutterer M., Chernysheva E., Dorvaux O., Hanappe F., Hambsch F.-J.* ..... 76

**Spatial-, Spectral- and Time-Correlated Detection of Fission Fragments**
*Granja C., Kraus V., Kopatch Yu., Telezhnikov S.A., Pospisil S., Vykydal Z.* ..... 77

**Sorption Behaviour of Radionuclides in System Soil-Solution**
*Filippov M.F., Maslov O.D.* ..... 78

**New Spectrometer for Test of Equivalence Principle with UCN**
*Frank A.I., Geltenbort P., Jentschel M., Kulin G.V., Goryunov S.V., Kustov D.V., Strepetov A.N., Koch H.-Ch., Lauer T.* ..... 79

**Measurement of the Fast Neutron Spectra by Telescope of Recoil Protons**
*Milkov V., Panteleev Ts., Bogdzel A., Shvetsov V., Kutuzov S., Sedishev P., Borzakov S.* ..... 80

**Detection and Characterization of Radiation by the Pixel Detector Timepix: An Overview**
*Pospisil S.* ..... 81

# Preliminary Program of ISINN-19

## Wednesday, 25.05

Plenary talk, devoted to the 50th anniversary of the space flight

| | |
|---|---|
| 1. | Gindilis L.M.<br>Space Era of the XXI Century. To the 50th Anniversary of the Yuri Gagarin Flight |

Ultra-cold neutrons, related topics

| | |
|---|---|
| 2. | Frank A.I.<br>Interaction of Waves with Birefringent Medium Moving with Acceleration |
| 3. | Goryunov S.<br>New Spectrometer for Test of Equivalence Principle with UCN |
| 4. | Geltenbort P.<br>q-Bounce: Demonstration of a Gravity Resonance Spectroscopy Technique |

Fundamental properties of the neutron

| | |
|---|---|
| 5. | Voronin V.V., Fedorov V.V., Kusnetsov I.A., Semenikhin S.Yu, Vezhlev E.O., Chekmenev S.V.<br>Study of the Neutron Laue Diffraction in Large Silicon Crystal for the Bragg Angles Close to $90^0$ |
| 6. | Altarev I., Stuiber S.<br>Magnetic Shielding for the New Measurements of the Neutron EDM |
| 7. | Konobeevski E.<br>nd- Breakup Reaction as a Tool for Studying Neutron-Neutron Interaction |
| 8. | Khafizov R. U.<br>Measurement Methodology for the Main Characteristic of Radiative Neutron Decay |

Violations of fundamental symmetries

| | |
|---|---|
| 9. | Tchuvil'sky Yu.M.<br>Exotic P- Noninvariant Correlations in Fission |
| 10. | Lyuboshitz V.V., Lyuboshitz V.L.<br>Mixing of the S-wave and P-wave Resonances and P-odd Asymmetry of $\gamma$-Quantum Emission in the Radiative Capture of a Slow Polarized Neutron by a Spinless Nucleus |
| 11. | Sharapov E.I.<br>Parity-Violating Gamma-Asymmetry in np- Capture (NPD Gamma Collaboration) |
| 12. | Vesna A.., Gledenov Yu.M., Lazebnik I.M., Nesvizhevsky V.V., Sedyshev P.V., Shulgina E.V.<br>Measurement of P- Odd Effect in Radiative Cross Section on Natural Lead |



## Thursday, 26.05

Neutron induced reactions, nuclear structure

| | |
|---|---|
| 1. | Khryachkov V.<br>Investigation of $^{50}Cr(n,\alpha)^{47}Ti$ Reaction Cross Section for Neutron Energy less than 7.2 MeV. |
| 2. | Maslov V.M., Pronyaev V.G., Tetereva N.A., Zolotarev K.I.<br>Isomer Ratios for $^{241}Am(n,\gamma)$ and $^{243}Am(n,\gamma)$ Reactions |
| 3. | Stephenson Sh.<br>Nuclear Structure Physics with the MoNA- LISA |
| 4. | Sukhovoj A.M., Furman W.I., Khitrov V.A.<br>Modified Model of Neutron Resonances Width Distribution |
| 5. | Jovancevic N., Krmar M.<br>Influence of Neutrons Inelastic Scattering on the Low Energy Part of the Background Gamma Spectra |
| 6. | Plujko V.A., Gorbachenko O.M., Bondar V.M.<br>Giant Dipole Resonance Parameters within Renewed Systematics |
| 7. | Bondar B.M., Bondar V.M., Gorbachenko O.M., Kadenko I.M., Leshchenko B.Yu., Onishchuk Yu.M., Plujko V.A.<br>Gamma-Spectrum of (n,x$\gamma$) Reactions Induced by 14 MeV Neutrons with Cadmuim |
| 8. | Tulupov B.A., Urin M.H.<br>Semimicposcopic Description of the Fast Neutron Radiative Capture |
| 9. | Urin M.H.<br>Damping of High- Energy Particle- Hole- Type Excitations: a Semimicroscopic Model |

Basic facilities

| | |
|---|---|
| 10. | Shvetsov V., Moo-Hyun Cho, Guinyun Kim, Manwoo Lee, Won Namkung and Skoy V.<br>Comparative Analysis of the Pohang Neutron Facility and IREN Source. The Joint Program on Nuclear Data Measurements |
| 11. | Shcherbakov O.A.<br>Neutron Beam at the Synchrocyclotron of the PNPI for Radiation Tests of Electronic Components |
| 12. | Guinyun Kim<br>Status of Pulsed Neutron Facility in Korea |
| 13. | Guinyun Kim<br>Photo- Neutron Cross- Sections for $^{208}Pb$ and $^{209}Bi$ Induced by Bremsstrahlung |

# Friday, 27.05

Fission

| | |
|---|---|
| 1. | Pyatkov Yu.<br>New Physical Spectator of the Collinear Cluster Tri- Partition of $^{252}$Cf (sf) |
| 2. | Kamanin D.V.<br>Collinear Cluster Tri-Partition: Current Status of Studies |
| 3. | Kamanin D.V., Pyatkov Yu. V., Malaza V., Aleksandrov A.A., Aleksandrova I.A., Jacobs N., Kondratyev N.A., Kuznetsova E.A., Strekalovsky O.V., Zhuchko V.E.<br>Studying of Some Rare Modes of Collinear Cluster Tri- Partition of $^{252}$Cf (sf) |
| 4. | Granier Th.<br>Measurements of Prompt Fission Neutron Spectra in Fast Neutron- Induced Fission of Major Actinides |
| 5. | Zeynalov Sh.<br>PFN Data Analysis in Spontaneous Fission |
| 6. | Danilyan G.V., Klenke J., Krakhotin V.A., Kopatch Yu.N., Novitsky V.V., Pavlov V.S., Shatalov P.B.<br>T- Odd Angular Correlations in the Emission of Prompt Neutrons in $^{235}$U Fission Induced by Polarized Neutrons |
| 7. | Petrov G.A., Gagarski A.M., Guseva I.S., Kopach Yu.N.<br>T- Odd Asymmetry Effects in Low Energy Fission |
| 8. | Kadmensky S.G., Bunakov V.E., Kadmensky S.S., Lubashevsky D.E.<br>The Nature of the T- Odd Asymmetries for the Prescission and Evaporation Third Particles in the Ternary Fission of Nuclei by Cold Polarized Neutrons |
| 9. | Bunakov V.E., Kadmensky S.G.<br>Quasi- Classical and Quantum Descriptions of the T- Odd Asymmetries in Ternary Fission |
| 10. | Barabanov A.L.<br>Discussion of Nuclear "Rotation Effect" in Ternary Fission and in Gamma Emission from Fission Fragments |

**Poster session** (see list of posters below)



# Saturday, 28.05

Experimental technique

| | |
|---|---|
| 1. | Pospisil S.<br>Detection and Characterization of Radiation by the Pixel Detector Timepix: An Overview |
| 2. | Granja C.<br>Spatial-, Spectral- and Time-Correlated Detection of Fission Fragments |
| 3. | Kraus V.<br>Coincidence System for Spectral- and Time- Correlated Multi- Particle Detection with Four Pixel Detectors Timepix |
| 4. | Borzakov S.B., Mareev Yu.D., Pikelner L.B., Sedyshev P.V., Shvetsov V.N.<br>Application of Neutron Spectroscopy Techniques to Determine the Isotopic Composition of Samples under Study at the IREN Facility |
| 5. | Bogdzel A.A., Milkov V.M., Panteleev Ts.Ts.<br>Measurements of the Fast Neutron Spectra by Telescope of Recoil Protons |

ADS studies

| | |
|---|---|
| 6. | Goverdovsky A.<br>Multi- Functional Scientific and Technological Facility Based on Accelerator Driven Super High Flux Research Fast Reactor "DLiADS" |
| 7. | Chilap V.<br>Preliminary Results of March Run with QUINTA at Nuclotron |
| 8. | Kurachenko Yu.A., Grudzevich O.T., Goverdovsky A.A.<br>Simulation of Neutron Yield from Lead Targets |

Nuclear Analytical Methods in the Life Sciences (parallel session)

| | |
|---|---|
| 1. | Tiginyanu I.<br>Nanomaterials Modification by Ionizing Radiation |
| 2. | Frontasyeva M.V., Pavlov S.S., Zinicovscaia I., Kalabegishvili T., Murusidze I., Pataraya D., Kirkesali E.I., Ginturi E.N.<br>Biosynthesis of Silver and Gold Nanoparticles Using Microbial Biomass |
| 3. | Frontasyeva M.V., Pavlov S.S., Zinicovscaia I.I., Kalabegishvili T.L., Murisidze I.G., Pataraya D.T., Kirkesali E.I., Ginturi E.N.<br>Microbial Biotechnology Studied by ENAA |
| 4. | Zaichick S., Zaichick V., Karandashev V., Nosenko C.<br>Neutron Activation Analysis of Ca, Cl, K, Mg, Mn, Na, P, and Sr Contents in the Human Osteogenic Sarcoma<br>Zaichick S., Zaichick V.<br>The Effect of Age on the Zinc Content in Prostate of Healthy Men |
| 5. | Goryainova Z, Mankovska B., Frontasyeva M.V.<br>Measurement of the Anthropogenic Loading on the Three Slovak Industrial Sites Using Teeth of Roe Deer |

| | |
|---|---|
| 6. | Gorelova S.V., Frontasyeva M.V., Gorbunov A.V., Lyapunov S.M., Okina O.I. Woody Plants in Passive Biomonitoring and Bioremediation of Urban Ecosystems. Aspects of Heavy Metals Accumulation |
| 7. | Pantelica A., Culicov O.A., Frontasyeva M.V., Ene A., Ciortea C., Gugiu M. INAA and PIXE Comparison on Some Vegetable Species (Cabbage, Tomato, Pepper and Parsnip) |
| 8. | Dunaev A.M., Rumyantsev I.<br>Study of the Heavy Metal Content in Soil, River Water, Snow, Needles and Mosses in Ivanovo Region |
| 9. | Korokin A., Pankratova Yu.S., Frontasyeva M. V.<br>Pine Needles as a Bioindicator of Atmospheric Pollution of Republic Karelia |
| 10. | Popescu I.V., Ene A., Cucu-Man S., Todoran R., Frontasyeva M., Culicov O., Stihi C., Gheboianu A.<br>Moss Biomonitoring in Romania in the Frame of JINR- Romania Collaboration |
| 11. | Anicic M., Tomašević M., Frontasyeva M.<br>Active Biomonitoring of Trace Elements Atmospheric Deposition in Urban Area Using Moss *Sphagnum girgensohnii Russow* (overview) |
| 12. | Frontasyeva M.V., Steinnes E., Barandovski L., Marinova S.<br>Marine Gradients of Halogens and Selenium in Moss and Soil Studied by ENAA |
| 13. | Hristov H., Marinova S., Gustova M., Maslov O.<br>Radioecological Research in the Construction of Belene NPP |
| 14. | Sykora I., Povinec P., Brestakova L., Florek M., Holý K., Masarik J., Frontasyeva M.V., Steinnes E.<br>Temporal Variations of $^{137}Cs$ in Surface Air in Bratislava, Slovakia, over 33 Years |
| 15. | Filippov M.F., Maslov O.D.<br>Sorption Behaviour of Radionuclides in System Soil- Solution |



## Posters

| | |
|---|---|
| 1. | Alexandrov Yu., Anikin G., Anikin V.<br>On Perspectives of Use of the Complicated ("Flaky") Neutron- Optical Potential |
| 2. | Kovalev N.V., Ryzhov I.V., Tutin G.A., Shcherbakov O.A., Vorobyev A.S., Vaishnene L.A.<br>A Multi- Section Frisch- Gridded Ionization Chamber for Investigation of Fission at GNEIS Facility |
| 3. | Ivanova T.<br>Excitation Function of $^{14}N(n,t)^{12}C$ Reaction in Fast Neutron Energy Region |
| 4. | Bondarenko I.<br>Experimental Study of Branching Ratio $^{10}B(n,a_0)$ to $^{10}B(n,a_1)$ in Energy Region from 4 to 7 MeV |
| 5. | Mitsyna L.V., Popov A.B., Song Zhaohui<br>On the Possibility to Increase a Neutron Beam Flux of IREN |
| 6. | Khuukhenkhuu G., Gledenov Yu.M, Sedysheva M.V., Odsuren M.<br>Statistical Model Analysis of (n,α) Cross Sections Averaged over the Fission Neutron Spectrum |
| 7. | Mitsyna L.V., Popov A.B.<br>Calculation of Corrections for Precise Obtaining the n,e- Scattering Length from the Angle Anisotropy of Slow Neutrons Scattered by Noble Gases |
| 8. | Grigoriev Yu.V., Khlustin D.V., Mezentseva Zh.V., Vasiliev I.A., Ryabov Yu.V.<br>Measurement of Parameters of Pulsed Neutron Sources RADEX and IN-06 at Moscow Meson Factory |
| 9. | Telezhnikov S.A.<br>Investigations of the Neutron "Cross- Talk" Effect in DEMON Detectors |
| 10. | Maslov O.D., Gustova M.V., Belov A.G., Drobina T. P.<br>Determination of the Magnesium, Aluminum and Silicon Contents of Water Samples by IGAA and NAA |
| 11. | Zaichick S., Zaichick V.<br>Relationship Between Ca, Cl, K, Mg, Mn, Na, P, and Sr Contents in the Human Rib Bone Investigated by Neutron Activation Analysis |
| 12. | Aleksiayenak Y.V., Frontasyeva M.V., Vermaercke P.<br>Trace Element Atmospheric Deposition in Belarus – Estimations Based on Moss Biomonitoring Technique |
| 13. | Luu Viet Hung, Trinh Thi Thu My, Maslov O.D., Dang Duc Nhan, Frontasyeva M.V., Gustova M.V.<br>Behaviour of Rare Earth Elements in Systems of Plants and Main Typical Soils of Northern Vietnam |
| 13. | Sukhoruchkin S.I., Sukhoruchkina M.S.<br>Study of Nonstatistical Effects due to Tenzor Forces |
| 14. | Sukhoruchkin S.I., Soroko Z.N., Sukhoruchkin D.S.<br>Compilation of Nuclear Exited States CRF |
| 15. | Sukhoruchkin S.I., Sukhoruchkin D.S.<br>Compilation of Nuclear Binding Energies MDF |

## TRACE ELEMENT ATMOSPHERIC DEPOSITION IN BELARUS – ESTIMATIONS BASED ON MOSS BIOMONITORING TECHNIQUE

Aleksiayenak Y.V.[1], Frontasyeva M.V.[1], Vermaercke P.[2]

[1]*FLNP JINR, Dubna, Russian Federation*

[2]*Belgian Nuclear Research Centre, Mol, Belgium*

For the first time atmospheric deposition of trace elements in Belarus was monitored by the moss biomonitoring technique widely used in Europe for air pollution studies. Samples of moss species *Pleurozium shreberi* and *Hylocomium splendens* were collected at 200 sites over the Minsk, Gomel and Grodno regions in summer – autumn periods in 2005–2008. A total of 40 elements were determined by Instrumental Neutron Activation Analysis carried out at the reactor IBR-2 in Dubna, Russia and at the BR1 reactor of SCK·CEN, Belgium. Geographical Information System technology was applied to construct maps of elemental distributions over the sampled areas. Principal Component Analysis allowed distinguishing heavy and light crust elements, and those of vegetation and anthropogenic origin. Comparison of the results obtained with the analogous data for the neighbouring countries showed relatively low contamination levels for most of heavy and toxic elements.



## On perspectives of use of the complicated ("flaky") neutron-optical potential

Yu.Alexandrov[1], G.Anikin[2], V.Anikin[2]

[1]*FLNP, JINR, Dubna, Russia, e-mail: alex@nf.jinr.ru*
[2]*Instuitute of Physics and Power Engineering, Obninsk, Russia*

The big work on research of thin structure of neutron-optical potential for heavy nuclei has been done.

Motivation of these researches it is connected with necessity of an explanation of following phenomena:

1. Presence enough sharp fluctuation of parameters of potential studying of their power dependence which at neutron energies more than 0.5 MeV appear very close, for example, for lead and uranium nuclei.
2. Correlation of structures in energy dependence of any characteristics of interaction of neutrons with nuclei: full cross sections, cross sections of fission, kinetic energy of products of fission and etc.
3. Equidistant arrangement of correlating structure similar under the form not in scale of energies but in a scale of lengths of waves of neutrons.
4. Small angle neutron scattering of MeV neutrons by heavy nuclei.

The assumption of possibility to explain the observable phenomena by diffraction of neutron waves on spatially divided structures of a nucleus with inevitability has raised the question about existence of correlations in cross sections for various radiations, for example, neutrons and gamma beams, at coincidence of their lengths of waves. The first attempts to find such correlations have crowned success and are the most difficulty refutable proof of existence of spatially divided nuclear structures.

## MAGNETIC SHIELDING FOR THE NEW MEASUREMENTS OF THE NEUTRON EDM

Altarev I., Stuiber S.

*Munich Technical University, Germany*

The Standard Model (SM) of particle physics proposes the value of a neutron electric dipole moment (EDM) at the level of $10^{-32}$ e·cm. Extensions to the SM, for example SUSY, increase the limit by the several orders of magnitude. Whereas the current experimental measurements set the upper limit of the neutron EDM $2.9 \cdot 10^{-26}$ e·cm, the new generation of the EDM experiment (n2EDM) aims at the level of $10^{-28}$ e·cm. The new UCN sources are currently under construction at PSI, Switzerland and TUM, Germany. They will provide significantly increased intensity of the UCN to obtain the sufficient statistical accuracy of the measurements. The necessary control of possible systematical uncertainties is mainly provided by the stability and homogeneity of the magnetic fields in the EDM spectrometer. In order to achieve the desired field parameters we have built a model combining a cylindrical μ-metal shell and a system of coils with electrical currents that create a uniform magnetic field of 1 μT over a volume of about 1/8 cubic meter inside the magnetic shield. The main magnetic shielding will be realized by an appropriate industry standard magnetically shielded room with a shielding factor $10^5$. Our setup will then be placed inside this magnetically controlled environment. The model was evaluated using the finite element method (FEM). We have achieved a relative field inhomogeneity better than $10^{-4}$ which is well below the required value. A prototype of the proposed shield and coil system is under construction.



## ACTIVE BIOMONITORING OF TRACE ELEMENTS ATMOSPHERIC DEPOSITION IN URBAN AREA USING MOSS *Sphagnum girgensohnii* Russow

Aničić M.[1], Tomašević M.[1], Frontasyeva M.[2]

[1]*Institute of Physics, University of Belgrade, 11080 Belgrade, Serbia*
[2]*Frank Laboratory of Neutron Physics, JINR, 141980 Dubna, Russia*

The use of native moss as biomonitors is a convenient way of determining levels of heavy metals atmospheric deposition, as an alternative to instrumental monitoring techniques. To clarify the peculiarities on the influence of exposure time on trace element accumulation in moss bags technique (active biomonitoring), moss *Sphagnum girgensohnii* Rusow were exposed in the urban area of Belgrade. Moss was exposed in bags (dry and wet) at several representative urban sites for five 3-months periods (July, 2005-October, 2006), as well as, at one sub-urban site for 15 days up to 5 months, in consecutive 15 days periods (July-November, 2007) to examine effects of spatial and temporal variations of the trace elements atmospheric concentration on their content in the moss tissue. About 60 trace elements were determined in the moss bags samples using three analytical methods (INAA, FAAS, HR-ICP-MS). The moss element accumulation capability was also tested in relation to atmospheric bulk deposition.

The most of the investigated elements showed a statisticaly significant increase of the elements concentration with time regarding the initial content of elements in unexposed moss [1, 2, 3]. However, some physiologically active elements (Na, P, Na, P, Cl, K, etc.) was depleted from moss tissue with time of exposure due to damaging of cell walls and leaking of the elements. A significant correlation between moss and bulk deposition was obtained for some of the elements (especially V and Ni) [2]. Removal of *S. girgensohnii* from the natural habitat is stressful for the moss, expecially in sense of dehidration, so the moss bags in all experiments were exposed in two paralel designs: dry (freely hanging) and wet (above the reservoires with water) moss bags. The majority of measured elements was accumulated more efficiently by wet moss bags (especially Cu, Sr, Zn, Cr, Al, Fe, Pb, Cd) and depletion of physiologically active elements was diminished comparing to dry ones. Aiming to estimate the physiological condition of the exposed moss, the concentrations of the photosynthetic pigments (chlorophyll *a* and *b*; index chlorophyll *a*/*b*) were determined as well as index of characteristic absorbancies (*A665*/*A665a*) before and after acidification of the pigments extracts. Also an assessment of a stability of the mitochondrial membranes, applying colorimetric triphenyltetrazolium chloride (*TTC*) test, was further made.

According to the obtained results, *S. girgensohnii* Russow moss bags may be applied as an appropriate biomonitor of some trace elements atmosferic deposition in urban areas. Also, wetting of moss bags during exposure period improves accumulation abilities and sensitivity of the moss.

REFERENCES

1. Aničić M. *et al.*, Environ. Chem. Lett. 7 (2009), 55-60.
2. Aničić M. *et al.*, Environ. Pollut. 157 (2009), 673-679.
3. Aničić M. *et al.*, J. Haz. Mat. 171 (2009), 182-188.

# DISCUSSION OF NUCLEAR "ROTATION EFFECT" IN TERNARY FISSION AND IN GAMMA EMISSION FROM FISSION FRAGMENTS

Barabanov A.L.

NRC "Kurchatov Institute", Moscow 123182, Russia; Moscow Institute of Physics and Technology, Dolgoprudny 141700, Moscow Region, Russia

Asymmetries of emission of a third light charged particle, usually an $\alpha$-particle, in ternary fission of nuclei $^{233}$U and $^{235}$U by thermal longitudinal polarized neutrons with respect to a plane formed by the spins of an incident neutron and the momentum $\mathbf{p}_{LF}$ of a light fragment (see, e.g., [1,2]) formally correspond to 3-vector correlation $(\mathbf{p}_{TP}[\mathbf{s} \times \mathbf{p}_{LF}])$ ("TRI-effect") and 5-vector correlation $(\mathbf{p}_{TP}[\mathbf{s} \times \mathbf{p}_{LF}])(\mathbf{p}_{TP}\mathbf{p}_{LF})$ ("ROT-effect"), where $\mathbf{p}_{TP}$ is the momentum of the third particle. The late effect got its name due to an assumption that it is caused by a rotation of the fissioning nucleus.

The scheme of formation of the 3-vector correlation due to an interaction of the spin of the fissioning system and the orbital momentum of the third particle has been proposed in [3] before the 5-vector correlation have been found. In fact, the specified spin-orbit interaction describes both effects (no reference to rotation of the fissioning nucleus is needed). It has been argued qualitatively in [4]. In this work the statement is explained in more details.

Searches of the above 3-vector and 5-vector correlations in fission of $^{235}$U by neutrons for a gamma-quantum or for a neutron as the third particle have been performed in [5-7], and a nonzero result has been found for the 5-vector correlation in emission of gamma-quanta. In this work the ways of quantitative explanation of this result are discussed with the use of a consistent quantum description of the fission process, without the reference to classical picture with the rotating fissioning nucleus. Possible reasons of absence of the effect (at the reached level of accuracy) in emission of neutrons are discussed also.

1. F. Goennenwein et al. Phys. Lett. B, 2007, V. 652, P. 13.
2. G.V. Val'skii et al. Bull. Rus. Acad. Sci., 2007, V. 71, P. 354.
3. A.L. Barabanov. Proc. 9-th ISINN, Dubna, 2001, P. 93; arXiv: 0712.3543.
4. A.L. Barabanov. Symmetries and spin-angular correlations in reactions and decays. – Moscow, Fizmatlit, 2010 (in Russian).
5. G.V. Danilyan et al. Phys. Lett. B, 2009, V. 679, P. 25.
6. G.V. Danilyan et al. Phys. At. Nucl., 2009, V. 72, P. 1812.
7. G.V. Danilyan et al. Phys. At. Nucl., 2010, V. 73, P. 1116.



# GAMMA-SPECTRUM OF (N,Xγ) REACTIONS INDUCED BY INTERACTION OF 14 MEV NEUTRONS WITH CADMIUM.

B.M. Bondar[1], V.M. Bondar[1], O.M. Gorbachenko[1], I.M. Kadenko[1], B.Yu. Leshchenko[1], Yu. M. Onishchuk[1], V.A. Plujko[1,2]

[1] *Taras Shevchenko National University, Kiev, Ukraine*
[2] *Institute for Nuclear Research, Kiev, Ukraine*
vira_bondar@ukr.net

Determination of (n, xγ) reaction cross sections are important for the reactor calculations as well as for investigation of different nuclear reaction mechanisms, characteristics of excited nuclear states and their decay.

In this contribution we present differential cross sections of $^{nat}$Cd(n, xγ) reactions induced by 14 MeV neutrons. Experimental measurements have been performed by the use of time-of-flight technique based on neutron pulse generator [1]. Differential cross sections were unfolded from amplitude γ-spectrum by using different regularization procedures. The best result was obtained with regularization algorithm on the compact set of limited variations. The detector response function was based on analytical approximation of the bremsstrahlung experiment with correction both on Monte Carlo simulations and detection of 4.43 MeV γ-rays from neutron inelastic scattering on carbon. Cross section errors are estimated using combination of multiple randomization of initial γ-spectra with subsequent regularization procedure. It was assumed that errors of the amplitude instrumental spectra are distributed in accordance with Gauss distributions due to the effect of large number of external factors in the measurements.

Experimental results were compared with theoretical calculations performed by the Empire [2] and TALYS [3] codes. Sensitivity of calculated cross sections to characteristics of nuclear excited states is analysed [4].

[1] V.M. Bondar, I.M. Kadenko, B.Yu. Leshchenko, Yu.M. Onishchuk, V.A. Plujko, *Reactor Dosimetry State Of The Art 2008: Proc. 13th Int. Symp.* (25-30 May, 2008, Alkmaar, Netherlands), World Scientific Publ.Co., (2009) 516.
[2] M.Herman, R.Capote, B.V. Carlson, P.Oblozinsky, M.Sin, A.Trkov, H. Winkle, V.Zerkin, *Nucl.Data Sheets*, **108**, (2007) 2655.
[3] A. J. Koning, S. Hilaire, and M.C. Duijvestijn, in TALYS-1.0, Proceedings of the Int. Conf. on Nuclear Data for Science and Technology, –ND2007, May 22-27, 2007, Nice, France, **1** (2007) 211.
[4] T. Belgya, O. Bersillon, R. Capote, T. Fukahori, G. Zhigang, S. Goriely, M. Herman, A.V. Ignatyuk, S. Kailas. A. Koning, P. Oblozinsky, V. Plujko and P. Young. IAEA-TECDOC-1506: Handbook for calculations of nuclear reaction data: Reference Input Parameter Library- 2, IAEA, Vienna, 2005; http://www-nds.iaea.org/RIPL-2/.

# Application of neutron spectroscopy techniques to determine the isotopic composition of samples under study at the IREN facility.

S.B.Borzakov, Yu.D.Mareev, L.B.Pikelner, P.V.Sedyshev, V.N.Shvetsov

Frank Laboratory of Neutron Physics, JINR

Annotation

One of the applications of the neutron spectroscopy method for applied purposes is a non-destructive determination of the isotopic composition of samples under study. The method is based on the fact that resonance energies are known practically for all stable nuclei and a set of energies does not coincide completely for any pair of isotopes.

At present, the IREN pulsed neutron source that allows investigations using the neutron spectroscopy method, has been put into operation at FLNP JINR. A linear accelerator of electrons bombarding a tungsten target is the basic component of the IREN facility. The bremsstrahlung γ-radiation generates neutrons as a result of the (γ,n)-reaction. The neutron yield in the form of bursts with a duration of 100 ns and frequency of 50 Hz is $10^{11}$ n/s. This makes it possible to use the time-of-flight technique to study the radiative resonance neutron capture. A high-efficiency liquid scintillation detector with a volume of 210 l is used to detect gamma-quanta and determine the energy of resonances. The combination of this detector and the IREN source allows us to carry out accurate measurements of the energy of resonances and to determine the isotope content in samples under study by the number of detector counts in a resonance.

These measurements have been performed for a number of targets.



# QUASI-CLASSICAL AND QUANTUM DESCRIPTIONS OF THE T-ODD ASYMMETRIES IN TERNARY FISSION

V.E. Bunakov[1], S.G. Kadmensky[2]

*1 - PNPI RAS, 188300 Gatchina, Russia*
*2 - Voronezh State University, Voronezh, Russia*

The comparison is carried out of the quasi-classical and quantum approaches to the description of the T-odd effects in ternary fission caused by the cold polarized neutrons. In both approaches these effects result from the rotation of the polarized fissioning system caused by the absorption of the polarized neutron.

In the quasi-classical approach [1] the ROT effect (the shift of the alpha angular distribution with respect to the direction of light fragment emission) is just a well-known Coriolis effect when the alpha moving from the centre of the rotating fissioning system lags behind the rotation of the system. The TRI effect (different probability of alpha emission in the upper and lower hemisphere with respect to the plain containing the vectors of neutron polarization and light fragment's momentum) can be explained [2] by the difference in the initial energy of the emitted alphas in the internal frame of the rotating fissioning system. This difference $\Delta E$ arises from the Coriolis term

$$\Delta E = H_{Cor} = \vec{l} \cdot \vec{\omega}$$

were $\vec{l} = [\vec{r} \times \vec{p}]$ is the alpha angular momentum and $\vec{\omega}$ is the rotation angular velocity of the system. Vector $\vec{l}$ is parallel or anti-parallel to $\vec{\omega}$ for the particle momentum $\vec{p}$ directed up or down.

These approaches explain well the order of magnitude of the effects but can not explain the changes of their absolute values and the signs for the neighboring target nuclei $^{233}U$, $^{235}U$ and $^{239}Pu$. These changes can be explained in the purely quantum approach to the effects (see e.g. [3]). The physical background of this approach is exactly the same as in the case of the quasi-classical ones--the Coriolis interaction of the outgoing ternary particles with the polarized rotating fissioning system. The above difference of the values and signs is caused by the interference of neighboring neutron resonances contributing to fission. These interference effects can not be taken into account in the quasi-classical approaches.

1. I.S.Guseva, Yu.I.Gusev. *Proc. of 14 International Seminar on Interaction of Neutrous with Nuclei, Dubna, Russia, 2006.* (Dubna, JINR, 2007) p.101.
2. V.E.Bunakov, S.G.Kadmensky. *Abstracts of 18 International Seminar on Interaction of Neutrons with Nuclei, Dubna, Russia, 2010.* (Dubna, JINR, 2010) p.18.
3.V.E.Bunakov, S.G.Kadmensky, S.S.Kadmensky. Phys.At. Nucl. 71 (2008) 1887.

# T-ODD ANGULAR CORRELATIONS IN THE EMISSION OF PROMPT NEUTRONS IN $^{235}$U FISSION INDUCED BY POLARIZED NEUTRONS

Danilyan G.V.[1], Klenke J.[2], Krakhotin V.A.[1], Kopatch Yu.N.[3], Novitsky V.V.[3], Pavlov V.S.[1], Shatalov P.B.[1]

[1]*Institute for Theoretical and Experimental Physics, Moscow, Russia*
[2]*Forschungs-Neutronenquelle Heinz Meier-Leibnitz (FRM II), Garching, Germany*
[3]*Frank Laboratory of Neutron Physics, JINR, Dubna, Russia*

Study of the T-odd three-vector correlation in the emission of prompt neutrons from $^{235}$U fission by polarized cold neutrons has been continued at the facility MEPHISTO of the FRM II reactor (Technical University of Munich). The sought correlation was not found within experimental error of $2.3\times10^{-5}$. The upper limit for the asymmetry coefficient has been set to $|D_n| < 6\times10^{-5}$ at 99% confidence level, whereas for ternary fission correlation coefficient $D_\alpha = (170 \pm 20)\times10^{-5}$. At the same time, five-vector correlation in the emission of prompt fission neutrons has been measured, which describes the rotation of the fissioning nucleus at the moment it breaks (ROT-effect). At the angle 22.5° to the fission axis, the correlation coefficient was found to be $(1.57 \pm 0.20)\times10^{-4}$, while at the angle of 67.5° it is zero within the experimental uncertainty. The existence of ROT-effect in the emission of prompt fission neutrons can be explained by the anisotropy of neutron emission in the rest frame of the fragment (fission fragments are aligned with respect to the axis of deformation of the fissioning nucleus), similar to the mechanism of ROT-effect in the emission of prompt γ-rays.



# Interaction of waves with birefringent medium moving with acceleration

**A. I. Frank**

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

Almost 30 years ago it was theoretically predicted that the frequency and wave number of a wave would change as it went through an accelerating sample of refractive medium. K. Tanaka was the first to prove that in the case of light optics. Later the same result was obtained for neutron waves. More generally, a refractive index may be introduced for waves of any nature with the only requirement that scatterers are present in the medium. So, one can speak about a very general Accelerating Matter Effect (AME). As far as we know the AME has not been observed for light yet. However, neutron-optics experiments of the kind were performed with ultra-cold neutrons (UCN). AME new exciting features may demonstrate themselves in the case of birefringent matter and neutrinos. On transmission of a neutrino through an accelerated matter two components of its wave function change their energy by different amounts. This should influence further evolution of neutrino states in the course of propagation in space.

# BIOSYNTHESIS OF SILVER AND GOLD NANOPARTICLES USING MICROBIAL BIOMASS

Frontasyeva M.V.[1], Pavlov S.S.[1], Zinicovscaia I.[1,2], Kalabegishvili T.[3,4], Murusidze I.[3], Pataraya D.[5], Kirkesali E.I.[3], Ginturi E.N.[3]

[1]*FLNP JINR, Dubna, Russian Federation*

[2]*Institute of Chemistry of the Academy of Science of Moldova, 3, Academiei Str., Chisinau, Moldova*

[3]*Andronikashvili Institute of Physics, 6, Tamarashvili Str., Tbilisi, 0177, Georgia*

[4]*Ilia State University, 3/5, K. Cholokashvili Ave., Tbilisi 0162, Georgia*

[5]*Durmishidze Institute of Biochemistry and Biotechnology, D. Agmashenebeli Kheivani, 10 km, 0159, Tbilisi, Georgia*

Microbial synthesis of silver and gold nanoparticles has a potential to develop simple, cost-effective and eco-friendly methods for production of technologically important materials for using in industry and medicine. For the first time a novel actinomycetes strain *Streptomyces glaucus* 71 MD (isolated from a soy rhizosphere) was used for the synthesis of silver nanoparticles and bacteria *Arthrobacter globiformis* (isolated from basalts in Georgia) – for the synthesis of gold nanoparticles. Production of silver and gold nanoparticles proceeded extracellularly with the participation of another microorganism, the blue-green microalgae *Spirulina platensis* (*S. platensis*) from the collection of the Timiriazev Institute for Plant Physiology. To synthesize silver and gold nanoparticles solutions of $AgNO_3$ and $HAuCl_4$ were added to form the microbial suspension. The time dependence of nanoparticles formation was studied during a few days. Scanning Electron Microscopy (SEM) and Transmission Electron Microscopy (TEM) were used as the key techniques to obtain images of nanoparticles in the samples. In addition to the images, EDAX (Energy dispersive analysis of X-rays) spectra were also registered proving the presence of silver and gold in samples. The dependence of nanoparticles size on the exposure time was established. SEM images showed formation of nanoparticles by *Spirulina platensis* in the range of 75–235 nm.





Frontasyeva M.V.[1], Pavlov S.S.[1], Zinicovscaia I.I.[1], Kalabegishvili T.L.[2,3], Murusidze I.G.[3], Pataraya D.T.[4], Kirkesali E.I.[2], Ginturi E.N.[2]

[1]*JINR, Dubna, Moscow Region, Russian Federation*

[2]*Andronikashvili Institute of Physics, 6, Tamarashvili Str., Tbilisi, 0177, Georgia*

[3]*Ilia State University, 3/5, K. Cholokashvili Ave., Tbilisi 0162, Georgia*

[4]*Durmishidze Institute of Biochemistry and Biotechnology, D. Agmashenebeli Kheivani, 10 km, 0159, Tbilisi, Georgia*

The results of 10 years joint investigations in the field of microbial biotechnology for medical, environmental and industrial applications carried out by the Sector of NAA and Applied Research, FLNP JINR, and the biophysicists of the Andronikashvili Institute of Physics, Tbilisi, Georgia, are reviewed. Epithermal neutron activation analysis (ENAA) was used to study multielemental composition of some microorganisms. It was shown that the blue-green alga *Spirulina platensis* biomass can serve a as matrix for the development of pharmaceutical substances containing such trace elements as Se, Cr and I. The adsorbtion of toxic metals such as Hg and Cr(VI) by *Spirulina platensis* biomass in dynamics of growth has been studied for purposes of the environmental remediation. ENAA was successfully applied in biotechnology of toxic Cr(VI) transformation into non-toxic form Cr(III) and Hg(II) into Hg(0) by bacteria *Arthrobacter* genera isolated from the polluted basalts in Georgia. To identify Cr(III) in these experiments electron spin resonance (ESR) spectrometry was employed. Natural organic biomass of vegetal origin, peat, was applied as a source of microorganisms to study the bacterial leashing of metals from lean ores, rocks and industrial wastes. Microbial synthesis of Ag and Au nanoparticals by actinomycetes *Streptomyces glaucus* 71MD, bacteria *Arthrobacter globiformis* 151B and blue-green alga *Spirulina platensis* has been studied by using transmission electron microscopy (TEM), scanning electron microscopy (SEM) and ENAA.

## MARINE GRADIENTS OF HALOGENS AND SELENIUM IN MOSS AND SOIL STUDIED BY ENAA

Frontasyeva M.V.[1], Steinnes E.[2], Barandovski L.[3], Marinova S.[4]

[1]*FLNP JINR, Dubna, Moscow Region, Russian Federation*

[2]*Department of Chemistry, Norwegian University of Science and Technology, NO-749 Trondheim, Norway*

[3]*Sts. Cyril and Methodius University, Faculty of Sciences, POB 162, 1000 Skopje, Macedonia*

[4]*University «Paisii Hilendarski», Plovdiv, Bulgaria*

INAA is known to be a powerful technique for the simultaneous determination of chlorine, bromine, iodine, and selenium. Activation with epithermal neutrons is shown to be particularly useful to elucidate marine gradients of these elements. Examples are from the transects studies in Norway where samples of the moss *Hylocomium splendens* were collected at distances of 0–300 km from the coastline as well as in the transect through the Balkans where samples of the moss *Pleurozium schreberi* were collected from the Adriatic to the Black Sea via Macedonia (0–300 km) and Bulgaria (0–400 km). All four elements decrease exponentially as a function of distance from the seas in the moss strongly indicating that the atmospheric supply from the marine environment is a predominant source of these elements to the terrestrial ecosystem. Corresponding gradients are demonstrated for natural surface soils in Norway. Simultaneous determination of Cl, Br, and I facilitates the investigation of fractionation processes involving these elements. Iodine is a particularly important element in the environment because it is essential to man and animals, and ENAA should find many applications in environmental studies related to iodine deficiency. Another area coming up at present is the potential use of stable $^{128}$I to elucidate the environmental behavior of long-lived $^{129}$I from the nuclear fuel cycle. The authors believe that the studies of halogens are going to be one of the main pillars to support the future existence of neutron activation analysis.



## Woody plants in passive biomonitoring and bioremediation of urban ecosystems. Aspect of heavy metals accumulation.

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

[1]*Department of Botany and Technology of Plant Growing, Faculty of Natural Sciences, L.N. Tolstoy Tula State Pedagogical University, Lenin Avenue, 125, 300026 Tula, Russia, gsvphysiology08@rambler.ru*

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

[3]*Geological Institute, Russian Academy of Sciences, Pyzhevskii per. 7, 109017 Moscow, Russia*

Trees and bushes have a high potential for the purpose of passive biomonitoring and bioremediation of urban ecosystems, including the industrial zones and exposed to intensive antropogenic stress. Prospects of using woody plants is determined by the high productivity of biomass during the season, the ability to absorb heavy metals (HM) from soil with extensive root system, the ability to accumulate pollutants from the air at different levels (1.5-35 m), as well as their high adaptive capacity in relation to HM and resistance to the toxic effects.

To investigate the possibility of bioremediation of soils two groups of 7 species of trees and bushes were selected in the green zone of industrially contaminated region of the Tula town, Russia. The most clean site in the study area (central park) was chosen as a control one. In addition to leaves of these woody plants, soil and aerosol samples were collected in the same places.

According to the obtained results, leaves of several species of trees and bushes in the conditions of soil pollution accumulate heavy metals in amounts exceeding those characteristic for the "Reference plants" (RP) (Markert, 1992) were identified:

Species of trees:

- *Populus nigra* L;
- *Acer platanoides* L.;
- *Tilia cordata* Miller;
- *Betula pendula* Roth.;
- *Sorbus aucuparia* L;
- *Larix sibirica* Ledeb.

Species of bushes:

- *Cotoneaster lucidus* Schlecht;
- *Philadelphus coronarius*;
- *Crataegus monogina* Jacq.;
- *Crataegus sanguinea* Pall.;
- *Syringa vulgaris* L

Parallelly, the adaptive capacity and vitality of woody plants in a technogenic stress conditions were assessed.

Species that accumulate more heavy metals and having a low and average vitality in conditions of industrial pollution could be used for passive biomonitoring (*Populus nigra, Tilia cordata, Betula pendula, Crataegus*).

For phytoremediation it is better to use the species which have positive adaptive changes (activity of the antioxidant system and the state of pigment system) and a good vitality in conditions of polimetallic pollution. The set of absorbed heavy metals in this case reduces but the possibility of the environment prolonged detoxification increases.

Most resistant studied species are: Larix sibirica, Acer platanoides, Sorbus aucuparia, Tilia cordata, Cotoneaster lucidus, Philadelphus coronarius, Syringa vulgaris.

# SPACE ERA OF THE XXI CENTURY: TO THE 50-TH ANNIVERSARY OF THE YURI GAGARIN FLIGHT

Gindilis L.M.

*Sternberg State Astronomical Institute, Moscow State University, University prospect, 13, 119992 Moscow, Russian Federation*
*e-mail: lgindilis@mail.ru*

Space era on Earth, if we bear in mind the technical aspect, began on October 4, 1957 with the launch of the first Soviet artificial Earth satellite. By the beginning of the XXI century, the explosive development of space was over, the pace became slower and public attitude changed. In the XXI century the *satellite connection* went into the life becoming an integral part of everyday life of every person due to cell phones, *satellite television* and *satellite navigation*. Near-term prospects are the Moon base and human landing on Mars. Perhaps, by the end of the century there will be attempts to send robotic probes to nearby stars. Astronautics has made it possible to study the Universe in all ranges of electromagnetic waves. Due to astronautics become possible and were made discoveries that are *radically changing the scientific picture of the world*. Among the major achievements of the Space science are the discovery of exoplanets, the discovery of new kinds of matter (dark matter and dark energy), the discovery of accelerated expansion of the Universe, the multidimensionality of space, its topological properties, and Multiverse. An important trend in modern science is to establish a close connection between matter and consciousness. The problem of consciousness and its role in our vision of the World is particularly acute in modern quantum cosmology. Humanity has entered the XXI century burdened with serious problems of social, political and environmental order. According to experts, these problems have reached crisis proportions. We are talking about the survival of humanity and the preservation of Earth as a planet, at least the preservation of its biosphere. It is impossible to solve these problems by traditional measures. There is need in a radical change of the behavior of mankind on the planet. This requires, above all, change of human consciousness. It is impossible to develop the right strategy not having adequate view of a world in which we live. Astronautics plays the important role in the process of changing consciousness. Prospects for the development of humanity in the XXI century will be possible only if our civilization will find the strength to overcome the deep crisis in which it resides. The situation is exacerbated by frequent natural disasters. Humanity must be prepared for the serious tribulations. The better we are prepared, the better, with fewer victims, we pass through them.



# Measurement of parameters of pulsed neutron sources RADEX and IN-06 at Moscow Meson Factory

Yu. V. Grigoriev[1], D.V. Khlustin[1], Zh. V. Mezentseva[2], I.A. Vasiliev[1], Yu. V. Ryabov[1]
*1 Institute for Nuclear Research RAS, Moscow, Russia*
*2 Joint Institute for Nuclear Research, Dubna, Russia*

The source of thermal neutrons IN-06 MMF INR RAS was operated in November, 2010. First time-of-flight spectra on 4 flight bases of IN-06 were received in November, 23, 2010. We carry out measurements of time-of-flight spectra on 22.4 meter flying base of neutron source IN-06 beam in parallel with measurements of group from the institute FIAN. So as IN-06 worked in a starting mode, i.e. the beam of protons moved on a tungsten target only in the afternoon, and at night the proton beam moved on a tungsten target of neutron source RADEX, there was an opportunity to carry out measurements in the afternoon on IN-06, and at night on 50-meter flight base of installation REPS with 8-section liquid (n, gamma) detector (49.5 m) and neutron cylindrical He-3 counter (51.5 m). Efficiency of registration of thermal neutrons by this neutron detector was close to approximately 100%. It was used in the afternoon on 22.4 meter flight base of IN-06, and at night on 51.5 meter flight base of RADEX. It has allowed to determine parameters of two neutron sources simultaneously and to carry out the comparative analysis. Parameters of a proton beam of the linear accelerator during measurements were identical and made: energy of protons $E_p = 209$ Mev, proton pulse current I = 5 mA, proton pulse duration dT = 92 mcs, frequency of proton pulses rapitition rate f = 1, 10, 25 and 50 Hz. Time–of–flight spectra were measured with using two systems of the experimental information accumulation: slowly with the minimal time channel width 1 mcs, and speeds of a set of the information $< 10^5$ Hz and new fast system which has width of the time channel 121 ns and speed of a set of the information $< 10^7$ Hz. From experimental spectra the flux of thermal neutrons on 22.4 meter flight base of IN-06 was determined at frequency f = 50 Hz, which reached about 500 n/sm$^2$s, that corresponds to a flux of thermal neutrons on a moderator surface of the source at $0.3 \cdot 10^9$ n/sm$^2$s.

## Radioecological research in the construction of Belene NPP

H. Hristov, S. Marinova, M. Gustova*, O. Maslov*

*Plovdiv university "Paisii Hilendarski", Department of Atomic Physics*
**Joint Institute for Nuclear Research, Dubna, Russia*

This paper presents initial research data of the current radiation status (presence of radioactive elements, natural background radiation level)of the environment in the surrounding areas of the Belene NPP prior to the operating period. The paper presents the results of U-238, Ra-226, Pb-210, Th-232, K-40 and Cs-137 concentrations in soils from the region of the Belene NPP. All results are within the range of the average level for the country. The natural radiation background found region under investigation is about 0,13 μSv/h. This value is within the average radiation background levels in the country. The paper also presents the content of elements in concretes for nuclides contributing to the long-lived radioactivity – Eu, Cs, Co, Fe etc. These concretes are used in shielding constructions of the Belene NPP. The report presents the results for the concentrations in concretes of a total of 15 chemical elements from the Belene NPP. The concentration of elements was determined by XRF-analysis in the Joint Institute for Nuclear Research, Dubna, Russia.



## INFLUENCE OF NEUTRONS INELASTIC SCATTERING ON THE LOW ENERGY PART OF THE BACKGROUND GAMMA SPECTRA

Authors: Jovancevic N., Krmar M.

University of Novi Sad, Faculty of Science, Department of Physics
Trg Dositeja Obradovića 4, Novi Sad, Serbia

Neutrons created by cosmic muons in the detector shield and in the surrounding materials have influence on the background in low-level gamma spectroscopic measurements. Neutrons produce gamma activity by capture and scatter reactions with the materials of the detector system. The goal of this paper was to investigate the influence of neutron interactions on the low energy part of the background gamma spectrum. Detection of recoils of Ge nuclei after neutron scattering could increase the count rate in regions up to 100 keV in gamma spectra measured by HPGe detector. The reduction of this neutron background component is of great importance in dark mater research experiments (detection of WIMPs).

In this work background spectrum in energy region 4 - 3000 keV was measured by HPGe detector with different thicknesses of the thermalizaton material (PVC foil) around the detector. Neutron energy spectrum had been modified by the PVC foil located around the detector. Obtained results show that increase of the thickness of the PVC can reduce the integral count rate in energy region between 6 – 50 keV. It is correlated with the decreasing of the count rate of the energy asymmetric Ge(n,n') gamma lines. In conclusion, it is possible to estimate the influence of recoil of the Ge nuclei to the low energy part of the background gamma spectra.

# THE NATURE OF THE T – ODD ASYMMETRIES FOR THE PRESCISSION AND EVAPORATION THIRD PARTICLES IN THE TERNARY FISSION OF NUCLEI BY COLD POLARIZED NEUTRONS.

S. G. Kadmensky[1], V. E. Bunakov[2], S. S. Kadmensky[1], D. E. Lubashevsky[1]

[1] *Voronezh State University, 394006, University square 1, Russia*
[2] *Petersburg Nuclear Physics Institute, 188300, Gatchina, Russia*

The comparative analysis of results of the experimental and theoretical studies of the T – odd asymmetries for different prescission and evaporation third particles in the differential cross - sections of reactions of the true and delayed ternary nuclear fission by cold polarized neutrons has been carried out. It has been confirmed that the named above asymmetries are caused by the collective rotation of the polarized fissioning system, which leads to the changes of the prescission third particles angular distributions and the fission fragments angular distribution at the moment of nuclear scission time $t_0$ defining the light fission fragment flight direction $\vec{n}_0$ relatively the asymptotic direction $\vec{n}$ of the light fission fragment motion. It has been shown that the influence of this rotation is connected with Coriolis interaction of the fissioning system total spin with the orbital moments of the prescission third particles or the fission fragments (for the evaporation third particles).

It has been demonstrated that the T – odd asymmetry appearance is the quantum effect connected with the interference of the fission amplitudes of the different pairs $sJ_s$ and $s'J_{s'}$ of neutron resonance states in the compound nucleus formed for the capture of cold neutron by the nucleus – target. It has been found that the named above differential cross – sections linearly depend from the qualities $\sin(\delta_{sJ_ss'J_{s'}} + \delta^{(1)} - \delta^{(0)})$, in which $\delta_{sJ_ss'J_{s'}} = \delta_{sJ_s} - \delta_{s'J_{s'}}$; $\delta_{sJ_s}$ is the total phase for the neutron resonance $sJ_s$; $\delta^{(1)}$ and $\delta^{(0)}$ are the phases of the perturbated and nonperturbated by Coriolis interaction amplitudes of the angular distributions of the prescission third particles or the fission fragments (for the evaporation third particles). With taking into account the symmetry of the differential cross – sections of analysed reactions for the mutual transpositions of the interfering neutron resonances indexes $sJ_s$ and $s'J_{s'}$ and the dependence of Coriolis interaction from the fissioning system moment of inertia and consequently from distance R between flying out fission fragments it has been shown that the T – odd asymmetries appear only for the nonzero differences of phases $\delta^{(1)}$ and $\delta^{(0)}$. It has been demonstrated that the T – odd TRI – and ROT – asymmetries having the different angular behavior for the different nuclei can appear only for the charged prescission third particles ($\alpha$ - particles and light nuclei). It has been shown that the T – odd asymmetries for the fixed evaporation third particles have the universal angular dependences for different nuclei.



# STUDYING OF SOME RARE MODES OF COLLINEAR CLUSTER TRI-PARTITION OF $^{252}$CF (SF)

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], 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 studying of a new ternary decay of low excited heavy nuclei called "collinear cluster tri-partition" (CCT) [1÷3] a specific CCT mode was observed based on double magic $^{132}$Sn cluster. Prescission configuration which presumably gives rise to the mode under discussion is shown in ig.1. Sn cluster can "move" as a whole along the cylinder like configuration consists of residual nucleons. Two light fragments marked by symbols M1 and M2 were actually detected in previous experiment. The mass M2 is changed in the range {0÷(252-132-95)} amu while M1 cannot be less 95 amu (deformed magic $^{95}$Rb). The question arises whether $^{132}$Sn can be changed by also double magic $^{208}$Pb? It would be a new type of lead radioactivity. Searching for such mode is one of the goals of forthcoming experiment. We need as well better statistics to be collected and more precise measurement of time-of-flights. Testing of a special designed setup aimed at solving these problems is in our nearest plans.

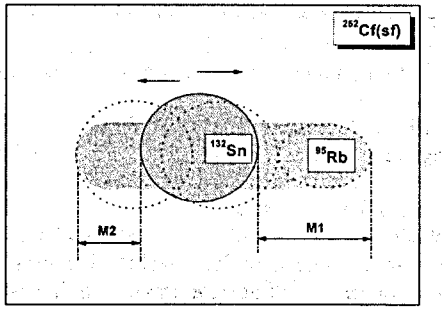



Fig. 1. Schematic prescission configuration of the CCT mode based on double magic $^{132}$Sn cluster.

**References**

1. Yu.V. Pyatkov et al., Romanian Reports in Physics, 59 (2007) 388.
2. D.V.Kamanin et al., Int. Journal of Modern Physics E 17 (2008) 2250.
3. Yu.V. Pyatkov et al., Eur. Phys. J. A 45 (2010) 29.

## COLLINEAR CLUSTER TRI-PARTITION: CURRENT STATUS OF STUDIES

D.V. Kamanin[1], Yu. V. Pyatkov[1,2], A.A. Aleksandrov[1], I.A. Aleksandrova[1], N. Jakobs[3], N.A. Kondratyev[1], E.A. Kuznetsova[1], V. Malaza[3], 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]Faculty of Military Science, Military Academy, Saldanha 7395, South Africa

In series of experiments at different time-of-flight spectrometers we have observed multiple manifestations of a new type of multibody decay of low excited heavy nuclei called by us collinear cluster tri-partition (CCT) [1, 2]. Recently new COMETA spectrometer was started in the Flerov Laboratory of the JINR. It consists of two mosaics of PIN diodes provided both energy and timing signals and micro-channel plates based "start" detector with a $^{252}$Cf (sf) source inside. Spectrometer is added by a "neutron belt" which comprises 30 $^{3}$He filled neutron counters located around the source in the plane perpendicular to the symmetry axis of the setup.

Following conclusions can be drawn from first experiments performed at the COMETA setup.

- Results obtained reliably confirm existence of the CCT channel in $^{252}$Cf (sf).
- Much less fraction of scattered fission fragments (FF) as compared to those at the gas filled FOBOS spectrometer used earlier let us to observe specific bump [4] in the mass correlation plot without any additional selection of fission events.
- Almost all fission events linked with essential missing of mass (i.e. to be at least ternary) are followed by knocking out of light ion from the source backing. Likely it points to breakdown of the di-nuclear system in inelastic scattering setting both constituents free.

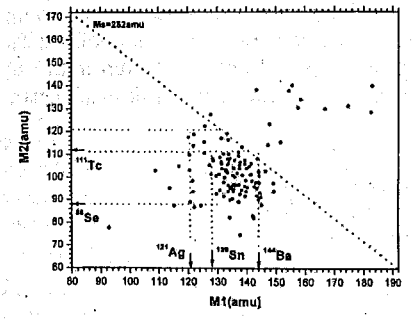



Fig. 1. Mass distribution of two heavy decay partners from the CCT of $^{252}$Cf nucleus.

Fig. 1 shows mass distribution for the heavy products of ternary decay observed at the COMETA setup. Rectangular structure lying below the line M1 + M2 = 252 amu (thus it is a manifestation of at least ternary decay) is bounded by known magic nuclei with the masses marked by the arrows. Experimental yield of these events does not exceed $2.5 \times 10^{-5}$ per binary fission.

It should be mentioned as well that physics of the CCT process more and more attracts attention of the theoreticians [3, 4] but of course, the problem is far from adequate theoretical description.

**References**

1. D.V. Kamanin et al., Int. Journal of Modern Physics E 17 (2008) 2250.
2. Yu.V. Pyatkov et al., Eur. Phys. J. A. 45 (2010) 29.
3. A.K. Nasirov et al., Proc. Int. Conf. on Nuclear Physics "Nucleus 2010", Petergof, Russia, July 6–9, 2010 (in press).
4. K. Manimaran and M. Balasubramanian submitted to EPJ A



## Measurement methodology for the main characteristic of radiative neutron decay

Khafizov R.U. [a], Kolesnikov I.A. [a], Nikolaenko M.V., Tarnovitsky S.A., Tolokonnikov S.V. [a], Torokhov V.D. [a], Solovei V.A. [b], Kolhidashvili M.R. [b], Konorov I.V. [c], Plonka-Spehr C. [d]

[a]RNC "Kurchatov Institute", Moscow, Russia
[b]Petersburg Nuclear Physics Institute, Gatchina, Russia
[c]Technical University of Munich, Munich, Germany
[d]University Mainz, Germany

Based on critical analysis of our experiment on radiative decay [1, 2], as well as the experiment of emit group [3] and work conducted at NIST [4, 5], we present the methodology for measuring the main characteristic of radiative neutron decay, namely, its relative intensity (B.R.). Relying on spectra measurements of double beta-electron and proton coincidences and triple coincidences of beta-electron and proton with the gamma quantum, we discovered the events of radiative neutron decay and measured its relative intensity B.R.=$(3.2\pm1.6)10^{-3}$ (with C.L.=99.7% and gamma quantum energy over 35 kev) [1].

The double coincidences spectrum we measured corresponds in all of its characteristics with an analogous spectrum obtained by emiT group studying ordinary beta neutron decay [3]. In particular, this group also observed a significant ionic background, comparable with the value of the beta-decay peak. From Avogardo's law it follows that even with a very deep vacuum inside the vacuum chamber, molecule concentration remains sufficient for the creation of a significant ionic background, comparable to the effect itself. Besides, the value of the ionic background is only very slightly dependent on the vacuum: it is proportional to the cubic root of pressure. Even if the pressure is reduced by two orders of magnitude, the value of the ionic background goes down only by a few times. The analysis of ionic background structure shows that research publication [5] presents not a narrow beta-decay peak but rather a wide ionic peak. Gamma background must also be considered when measuring the triple coincidences. Besides, the gamma spectrum shows a wide peak of artificial radioactivity due to the presence of intense radiation. In its width, the peak corresponds to the only gamma peak measured at NIST [4, 5] and so has no relation to radiative neutron decay. Our spectrum [1, 2] of triple coincidences shows not only this wide peak of artificial radioactivity but also a narrow peak, formed by the events of radiative neutron decay. However, our spectra also show additional background response peaks, arising from the response of our electronic system to the registration of beta-electrons and protons. The only solution to the situation where backgrounds cannot be ignored is precisely measuring the time spectra of double and triple coincidences and clearly distinguishing both the ionic and the gamma backgrounds from these spectra. For our new experiment on precise BR measurements we created a new electronic system, which significantly overcomes the response and which allows to obtain a BR value with 1% precision by measuring the time spectra of double and triple coincidences.

[1] R.U. Khafizov et al. JETP Letters, v. 83(1), 2006, p. 5
[2] Khafizov R.U., Tolokonnikov S.V., Solovei V.A., Kolhidashvili M.R. Status of the experiments on radiative branch of decay. ISINN-16, Dubna, 2008, Reports, p. 69
[3] L.J. Lising, et al., Phys. Rev. C. v.6, 2000, p. 055501
[4] J.S. Nico, et al., Nature v. 444, 2006, p.1059
[5] R.L. Cooper, et al., Phys. Rev. C v. 81, 2010, p.035503

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

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

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

Investigation of (n, α) reaction cross sections averaged over the fission neutron spectrum is important to estimate radiation damage due to helium production, nuclear heating and transmutations in the structural materials of reactors. On the other hand, systematical analysis of neutron cross section 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.

Systematical analysis of the experimental (n,α) cross sections in the energy range of 14-15 MeV was carried out in 1973 by Levkovskii [1] and so-called isotopic effect was observed. In last decade we have observed a similar dependence for the (n,α) cross sections in the wide energy range of 6 to 20 MeV [2,3]. Moreover, the statistical model was suggested [4] to explain the dependence of the (n,α) cross sections on the relative neutron excess parameter (N-A+0.5)/A for wide energy range.

In this paper the statistical model based on the Weisskopf-Ewing theory [5] is used for systematical analysis of known experimental (n,α) cross sections averaged over the fission neutron spectrum [6]. A certain systematical behaviour in the fission neutron spectrum averaged (n,α) cross sections was observed and it was shown that the experimental data is satisfactorily described by the statistical model. The average effective neutron energy for (n,α) reactions induced by fission neutrons was found to be around 4 MeV, as in the case of (n,p) reactions [7].

### References

1. V.N.Levkovskii. Yademaya Fizika, v.18, 1973, p.705
2. G.Khuukhenkhuu *et al.*, In book: Proceedings of the XV International Seminar on Interaction of Neutrons with Nuclei, ISINN-15, May 16-19, 2007. JINR, Dubna, 2008, p.157
3. M.Odsuren. Ph.D. Thesis, National University of Mongolia, Ulaanbaatar, 2010
4. G.Khuukhenkhuu *et al.*, JINR communications, E3-2007-25. Dubna, 2007
5. V.F.Weisskopf and D.H.Ewing. Phys.Rev., v.57, 1940. p.472
6. E.M.Gryntakis. J.Radioanal.Chem., v.52, 1979, p.219
7. G.Khuukhenhkuu *et al.*, In book: Proceedings of the XVII International Seminar on Interaction of Neutrons with Nuclei. ISINN-17. May 27-29, 2009, JINR, Dubna, 2010, p.337.



## Status of Pulsed Neutron Facility in Korea

Guinyun Kim[1], Manwoo Lee[1], Kyung Sook Kim[1], Sungchul Yang[1], Moo-Hyun Cho[2], and Won Namkung[2]

*[1]Department of Physics, Kyungpook National University, Daegu 702-701, Korea*
*[2]Department of Physics, Pohang University of Science and Technology, Pohang 790-784, Korea*

We report the activities by using the pulsed neutron facility which consists of an electron linear accelerator, a water-cooled Ta target with a water moderator, and a 12 m time-of-flight path. It can be possible to measure the neutron total cross-sections in the neutron energy range from 0.01 eV to few hundreds eV by using the neutron time-of-flight method and also measured the photo-neutron cross-sections by using the bremsstrahlung from the electron linac. A $^{6}$LiZnS(Ag) glass scintillator was used as a neutron detector. The neutron flight path from the water-cooled Ta target to the neutron detector was 12.1 m. We reported total cross-sections of Dy and Nb and also resonance parameters which were obtained by using the SAMMY fitting program. The present results are compared with the previous experimental results and the evaluated data in ENDF/B-VII. We also report the mass-yield distribution of fission products in the 2.5-GeV bremsstrahlung-induced fission of $^{nat}$Pb and $^{209}$Bi has been measured by using a recoil catcher and an off-line γ-ray spectrometric technique in the 2.5-GeV electron linac.

## *nd* BREAKUP REACTION AS A TOOL FOR STUDYING NEUTRON-NEUTRON INTERACTION

Konobeevski E.S.

*Institute for Nuclear Research of RAS, 117312 Moscow, Russia*

The study of *nd* breakup reaction is a powerful tool of studying *nn* interaction. In view of absence of a free neutron target the use of deuterium target and neutron beam is, as a matter of fact, unique effective way of studying *nn* interaction. Rather small number of nucleons in system allows the accurate strict solution of the three-body problem. Despite the simplicity of final *pnn* system the experiments can be performed in different kinematical arrangements of the outgoing three nucleons and their results be compared with rigorous theoretical predictions.

Important argument for continuation both experimental and theoretical works in this area are the clear cut discrepancies between the theory and existing data. The strongest discrepancies occur in the *nn* quasifree scattering (QFS) and in the *nd* STAR (three nucleons are flying in the c.m. system with momenta of equal magnitude) geometries. The final state interaction (FSI) geometry is widely used for determination of singlet *nn*-scattering length characterizing the *nn* scattering at zero energy. Data for $a_{nn}$ together with analogous data for *pp* scattering length $a_{pp}$ (difference $a_{nn} - a_{pp}$) define a quantitative measure of the charge symmetry breaking (CSB) of nuclear forces.

The goal of our study is the determining characteristic parameters of neutron-neutron interaction, as well as obtaining new accurate estimation of CSB effect. To study the *nd* breakup reaction the experimental setup allowing registration of all secondary particles was installed at neutron channel of Moscow Meson Factory of the Institute for Nuclear Research. Experiment is performed in broad energy region of neutrons (20-100 MeV) incident on deuterium ($CD_2$) target. The setup allows obtaining data in different kinematical arrangements. We present the first preliminary data on $a_{nn}$ obtained in the FSI geometry at our setup. The test measurements in the *np* QFS arrangement showed the possibility of our setup to obtain data on neutron-neutron QFS in broad region of neutron energy.



## PINE NEEDLES AS A BIOINDICATOR OF ATMOSPHERIC POLLUTION IN REPUBLIC KARELIA

Korokin A., Pankratova Yu.S., Frontasyeva M.V.

*FLNP JINR ,Dubna, Russian Federation*

For the first time atmospheric deposition of trace elements in Karelia was monitored by the bioindication technique using pine needle sampling. Samples of pine needles were collected at 98 sites over the investigated area. A total of 11 elements were identified by AES, AAS, ICP-AES. The GIS technology was applied to construct maps of elemental distributions over the sampled territory. Principal Component Analysis allowed determination of heavy and light elements, of vegetation and geological origin including crust elements. Comparison of the results obtained with the analogous data for the neighboring region of Kola Peninsula showed relatively low contamination levels for most of heavy and toxic elements.

# A multi-section Frisch-gridded ionization chamber for studies of neutron-induced fission at the GNEIS facility

N.V. Kovalev[1], I.V. Ryzhov[1], G.A. Tutin[1], O.A. Shcherbakov[2], A.S. Vorobyev[2] and L.A. Vaishnene[2].

[1)]*Khlopin Radium Institute, Saint-Petersburg, Russia*
[2)]*Petersburg Nuclear Physics Institute, Gatchina, Russia*

A multi-section Frisch-gridded ionization chamber adopted for operation at the neutron time-of-flight spectrometer GNEIS is described. The data acquisition system based on a waveform digitizer is discussed as well as the digital signal processing. Result of test measurements carried out in the neutron energy range 1-200 MeV with $^{235}U$ and $^{232}Th$ targets are reported.



# COINCIDENCE SYSTEM FOR SPECTRAL- AND TIME-CORRELATED MULTI-PARTICLE DETECTION WITH FOUR PIXEL DETECTORS TIMEPIX

Author(s): Vaclav Kraus[1,2], Carlos Granja[1]

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

[2]*Faculty of Electrical Engineering, University of West Bohemia, Pilsen, Czech Republic*

An integrated Coincidence System for multi-particle detection has been built for validated coincidence and synchronized detection of multi-particle events. A system of four detectors has been built (see Fig.1) for measurements of angular correlations of rare fragments in ternary and quaternary Fission. The pixel detectors are operated each with the readout interface FITPix which provide power, control and DAQ. FITPix provides extended operability for the Timepix detectors (such as widely adjustable internal clock, external clock, clock gating, etc.), enables advanced triggering and high frame rate (up to 90 fps). The whole measurement can be triggered by a single event (shown in the Fig.1).

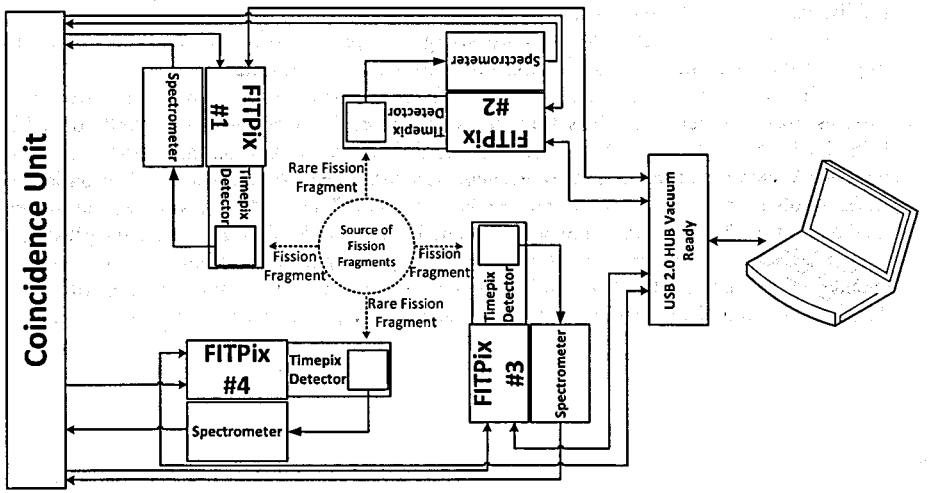



**Fig. 1** The block diagram of Coincidence system for multi-particle detection.

Spectrometer is based on the USB 1.1.2 readout interface equipped with integrated spectrometric module which is the source for triggers. The Coincidence Unit validates and synchronizes digital data. Operation and DAQ are managed by the modular software package Pixelman. The whole system can operate in vacuum and can be configured and extended of several more detectors for a wide range of particle coincidence physics experiments. Work carried out in frame of the Medipix Collaboration.

# Behaviour of rare earth elements in systems of plants and main typical soils of northern Vietnam

**Luu Viet Hung[1], Trinh Thi Thu My[2], Maslov O. D.[3], Dang Duc Nhan[1], Frontasyeva M.V.[2], Gustova M.V.[3]**

[1] *Institute for Nuclear Science and Technology, Hanoi, Vietnam*
[2] *Laboratory of Neutron Physics, JINR, Dubna, Russia*
[3] *Laboratory of Nuclear Reactions, JINR, Dubna, Russia*

Rare-earth elements consist of 15 elements with successive atomic numbers (Z from 57 to 71, besides, scandium and yttrium are considered rare earth elements) and the same outer electron configuration; therefore, they tend to have similar chemical and physical characters. Many years ago, the relationships in the REE group were expected as constant ratios no matter what processes they had been subject to, but year by years there have been many articles about fractions of REEs in different media. Besides, the REEs have been characterized neither as essential elements for life, nor as strongly toxic elements in a long time but recently, more and more researches about their uses and their toxicities have been published, however, REEs remain a field with many thing need more study.

In Vietnam, two REE deposits are going to exploit in the next few years it would imply a future appearance of REE impact on the country environment.

REE accumulation in plant by soil transfer would be the toxic source, but it would be used as a way to remove REEs from the contaminated soils. The study works on REE behavior in the systems of some potentially useful plants growing on main typical soils of northern Vietnam and focus on two problems: the total REE content and the distribution of REEs in plant parts and corresponding soils. Inductive Couple Plasma Mass Spectrometry method was used to determine concentration of 13 REEs in 32 bio- and 4 soil samples. The study has observed anomalies of Cerium, Europium and Gadolinium in the systems depending on factors of pH and soil composition. Besides, distribution pattern of REEs determined in the plant parts and in the corresponding soils has been examined.



# MIXING OF THE *S*-WAVE AND *P*-WAVE RESONANCES AND *P*-ODD ASYMMETRY OF $\gamma$ QUANTUM EMISSION IN THE RADIATIVE CAPTURE OF A SLOW POLARIZED NEUTRON BY A SPINLESS NUCLEUS

V. L. Lyuboshitz, V. V. Lyuboshitz *

*Joint Institute for Nuclear Research, 141980 Dubna, Moscow Region, Russia*

* *E-mail: Valery.Lyuboshitz@jinr.ru*

Using the technique of helicity amplitudes, the theoretical consideration of the *P*-odd asymmetry of $\gamma$ quantum emission in the radiative capture of an *S*-wave neutron by a nucleus with zero spin, which is conditioned by the mixing of *S*-wave and *P*-wave resonances with equal spins and opposite space parities on account of weak interaction, has been performed. It is shown that, under the parity nonconservation, the differential cross section of the radiative capture of a slow neutron by a spinless nucleus is anisotropic and has the following structure:

$$\frac{d\sigma}{d\Omega} = A + B\,P\,(\mathbf{l}_n \mathbf{l}_\gamma),$$

where the coefficients $A$ and $B$ depend on the neutron energy, but do not depend upon the angle of $\gamma$ quantum emission, the coefficient $A$ depends also on the parameters of the *S*-wave resonance, and the coefficient $B$ depends upon the parameters of both the *S*-wave and *P*-wave resonances as well as upon the matrix element of mixing due to weak interaction, $P$ is the degree of neutron longitudinal polarization and $\mathbf{l}_n$, $\mathbf{l}_\gamma$ are the unit vectors directed along the momenta of the neutron and $\gamma$ quantum, respectively.

# Determination of the Magnesium, Aluminum and Silicon Contents of Water Samples by IGAA and NAA

Maslov O.D., Gustova M.V., Belov A.G., Drobina T.P.

*Joint Institute for Nuclear Research, Dubna, Russia*

The possibility of determining the Mg, Al and Si contents of water samples using nuclear physical methods was studied.

Detections limits of 0.1, 0.03 and 0.1 mg/l for Mg, Al and Si in water samples are obtained.

Monitoring of the aluminum and silicon contents in water is important because the high concentration of aluminum or the low content of silicon in drinking water may be risk factors for Alzheimer's disease.



# ISOMER RATIOS FOR $^{241}$Am(n, γ) AND $^{243}$Am(n, γ) REACTIONS

V.M. Maslov[1], V.G. Pronyaev[2], N.A. Tetereva[1], K.I. Zolotarev[2]

[1]Joint Institute of Nuclear and Energy Research, 220109, Minsk-Sosny, Belarus
[2]Institute of Physics and Power Engineering, 249033, Obninsk, Russia
[3]International Atomic Energy Agency, Vienna, Austria

The neutron capture reaction $^{241}$Am(n, γ) populates either the $T_{1/2}$ =16 h ground state $^{242g}$Am with $J^{\pi}=1^-$ or the $^{242m}$Am isomer $J^{\pi}=5^-$ with $T_{1/2}$ =141 y. The former state $^{242g}$Am mostly β⁻-decays to $^{242}$Cm, or goes to $^{242}$Pu via electron capture. The yield of the $^{242g}$Am short-lived ground state in the reaction chain $^{241}$Am(n,γ)$^{242g}$Am(β⁻)$^{242}$Cm influences the α–activity and neutron activity of the spent fuel due to emerging nuclides $^{242}$Cm and $^{238}$Pu. The yield of the $^{242m}$Am long-lived isomer state, which due to large and odd value of $J^{\pi}=5^-$ may decay to $^{242g}$Am via isomeric transition only, in the capture reaction $^{241}$Am(n, γ)$^{242m}$Am influences the neutron activity of the spent fuel due to spontaneous fission of $^{242m}$Am. It gives a path for the $^{244}$Cm yield via $^{242m}$Am(n,γ)$^{243}$Am(n,γ)$^{244m}$Am(β⁻(ε))$^{244}$Cm($^{244}$Pu) or $^{242m}$Am(n,γ)$^{243}$Am(n,γ)$^{244g}$Am(β⁻)$^{244}$Cm. If not the forbidden β⁻-decay of $^{242m}$Am state, the major path for the $^{244}$Cm accumulation would have been closed. That is what actually happens in case of $^{243}$Am(n,γ) reaction, when both states, either $^{244m}$Am ($T_{1/2}$ =10.1 h) and $^{244g}$Am ($T_{1/2}$ =26 m), convert into $^{244}$Cm via β⁻-decay. Yield of $^{244}$Cm influences α–activity and neutron activity of spent fuel.

The branching ratios $R(E_n)=1/(1+r(E_n))$, $r(E_n)=\sigma^m_{n\gamma}(E_n)/\sigma^g_{n\gamma}(E_n)$ from thermal energy to 20 MeV are defined by the ratio of the populations of these two lowest states. These populations are defined by the γ-decay of the excited states, described by the kinetic equation, developed by Strutinsky et al. (1960). E1, E2, M1 and M2 transitions are allowed in a continuum excitation energy range. Modeling of low-lying levels by Sood et al. (1982) is accomplished within the assumption that ground and first few excited states are of two-quasi-particle nature. In that approach the populations of the lowest five level doublets are calculated. We assume that the transition to the high spin long-lived state or low-spin, short-lived ground state is defined using the populations of discrete states via the "minimum multipolarity" rule:

$$r(E_n)=\frac{\sum_{J>(J_g+J_m)/2} W(U,J^{\pi})}{\sum_{J\le(J_g+J_m)/2} W(U,J^{\pi})} \qquad (1)$$

Adopted level scheme appear to be quite compatible with the post-irradiation integral experiments data. The discrepancy of our calculated branching ratio with that of ENDF/B-VII.0 is supported by the underestimation of the capture rates to $^{242g}$Am in integral benchmarks.

Strutinsky V.M., Groshev L.V., Akimova M.K., Atomnaya Energiya, 38, 598 (1960).
Sood P.C., Singh R.N. Nucl. Phys. A373, 519 (1982).

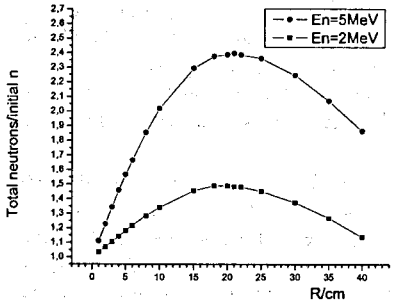
## On the Possibility to Increase a Neutron Beam Flux of IREN.

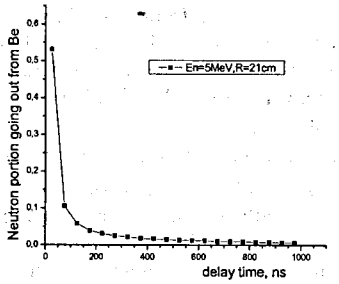
L.V.Mitsyna, A.B.Popov, Song Zhaohui[1]

*Frank Laboratory of Neutron Physics, JINR,, 141980, Dubna, Russia*

*[1]Northwest Institute of Nuclear Technology, 710024, Xi'an, China*

A system of the neutron generating IREN target circled with beryllium cylinder of 10 - 20 cm thickness is considered. A sizeable (n,2n) cross section for beryllium, which has a value about 0.6 b at 3 –10 MeV neutrons energies, allows to increase a neutron flux of IREN experimental beams. Using GEANT and FLUKA codes the flux and time parameters of neutron W-Be source were estimated. The figures show the preliminary results obtained by GEANT for beryllium sphere with neutron source in the center.






## CALCULATION OF CORRECTIONS FOR PRECISE OBTAINING THE n,e- SCATTERING LENGTH FROM THE ANGULAR ANISOTROPY OF SLOW NEUTRONS SCATTERED BY NOBLE GASES

*L.V.Mitsyna, A.B.Popov*

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

For the precise measuring the angular anisotropy of neutrons scattered by noble gases in energy region from a few meV up to 1 eV with use of time-of-flight method it is necessary to know all corrections with the accuracy not worse than of $10^{-4}$. Only in this case one can assure obtaining the n,e-scattering length $b_{ne}$ with the accuracy 2 – 3 %. The corrections for efficiency difference of detectors, which register slow neutrons scattered forward or backward, with taking into account the thermal motion of argon atoms are calculated by Monte Carlo method in real geometry.

## Photo-neutron cross-sections for $^{208}$Pb and $^{209}$Bi induced by bremsstrahlung

Haladhara Naik[a], Sarbjit Singh[a], Ashok Goswami[a], Vijay Kumar Manchanda[a], Guinyun Kim[b,1], Kyung Sook Kim[b], Man-Woo Lee[b], Md. Shakilur Rahman[b], Devesh Raj[c], Srinivasan Ganesan[c], SaraswatulaVenkata Suryanarayana[d], Moo-Hyun Cho[e], and Won Namkung[e]

[a] Radiochemistry Division, Bhabha Atomic Research Centre, Trombay, Mumbai-400085, India.

[b] Department of Physics, Kyungpook National University, Daegu 702-701, Republic of Korea.

[c] Reactor Physics Design Divisison, Bhabha Atomic Research Centre,Trombay, Mumbai-400085, India.

[d] Nuclear Physics Division, Bhabha Atomic Research Centre, Trombay, Mumbai-400085, India.

[e] Pohang Accelerator Laboratory, Pohang University of Science and Technology, Pohang 790-784, Republic of Korea.

**Abstract**

The photo-neutron cross-sections of $^{208}$Pb and $^{209}$Bi induced by 50-70 MeV bremsstrahlung have been measured by using the off-line γ-ray spectrometric technique in the electron linac at the Pohang Accelerator Laboratory. The experimental photo-neutron cross-sections for the $^{208}$Pb(γ,xn) and the $^{209}$Bi(γ,xn) reactions at the bremsstrahlung energy region of 50-70 MeV, which are determined for the first time, are in general good agreement with the theoretical values based on the TALYS 1.0 code. We observed that the photo-neutron cross-sections for the (γ,xn) reactions of $^{209}$Bi and $^{208}$Pb increase with increasing the bremsstrahlung energy from 50 to 70 MeV, which indicates the role of excitation energy. It was also observed that the (γ,xn) reaction cross-sections of the doubly magic shell nuclei $_{82}$Pb$^{126}$ are always higher than those of the singly magic shell nuclei $_{83}$Bi$^{126}$ in the bremsstrahlung energy of 50-70 MeV. This may be due to the fact that either the shell effect are washed out at the higher excitation energy or due to the lower fission cross-section of $^{208}$Pb compared to that of $^{209}$Bi. This observation indicates that there is a competition reaction between fission and neutron emission.

[1] Corresponding author. Tel.: +82 53 950 5320; fax: +82 53 939-3972. E-mail address: gnkim@knu.ac.kr (G. N. Kim)



## INAA AND PIXE COMPARISON ON SOME VEGETABLE SPECIES (CABBAGE, TOMATO, PEPPER AND PARSNIP)

Pantelica A.[1], Culicov O.A.[2,3], Frontasyeva M.V.[2], Ene A.[4], Ciortea C.[1], Gugiu M.[1]

[1] *Horia Hulubei National Institute for R&D in Physics and Nuclear Engineering (IFIN-HH), 30 Reactorului St., Magurele, jud. Ilfov, P.O.B. MG-6, RO-07712, Romania, E-mail: apantel@nipne.ro*

[2] *Joint Institute for Nuclear Research, 141980 Dubna, Russian Federation, E-mail: marina@nf.jinr.ru*

[3] *National Research and Development Institute for Electrical Engineering, ICPE-Advanced Research, Splaiul Unirii, 74204, Bucharest, Romania, E-mail: culicov@nf.jinr.ru*

[4] *"Dunarea de Jos" University of Galati, Faculty of Sciences, Physics Department, 111 Domneasca St, 800201 Galati, Romania, E-mail: aene@ugal.ro*

This paper presents a comparison of Instrumental Neutron Activation Analysis (INAA) and Proton-Induced X-ray Emission (PIXE) analytical techniques applied to determine major, minor and trace constituents of some edible vegetable species (tomato, cabbage, pepper, and parsnip) collected from agricultural zones in Romania with no specific type of pollution (Crevedia and Magurele localities). This study is part of a larger investigation of possible foodstuff contamination with toxic elements originated from industrial activities. Thin target PIXE was performed using a 3 MeV proton beam generated by the 9 MV FN-type Van de Graaff Tandem accelerator of the Horia Hulubei National Institute of Physics and Nuclear Engineering (IFIN-HH) in Magurele (near Bucharest, Romania). INAA was applied at IFIN-HH for the long-lived radionuclides and Joint Institute for Nuclear Research (JINR) in Dubna, Russia for the short-lived radionuclides. Neutron irradiation in INAA was carried out at the TRIGA nuclear reactor of the Institute of Nuclear Researches (RAAN-SCN) Pitesti, as well as IBR-2 reactor of JINR Dubna. A comparison was made for the elements determined both by PIXE and short-term irradiation INAA (Al, Cl, K, Ca, Mn, and Cu), as well as for those determined both by PIXE and long-term irradiation INAA (K, Ca, Cr, Fe, Co, Ni, Zn, As, Se, Br, Rb, and Sr). The capability of INAA in analyzing Na, K and Ca by short- and long-term irradiation was also discussed. It was observed that PIXE is a complementary technique to INAA in determination of S, Ti, and Pb in this type of samples. This work was supported in part by the PNCDI II Project No. 72-172/2008 in Romania and Joint Research Project No. 3871-4-08/10 between JINR Dubna and IFIN-HH.

## T-ODD ASYMMETRY EFFECTS IN LOW ENERGY FISSION
(nearest perspectives)

G.A. Petrov[1], A.M. Gagarski[1], I.S. Guseva[1], Yu.N. Kopach[2]
[1] PNPI of RNC "Khurchatov Institute", Gatchina Leningrad district Russia
[2] JINR, Dubna, Moscow District Russia

Recently the interference effects of LCP and γ-rays accompanied ternary and binary fission induced by polarized neutrons have been firstly observed and investigated for some fissile nuclei [1, 2]. As it had been remarked already in the first theoretical considerations these interesting and unexpected physical effects can allow absolutely new possibilities for new comprehensive studies of low energy fission dynamics [3,4]. With the aim to widen directions for further investigations of these T-odd effect properties and to determine the real possibilities to make use of them for fission dynamic studies we propose for discussion the following experiments:

- Precise comparative measurements of TRI and ROT-asymmetry effects for α and t-particles in ternary fission (Perspective targets $^{233,235}$U).
- Investigations of the TRI and ROT-effect values for different fissioning system elongations ("Standard I and Standard II" fragment mass distributions.). (Perspective targets: $^{233,235}$U).
- Precise comparative investigations of ROT-asymmetry effects for LCP, fast neutrons, and γ-rays accompanied ternary and binary fission. (Perspective target $^{235}$U)
- Comparison of the TRI and ROT-asymmetry effects for the cases of two different transition states mixture and for single isolated transition state of fissioning nuclei. (Perspective targets $^{239}$Pu and maybe $^{241}$Pu)
- Investigations of the influence of different spin values of the transition states on the TRI and ROT-effect properties (Perspective targets $^{239}$Pu and $^{241}$Pu with resonance energies 0,3 eV and 0,25 eV and transition state spins $1^+$ and $3^+$ respectively).

In nearest future all experimental measurements with the cold polarized neutrons may be performed mainly at the High Flux Reactor ILL. For the beginning, resonance measurements of ROT-effects for the neutron and γ-radiations really may be performed at the radial neutron beam of the WWR-M reactor (PNPI) with epithermal neutrons. After completion of the Pulse Reactor IBR-2M (JINR) modernization such experiments may be continued at the resonance polarized neutron beam. But it is evident that only after putting into operation High Flux Reactor PIK Russia will get the real and wide possibilities to use the T-odd asymmetry effects for low energy fission dynamics investigations.

References

1.A.M. Gagarski, F. Goennenwein, I.S Guseva et al. Proc. Sem. ISINN-17, JINR, 2010, p. 17
2. G.V. Danilyan, V.A. Krakhotin et al. Yad.Fiz. v.82, 2009, p.1872
3.I.S. Guseva, Yu. Gusev. Bull. RAS. (physics) v.71, 2007, p. , 367
4. V.E Bunakov and S.G. Kadmenski. Pros. Int. Sem. ISSIN-16, JINR, 2009, p.325



## GIANT DIPOLE RESONANCE PARAMETERS WITHIN RENEWED SYSTEMATICS

V.A. Plujko[1,2], O.M. Gorbachenko[1], V.M. Bondar[1]
[1] *Taras Shevchenko National University, Kiev, Ukraine*
[2] *Institute for Nuclear Research, Kiev, Ukraine*
vira_bondar@ukr.net

A reliable parameterizations of Isovector Giant Dipole Resonance (IVGDR or GDR) parameters are of considerable importance for the calculations of gamma-ray (radiative) strength functions (RSF)(see Ref. [1] and references therein) as well as for the verification of different theoretical approaches used to describe GDR resonances nuclei.

In this contribution general expression for average RSF of gamma-decay is given and practical phenomenological methods are considered for the calculations of dipole radiative strength function both for γ-decay and for photoabsorption. It is shown that approaches with asymmetric shape of the electric dipole RSF [1] are preferable among other phenomenological methods for RSF calculations in relatively wide gamma-ray energy interval from zero to slightly above the energy of GDR peak. Brief overview of existing GDR parameters systematics is given. Renewed systematics of giant dipole resonance (GDR) parameters were obtained within different forms proposed by different theoretical predictions. Updated GDR parameter values and their uncertainties were used [2]. GDR energies and GDR widths within this systematics in general agree with previous results and can be used for reliable description of gamma-decay processes. Fitting coefficients of the energy systematics were used to estimate values of symmetry energy coefficient and ratio of symmetry energy coefficient to neutron skin stiffness coefficient by means of different methods which were found to be in agreement with results of other authors. It is demonstrated that the excitation functions and gamma-ray spectrum from (n,xγ) reactions on middle-weight and heavy atomic nuclei can largely dependent on the GDR parameter uncertainties.

1. R. Capote, M. Herman, P.Oblozinsky, P.G. Young, S. Goriely, T. Belgya, A.V. Ignatyuk, A.J.Koning, S.Hilaire, V.A.Plujko et al // Nucl. Data Sheets. 2009. V.110. P.3107-3213.

2. V.A. Plujko, R. Capote, O.M. Gorbachenko Giant Dipole Resonance Parameters with Uncertainties from Photonuclear Cross Sections // At.Data Nucl.Data Tables, 2011, in press.

# MOSS BIOMONITORING IN ROMANIA IN THE FRAME OF JINR-ROMANIA COLLABORATION

Popescu I.V. [1,2,3], Ene A.[4], Cucu-Man S.[5], Todoran R.[6], Frontasyeva M.[7], Culicov O.[7], Stihi C.[1,2], Gheboianu A.[2],

[1] "Valahia" University of Targoviste, Faculty of Sciences and Arts, Sciences Department, 2 Carol I street, 130022, Targoviste, Romania
[2] "Valahia" University of Targoviste, Multidisciplinary Research Institute for Sciences and Technologies, 130024, Targoviste, Romania
[3] Academy of Romanian Scientists, Bucharest, Romania
[4] „Dunarea de Jos" University of Galati, Faculty of Sciences, Department of Chemistry, Physics and Environment, Physics Unit, 111 Domneasca St., 800201 Galati, Romania
[5] „Al.I.Cuza" University of Iasi, Faculty of Chemistry, Iasi, Romania
[6] University of Baia Mare, Physics Department, Baia Mare, Romania
[7] Joint Institute of Nuclear Research, Frank Laboratory of Neutron Physics, Dubna, Russia

The first systematic study in Romania of atmospheric pollution from heavy metals and other toxic elements based on moss analysis was undertaken as a Romanian–Russian–Norwegian collaboration, in order to assess the general state of heavy metal pollution in Romania in the period 1995–2001. The results on moss samples collected in different regions of Romania in 1990, 1995 and 2000 were unified and reported by UNECE in "Spatial and temporal trends in heavy metal accumulation in mosses in Europe (1990-2005)", Programme Coordination Centre for the ICP Vegetation, Centre for Ecology and Hydrology, Bangor, UK.

In present in Romania are carried out activities related to implementation of nuclear and related techniques for the analysis of environmental bio-monitors, including mosses, and moss sampling from the sites covered in previous surveys, in the frame of the collaboration between Joint Institute of Nuclear Research (JINR) and a Romanian consortium constituted of "Valahia" University of Targoviste (UVT-coordinator), and partners „Dunarea de Jos" University of Galati, "Al.I. Cuza" University of Iasi and University of Baia Mare (Bilateral Project JINR-Romania, 2010, "Nuclear and related analytical techniques for Environmental and Life Sciences", Theme no. 03-4-1036-2001/2010 and 03-4-1104-2011/2013). The Romanian teams from the four universities collected approx. 300 samples in summer-autumn time during 2010, from the Carpathian Mountains, Transylvanian plateau, and Prut river catchment, following internationally accepted guidelines. The concentrations of elements will be determined using NAA (at JINR) and AAS (at UVT) and compared to those observed in previous surveys. The goal is to contribute to the European moss survey 2010/11, conducted under the auspices UNECE ICP Vegetation, covering some "white areas" on the map of atmospheric deposition of heavy metals in Europe.



# NEW PHYSICAL SPECTATOR OF THE COLLINEAR CLUSTER TRI-PARTITION OF $^{252}$CF (SF)

Yu.V. Pyatkov[1,2], D.V. Kamanin[1], A.A. Aleksandrov[1], I.A. Aleksandrova[1], N.A. Kondratyev[1], E.A. Kuznetsova[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 recent publications [1] we have presented experimental evidences of existing of a new type of ternary decay of heavy low excited nuclei called by us collinear cluster tri-partition (CCT). The results were obtained in the frame of the "missing mass" approach. It means that only two from at least three decay partners were actually detected whereas a total mass of these fragments being less the mass of mother system serves a signature of multibody decay. Evidently direct detection of all CCT products proves to be a most convincing experimental approach but much complicated one because mosaic detection systems must be used to achieve the goal.

COMETA (Correlation Mosaic E-T Array) setup aimed at studying rare multibody decays was put into operation recently in the Flerov Laboratory of the JINR. It is a double arm time-of-flight spectrometer which includes micro-channel plate (MCP) based "start" detector with the $^{252}$Cf source inside, two mosaics of eight PIN diodes each and a "neutron belt" comprises 30 3He filled neutron counters. Analyzing the data from COMETA spectrometer we came to conclusion that sometimes unknown ionizing substance hits directly MCP of the start detector. Normally in the detector with an electrostatic mirror electrons scattered by the FF from the emitting foil are deflected by the mirror onto the MCP surface. The mirror was switched off in a special test experiment in order to provide signals exclusively directly from MCP. Such signals were used as specific labels for selection of the events standing behind. Second start detector operated in "normal" mode delivered "start" signals for measuring of the FFs time-of-flights. Mass-energy distribution for fission events having such labels and total mass of two detected fragments (M1 + M2) < 236 amu is shown in Fig. 1. The plot vividly demonstrates manifestation of two different CCT modes. Corresponding prescission configurations are shown schematically in the bottom of the figure. Right side configuration corresponds to sequential process resulted in forming of the light FF similar to this known in conventional binary fission. Left side configuration let explain extremely low energy of the FF with the mass of typical light binary fragment. We see as well mass-energy trend of the fragment in this CCT mode.

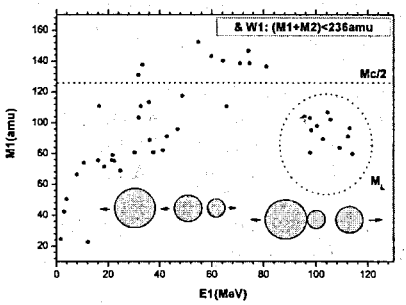



Fig. 1. Mass-energy distribution for the FFs from $^{252}$Cf (sf). The following selection rules were applied: total mass of two detected FFs does not exceed 236amu; unknown physical spectator hit reference MCP. See text for details.

**References**

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

# Parity-Violating Gamma Asymmetry in np-Capture

E.I. Sharapov[1], R. Alarcon[2], S. Balascuta[2], L. Barrón-Palos[3], J.D. Bowman[4], R.D. Carlini[5], W. Chen[6], T.E. Chupp[7], C. Crawford[8], S. Covrig[5], M. Dabaghyan[9], N. Fomin[10], S.J. Freedman[11], T.R. Gentile[12], M.T. Gericke[13], R.C. Gillis[6], G.L. Greene[4,10], F.W. Hersman[14], T. Ino[15], G.L. Jones[16], B. Lauss[17], M. Leuschner[6], W.R. Lozowski[6], R. Mahurin[5,13], Y. Masuda[15], J. Mei[6], G.S. Mitchell[18], S. Muto[15], H. Nann[6], S.A. Page[13], S.I. Penttilä[4], W.D. Ramsay[13], A. Salas-Bacci[19], S. Santra[6], M. Sharma[7], P.-N. Seo[20], T.B. Smith[21], W.M. Snow[6], W.S. Wilburn[19], V. Yuan[19]

[1]Joint Institute for Nuclear Research, 141980 Dubna, Russia
[2]Arizona State University, Tempe, AZ 85287, USA
[3]Universidad Nacional Autónoma de México, C.P. 04510, D.F., Mexico
[4]Oak Ridge National Laboratory, Oak Ridge, TN 37831, USA
[5]Thomas Jefferson National Accelerator Facility, Newport News, VA 23606, USA
[6]Indiana University, Bloomington, IN 47405, USA
[7]University of Michigan, Ann Arbor, MI 48104, USA; [8]University of Kentucky, 40506, USA
[9]University of New Hampshire, Durham, NH 03824, USA; [10]University of Tennessee, Knoxville, TN 37996, USA; [11]University of California, Berkeley, CA 94720-7300, USA
[12]National Institute of Standards and Technology,Gaithersburg, MD 20899-0001,USA
[13]University of Manitoba, Winnipeg, MB, R3T 2N2, Canada
[14]University of New Hampshire, Durham, NH 03824, USA
[15]High Energy Accelerator Research Organization, Oho 1-1, Tsukuba-shi, 305-0801, Japan
[16]Hamilton College, Clinton, NY 13323, USA; [17]Paul Scherrer Institut, CH-5232, Switzerland
[18]Department of Biomedical Engineering, University of California, Davis, CA 95616, USA
[19]Los Alamos National Laboratory, Los Alamos, NM 87545, USA
[20]Department of Physics, North Carolina State University, Raleigh, NC 27695, USA
[21]University of Dayton, Dayton, OH 45469, USA

## Abstract

The NPDGamma Collaboration uses a pulsed, polarized, cold neutron beam, a para-hydrogen target, and an array of 48 CsI scintillation detectors to measure the parity-violating asymmetry $A_\gamma$ in the emission of photons along the neutron spin and opposite to it in the reaction $\vec{n} + p \rightarrow d + \gamma$. Knowledge of $A_\gamma$ (this asymmetry has a predicted size of $\simeq 0.5 \times 10^{-7}$) and other parity-violating observables in few-body nuclear systems should provide constraints for a parameterized description of the parity-violating phenomena, free from complications of nuclear structure. The collaboration completed the first phase of the experiment which took place at the spallation neutron source of the Los Alamos Neutron Science Center. We report the final (although an intermediate) result for the parity-violating asymmetry $A_\gamma = -(1.2 \pm 2.1(\text{stat.}) \pm 0.1(\text{sys.})) \times 10^{-7}$, and the result for the parity allowed, left-right (LR) asymmetry $A_\gamma^{LR} = -(1.28 \pm 1.9(\text{stat.}) \pm 0.2(\text{sys.})) \times 10^{-7}$. Our $A_\gamma$ value reproduces the previous upper limit from a measurement at the Grenoble ILL reactor facility, while the $A_\gamma^{LR}$ value is obtained for the first time. The second phase of the experiment, aimed at a better statistical accuracy, is presently under way at the Spallation Neutron Source of the Oak Ridge National Laboratory.



# NEUTRON BEAM AT THE SYNCHROCYCLOTRON OF THE PNPI FOR RADIATION TESTS OF ELECTRONIC COMPONENTS

O.A. Shcherbakov[1], E.M. Ivanov[1], N.A. Ivanov[1], G.F. Mikheev[1], E.V. Mitin[2], V.V. Pashuk[1], G.A. Ryabov[1], M.G. Tverskoy[1], L.A. Vaishnene[1], A.S. Vorobyev[1]

[1] *Petersburg Nuclear Physics Institute, 188300, Gatchina, Russia*

[2] *Elektronstandart Russian Research Institute, St.-Petersburg, Russia*

The characteristics of neutron beam of the GNEIS facility based on the PNPI synchrocyclotron which resembles that of atmospheric neutron radiation in the energy range 1 – 1000 MeV are presented. The beam is intended for testing the radiation resistance of electronics and meets the requirements of the JEDEC international standard. The development of neutron test facility extends considerably experimental potential of radiation research at the PNPI and can be used as a basis for establishing a unique Center for radiation tests of electronic equipment intended for nuclear industry, aviation and space research.

The first radiation tests of electronic components have been done at the neutron beam of the GNEIS facility. It was carried out irradiation of the CCD-matrix Sony ICX-259 used in the equipment intended for work under space conditions. The results of the investigation of matrix dark currents as a function of the absorbed neutron fluence are presented in comparison with analogous data obtained at the PNPI synchrocyclotron under irradiation by 1 GeV protons.

# Comparative Analysis of the Pohang Neutron Facility and IREN Source. The Joint Program on Nuclear Data Measurements.

Valery Shvetsov[1,2], Moo-Hyun Cho[2], Guinyun Kim[3], Manwoo Lee[3], Won Namkung[4], and Vadim Skoy[1]

[1]*Frank Laboratory of Neutron Physics, Joint Institute for Nuclear Research, 141980, Joliot-Curie-6, Dubna, Russia*
[2]*Division of Advanced Nuclear Engineering, Pohang University of Science and Technology, Pohang 790-784, Korea*
[3]*Department of Physics, Kyungpook National University, Daegu 702-701, Korea*
[4]*Department of Physics, Pohang University of Science and Technology, Pohang 790-784, Korea*

Authors report the comparative analysis of the Pohang Neutron Facility[i] and IREN[ii] neutron source and joint program on nuclear data measurements. Both facilities are electron accelerator based pulsed neutron sources with nonmultiplying neutron producing targets. The parameters of the source are quite similar which makes possible easy transfer of the experimental techniques from one facility to another one and makes possible efficient coordination between Russian and Korean teams in implementation of the joint nuclear data experimental program. We report also the analysis of the current situation with nuclear data needs for Generation IV nuclear energy systems and other applications according to the latest evaluations of the sensitivity of advanced energy systems design and performance on accuracy of the nuclear data[iii,iv]. We report also the joint experimental program on nuclear data measurements at PNF and IREN, which based on abovementioned analysis.

This research was supported by WCU (World Class University) program through the National Research Foundation of Korea funded by the Ministry of Education, Science and Technology (R31 - 30005)

[i] STATUS OF POHANG NEUTRON FACILITY BASED ON 100-MEV ELECTRON LINAC, *Proceedings of LINAC2002, Gyeongju, Korea*
[ii] Physical start-up of the first stage of IREN facility, 2010 *J. Phys.: Conf. Ser.* **205** 012053
[iii] SENSITIVITY OF ADVANCED REACTOR AND FUEL CYCLE PERFORMANCE PARAMETERS TO NUCLEAR DATA UNCERTAINTIES, *Proceedings of the International Workshop Nuclear Data Needs For Generation IV Nuclear Energy Systems, Antwerpen, Belgium, 5-7 April 2005*
[iv] Nuclear data requirements for the ADS conceptual design EFIT: Uncertainty and sensitivity study, *Annals of Nuclear Energy 37 (2010) 1570–1579*



# NUCLEAR STRUCTURE PHYSICS WITH MoNA-LISA

S. L. Stephenson,[1] J. A. Brown,[2] P. A. DeYoung,[3] J. E. Finck,[4] N. H. Frank,[5] J. D. Hinnefeld,[6] R. A. Kaye,[7] B. A. Luther,[8] G. F. Peaslee,[3] D. A. Meyer,[9] W. F. Rogers[10] and the MoNA Collaboration

[1]Gettysburg College, Gettysburg Pennsylvania 17325, USA
[2]Wabash College, Crawfordsville Indiana 47933, USA
[3]Hope College, Holland Michigan 49423, USA
[4]Central Michigan University, Mount Pleasant Michigan 48859, USA
[5]Augustana College, Rock Island Illinois 61201, USA
[6] Indiana University South Bend, South Bend Indiana 46634, USA
[7]Ohio Wesleyan University, Delaware Ohio 43015, USA
[8] Concordia College, Moorhead Minnesota 56562, USA
[9] Rhodes College, Memphis Tennessee 38112, USA and
[10] Westmont College, Santa Barbara California 93108, USA

Interesting nuclear structure physics exists near the neutron dripline; extremely neutron-rich nuclei can even have different magic numbers than their more stable peers. Studies of these exotic nuclei at the National Superconducting Cyclotron Laboratory (NSCL) at Michigan State University demand knowledge of the complete reaction kinematics and require high detector efficiency as well as the capability for multiple neutron detection and discrimination. The NSCL's Modular Neutron Array (MoNA) [1] has been successful at meeting these demands and has led to furthering our understanding of the nuclear structure for a number of exotic nuclei such as $^{12}$Li [2], $^{15}$Be, $^{28}$F, and $^{18}$B [3]. The first decay energy spectrum for neutron unbound states in $^{24}$O was observed by this array, and data suggest $^{24}$O is a doubly magic nucleus [4]. This year MoNA will be used with LISA (Large multi-Institutional Scintillator Array) for a higher-resolution measurement of the first two excited states of $^{24}$O with possible confirmation of a newly found excited state at 7.5 MeV. A MoNA-LISA study of $^{20}$C in an effort to better understand how the *sd* shell evolves with neutron number is also in preparation.

This work was supported in part by US National Science Foundation Awards 0922409, 0922446, 0922462, 0922473, 0922537, 0922559, 0922622, 0922794 and 0922335.

[1] T.Baumann et al., Nucl. Instr. and Meth. A 543, 517 (2005).
[2] C. Hall, et al., Phys. Rev. C 81 (2010) 021302(R).
[3] A. Spyrou et al., Phys. Lett. B 683, 129 (2010).
[4] C.R. Hoffman et al., Phys. Lett. B672 (2009) 17.

# Study of nonstatistical effects due to tensor forces

S.I.Sukhoruchkin, M.S.Sukhoruchkina

Petersburg Nuclear Physics Institute, 188300 Gatchina

In this report we search for additional independent data on tensor force action in connection with the discussed in the literature the distinguished role of pion (Goldstone) exchange dynamics which needs to be checked. The excited states of antimony isotopes studied by T.Otsuka (Table top part) permitted not only to derive the parameter 161 keV of the tensor force action from the linear trend in excitations (boxed values n×161 keV) but also to study nonstatistical effects in highly excited state of the same nuclei.

Grouping effect in spacing distributions of $^{122,124}$Sb found at D=160 keV (boxed in Table, center) confirms the linear trend under discussion. The grouping effect in excitation of all antimony isotopes was found at fourfold value of this period 4×161 keV=644 keV. The grouping persists in sum $E^*$-distribution of Z-odd nuclei Z=47-57.

**Table.** Comparison of $E^*$ in $Z = 51$ nuclei with n×(161 keV=1293 keV/8).

| $^{A}$Z | $^{133}$Sb | $^{131}$Sb | $^{129}$Sb | $^{127}$Sb | $^{125}$Sb | $^{123}$Sb | $^{125}$Sb | $^{119}$Sb | $^{113}$Sb | $^{116}$Sn |
|---|---|---|---|---|---|---|---|---|---|---|
| $2J^\pi$,$J^\pi$ | $5^+$ | $5^+$ | $5^+$ | $5^+$ | $5^+$ | $5^+$ | $3^+,5^+$ | $1^+$ | $1^+$ | $2^+$ |
| $E^*$, keV | 962.0 | 798.4 | 645.2 | 491.2 | 332.1 | 160.3 | 644 | 644.0 | 644.8 | 1293.0 |
| n$\frac{D_0}{8}$ | 969 | 808 | 646 | 484 | 323 | 161 | 646 | 646 | 646 | 1293 |
| n | 6 | 5 | 4 | 3 | 2 | 1 | 4 | 4 | 4 | 8 |
| N | 82 | 80 | 78 | 76 | 74 | 72 | | | 62 | 64 |
| $E^*$, D(Sb) | | | 644 | | | 160 | | | | |
| Pd, keV | | | 648 | 512 | | | | | | 1293 |
| Sb,Pd, eV | | | 750 | | 375 | | | | | 1500 |

For existing two stable antimony isotopes many neutron resonances are known. They correspond to the highly excited states and the grouping effect at D=375 and 570 eV was noticed in the D-distribution of $^{124}$Sb. Intervals corresponding to the first maximum are forming sequences of stable intervals D=375-750-1500 eV, this 1:2:4 effect was found with the Adjacent Interval Method (AIM) described elsewhere.

Similar stable intervals 750-1500 eV were observed in neutron resonance spacing distributions in $^{104}$Rh and $^{105}$Pd (Table bottom). Stable intervals D=648 – 1293 keV similar to that in antimony isotopes are present in low-lying levels of $^{97,98}$Pd (Table center). Such similarity in stable intervals observed in several independent spacing distributions, namely $E^*$, D=646-1293 keV in low-lying levels and D=375-750-1500 eV in highly excited states permits to estimate the ratio between them 1500 eV/1293 keV=$1.16\cdot10^{-3}$ which is close to the QED-correction $\alpha/2\pi$=$1.16\cdot10^{-3}$. Similar intervals D=750-1500 eV were observed also in neutron resonances of hafnium, holmium and $^{79}$Br. This correspondence was used for the confirmation of effects due to the tensor force in levels of the same nuclei.



# Compilation of nuclear excited states CRF

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

Petersburg Nuclear Physics Institute, 188300 Gatchina

We present the contains (numbers of levels in books and in the Supplements) and some scientific applications of 5-volumes compilation CRF (Combined Reaction File) of excited states of all nuclei prepared in PNPI for LB Springer (Editor H.Schopper). Volumes A,B,C,D,E contain data for nuclei with Z=1-29, 30-47, 48-60, 61-73 and 74-104.

Each volume of CRF Compilation contains a special chapter in its Introduction written by invited author to present one of the advanced methods of nuclear data measurements.

Such a chapter of the first volume is written by A. Sukhovoy and V. Khitrov under the title "Capture $\gamma$-ray cascade measurements in JINR (Dubna)". It describes the main advantages of the neutron capture gamma-gamma method developed in LNF JINR by the group of scientists headed by Yu. Yazvitsky and Yu. Popov.

The chapter has the following parts: 1) Methods of neutron capture $\gamma$-ray measurements; 2) Spectroscopic information from the summation of amplitudes of coinciding pulses from Ge-detectors (SACP method); 3) Construction of the $\gamma$-decay schemes and 4) Method for the determination of the population of levels in cascade.

The great numbers of excited states in Nuclear Data Sheets compilation (and in CRF as well) measured at JINR is the important step forward in the nuclear spectroscopy.

A special chapter in the second volume written by Ulrich Kneissl (Darmstadt) is devoted to Nuclear Resonance Fluorescence method in nuclear spectroscopy.

Compilation CRF contains also data on highly excited states of light and near-magic nuclei derived from charge-particle and neutron resonances. In many cases it permits the additional study of few-nucleon effects observed in low-lying levels of these nuclei.

In a special chapter of the first volumes correlations in energy levels due to tensor force are considered (see Figure). The selection of the interacting nuclei according to their spin-orbit orientation was used during the study of nonstatistical effects.

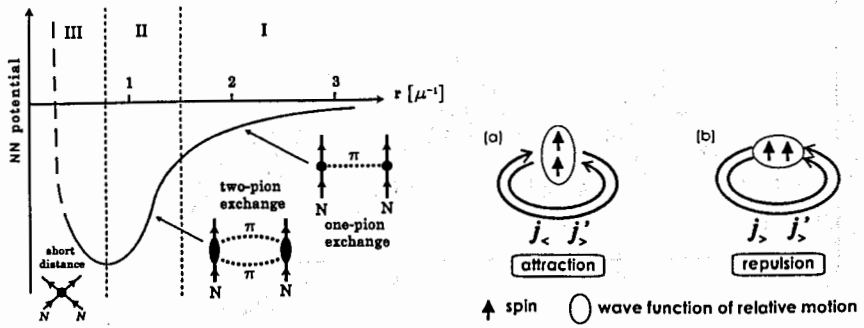



**Figure** *left*: Hierarchy of scales governing the NN interaction (from M.Taketani). The distance $r$ is given in units of the pion Compton wavelength, $\mu^{-1} \simeq 1.4$ fm. *right:*. Intuitive illustration of tensor forces acting between two nucleons on orbits j and j' (from T.Otsuka).

# Compilation of Nuclear Binding Energies MDF

S.I.Sukhoruchkin, D.S.Sukhoruchkin

Petersburg Nuclear Physics Institute, 188300 Gatchina

In this report we describe recently published compilation MDF (Mass Difference File) and some of its scientific application. It was noticed by A.Arima and A.Bohr that nuclear binding energies and nuclear excitations are results of the same nucleon interaction and hence from these fundamental point of view positions of neutron resonances being the difference between them could provide important information. It was found earlier that the same parameters should be used for the description of few-nucleon effects in both these nuclear characteristics. Cluster effects in binding energies is one of ways for a study such common fundamental parameters. The stability of experimental differences of binding energies $\Delta E_B$ in nuclei with magic number N=82 and their closeness to $45\varepsilon_o$ can be seen in the Table (boxed values in the central part of Table) and in the Figure. Theoretical values $\Delta E_B$ do not show such effect. Parameter $\varepsilon_o$ is derived from the tensor force effects in nuclear excitations.

**Table** Comparison of $\Delta E_B$ (keV) in nuclei differing by $2\Delta Z=\Delta N=4$ with $45\varepsilon_o$=45990 keV.

| Nucleus | $^{133}$Cs | $^{135}$Cs | $^{137}$Cs | $^{135}$La | $^{137}$La | $^{139}$La | $^{136}$Ce | $^{138}$Ce | $^{140}$Ce | $^{139}$La |
|---|---|---|---|---|---|---|---|---|---|---|
| Z | 55 | 55 | 55 | 57 | 57 | 57 | 58 | 58 | 58 | 57 |
| N | 78 | 80 | [82] | 78 | 80 | [82] | 78 | 80 | [82] | [82] |
| $\Delta E_B$ | 45952 | 45946 | 45970 | 46018 | 45927 | 46024 | 46087 | 45997 | 45996 | 91975 |
| diff. | -38 | -44 | [-20] | 28 | -63 | [34] | 97 | [7] | [6] | [-5] |
| Theory | 46143 | 46353 | 46550 | 45933 | 46203 | 46673 | 46373 | 46573 | 47063 | 92816 |
| diff. | 153 | 363 | [563] | -57 | 213 | [683] | 383 | 583 | [1073] | [836] |

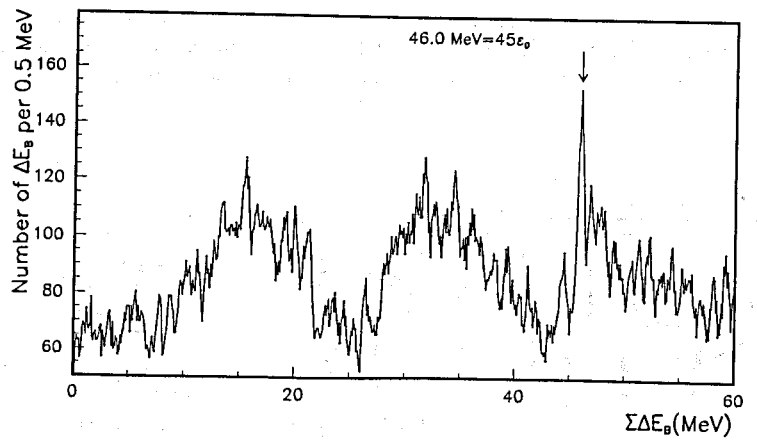



**Figure.** Distribution of differences of binding energies $\Delta E_B$ in nuclei with Z≤58; the maximum at $45\varepsilon_o$=46.0 MeV corresponds to the grouping of $\Delta E_B$ in nuclei differing with $\Delta Z$=2, $\Delta N$=4.



# MODIFIED MODEL OF NEUTRON RESONANCES WIDTH DISTRIBUTION. RESULTS OF NEUTRON REDUCED WIDTHS APPROXIMATION FOR MASS REGION 35 ≤A ≤249

**A.M. Sukhovoj, V.A. Khitrov**

*Joint Institute for Nuclear Research, Dubna, Russia*

The distributions of the reduced neutron widths of *s*-, *p*- and *d*-resonances of nuclei of any type from nuclear mass region 35≤A≤249 were approximated with maximal precision by the model which presents experimental data set as a superposition of, maximum, four independent neutron amplitudes. Under the assumption that each of these amplitudes has the Gauss distribution with the unique maximum there were determined the most probable values of contribution of each amplitude in total width distribution, their most probable mean values and dispersions. Comparison of the obtained $\chi^2$ values with value $\chi^2$ at description of the experimental data by one distribution of neutron amplitudes with best fitted parameters shows that all widths from more than 157 analyzed data sets can have few different types of their wave functions.

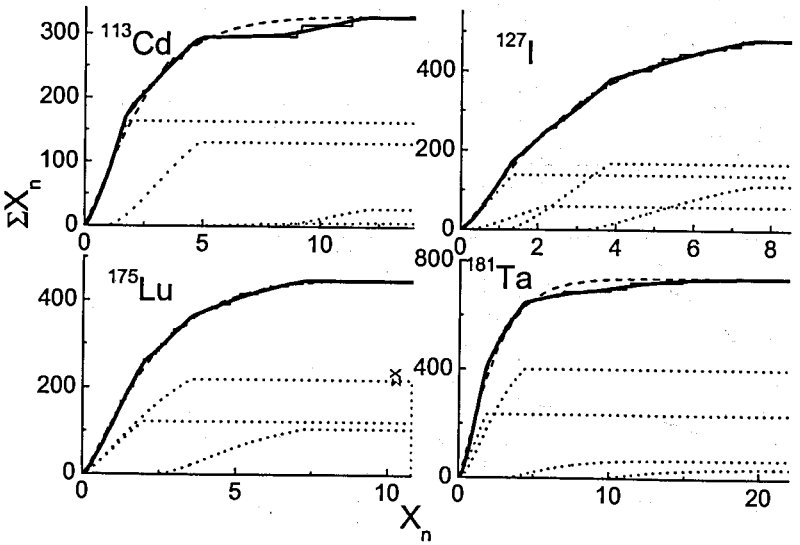



Fig. 1. The results of approximation of distribution of neutron reduced widths for $^{113}$Cd, $^{127}$I, $^{175}$Lu and $^{181}$Ta. Histogram – the experiment, dash line – approximation for $k$=1, thick line – $k$=4, dot lines – the variant of decomposition of experimental distribution over 4 partial functions.

## MODIFIED MODEL OF NEUTRON RESONANCES WIDTH DISTRIBUTION. ESTIMATION OF THE QUALITY OF RESULTS AND INTERPRETATION OF AVIALABLE PHYSICS INFORMATION

**A.M. Sukhovoj, W.I. Furman, V.A. Khitrov**

*Joint Institute for Nuclear Research, Dubna, Russia*

In the work was performed analysis of parameters of approximation of 157 sets of resonances in the mass region of nuclei 35 $\leq$A $\leq$249. It was shown that the experimental values of widths can correspond with high probability to superposition of several independent neutron widths with their non-zero mean values and non-unit dispersion.

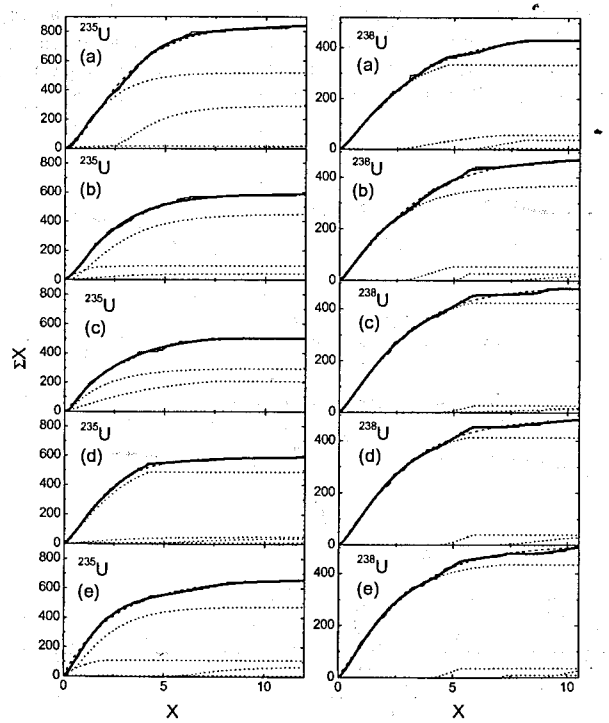



Fig. 1. Approximation of cumulative sums of the relative $X$ values for five intervals of neutron energies of constant width in $^{235,238}$U. Histogram – the experiment, dash line – approximation for $k$=1, thick line – for $k$=4, dot lines – the variant of decomposition of the best fit functions over partial functions.



## MODIFIED MODEL OF NEUTRON RESONANCES WIDTH DISTRIBUTION. RESULTS OF TOTAL GAMMA-WIDTHS APPROXIMATION

**A.M. Sukhovoj, V.A. Khitrov**

*Joint Institute for Nuclear Research, Dubna, Russia*

Functional dependences of probability to observe given $\Gamma_n^0$ value and algorithms for determination of the most probable magnitudes of the modified model parameters distribution were used for analysis of the experimental data on the total radiative widths of neutron resonances. As in the case of neutron widths, for precise description of the $\Gamma_\gamma$ distributions requires a superposition of 3 and more probabilities distributions for squares of the random normally distributed values with the non-zero average and non-unit dispersion .

This result confirms the preliminary conclusion obtained earlier at analysis of $\Gamma_n^0$ on presence in all 56 tested sets of resonances several groups noticeably differing by the structure of their wave functions from each other.

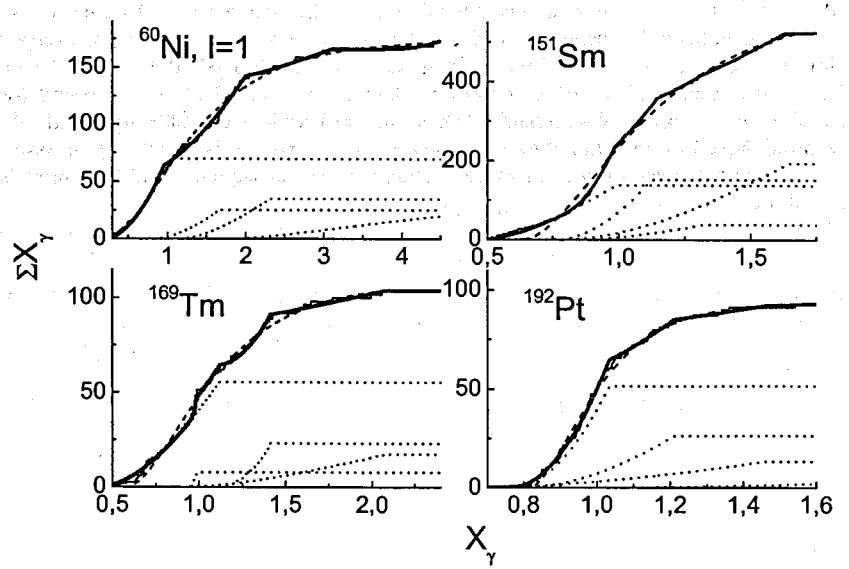



Fig. 1. The results of approximation of distribution of total radiative widths for $^{60}$Ni, $^{151}$Sm, $^{169}$Tm and $^{192}$Pt. Histogram – the experiment, dash line – approximation for $k$=1, thick line – $k$=4, dot lines – the variant of decomposition of experimental distribution over 4 partial functions.

# TEMPORAL VARIATIONS OF $^{137}$Cs IN SURFACE AIR IN BRATISLAVA, SLOVAKIA, OVER 33 YEARS

Sykora I., Povinec P., Brestakova L., Florek M., Holý K., Masarik J., Frontasyeva M.V.[1], Steinnes E.[2]

*Dept. of Nuclear Physics and Biophysics, Faculty of Mathematic, Physics and Informatics, Comenius University, Bratislava, Slovak Republic, E-mail: sykora@fmph.uniba.sk*

*[1]FLNP JINR, Dubna, Russian Federation,*

*[2]Norwegian University of Science and Technology, NO-7491 Trondheim, Norway*

The objective of this study is to evaluate the changes in surface atmospheric distribution of $^{137}$Cs before and after the Chernobyl accident. Measurements of $^{137}$Cs in the air carried out in Bratislava, Slovak Republic from 1977 until present show that the main source of $^{137}$Cs surface air activity is the residue of the global fallout from atmospheric nuclear weapon tests. From these measurements it follows that the decrease of $^{137}$Cs concentration in the air has exponential dependence with ecological half-life $\tau \approx 59.1$ months, except for a significant increase in activity level during the years 1986–1988 due to the Chernobyl accident. At present the level of airborne $^{137}$Cs activity is about 0.3 $\mu$Bq/m$^3$. It seems that the decreasing trend (with ecological half-life) has stopped after the year 2008 and a shift of $^{137}$Cs concentration peak from summer to winter season is observed. This effect may be associated with transfer of radiocaesium from soil to vegetation and subsequent burning of biomass, or with soil resuspension.



# EXOTIC P-NONINVARIANT CORRELATIONS IN FISSION

Yu.M.Tchuvil'sky

*Skobeltsyn Institute of Nuclear Physics, Moscow State University Moscow, 119991, Russia*

Correlations of fission products such as ROT-effect and TRI-effect are now subjects of keen interest. Both these correlations are P-even T-odd (pseudo-T-noninvariant) constructions of polarization observables and linear momenta. Final state interaction (FSI) of fission products simulates T-invariance break up.

Correlations of a similar type namely actual P-noninvariant, pseudo-T-noninvariant ones look even more interesting. The matter is that P-violating effect is not simulated by FSI phase shifts. Consequently a measurement scheme of a P-odd T-odd correlation turns out to be the experiment designed for search for parity violation. In [1] it was proposed to use a five-vector correlation in (p,αγ) cascade $(k_\alpha[k_p \times k_\gamma])(k_p \cdot k_\gamma)$ in search for P-violation in the proton resonances. Thus an unexpected possibility to study P-odd T-invariant effect in the framework of the scheme, which includes neither a polarized beam nor a polarimeter has come to light. And what is more such a way seems to be optimal for this purpose.

The cited property provides considerable possibilities for search for P-odd effect in fission. The approaches using one of the following correlations: $(k_{FF}[k_{ni} \times k_\gamma])(k_{ni} \cdot k_\gamma)$, $(k_{FF}[k_{ni} \times k_{nf}])(k_{ni} \cdot k_{nf})$ – for p-resonance or fast neutron induced fission; $(k_{FF}[k_\alpha \times k_{nf}])(k_\alpha \cdot k_{nf})$, $(k_{FF}[k_\alpha \times k_\gamma])(k_\alpha \cdot k_\gamma)$ – for thermal neutron induced or spontaneous ternary fission; $(k_{FF}[J \times s_{nf}])$ – for the polarized neutron induced fission of a polarized target to study the P-violation effect are discussed.

It is also demonstrated that parity violation effect can display itself as longitudinal polarization of fission neutrons and/or circular polarization gamma radiation of fission fragments of unpolarized sample.

1. I.S. Okunev, S.S. Parzhitski, Yu.M. Tchuvil'sky. In: Proceedings of ISINN - 14, Dubna, JINR, 2007. P. 160.

# SEMIMICROSCOPIC DESCRIPTION OF THE FAST NEUTRON RADIATIVE CAPTURE

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

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

Based on the continuum random phase approximation (cRPA) approach is used for the study of some features of the fast neutron radiative capture accompanied by excitation of the isovector giant dipole and quadrupole resonances (IVGDR and IVGQR, respectively). The suggested so-called semimicroscopic approach (see Ref. [1] and references therein) takes into account all the main giant-resonance relaxation modes (the Landau damping, coupling with the single-particle continuum, the spreading effect). The last one is taken into account phenomenologically with the help of the imaginary part (with the intensity $\alpha$) of an effective optical-model potential directly used in the cRPA equations.

In the present work we suggest an extended version of the approach. The extension consists in (i) the explicit use of the isovector part of (separable) momentum-dependent forces (with intensity $k'$ ); (ii) taking into account the giant-resonance energy shift due to the spreading effect [2]; (iii) the use of the version of the phenomenological partially self-consistent mean field [3]. Two specific parameters ($\alpha$ and $k'$) are adjusted to describe the experimental photoabsorption cross section in the IVGDR energy region for a given (spherical) nucleus. Then, the partial (n,γ)–reaction cross sections in the IVGDR energy region as well as the asymmetry (relatively 90°) of the differential (n,γ)–and inverse reaction cross sections in the IVGQR energy region (together with the main properties of the IVGQR) are calculated without the use of free parameters. The calculation results obtained for a number of magic and semimagic nuclei are compared with available experimental data.

This work is partially supported by RFBR, grant no. 09-02-00926.

1. M.H. Urin // Nucl. Phys. A. 2008. V.811. P.107.
2. B.A. Tulupov, M.G. Urin // Phys. At. Nucl. 2009. V.72. P.737.
3. S.Yu. Igashov, M.G. Urin // Bull. RAS. Phys. 2006. V.70. P.186.



# DAMPING OF HIGH-ENERGY PARTICLE-HOLE-TYPE EXCITATIONS: A SEMIMICROSCOPIC MODEL

Urin M.H.

National Research Nuclear University "MEPhI", Moscow, Russia

A great variety of high-energy particle-hole-type excitations (including the giant resonances (GRs)) is characterized by three main relaxation modes: (i) particle-hole (p-h) strength distribution (Landau damping), which is a result of the shell-structure of nuclei; (ii) coupling of (p-h)-type-states with the single-particle (s.p.) continuum, that leads to direct nucleon decay and related phenomena; (iii) coupling of (p-h)-type-states with many-quasiparticle configurations (chaotic states), which leads to the spreading effect. Actually, interplay of these relaxation modes is being changed with increasing the excitation energy. As applied to description of GR damping we developed the continuum-RPA-based semimicroscopic approach. Within the approach the spreading effect is phenomenologically taken into account directly in the cRPA equations for energy-averaged quantities in terms of an effective s.p. optical-model potential. Such a method allowed us to realize the statistical assumption about independent spreading different (p-h)-type states having the same total angular momentum and parity. Formulation and implementations of the approach, which is valid in the "pole" approximation (i.e. at the GR energy), are reviewed in Refs. [1,2].

In the present work we formulate a new model (p-h optical model), which is valid at arbitrary (but high enough) excitation energy [3,2]. The basic quantity of the model is the nonlocal p-h Green function, which satisfies the Bethe-Goldstone-type equation. Along with the usual p-h interaction responsible for long-range correlations the equation contains a specific p-h interaction (the fragmentation p-h scattering amplitude), which after energy averaging has an imaginary part. The latter is taken in the form allowing to realize the statistical assumption. The model is formulated for practical implementations and in a vicinity of a GR leads to the results obtained within the semimicroscopic approach.

This work is partially supported by RFBR, grant no 09-02-00926.

1. M.H. Urin // Nucl. Phys. A. 2008. V.811. P. 107.
2. M.G. Urin // Phys. At. Nucl. 2011. V.74 (in press).
3. M.G. Urin // Phys. At. Nucl. 2010. V.73. P. 1427;
arXive:1005.2349v1 [nucl-th].

# MEASUREMENT OF THE P-ODD EFFECT IN RADIATIVE CROSS SECTION ON NATURAL LEAD

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

[1] *Petersburg Nuclear Physics Institute RAS, Gatchina, Russia*
[2] *Joint Institute for Nuclear Research, Dubna, Russia*
[3] *Institut Laue-Langevin, Grenoble, France*

The measurements of the P-odd asymmetry in radiative cross section on natural lead (99.95% purity) have been performed at the PF1B instrument of the ILL reactor (Grenoble, France). The flux of cold neutrons (mean wave length is 4.7 Å) was ~ $10^{10}$ 1/c. The neutron polarization was not worse than 92 %.

The sample was placed into a box of lithium rubber ($^6$LiF) with the thickness of ~1.9 mm opened from a side of beam entrance. For "zero" experiment the box without a led sample was installed to the place of target between two γ-quanta detectors. The crystals of NaI (Tl) 200 mm in diameter and 100 mm height served as the detectors. Polarization of neutrons was been switching by an adiabatic flipper.

The integral method of P-odd effect measurement was applied. For reducing influence of the reactor power fluctuations, the frequency of neutron polarization switching was higher than main frequencies of reactor neutron nose spectrum. Frequency of switching of polarization in experiment was equal to 8.3 Hz.

Measurements on lead were carried out during ~ 10 days. The result of measurement corrected for the neutron polarization is $\alpha_\gamma^{exp} = (3.3 \pm 2.9) \times 10^{-7}$.

The result of measurement of the "zero" test without a lead target at the beam is $\alpha_{0-test} = (1.0 \pm 2.0) \times 10^{-7}$. Result is normalized to the constant part of signals in main experiment and corrected for the neutron polarization. Measurement time was 6.5 days.

Taking into account "0-test", effect of asymmetry is $a_\gamma(^{nat}Pb) = (2.3 \pm 3.5) \times 10^{-7}$ or $\alpha_\gamma \leq 8.1 \times 10^{-7}$ at 90 % c.l.

This work is supported by the Russian Foundation for Basic Research, Grant No. 10-02-00174-a



# STUDY OF THE NEUTRON LAUE DIFFRACTION IN LARGE SILICON CRYSTALS FOR THE BRAGG ANGLES CLOSE TO 90°

**V.V. Voronin[1], V.V. Fedorov[1,2], I.A. Kusnetsov[1], S.Yu. Semenikhin[1], E.O.Vezhlev[1,2], S.V. Chekmenev[1,2]**

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

The crystal-diffraction experiment to test a weak equivalence principle for the neutron was proposed [1,2]. It is based on an essential magnification of an external affect on neutron diffracting by Laue for the Bragg angles close to the right one [2,3]. Recently we observed an additional enhancement factor of small effects exerting influence on a neutron undergoing Laue diffraction at such Bragg angles [2]. This factor exists due to the delay of the neutron inside the crystal during diffraction and is proportional to $\tan^2\theta_B$, and it's value can reach $10^2 + 10^3$. In the aggregate with diffraction enhancement factor, which is also known as decreasing of diffracting neutron effective mass [4], the total diffraction enhancement factor may be as large as $10^8 + 10^9$.

The Laue diffraction at (220) plane of silicon crystal with the length $L = 220$ mm was investigated for the Bragg angels up to $88°$. It was demonstrated that due to Borman effect the effective neutron absorption length for the low-absorbed Bloch wave can reach about 3 m instead of 40 cm for the non-diffracted neutrons. Therefore, we saw reasonable reflected neutron beam intensity for the Bragg angles about $87°$ and that a factor of diffraction enhancement for the neutron trajectory "curvature" due to external field for this angle can reach magnitude $0.8 \cdot 10^8$ in comparison with a freely flighting neutron.

So the accuracy of measuring inertial to gravitational neutron masses ratio for the introduced setup can reach $\sim 10^{-5}$, that is more than one order higher than the best modern result [5].

**References**

1. V.V. Fedorov, I.A. Kuznetsov, E.G. Lapin, S.Yu. Semenikhin, V.V. Voronin, JETP Lett., 2007, Vol. 85, No. 1, pp. 82–85.
2. V.V. Voronin I.A. Kuznetsov, E.G. Lapin, S.Yu. Semenikhin, V.V. Fedorov, Phys. Of At. Nucl., 2009, Vol. 72, 3, pp. 470-476.
3. V.V. Fedorov, I.A. Kuznetsov, E.G. Lapin, S.Yu. Semenikhin, V.V. Voronin. Nucl. Inst. Meth. in Phys. Res., A 593 (2008), pp. 505-509.
4. A. Zeilinger, C. G. Shull, M. A. Horne, and K. G. Finkelstein, Phys. Rev. Lett. 57, 3089 (1986).
5. J. Schmiedmayer, Nucl. Instr. Meth. A 284 (1989) 59.

# NEUTRON ACTIVATION ANALYSIS OF Ca, Cl, K, Mg, Mn, Na, P, and Sr CONTENTS IN THE HUMAN OSTEOGENIC SARCOMA

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

[1] *Medical Radiological Research Centre of RAMS, Koroleva str., 4, Obninsk, 249020, 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 introscopy 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 contents 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 contents of bone tumors with respect to different origin of disease. Therefore, we determined the Ca, K, Cl, Mg, Mn, Na, P, and Sr contents in the osteogenic sarcoma and intact bone tissue using NAA with spectrometric registration of short-lived radionuclides. Samples were obtained from 61 patients (18 females and 43 males from 6 to 71 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 NAA were received from biopsy and resected specimens. The control group consisted of 27 apparently healthy subjects 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, K, Mg, Mn, Na, P, and Sr (mg/kg on dry weight basis) in osteogenic sarcoma tissue were: 137000±10000, 8700±1000, 7000±2100, 2840±170, 0.18±0.03, 8730±510, 115000±9000, and 198±29 respectively. Mean values for mass fraction of these elements in intact cortical bone of femur and tibia were: 222000±9000, 1520±300, 1650±333, 2450±370, 0.23±0.02, 6400±360, 112000±6000, and 418±61 respectively. The statistically significant differences of Ca (≤0,001), Cl (≤0,001), K (≤0,05), Na (≤0,001), and Sr (≤0,01) content in osteogenic sarcoma compared to healthy bone suggest potential of these elements as sarcoma markers and validate NAA as detection method.



# RELATIONSHIP BETWEEN Ca, Cl, K, Mg, Mn, Na, P, and Sr CONTENTS IN THE HUMAN RIB BONE INVESTIGATED BY NEUTRON ACTIVATION ANALYSIS

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

[1] *Medical Radiological Research Centre of RAMS, Koroleva str., 4, Obninsk, 249020, 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.

The aim of this study was to determine mutual ratios and relationships between Ca, Cl, K, Mg, Mn, Na, P, and Sr in the normal human rib-bone. The chemical element content in the rib-bone of 78 relatively healthy subjects (37 women and 41 men, ages from 16 to 55 years) were studied using instrumental neutron activation analysis. Individual ratios of Cl/Ca, K/Ca, Mg/Ca, Mn/Ca, Na/Ca, P/Ca, Sr/Ca, Cl/P, K/P, Mg/P, Mn/P, Na/P, Sr/P, Cl/Mg, K/Mg, Mn/Mg, Na/Mg, Sr/Mg, K/Cl, Mn/Cl, Na/Cl, Sr/Cl, Mn/K, Na/K, Sr/K, Mn/Na, Sr/Na, and Mn/Sr were calculated. 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 all ratios were estimated. Additionally, the effect of age and gender on chemical element ratios in the intact rib-bone was investigated. A correlation analysis was used to identify relationships between elements.

# THE EFFECT OF AGE ON THE ZINC CONTENT IN PROSTATE OF HEALTHY MEN

S. Zaichick[1,3], V. Zaichick[1], V. Karandashev[2], C. Nosenko[2]

[1] *Medical Radiological Research Centre of RAMS, Koroleva str., 4, Obninsk, 249020, Russia, e-mail: vezai@obninsk.com*

[2] *Institute of Microelectronics Technology and High Purity Materials, Chernogolovka 142432, Russia*

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

Globally, prostate cancer is the sixth most common cancer, and the third most common cancer in males in Western industrialized countries. In North America, it is the most common cancer in males and, except for lung cancer, is the leading cause of death from cancer. Although the etiology of prostate cancer is unknown, several risk factors including age and diet (including zinc and some other nutrients) have been well identified. The possibility of developing prostate cancer drastically increases with age. The risk is three orders of magnitude higher for the age group 40–79 years compared to younger groups.

Questions on the effects of Zn on prostate are far from being answered. First of all, it is necessary first of all to establish the normal level and age-related changes of Zn in prostate. To that end, we studied the effect of age on the Zn content in prostate of healthy men. Contents of Zn in intact prostate of 64 relatively healthy men (age range: from 13 to 60 years, mean age 36.5 years) were determined by inductively coupled plasma atomic mass spectrometry. Mean value (M ± SEM) for the mass fraction of Zn in prostate of all subjects taken together was 782±97 milligram per kilogram of dry tissue. In order to estimate the effect of age on the investigated parameter we used three age groups: 13-20 years (mean age 16.3 years), 21-40 years (mean age 30.4 years), and 41-60 years (mean age 49.6 years). Mean values (M ± SEM) for the mass fraction of Zn (milligram per kilogram of dry tissue) in three age groups were as follows: 382±103, 557±44, and 1150±204, respectively.

A strongly pronounced and statistically significant ($p \leq 0.01$, the Student's $t$- test) tendency of age-related increase in Zn mass fraction was observed in prostate. For example, in prostate of 50 years old men the mean Zn mass fraction was 3.01 times greater than in prostate of 16 years old persons, respectively. For the first time it was shown that there is an age-dependent (from 13 to 60 years) logarithmical increase in the content of Zn in prostate of a healthy person. The results obtained may serve as indicative normal values for the zinc content in human prostate.



# PFN data analysis in spontaneous fission

*Sh. Zeynalov[a], O. Zeynalova[a], F.-J. Hambsch[b], S. Oberstedt[b]*

[a)]JINR-Joint Institute for Nuclear Research, Dubna Moscow region, Russia
[b)]EC-JRC-Institute for Reference Materials and Measurements, Retieseweg 111, B-2440 Geel, Belgium

The main motivation of the present work was investigation of the nature of anomalous (from the point of view of modern theory) dependence of the average PFN number on the total kinetic (TKE) energy of the fission fragments (FF) using modern digital signal processing (DSP) approach. A twin Frisch-grid ionization chamber (TGIC) was used for FF mass and kinetic energy spectroscopy. A fast neutron detector (ND) with NE213 (or analog) scintillation liquid was used for PFN time-of-flight measurement. Correlated FF kinetic energies, their masses, an angle between fission axis and the PFN, the PFN velocity all were measured with help of eight channel setup of synchronized waveform digitizers (WFD), having 100 MHz sampling frequency and 12 bit pulse height resolution. Special modifications in the data analysis procedure brought to reasonable agreement between experimental results and theoretical calculations. In the first time the linear dependence of the average number of PFN on TKE in the range of (140 – 220) MeV was demonstrated.

## INVESTIGATIONS OF THE NEUTRON "CROSS-TALK" EFFECT IN DEMON DETECTORS

S.Telezhnikov[1], Yu. Kopatch[1], Zh.Mezentseva[1], L. Stuttge[3], F.Goennenwein[4], M. Mutterer[5], E. Chernysheva[2], O. Dorvaux[3], F. Hanappe[6], and F.-J. Hambsch[7]

[1]*Frank Laboratory of Neutron Physics, JINR, 141980 Dubna, Russia*
[2]*Flerov Laboratory of Nuclear Reactions, JINR, 141980 Dubna, Russia*
[3]*Institut de Recherches Subatomiques, F-67037 Strasbourg Cedex, France*
[4]*Physikalisches Institut der Universität, D-72076 Tübingen, Germany*
[5]*Institut für Kernphysik, Technische Universität, D-64289 Darmstadt, Germany*
[6]*Universite Libre de Bruxelles, 1050 Bruxelles, Belgium*
[7]*EC-JRC-Institute for Reference Materials and Measurements, Retieseweg 111, B-2440 Geel, Belgium*

Recently, a new experiment has been performed, aimed at the search for the anisotropy of prompt neutron emission in the center-of-mass system of fission fragments using a spontaneous fission source of $^{252}$Cf. The anisotropy is expected with respect to the fragment spin direction due to the emission of neutrons with non-zero angular momentum. In order to observe such an anisotropy one has to examine triple neutron-neutron-fragment angular correlations. Fission fragments were measured by the double ionization chamber CORA while neutrons were detected by a set of 60 DEMON scintillator detectors.

One of the main sources of background in such type of measurements is the so-called "cross-talk" effect – scattering of neutrons between neighboring DEMON detectors. In order to estimate the magnitude of this effect and its influence on the experimental data two special test measurements have been performed. Am-Be neutron source was used in both test experiments. The advantage of such a source is that it emits only one neutron at a time, and in addittion produces some gamma-rays which can be used in coincidence and allow to determine the neutron energy by the time-of-flight method. Thus, all detected neutron-neutron coincidences (except for the pile-up events) should be due to scattering between different detectors. In the first experiment two DEMON detectors were placed at approximately the same distance to the source as in the main experiment, and the distance between the detectors was varied. In the second experiment the souce was placed at the same position as the $^{252}$Cf source in the main experiment, and the same electronics and the coincidence scheme was used.

In the analysis of both experiments the kinematic characteristics of each two-neutron coincidence event was carefully examined and the criteria for indetnification of the "cross-talk" events were developed. The proability of "cross-talk" as a function of distance between the detectors was also determined.



## Spatial-, Spectral- and Time-Correlated Detection of Fission Fragments

Carlos Granja[1], Vaclav Kraus[1], Yuri Kopatch[2], Sergei A. Telezhnikov[2], Stanislav Pospisil[1] and Zdenek Vykydal[1]

[1] *Institute of Experimental and Applied Physics, Czech Technical University in Prague, Czech Republic*
[2] *Frank Laboratory of Neutron Physics, JINR Dubna, Russia*

*Work carried out in frame of the Medipix Collaboration*

With the goal to study angular correlations of rare fission decays, charged-particle spatial- and temporal-correlated measurements of fission fragments are being investigated (see Fig. 1) with a built-in modular multi-parameter and flexible coincidence system based on two and up to four pixel detectors Timepix. This detector provides energy and time sensitivity capability per pixel. Data rate is up to 90 fps. Triggered measurements are done by integrated spectrometric module with analogue signal chain electronics. Results with a $^{252}$Cf source are presented.

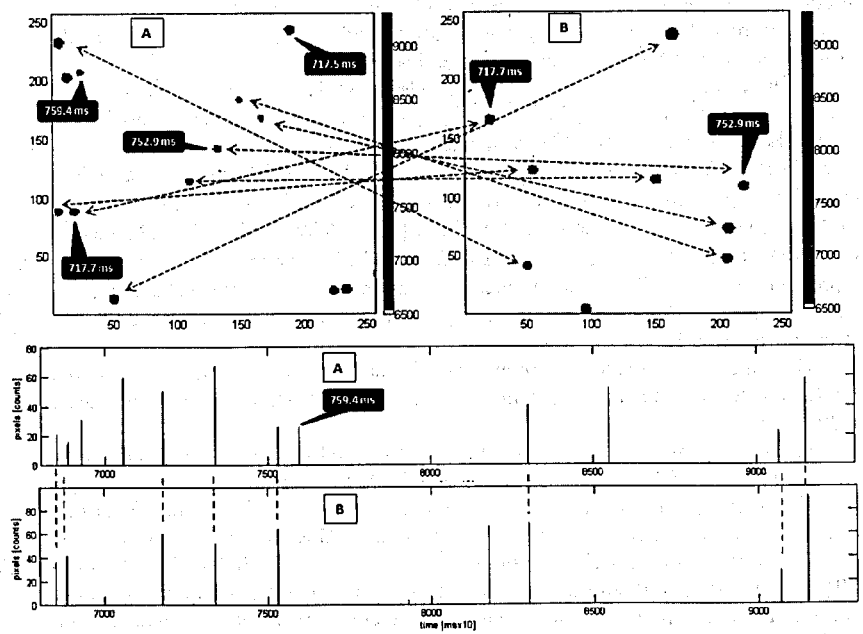



Fig. 1. *Spatially-correlated (top figures) detection of pairs of fission fragments by two Timepix pixel detectors operated in time mode and in high threshold (thus suppressing the alpha particles). Frames shown collected in 300 ms exposure time. The spatial information, given by the 256 × 256 pixel matrix of each detector, is coupled to the time-correlated information given by the grey scale in the range 650–950 ms. The time registry of events (bottom) with amplitude given by the number of pixels in each event (or cluster size). Correlated events are linked by dash arrows for clarity.*

## SORPTION BEHAVIOUR OF RADIONUCLIDES IN SYSTEM SOIL-SOLUTION

*Filippov M.F., Maslov O.D.*
*Flerov Labolatory of Nuclear Reaction, JINR, Russia*
*E-mail: mariofil@jinr.ru*

Sources of radioactive contamination are enterprises for nuclear fuel reprocessing, enterprises for the recovery and processing of uranium and thorium, global fallout due to nuclear explosions and radioactive waste repositories. Experiments on determination of the distribution coefficients ($K_d$) of radionuclides between water and soil, allowing evaluation of the radionuclide mobility in soil, are performed in territories that may be contaminated with radionuclides.

The purpose present work was the determination of the uranium, caesium, strontium, zirconium, molybdenum and technetium distribution between aqueous solutions containing radionuclides, and brown forest soil from radioactive waste in Bulgaria.

Instrumental gamma activation analyis and X-ray fruorescence analysis for determination of the element contents in the soil were used.

At investigation of sorption of U(VI), Cs(I), Sr(II), Zr(IV), Mo(VI) and Tc(VII) on soil was used radioactive nuclides $^{237}U$ [$T_{1/2}$=6.75 d, Eγ=59.54 keV (34.5 %); 208.00 keV(21.2 %)] produced by the $^{238}U(\gamma,n)$ photonuclear reaction [1] and $^{132}Cs$ [$T_{1/2}$=6.479 d, Eγ=505.79 keV (0,73 %); 630.19 keV (0.97 %); 667.718 keV (100 %)], $^{91}Sr$ [$T_{1/2}$=9.63 h, Eγ=652.9 keV (8.0 %); 749.8 keV (23.61 %); 1024.3 keV (33 %)], $^{97}Zr$ [$T_{1/2}$ = 16.91 h, Eγ = 507,64 кеV (5,03 %); 743,36 кеV (93 %)], $^{99}Mo$ [$T_{1/2}$ = 65.94 h, Eγ = 140,511 кеV (4,52 %); 181,063 кеV (6,08%)], $^{99m}Tc$ [$T_{1/2}$ = 6.01 h, Eγ = 140,511 кеV (89 %); 142,628 кеV (0,0187 %)] produced by the $^{238}U(\gamma,f)$ photonuclear reaction on an electron accelerator — MT-25 microtron (FLNR, JINR). Maximum energy of the bremsstrahlung was 23.5 MeV. The electron current was 15 μA.

The kinetics of sorption of uranium-237, caesium-132, strontium-91, zirconium-97, molybdenum-99 and technetium-99m on soil was investigated at room temperature (T = 20 ± 0,5 °C).

The measurement of gamma-spectra were carried out using HP Ge-detector by the 30 $cm^3$ volume and 2.5 keV resolution on line 1.333 MeV($^{60}Co$).

The uranium(VI), strontium(II), zirconium(IV) and molybdenum(VI) forms of state in solution were calculated in the range pH 1–7 using the Speciation program [2].

The sorption characteristics obtained for U(VI), Cs(I), Sr(II), Zr(IV), Mo(VI) and Tc(VII) in the system soil-solution can be use to predict the migration behavior of uranium, caesium, strontium, zirconium, molybdenum and technetium in brown forest soil under the conditions of accidents and acid rains.

### References

1. Maslov O.D., Bozhikov G.A., Ivanov P.I., Gustova M.V., Belov A.G., Dmitriev S.N. Use of a Nanostructured Material for Separation of $^{238}U$ and $^{237}U$ Produced by the Photonuclear Reaction $^{238}U(\gamma,n)^{237}U$. Radiochemistry 2010. V. 51, №1, pp. 87-89
2. www. acadsoft.co.uk ( Academic Software: Sol-Eq, Aqueous Solutions )



## New spectrometer for test of equivalence principle with UCN.

A.I.Frank [a], P.Geltenbort [b], M.Jentschel [b], G.V.Kulin [a], **S.V. Goryunov** [a], D.V.Kustov [a,c], A.N.Strepetov [d], H.-Ch. Koch [e],T.Lauer [e]

[a]Frank Laboratory of Neutron Physics, Joint Institute for Nuclear Research, Dubna, Moscow, Russia
[b]Institut Laue-Langevin, Grenoble, France
[c]Institute for Nuclear Research, Kiev, Ukraine
[d]Research Centre Kurchatov Institute, Moscow, Russia
[e]Johannes Gutenberg University of Mainz, Mainz, Germany

We present results of experiment devoted to tests of new gravitational spectrometer of UCN, which was constructed for new experimental test of the weak equivalence principal for the free neutron. The main idea of future experiment consists in using peculiar time-of-flight method. For this purpose the neutron flux will be modulated by a chopper and the detector will measure the corresponding oscillation of the count rate.

Two test experiments were performed. In the first one quasi-monochromatic neutron beam was modulated by chopper and the amplitude and phase of the count rate oscillation were measured for the different modulation frequencies. Due to that it was possible to recover time-of-flight spectrum of neutron beam by Fourier spectrometry and to obtain the value of UCN time of flight in the spectrometer with accuracy 0.02%. The second test experiment was to measure dependence of the count rate oscillation on the position of monochromator at fixed frequency.

Results of test experiments confirm opportunity of testing equivalence principle to an accuracy of $10^{-4}$, which in order of magnitude more then last experiment.

## MEASURMENT OF THE FAST NEUTRON SPECTRA BY TELESCOPE OF RECOIL PROTONS

Vasil Milkov, Tsvetan Panteleev, Andrey Bogdzel, Valeriy Shvetsov, Sergey Kutuzov, Pavel Sedishev, Sergey Borzakov

Joint Institute for Nuclear Research (JINR), Joliot-Curie 6, 141980 Dubna, Moscow region, Russia

A prototype of neutron spectrometer based on a gas proportional counter with recoil protons registration is created in the Frank Laboratory of Neutron Physics at the Dubna Joint Institute for Nuclear Research. The spectrometer is developed to measure the kinetic energy of scattered elastically at small angles protons that are produced by (n,p) reaction in an environment containing hydrogen. The elaborated prototype consists of two cylindrical proportional counters used as cathodes. They are placed in gas environment with a common central-situated anode wire. Studies on the characteristics of the neutron spectrometer were conducted using $^{252}Cf$ and $^{239}Pu$-Be radioisotope neutron sources, as well as monoenergetic neutrons produced by the $^{7}Li(p,n)^{7}Be$ reaction when a thin lithium target was bombarded with proton beam from an electrostatic accelerator EG-5.



## Detection and Characterization of Radiation by the Pixel Detector Timepix: An Overview

Stanislav Pospisil

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

*Work carried out in frame of the Medipix Collaboration*

The hybrid semiconductor pixel detectors of the Medipix family provide the ability to detect single particles with no noise while registering their position with μm spatial resolution. The Timepix device provides in addition either the time of arrival of the interacting particle or its energy deposited per-pixel with wide dynamic range. The pixels can be moreover independently configured to operate in one of three modes: counting, energy and time. The detector consists of a sensor (generally silicon 300 μm thick) which is bump-bonded to a readout chip containing the integrated per-pixel signal electronics (amplifier, amplitude discriminators, digital counter for each pixel). Operation of the detector with a compact USB-2.0-based readout interface (which provides all necessary power, control and DAQ with data rate up to 90 fps) and the modular software package Pixelman enables fast, easy and online utilization of the detector in different environments such as accelerator and reactor-based beams including vacuum. Use of a number of techniques developed by hardware/instrumentation adaptations (such as external trigger and coincidence operation with other detectors) and/or software algorithms (which permits online visualization of particle tracks in the solid-state sensor including pattern reconstruction analysis) enables significant background suppression with enhanced signal-to-noise ratio. Enhanced particle selection is accompanied with simultaneous and rather complete extraction of information of the interacting particle (such as energy, stopping power, position and direction of the particle trajectory). An overview of the current and future capabilities of the device in radiation imaging and spectroscopy will be presented on results of specific applications and nuclear physics experiments.

Научное издание

**NEUTRON SPECTROSCOPY, NUCLEAR STRUCTURE, RELATED TOPICS**
**XIX International Seminar on Interaction of Neutrons with Nuclei**
*Abstracts of the Seminar*

**НЕЙТРОННАЯ СПЕКТРОСКОПИЯ, СТРУКТУРА ЯДРА И СВЯЗАННЫЕ ВОПРОСЫ**
**XIX 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.

Е3-2011-37

Подписано в печать 25.04.2011.
Формат 60 × 90/16. Бумага офсетная. Печать офсетная.
Усл. печ. л. 5,06. Уч.-изд. л. 8,02. Тираж 160 экз. Заказ № 57302.

Издательский отдел Объединенного института ядерных исследований
141980, г. Дубна, Московская обл., ул. Жолио-Кюри, 6.
E-mail: publish@jinr.ru
www.jinr.ru/publish/