ISINN-3

III International Seminar

on Interaction of Neutrons with Nuclei

FLNP - JINR

Neutron Spectroscopy, Nuclear Structure, Related Topics

Dubna, 1995

Abstracts

JOINT INSTITUTE FOR NUCLEAR RESEARCH

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III International Seminar

on Interaction of Neutrons with Nuclei

NEUTRON SPECTROSCOPY, NUCLEAR STRUCTURE, RELATED TOPICS

Dubna, April 26—28, 1995

Abstracts

Dubna 1995

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Scientific Program of ISINN-3

April 26 First Morning Session	***Fundamental Interactions & Symmetries in Neutron Induced Reactions***	
Chairman:	Prof. Danilian G.V.	
9:30 - 9:40	**Meeting Opening**	
	Prof. Aksenov V.L. Director of the Frank Laboratory of Neutron Physics	
9:40 - 10:05	Correct analysis of P-violation measurements in neutron resonance reactions	
	Bunakov V.E., Novikov I.S.	PNPI, Gatchina
10:10 - 10:35	Parity violation in neutron resonances: the TRIPLE collaboration recent results	
	Bowman J.D , Sharapov E.I., et al.	JINR, Dubna
10:40 - 10:50	P-odd effects for a set of gamma-transitions and experimental evidence of sign correlation in the output channel of $^{117}Sn(n,\gamma)$-reaction	
	Smotritsky L.M.	PNPI, Gatchina
10:55 - 11:05	Comparison of experimental options for T-invariance tests in resonance reactions	
	Bunakov V.E.	PNPI, Gatchina
11:05 - 11:25	**Coffee Break**	
April 26 Second Morning Session	***Fundamental Interactions & Symmetries in Neutron Induced Reactions***	
Chairman:	Prof. Bunakov V.E.	
11:25 - 11:50	The measurement of parity violating neutron spin rotation in 207Pb	
	Krupchitsky P.A., Ermakov O.N., Karpikhin I.L.; Bolotsky V.P.	ITEP, Moscow
11:55 - 12:05	Evaluation of the mean intensity of P-odd mixing in nuclei compound-states	
	Urin M.H., Rodin V.A.	MEPI, Moscow
12:10 - 12:20	T-noninvariant neutron spin rotation in crystals with aligned nuclear spins	
	Baryshevsky V.G.	INP, Minsk
12:25 - 12:50	Model for resonant enhancement of P- and T-violation in neutron-nucleus interaction	
	Barabanov A.L.	RRC KIAE, Moscow
12:55 - 13:10	A probabilistic approach to the extraction of parity violating mixing matrix element from data on neutron resonances	
	Sharapov E.I., Bowman J.D.	JINR, Dubna

April 26 First Evening Session — *Fast Neutron Induced Reactions*

Chairman: Prof. Popov Yu.P.

15:00 - 15:25	The quantum molecular dynamics approach to nucleon-nucleus reactions at intermediate energy region Satoshi Chiba	NDC JAERI, Tokai, Japan
15:30 - 15:40	*Systematics of cross-sections in neutron threshold reactions* Manokhin V. N.	IPPE, Obninsk
15:45 - 15:55	Neutron scattering cross-sections for middle-mass nuclides in a large energy range Korzh I.A., Mishchenko V.O.	
16:00 - 16:10	Nuclear level density parameters and neutron cascade emission cross-sections from the analysis of the neutron spectra in (p,xn) and (α,xn) reactions Zhuravlev B.V.	IPPE, Obninsk
16:15 - 16:30	The isotopic effects in the (n,α) reaction induced by fast neutrons. Study of the fast neutron induced (n,α) reactions for ^{40}Ca, ^{58}Ni and ^{64}Zn Khuukhenkhuu G.	JINR, Dubna
16:35 - 16:50	**Coffee Break**	

April 26 Second Evening Session — *Gamma Decay of the Excited States*

Chairman: Prof. Pikelner L.B.

16:50 - 17:15	Statistical analysis of gamma multiplicity experimental data Madjarski T., Georgiev G., Janeva N.	INRAE, Sofia
17:20 - 17:30	A consistent description of γ-ray spectra from (n,xγ) reactions Blokhin A.	IPPE, Obninsk
17:35 - 17:55	Study of photon strength functions in 116In Honzatko J., Tomandl I.	NPI, Rez near Prague

April 27 First Morning Session — *Gamma Decay of the Excited States*

Chairman: Prof. Janeva N.

9:00 - 9:10	Spin dependence of neutron and photon strength functions in ^{156}Gd Murzin A.V.	INR, Kiev
9:15 - 9:25	Study of excited high-lying states of differently shaped heavy nuclei Boneva S.T., Khitrov V.A., et al.	JINR, Dubna
9:30 - 9:40	Low spin members of the $h_{11/2}$ family in $^{123,125}Te$ Honzatko J., Tomandl I.	NPI, Rez near Prague
9:45 - 10:10	The Berry phase of resonant states Mondragon A., Hernandez E.	UNAM, Mexico

10:15 - 10:25	A possible temperature dependence of width of 116In giant magnetic resonance Litvinsky L.L.	INR, Kiev
10:30 - 10:55	Neutron decay of high excited states of spherical nuclei Voronov V.V.	JINR, Dubna
11:00 - 11:20	Coffee Break	

April 27 Second Morning Session — ***Properties of the Excited Nuclei and Neutron Induced Reactions***

Chairman:	Prof. Voronov V.V.	
11:20 - 11:30	Population of high spin states of rare-earth elements nuclei and isomer ratios in (α,n)-reactions. Parfenova Yu.L.	INP, Moscow
11:35 - 12:00	Superconductivity and other nucleon phases investigated with neutron resonances Rohr Gert	IRMM, Geel
12:05 - 12:30	Recent level density research at Ohio university Steven M. Grimes	Ohio University, Athens
12:35 - 12:45	Energy dependence of s- and P- neutron strength functions and potential scattering radius of ^{238}U Novosiolov G.M., Litvinsky L.L.	INR, Kiev
12:50 - 13:00	Investigation of the neutron resonances in $^{113,115}In$ Faikov-Stanczyk H.	JINR, Dubna

April 27 First Evening Session — ***Methodical Aspects***

Chairman:	Prof. Hambsh F.J	
15:00 - 15:25	The new neutron source FRM-II Waschkowski W.	TU, Munich
15:30 - 15:55	SFERC -method for the estimation of stable intervals of superfine structure Sukhoruchkin S.	PNPI, Gatchina
15:45 - 16:10	Large solid angle spectrometer for studies of double-differential charged particle and neutron emission reaction cross-sections Mamoru Baba	Tohoku Univ, Japan
16:15 - 16:30	**Coffee Break**	

April 27 Second Evening Session — ***Methodical Aspects***

Chairman: Prof. Waschkowski W.

16:30 - 16:40
The new method for generation in moderator of Maxwellian neutron spectra with stellar temperatures
Popov Yu.P. — JINR, Dubna

16:45 - 17:05
Project of a new ionization spectrometer for (n,α) reaction investigations

Method of analysis of double-dimensional spectra of a-particles, registered by the ionization chamber
Khryachkov V.A., Ketlerov V.V. — IPPE, Obninsk

17:10 - 17:25
Origin of low energy "tail" for monoenergetic neutron sources

Method for determination of center-of-mass velocity with laboratory neutron spectra analysis
Kagalenko A.B., Kornilov N.V. — IPPE, Obninsk

April 28 First Morning Session — ***Fundamental Properties of the Neutron***

Chairman: Prof. Alexandrov Yu.A.

9:00 - 9:10
The problem of the neutron charge radius and the proposal of new experiment for the n-e amplitude estimation
Nikolenko V.G., Popov A.B., et al. — JINR, Dubna

9:15 - 9:25
Neutron interferometry method of study of parity violation in cold neutron transmission
Ioffe A. — HMI, Berlin

9:30 - 9:50
Dispersion law for neutrons at extremely low energy
Frank A.I., Nosov V.G. — JINR, Dubna

9:55 - 10:15
Consistent parameter sets for describing the neutron nuclear interaction
Waschkowski W. — TU, Munich

10:20-10:30
Precise measurements of σ_{tot} for ^{208}Pb
Enik T.L., Samosvat G.S., et al. — JINR, Dubna

10:35 - 10:50 Coffee Break

April 28 Second Morning Session — ***Fundamental Properties of the Neutron***

Chairman: Prof. Serebrov A.P.

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On the neutron mean square intrinsic charge radius
Alexandrov Yu.A. — JINR, Dubna

11:20 - 11:45
New presentation for the phase shifts of strong interaction for the evaluation of neutron fundamental parameters
Alekseievs A., Tambergs J. et al. — NRC, Salaspils-1 Latvia

11:50 - 12:00	The correlation experiments at free neutron beta decay as a verification of the V-A theory	
	Mostovoi Yu.A.	RRC KIAE, Moscow
12:05 - 12:15	Antineutrino-spin asymmetry in beta decay of the neutron and restriction for mass of W_R	
	Kuznetsov I. A., Serebrov A.P. et al.	PNPI, Gatchina
12:20 - 12:45	Measurement of the neutron total cross-section for 208Pb: estimate of the electric polarizability of the neutron	
	Laptev A.B.	PNPI, Gatchina

April 28 First Evening Session — ***Nuclear Fission***

Chairman:	Prof. Furman W.I.	
14:15 - 14:25	P-odd left-right and forward-backward asymmetries of fragment angular distributions in ^{233}U neutron induced fission and forward-backward asymmetry in ^{239}Pu fission	
	Sokolov V.E., Guseva I.S. et al.	PNPI, Gatchina
14:30 - 15:00	Generation of exotic nuclei in neutron induced fission process *Observation of deformed nuclear shell N=102 in high assymetric fission* process	
	Goverdovsky A.A., Mitrofanov V.F.	IPPE, Obninsk
15:05 - 15:15	Fragment angular .nizotropy for ternary fission of 238U by 1.6 Mev neutrons	
	Danilian G.V.	ITEP, Moscow
15:20 - 15:45	Multilevel fitting of ^{235}U data sensitive to Bohr- and Brosa- fission channels	
	Moore M.	LANL, Los-Alamos
15:50 - 16:15	New results on the reactions $^{237}Np(n,f)$ and $^{252}Cf(s,f)$	
	Hambsh F.J.	IRMM, Geel
16:20 - 16:35	**Coffee Break**	

April 28 Second Evening Session — ***Nuclear Fission***

Chairman:	Prof. Moore M	
16:35 - 16:45	Fluctuations of gamma-ray yields in 237Np low energy fission resonances	
	Dermendjiev E., Ruskov I. et al.	JINR, Dubna
16:50 - 17:15	Experimental grounds for nuclear shape isomerism hypothesis	
	Makarenko V.E.	RRC KIAE, Moscow
17:20 - 17:30	Influence of the dynamical effects on prefission neutron multiplicity in heavy ion induced reactions	
	Fotina O.V.	INP, Moscow
17:35 - 17:45	Fission modes in ^{252}Cf (s,f) by neutron multiplicity and time-of-flight measurements	
	Pyatkov Yu.	MEPI, Moscow
17:50 - 18:00	Investigation of resonance structure and Doppler-effect of cross-sections for ^{232}Th, ^{235}U and ^{239}Pu.	
	Grigoriev Yu.V., Georgiev G.P., et al.	IPPE, Obninsk

POSTER SESSION

Angular distributions of alfa-particles from $^{58}Ni(n,alfa)^{55}Fe$ reaction

Ostapenko Yu.B. IPPE, Obninsk

Brosa channel analysis of fission fragment mass-energy spectra for heavy nuclei

Mitrofanov V.F. IPPE, Obninsk

Combined file for the analysis of nonstatistical effects in spacing distributions

Sukhoruchkin S. PNPI, Gatchina

Investigation of the $^{6}Li(n,t)^{4}He$ reaction at the c.m. energies below 500 keV in the framework of the algebraic version of resonating group method

Igashov S.Yu. MEPI, Moscow

Collective excitations, induced by neutrons in the quasiparticle-phonon nuclear model

Storozhenko A. IPPE, Obninsk

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FAST NEUTRON INDUCED REACTIONS

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POSTER SESSION

CORRECT ANALYSIS OF P-VIOLATION MEASUREMENTS IN NEUTRON RESONANCE REACTIONS

V.E.Bunakov, I.S.Novikov
Petersburg Nuclear Physics Institute, 188350, Gatchina, Russia

Statistical methods are considered for extracting the estimates of P- and T- violating interaction constants out of a set of experimental data obtained for few neutron resonances. Bayesian statistical method (BSM) is shown to be most suitable for these purposes. The frequently used maximal likelihood method (MLM) might give a reasonable approximation to BSM in the limit of large number $n \gg 1$ of on-resonance observations provided the spins of compound-resonances are known. For small n the 68% confidence levels usually defined in MLM might be meaningless and misleading. In case of unknown resonance spins the correct analysis of P-violating experimental results gives **only reliable upper bounds** on weak interaction strength constant. The phenomenological form of the likelihood function previousely used for the analysis of those data is shown to produce the artificial suppression of all the null experimental results. Therefore the confidence levels of strength constants extracted in this analysis are practically undefined.

PARITY VIOLATION IN NEUTRON RESONANCES: THE TRIPLE COLLABORATION RECENT RESULTS

E.I.Sharapov[1], J.D.Bowman[2], B.E.Crawford[3], P.P.J.Delheij [4], C.M.Frankle[2], K.Fukuda[5], C.R.Gould[6], A.A.Green[4], D.G.Haase[6], M.Iinuma[7], J.N.Knudson[2], L.Y.Lowie[6], A.Masaike[7], Y.Masuda[8], Y.Matsuda[7], G.E.Mitchell[6], S.I.Penttilä[2], Yu.P.Popov[1], H.Postma[9], N.R.Roberson[3], S.J.Seestrom[2], H.M.Shimizu[8], S.L.Stephenson[6], Yi-Fen Yen[2], V.W.Yuan[2]

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[6] *Triangle University Nuclear Laboratory, Durham NC 27708, USA and North Carolina State University, Raleigh NC 27965, USA*
[7] *Physics Department, Kyoto University, Kyoto 606-01, Japan*
[8] *National Laboratory of High Energy Physics, Tsukuba-shi 305, Japan*
[9] *Delft University of Technology, Delft 2600 GA, The Netherlands*

The talk will cover following topics: A) Parity violation in the compound nuclei studied through the enhanced PNC (Parity NonConserving) effects in neutron p-wave resonances; B) Recent measurements of the PNC asymmetries in total and capture cross sections at LANL; C) Results for the mean squared matrix elements of the weak interaction in compound nuclei. The experiments were made at the Los Alamos Neutron Scattering Center with the use of polarization technique and the apparatus for time-of-flight measurements developed by the TRIPLE collaboration. The PNC asymmetries of neutron cross sections have been observed for several p-wave resonances in each studied nucleus from the mass region of A$\simeq$100 and A$\simeq$230. Applying statistical model and the likelihood technique, the mean squared weak matrix elements, M, were extracted from the experimental data. The mass dependence of M is discussed.

P-odd effects for a set of γ-transitions and experimental evidence of sign correlation in the output channel of $^{117}Sn(n,\gamma)$-reaction

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Abstract

An investigation of parity-odd angular asymmetry for a number of primary γ-transitions in the reaction $^{117}Sn(n,\gamma)$ using of Ge(Li)-detectors has been carried out.

For γ-transition with E_γ=9.33 MeV the coefficient of asymmetry has been measured to be $a_\gamma = (9.9 \pm 1.1) \times 10^{-4}$ with the corresponding matrix element of the weak interaction $W_{sp} = (9.3 \pm 1.7) \times 10^{-4}$ eV.

Non-zero P-odd effects have been found for E_γ=6.42 MeV γ-transition $a_\gamma = -(37 \pm 13) \times 10^{-4}$ and for unresolved E_γ=7.27 MeV and E_γ=7.28 MeV γ-transitions $a_\gamma = -(67 \pm 18) \times 10^{-4}$.

The experimental data are explained due to the sign correlation in the output channel of (n,γ)-reaction.

COMPARISON OF EXPERIMENTAL OPTIONS FOR T-INVARIANCE TESTS IN RESONANCE REACTIONS

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Petersburg Nuclear Physics Institute, 188350, Gatchina, Russia

The theoretical analysis is carried out of possible P-conserving T-invariance tests in isolated resonance reactions with special emphasis on various general enhancement and hindrance factors characterizing each particular type of experiment. It is stressed that transmission of polarized neutron beam through the oriented target (five-fold correlation - FC) always contains the entrance channel hindrance factor $\approx (kR)^2$ which cancels the resonance enhancement factor D/Γ. Contrary to that, the T-violation detailed balance tests (TVDB) on close-lying resonances retain the resonance enhancement together with possible additional structural enhancement factors. The TVDB experiments also do not require polarized beams and alligned targets and their sensitivity is practically limited only by the experimental energy resolution in the channels. Therefore the fine-resolution TVDB experiments are in principle more promising than any FC tests. Detailed analysis of FC experiments carried presently on ^{165}Ho oriented target shows that this particular case is unfortunately one of the less promising from the point of view of theoretically possible enhancements.

THE MEASUREMENT OF PARITY VIOLATING NEUTRON SPIN ROTATION IN ^{207}Pb.

V.P.Bolotsky[1], O.N.Ermakov[1], R.Golub[2] I.L.Karpikhin[1], P.A.Krupchitsky[1], S.Lamoreaux[3].

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2) Hahn-Meitner Institute,Postfach 390128,D-1000, Berlin 39,Germany.
3) Univ.Washington,Seattle,Washington 98195,USA.

The experiment was aimed for clearing up to situation with two theoretical approaches in the interpretation of parity violation in nucleon-nucleus interaction: the compound-nuclear mechanism [1] and the valence mechanism [2] of mixing of opposite parity states.

The investigation of transversally polarized cold neutrons spin rotation transmitting through isotopically enriched to 87% of ^{207}Pb sample (ℓ=6 cm) was made at HMI reactor.

The apparatus was a modification of neutron polarimeter at ILL (Grenoble) where the first observation of polarized neutrons spin rotation was measured [3].The PNC angle in natural lead was rather large[4]:

$$\varphi_{pnc} = (2.24 \pm 0.33) \times 10^{-6} \quad rad/cm.$$

The most suspicious for PNC effect in lead is isotope ^{207}PB. All the other isotopes have $J^{\pi} = 0^{+}$ ground states and or have a little abundance in a natural lead (^{204}Pb), or have no known low energy p-resonances (^{204}Pb, ^{206}Pb).

For minimization of the scattering systematic effects and for increasing counting rates we used end position of NL3B beam. Our polarimeter used a crossed supermirror polarizer and analyzer.The mean neutron wavelength was 6.8 Å which is greater then the Bragg threshold neutron wavelength in lead. The low magnetic field in the sample region formed within a double layer μ-metal shield was $H < 10$ mG. A reversal of current in the analyzer coil resulted in reversing the direction of the analyzed polarization component. The degree of spin rotation in the sample was deduced from the difference between counting rates for two current directions. An auxiliary π-coil was introduced to eliminate some instrumental effects. The π-coil rotated the neutron spins exactly through 180° over the time of flight through the coil.The sample was alternately moved between positions in front and behind the π-coil.

The result of our experiment counted to the ^{207}Pb isotope abundance in natural lead gave zero result:

$$\varphi_{pnc} < 1.3 \times 10^{-6} \quad rad/cm \qquad (90\% \quad C.L.),$$

which contradicts the result in natural lead [4]. So it confirms the compound-nuclear mechanism of parity mixing.

References

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[2] D.F.Zaretsky and V.K.Sirotkin, Sov.J.Nucl.Phys. 42(1985)561; 45(1987)808; 57(1994)39.

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[4] B.Heckel et al., Phys.Lett., B119(1982)298.

EVALUATION OF THE MEAN INTENSITY OF THE COMPOUND-STATE P-ODD MIXING IN NUCLEI

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The mean intensity of the mixing of nuclear compound states with the same spin and opposite parity is mainly determined by the compound-to-compound ($c - c'$) root-mean-squared matrix elements M_w of the parity-violating nuclear mean field. The experimental values of weak matrix elements M_w^{exp} are deduced from the data on the scattering of low-energy polarized neutrons from nuclei. These matrix elements are found only for the ^{233}Th and ^{239}U compound nuclei [1]. Found for many other nuclei weak matrix elements are usually assigned to the mixing of the certain $p_{1/2}$ and $s_{1/2}$ compound states (see,e.g. ref.[2]). Due to single-particle nature of the relevant external fields it is convinient to analyze the M_w values simultaneously with the mean-squared matrix elements M_{E1}^2 and M_{M1}^2 describing the intensity of the low-energy radiative $c - c'$ transitions. Found for many nuclei the mean total radiative width Γ_γ^{tot} of neutron resonances is the integral characteristics of the mentioned transitions (see,e.g. ref.[3]).

Since first qualitative estimations of the mean intensities of the $c - c'$ transitions (Blin-Stoyle,Shapiro), two alternative mechanisms (valence and many-particle ones) of these transitions have been widely discussed (see e.g. refs.[4,6] and refs. therein). Although the valence mechanism gives small contribution to the M values [4], it can provide a special interest (see e.g. refs.[1,5]). The nearly model-independent method of convertion from the product of the $s_{1/2}$ and $p_{1/2}$ neutron strength functions to the valence part of M^2 is given in refs.[4,5].

By definition , the strength function $M^2\rho$ (ρ is the c-state level density) is proportional to the imaginary part of the relevant polarizibility of the nucleus which is in the final compound state c'. Bearing in mind the averaging also over c' states we should calculate the strength function for the nucleus heated to the temperature corresponding to the mean energy of the c' states. The idea to evaluate the strength functions corresponding to the different external fields by this way (in the case of the P-odd mixing of compound states the transition energy ω is equal to zero) is adequate to the problem considered and has been widely used by many authors (in contrast with ref.[6]). Being based on this idea the most "microscopical" (and, therefore, most advanced) approach to the evaluation of the $E1$ and weak ($c - c'$)-transition strength functions has been proposed in refs.[4].

In the present work the extended version of this approach is given and the known data on M_w^{exp} are analized. The single adjustable model parameter α which determines the strength of the single-quasiparticle damping in heated nuclei [4] is found for each nucleus by the comparison of the calculated and experimental Γ_γ^{tot} values for the $s_{1/2}$ neutron resonances. Then the satisfactory description of the M_w^{exp} values for all nuclei considered has been obtained by the use of the method proposed. The systematical analysis of the valence mechanism contribution to the calculated M_w values is also given.

[1] J.D.Bowman et al., Phys.Rev.Lett.**65** (1990) 1192.
C.M.Frankle et al., Phys.Rev.Lett.**67** (1991) 564.
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[6] V.V.Flambaum and O.K.Vorov, Phys.Rev.Lett.**70** (1993) 4051.

T-NONIVARIANT NEUTRON SPINROTATION IN CRYSTALS WITH ALIGNED NUCLEAR SPINS

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M.Forte shows [1] that the T-noninvariant effect of spin rotation arises under neutron diffraction by crystals. This effect is de.irmined by coherent elastic scattering amplitude at a non-zero angle $f(\vec{k}', \vec{k})$. In the present paper [2] it is shown that it is possible to ivestigate the effects of T-noninvariant spin rotation and spin dichroism in crystals (diffraction gratings for ultra cold neutrons) even in case when diffraction are not fulfilled. The refractive index in our case is

$$\hat{N} = 1 + \frac{1}{2}\hat{g}(O) + \hat{g}(-\vec{\tau})\hat{g}(\vec{\tau})\alpha_B^{-1}$$

where

$$\hat{g}(\vec{\tau}) = -\frac{2m}{\hbar^2 k^2}\hat{U}_{eff}(\vec{\tau}); \hat{U}_{eff}(\vec{\tau}) = \frac{2\pi\hbar^2}{mV_0}\hat{F}(\vec{\tau})$$

$\hat{F}(\vec{\tau})$ - is the amplitude of neutron coherent scattering on crystal unit cell in the direction $\vec{k}' = \vec{k} + 2\pi\vec{\tau}$; $2\pi\vec{\tau}$ is the vector of crytal reciprocal lattice. As a result there is the reduction of requirement to the crystal quality and the angular and energy monochromaticity of the neutron beam. The increase of angular and energy intervale in our case in comparison with the required intervals from [1] leads to the sharp increase of neutron flux and permits to use large crystals and even sets of several crystals. As a result the measurement of T-nonivariant spin rotation angle with electric dipole moment $d \leq 10^{-2\sigma}$ in our case is possible even in the area of epithermal neutrons, that is absolutely unreal for methods considered in [1].

[1] M.Forte, J. of Phys G9 (1983) 745.
[2] V.G.Baryshevsky. Physics of Atomic Nuclei in press.

MODEL FOR RESONANT ENHANCEMENT OF P- AND T-VIOLATION IN NEUTRON-NUCLEUS INTERACTION

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In the last few years the parity nonconservation as well as possible T-noninvariant effects in neutron resonances are of special interest (see, e.g., Ref.[1]). They may be strongly enhanced in comparison with ones in nucleon-nucleon interaction [2-7].

This work deals with a simplified model of the resonant neutron-nucleus scattering based on the coupled channel scheme. The week P- and T-nonconserving interactions are considered as perturbations. The explicit expressions for the P- and T-odd corrections to the S-matrix are presented. In the framework of the model an energy dependence of P- and T-noninvariant observables as neutron transmission and spin rotation is studied. Radiative channels have not been considered. Due to this reason the results are directly applicable only to the light nuclei. However, the simplicity of the model promotes the better understanding of the nature of the resonant enhancement of P- and T-noninvariant effects, that is significant for the heavy nuclei.

It is shown that the magnitude of P- and T-noninvariant mixing of s- and p-waves in neutron resonance is proportional to the delay of the neutron inside the nucleus. So the enhancement factor $(\omega/\Gamma)^{1/2}$ arises, where ω is an energy of one-particle excitation and Γ is a total resonance width. For the first time this factor was obtained in Refs.[8,9]. The division of this factor into dynamic $(\omega/\gamma_s)^{1/2} \sim (\omega/D)^{1/2}$ and kinematic $(\gamma_s/\Gamma_p)^{1/2} \sim 1/(kR)$ ones is unnatural for the light nuclei. Here γ_s is a reduced width of s-wave resonance and D is a distance between resonances. The validity of Breit-Wigner approximation for mixing s- and p-wave resonant amplitudes also has been studied. It is shown that the exact expression for S-matrix corrections differs slightly by phase from the standard Breit-Wigner one provided the distance between the mixing resonances is greater than their reduced widths.

The possibilities of the model improvement are discussed. An including of radiative channels will allow to analyze P- and T-noninvariant effects, first, in heavy nuclei, secondly, in radiative neutron capture [10]. On the other hand, an increase of the number of the neutron coupled channels will lead to large sets of s- and p-wave resonances.

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A PROBABILISTIC APPROACH TO EXTRACTION OF PV-MATRIX ELEMENT FROM DATA ON NEUTRON RESONANCES

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We discuss the extraction of the root mean squares matrix elements M from parity violating asymmetries Pi in the p-wave neutron resonances measured for several target at LANL (see Ref.1, for the latest data). The essential feature of such measurements is that they furnished results for several resonances in each nucleus. This allows, in principle, to identify the M value with the variance of Gaussian distribution for the weak matrix elenments in the language of the statistical model, as discussed in Ref.2,3,4. The extraction procedure taken by the TRIPLE collaboration in the analysis of data for zero-spin targets is based on the likelyhood function formalism as described in Ref.4 and, with more details and derivations, - in Ref.5. We briefly review the main points of Ref.5, and compare them with an incorrect (in our view) delta-function approach of Ref.6. We then treat the important cese of the nonzero-spin targets where there is additional problem of an incomplete spectroscopic information on the p-wave spin-channel mixing ratios. For the case of known spins, we derive expression *for the probability density function P(p—MA,a,s) for finding the experimental* asymmetry p given as parameters the values of M, A, a and s. The parametr A is defined in Ref.4 and is known from the values of neutron widths and resonance energies, the parameter 'a' is taken as the square root from the known ratio of neutron j=1/2 and j=3/2 strength functions and the parameter 's' is the experimental error in p. With experimetal data Pi at hand, this probability function serves to construct the likelihood function L(M) and, therefore, for obtaining a reliable estimate of the value M and its error. The situation *for unknown resonance spins* is more complicated, and though we obtained the corresponding expressions for the L(M) the accuracy of the extracted matrix elements degrades in such a case. It is more important to know the spins of the s-wave resonances than the p-wave resonances. This emphasizes the importance of spectroscopic measurements on nuclei - candidates for PV-study.

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The Quantum Molecular Dynamics Approach to Nucleon-Nucleus Reactions at Intermediate-Energy Region

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Various kinds of simulation method have been developed in order to account for the complexity of nuclear reactions occurring in collisions between heavy-ions (HI). The Quantum Molecular Dynamics (QMD) is one of such methods, which describes the time evolution of distribution of nucleon many-body systems in the phase-space based on a self- consistent mean field and the stochastic nucleon(N)-nucleon collision which takes account of the Pauli blocking. The N-N collision in QMD is taken quite similarly with that of the cascade model, and this is the origin of the imaginary part of the optical model potential (OMP) which gives rise to reduction of flux from the entrance channel. On the other hand, the mean-field is calculated from an effective N-N interaction, which corresponds to the microscopic description of the real part of the OMP. The former, i.e., the N-N collision, plays an important role at high energy region where the cascade model becomes valid, while the latter is important in understanding low energy phenomena (e.g., success of the TDHF theory). Because of these two ingredients, the QMD gives a fully microscopic picture of not only the HI-HI reactions but also light-ion induced reactions including N-nucleus(A) reactions in a wide energy range. The QMD is particularly powerful in the "fast" stage of the reaction when the composite (projectile + target) system does not become fully equilibrated.

In (N,N'), which stands for (nucleon-in, nucleon-out), reactions at intermediate energy (several tens MeV to several GeV), a large fraction of nucleons forms a broad continuum spectra identified as the pre-equilibrium part. These nucleons are emitted after the projectile energy has been shared, through a sequence of the N-N collisions in the target, by a few to several nucleons, and thus corresponds to a "fast" process where the QMD is supposed to be applicable. The pre-equilibrium process have been investigated in the past in terms of the semi-classical models (e.g., exciton model, cascade model, hybrid model) or by more quantal ones (e.g., Tamura-Udagawa-Lenske theory, Feshbach-Kerman-Koonin theory, semi-classical distorted wave theory, etc.). Each theory is based on special assumptions, including mostly considerable number of phenomenological parameters. Differences in the assumptions and choice of the parameters leads to various predictions which sometimes are in contradiction to each other. On the other hand, the QMD, because it is a purely microscopic theory, has a potential to predict these cross sections without introducing phenomenological parameters. Therefore, QMD calculations of the pre-equilibrium N-A reactions at intermediate energy region will give new insights into the reaction mechanisms on the pre-equilibrium process.

In this study, we have analyzed the double-differential (p,xp), (p,xn) and (p,x) reactions from Al, Fe, Ni and Zr targets in the energy region from 100 MeV to several GeV, and verified the applicability of QMD to N-A collisions. Contribution of the statistical decay was also considered when necessary. Furthermore, information on the reaction mechanisms such as the contribution of multi-step and multiple pre-equilibrium processes has been obtained.

SYSTEMATICS OF CROSS SECTIONS IN NEUTRON THRESHOLD REACTIONS.

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ABSTRACT.

In the paper a systematics of the (n,2n)-reaction excitation functions is given. It is shown on the base of experimental data that in the incident neutron energy region from threshold up to ΔE_{max}, where (n,2n)-reaction cross section has maximum value, all the excitation functions have practically similar forms /1,2/, if normalize its to $\Delta E^{n,2n}_{max}$ and $\sigma^{n,2n}_{max}$, where $\Delta E^{n,2n}_{max}$- neutron energy values counted from the threshold.

If $Q_{n,2n} < Q_{n,np}$, then $\Delta E^{n,2n}_{max} = Q^{n,3n} - Q^{n,2n}$ and $\sigma^{n,2n}_{max}$ can be calculated from the expression: $\sigma_{max} = 65.4*A^{2/3}$ (mbarn), $(40 \leqslant A \leqslant 210)$.

It is shown that the (n,3n)-reaction excitation functions, normalized to $\Delta E^{n,3n}_{max}$ and $\sigma^{n,3n}_{max}$, have also similar forms from the threshold up to ΔE_{max} of the (n,3n)-reaction. In this case $\sigma^{n,3n}_{max}$ can be calculated from equation: $\sigma^{n,3n}_{max} = 10*A$ (mbarn).

This gives possibility to take into account a competition of the (n,3n)-reaction and evaluate the (n,2n)-reaction cross section in the neutron energy region from the threshold up to 20 Mev.

Having in mind the trends shown in /3/ for the (n,p) reaction cross sections at 14.5 MeV neutron energy, a systematics of the maximum cross sections of (n,p)-reactions as a function of (N-Z) and Z was developed. The systematics shows that $\ln(\sigma^{n,p}_{max})$ of isotopes of a given element is a linear function of (N-Z) and increases also linearly as a function of Z for a given (N-Z). It is useful for testing theoretical (n,p)-reaction excitation functions.

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NEUTRON SCATTERING CROSS SECTIONS FOR MIDDLE-MASS NUCLIDES IN LARGE ENERGY RANGE

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Systematic experimental data on cross sections of neutron interactions with nuclides form a basis for forming the files of evaluated data used in nuclear energetic installation design and in the accompanying technologies. Such the data were the main intention of the expensive experimental studies of fast neutron interactions with nuclides of reactor materials.

The energy and angle dependences of 1-7 MeV neutron elastic and inelastic scatterings are measured for 37 nuclides /1/. They are measured by time-of-flight spectrometer at pulsed electrostatic accelerator using highly enriched (mainly >90 %) isotopical samples: Mg-24;Si-28;S-32;Ti-48;Cr-50,52,54;Fe-54,56;Ni-58, 60,62,64; Zn-64,66,68,Se-76,78,80,82;Mo-92,94,96,98; Cd-110,116; Sn-116,118,120,122,124; Te-122,124,126,128,130; Ce-140. The inelastic scattering cross sections are measured for excitations of lowest levels (or level groups) of the nuclides under study. The attained errors of the measured cross sections are mainly 3-12 %.

The obtained experimental data are successfully used for forming evaluated data files and for elaborating and improving the theoretical models usable for adequate interpreting the processes under study and for study of the mechanisms of proceeding of them. A complex optical-statistical approach using the averaged optical model parameter set is elaborated. It allows to calculate cross sections of the processes under study as well as the total cross sections with the precisions which do not exceed the experimental errors /2/. That is why this approach is successfully being used for analysing the experimental data as well as for calculating the cross sections in the ranges of neutron energies and nuclide masses where the experimental data are absent.

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Nuclear level density parameters and neutron cascade emission cross-sections from the analysis of the neutron spectra in (p,xn) and (a,xn) reactions.

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Abstract.

The measurements and analysis of the double-differential neutron emission cross-sections in the reaction of In-115(p,xn) at proton energies of 11.2, 22.2 MeV and (a,xn) reaction on nuclei of Cd-113, In-115, Sn-122 at a-particle energies of 26.8, 45.2 MeV have been carried out. Interpretation of the equilibrium neutron emission in the framework of statistical model, used mathematical formalizm of Hauser-Feshbach for multistage processes allowed to determine the nuclear level density parameters in the wide range of excitation energies and neutron emission cross-sections on all stages of the cascade process. It is shown, that the nuclear level density parameter "a" for investigated nuclei with closed or nearly closed nucleon shells at first decreases with increase of the excitation energy, that agrees with prediction of the generalized model of superfluid nucleus, and later increases, pointing out breaking of the shell structure. It is shown also, that on the last steps of the evaporation cascade the radiative decay channel is predominant.

THE ISOTOPIC EFFECT IN THE (n,α) REACTION INDUCED BY FAST NEUTRONS

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Systematic analysis of known experimental cross sections of the fast neutron induced (n,α) reactions is carried out in the wide energy interval and for a wide range of mass numbers 19≤A≤140. It was found that the (n,α) cross sections in the energy range of 8 to 16 MeV are satisfactorily described by the formula [1].

$$\sigma_{n\alpha} = C\pi(R+\lambda)^2 \exp\left[-\frac{K(N-Z)}{A}\right]. \quad (1)$$

Here $\lambda = 4.55 \cdot 10^{-13}$ cm/$\sqrt{E(MeV)}$ is the wavelength of the incident neutrons divided by 2π; R, A, N and Z are the radius, mass number, number of neutrons and charge of the target nucleus, respectively; C and K are the fitting parameters.

As an example of the results, in Fig. 1 the dependence of reduced (n,α) cross sections on the relative neutron excess *(N-Z)/A* of the target nucleus at energy of 10 MeV is shown. The solid line is the best fit by expression (1). Plus and minus symbols denote the positive and negative Q-values of reactions. Similar dependencies were also observed at energies of 8, 14.5 and 16 MeV [1].

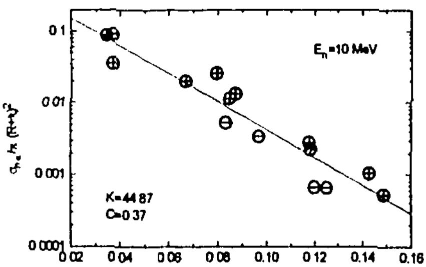

Fig.1. The dependence of reduced (n,α) cross sections on the relative neutron excess *(N-Z)/A* of the target nucleus at E_n=10 MeV.

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STUDY OF THE FAST NEUTRON INDUCED (n,α) REACTIONS FOR ^{40}Ca, ^{58}Ni AND ^{64}Zn

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Energy spectra and angular distribution of α-particles emitted in the (n,α) reaction were measured with the help of a gridded ionization chamber for the target nuclei ^{40}Ca, ^{58}Ni and ^{64}Zn in the energy range of 4 to 7 MeV using the D(d,n)^{3}He reaction [1,2]. The (n,α) cross sections were also obtained for these target nuclei.

Experimental results are compared with data of other authors and theoretical model calculations.

As an example, in Fig.1 is shown our result of angular distribution for the ^{40}Ca(n,α_0)^{37}Ar reaction at E_n=5 MeV in comparison with the experimental data by Abaschi et al. [3] at E_n=5.13 MeV and statistical model calculation.

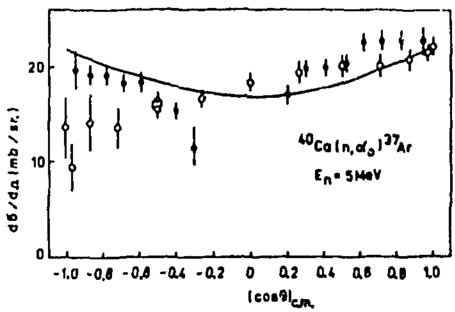

Fig.1. Angular distribution of α-particles emitted in the ^{40}Ca(n,α_0)^{37}Ar reaction at 5 MeV. Experimental points: O - ref. [3], ● - present work. The solid curve is the least - squares fit of our data by the expression $P(\cos\theta) = a + b\cos^2\theta$.

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A CONSISTENT DESCRIPTION OF THE γ-RAY SPECTRA FROM (n,xγ)-REACTIONS

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Neutron capture and inelastic scattering reactions and related phonon production cross-sections and spectra have found important interest in basic nuclear physics research. This paper briefs the non-statistical processes of γ-deexcitation of highly excited nuclei in neutron reactions. Calculations of γ-production cross-sections and γ-ray spectra for $^{92}Zr(n,x\gamma)$, $^{93}Nb(n,x\gamma)$ and $^{208}Pb(n,x\gamma)$ have been carried out and the results obtained were analyzed.

STATISTICAL ANALYSIS OF GAMMA MULTIPLICITY EXPERIMENTAL DATA

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Gamma multiplicity is an integral characteristic of the radiative capture. The investigation of this value in the resonance region is not a simple problem due to the lack of the clear theoretical interpretation of the compound nucleus decay. Moreover in the case of the 4π-multidetector system the response function of the facility is also important for the precise interpretation of the experimental data. It is necessary to apply a statistical modelling approach to solve the problem of treatment and physical understanding of the data

In the case of s-neutrons and odd target-nucleus two spin systems of compound nucleus resonance levels can be formed The significant correlation of gamma multiplicity with the level spin has been observed [1]. The statistical analysis of the experimental data can be performed to clarify which of the characteristics of the multiplicity spectrum are more sensitive to the spin dependence The distribution of the initial moments of gamma multiplicity spectrum for a set of compound nucleus levels were investigated. The spin dependence of the first, second and third moments were examined simultaneously. The important theoretical characteristics of the compound nucleus has been considered too.

The developed practical scheme of statistical analysis was applied to the set of experimental data for gamma multiplicity spectra of ^{119}Sn resonances. The experiments were performed on the IBR-30 neutron spectrometer of JINR Dubna [2].

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STUDY OF PHOTON STRENGTH FUNCTIONS IN ^{116}IN*

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The facility installed at the LWR-15 nuclear reasearch reactor at Řež and the method of two-step cascades[1,2], based on measurements of spectra of two-step γ cascades following the thermal-neutron capture, have been used for a study of E1 and M1 strength functions in the odd-odd nucleus ^{116}In. Experimental data have been compared with model predictions. Further support for conclusions about partial break-down of the Brink hypothesis[3] has been obtained. Like in cases of even-even spherical nuclei ^{144}Nd[4] and ^{146}Nd[5], the models of the E1 strength function with an energy-dependent damping width describe experimental intensities of two-step γ cascades on ^{116}In much better than the standard Lorentzian expression. The problem of the presence of a magnetic GDR is also discusssed.

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Spin Dependence of Neutron and Photon Strength Functions in ^{156}Gd.

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The measurements of averaged through many resonances primary γ-transitions (ARC spectra) in $^{155}Gd(n,\gamma)^{156}Gd$ reaction have been carried out at the quasimonoenergetic filtered neutron beams with mean neutron energies 1.9, 3.5, 45, 58 and 132 keV [1]. The neutron beams were obtained at the VVR-M reactor in Kiev by means of thick neutron filters of Sc, ^{52}Cr, ^{54}Fe, ^{58}Ni, ^{60}Ni. The ARC spectra were measured by six pair srectrometer. Due to the good statistics of the measurements and the averaging through ~10^3 resonances in each ARC measurement the spin dependence investigations of neutron and photon strength functions in ^{156}Gd proved to be possible.

Since in ARC spectra the reduced intensities $I^{o}_{\gamma f}$ of separate E1-transitions to the final states $0^+ \div 3^+$ are well determined, the correlation of $I^{o}_{\gamma f}$ for the decay of all s-resonances ^{155}Gd $1^-,2^-$ to final states $1^+,2^+$ and for the decay only 1^- resonances to 0^+ states and 2^- resonances to 3^+ states gives the possibility to investigate the dependence of neutron and photon strength functions from spins of initial and final states.

The results of these calculations have shown the independence of neutron strength functions and photon strength functions (averaged through all final states) from spins of resonances. But the statistical reliable dependence is obtained for the photon strength functions (or for the partial radiative widths) from spins of final states.

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STUDY OF EXCITED HIGH-LYING STATES OF DIFFERENTLY SHAPED HEAVY NUCLEI

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Recently obtained primary transition intensities from two-step gamma-ray cascade investigations of 14 heavy nuclei: $^{137,138,139}Ba$, ^{146}Nd, ^{150}Sm, $^{156,158}Gd$, ^{160}Tb, ^{164}Dy, ^{168}Er, ^{174}Yb, ^{181}Hf, ^{196}Pt and ^{198}Au are analysed. Experiments based on thermal neutron capture were undertaken mainly at the Frank Laboratory of Neutron Physics. Comparing these measured intensities and statistical model predictions, some properties of compound-state depopulation were derived. For the spherical nuclei of $^{137,138,139}Ba$, ^{146}Nd, ^{196}Pt and ^{198}Au very intense cascades with high-energy primary transitions were observed. Rather different is the behaviour of the cascade intensity in the strongly deformed nuclei of $^{156,158}Gd$, ^{160}Tb, ^{161}Dy, ^{168}Er and in the transitional nucleus of ^{150}Sm - where the intensity of primary γ-rays $E_1 \sim 2-3\ MeV$ exceeds the calculated value.

Low spin members of the $h_{11/2}$ family in ^{123,125}Te

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The high-spin states in odd Te nuclei have been extensively studied through the (HI,xnγ) reactions [1]. An observed set of high-spin negative parity states was previously described as a result of alignment of unique $h_{11/2}$ neutron orbit to a motion of a slightly deformed prolate core. A simple rotor model predicts not only aligned high-spins (j+R) but also low-spins (j-R) which should not be available in HI reactions. Up to the present time only a small amount of such antialigned states has been identified in Pd isotopes [2].

Using the neutron guide facility at the LWR-15 reactor at Rez [3] the singles and γ-γ coincidences were measured in the (n,γ) reaction. Most of the known low-lying states were confirmed and many high-lying levels with spin values of 1/2 or 3/2 were observed as populated by primary transitions from the capture state of $1/2^+$. Among the large number of levels the negative-parity states deserve a special attention.

In both nuclei we see $7/2^-$ - $3/2^-$ branches which are connected with the $11/2^-$ state by the cascade of enhanced E2 transitions. The energy position of $7/2^-$ and $3/2^-$ states in ^{125}Te is only slightly lowered relative to the position of the $15/2^-$ and $19/2^-$ states. We find $5/2^-$ states which are also connected by strong E2 transitions to the $9/2^-$ states and second $7/2^-$ states *deexciting predominantly to the lower lying $11/2^-$, $9/2^-$ and $5/2^-$ states. The strongly preferential* decay within the odd-parity states as well as close resemblance of energy spacings between low and high-spin states give us a possibility to assign them to the $h_{11/2}$ neutron family.

We observed a group of about 5-7 states with $1/2^-$ or $3/2^-$ characteristics spreaded on interval of only 360 keV with a centroid corresponding to the position of approximately between 6^+ and 8^+ core states in adjacent even-even ^{124,126}Te. These higher lying states in contrast to their low-lying partners have not a preferential decay mode indicating the influence of other negative j-states on their structure and can be understood in terms of IBFM.

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BERRY PHASE OF RESONANT STATES

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We study the adiabatic dynamics of a nuclear state which is a superposition of resonant states and evolves irreversibly due to the spontaneous decay of the unstable states[1]. The Hamiltonian of the system is smoothly parametrized by collective or slow variables. We give the geometrical structure of the energy surfaces close to the degeneracy[2]. The condition for accidental degeneracy of two resonances defines a circle in parameter space. Hence, in this case, instead of the point "monopole" singularity or "diabolical" point occurring in the accidental degeneracy of bound states, we obtain an extended "string" singularity which we call the "diabolical" circle. In the special case of two overlapping resonances mixed by a Hermitian interaction, the energy surface has two *pieces embedded in orthogonal subspaces*. The surface corresponding to the level repulsion regime has the shape of an open sandglass or diabolo, with its waist at the diabolical circle. The surface corresponding to the width attraction regime is a sphere with the equator at the diabolical circle. The two surfaces touch each other at all points on the diabolical circle[3]. We also give a closed analytical expression for the Berry phase of a resonant state which is now complex. Its real part is similar to the well known expression for the Berry phase of a stable state. Its imaginary part is proportional to the difference of the half-widths of the unperturbed resonances. This means that, in the adiabatic evolution of the system, besides the change in phase and magnitude of dynamic origin, the wave function of the unstable system suffers a change in phase *and magnitude of purely geometric origin.The validity of the adiabatic approximation* in this case is shortly discussed.

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A POSSIBLE TEMPERATURE DEPENDENCE OF WIDTH OF ^{116}In GIANT MAGNETIC RESONANCE

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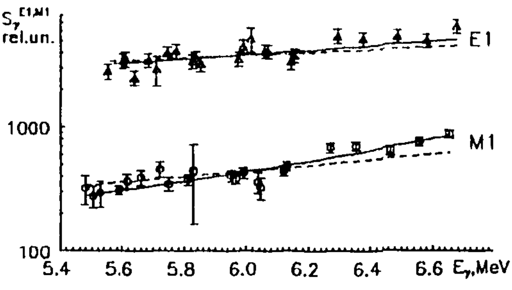
The analysis of the data [1] on averaged over resonances intensities of primary γ transitions from the ^{115}In(n,γ)-reaction at the neutron energies E_n = 1.9, 24.3 and 134 keV was carried out in according with the approach [2]. The spin-orbit splitting factor k_1 for one-channel p-neutron strength functions and the total strength function S_{n1} were determined as $k_1 = S^{1/2}_{n1} / S^{3/2}_{n1} = 3.0 \pm 1.5$ and $S_{n1} = (4.9 \pm 0.7)\ 10^{-4}$.

The energy dependence of E1 and M1 radiative strength functions S^{E1}_{γ} and S^{M1}_{γ} are shown at the figure. Its ratio was determined as $S^{M1}_{\gamma} / S^{E1}_{\gamma} = 0.14 \pm 0.04$. The standard Lorentzian (L) form (dashed curve) and the Kadmenski-Furman (KF) form [3] (solid one) were used to parameterize the experimental data. For S^{E1}_{γ} the fixed parameters of giant electric dipole resonance (GEDR) were used averaged over neighboring nuclei: E^{E1}_G = 16 MeV, Γ^{E1}_G=7 MeV [2]. The χ^2 values were obtained as χ^2= 1.5 and 1.1 for the L- and KF-forms respectively. To parameterize the data on S^{M1}_{γ}, only width of giant magnetic resonance (GMR) was fixed as Γ^{M1}_G= 4 MeV [2]. The values of χ^2 criterion and GMR energy E^{M1}_G were obtained as χ^2= 2.9, E^{M1}_G= 9 ± 5 MeV for the L-form and χ^2=1.1, E^{M1}_G= 8.6 ± 0.2 MeV for the KF-form. As seen from these results, a temperature dependence of the giant resonance width similar the KF-form [3] is preferable not only for the GEDR but also for the GMR.



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NEUTRON DECAY OF HIGH EXCITED STATES OF SPHERICAL NUCLEI

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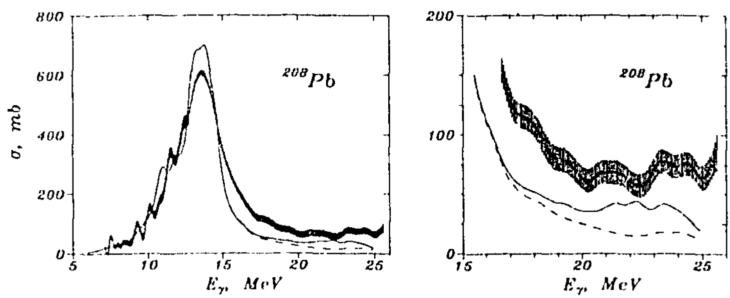
The investigation of the partial decay channels of the high lying nuclear states gives direct insight into their wave functions. The photoneutron reaction is one of the most effective tools to study the giant dipole resonance (GDR) properties. Recently the photoneutron cross sections in *even and odd spherical nuclei were measured* using the bremsstrahlung radiation technique [1]. As a result, the substructures in the (γ, n) cross sections were observed. The experimental data for ^{208}Pb versus theoretical calculations within the quasiparticle phonon nuclear model are presented in figure. The dashed curve shows the photoexcitation of the GDR, the solid curve is the sum of the GDR and GQR.



Another example of the decay of the high lying states is the neutron decay of high-lying single particle giant resonance states. The investigation of the decay of such states enables one to study the damping process through the determination of the relative contributions *of the direct and statistical components*. Recently, the neutron decay of high-lying states in ^{209}Pb excited by means of the $(\alpha, ^3He)$ reaction has been studied at 122 MeV incident energy using a multidetector array [2].

A method for calculating non-statistical particle decay of excited states in odd nuclei is presented [3]. Using the quasiparticle-phonon model, the partial cross sections and branching ratios for the neutron decay of the high angular momentum states in ^{209}Pb and ^{91}Zr excited by means of the $(\alpha, ^3He)$ reaction have been evaluated.

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POPULATION OF HIGH-SPIN LEVELS AND ISOMER RATIOS IN $\alpha, n\gamma$-REACTIONS

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Present paper is devoted to the experimental and theoretical investigations of isomer ratios in $(\alpha, n\gamma)$ -reactions, which gives an unique possibility to study the deexcitation mechanisms level density structure in nuclei. Isomer ratios for nuclei $^{112}In^{m\ 4+, g\ 1+}$, $^{116}Sb^{m\ 8-, g\ 3+}$, $^{133}Xe^{m\ 11/2-, g\ 3/2+}$, $^{137}Ce^{m\ 11/2-, g\ 3/2+}$ are analyzed.

The calculations were performed in the frame of the statistical model of nuclear reactions. The reactions were assumed to proceed by preequilibrium particle emission, followed by evaporation of equilibrium particles and γ -quanta. The first and the second were treated by exciton model and Hauser-Feshbach formalism with regard for the width fluctuation correction, respectively. The exciton model does not include angular momentum, and we considered it by decreasing the maximal angular momentum of compound nucleus.

The level densities of investigated nuclei were estimated in the frame of generalized nuclear model using Monte-Carlo method. We have obtained the difference of level densities with various parities and have considered it by variation of the spin cutoff parameter. We found out that this difference becomes negligible at the excitation energies about 8 - 10 MeV. And we have matched obtained level densities with those obtained in the frame of Gilbert-Cameron systematics [1] at the neutron binding energy.

The results of calculations and experimental data on isomer ratios for the investigated nuclei are presented in the table.

E_α	^{112m,g}In		^{116m,g}Sb		^{133m,g}Xe		^{137m,g}Ce	
15	0.22 ± 0.02	0.56			0.5 ± 0.1 [4]	0.55	1.0 ± 0.2 [5]	0.63
16	2.8 ± 0.7[2]	0.70						
17					1.0 ± 0.2 [4]	0.82	0.8 ± 0.2 [5]	0.91
18	5.0 ± 2.0[2]	1.73						
20	6.0 ± 2.0[2]	2.87			1.8 ± 0.4 [4]	1.14	1.9 ± 0.2 [5]	2.86
21			1.91 ± 0.20[3]	2.27				
23			3.37 ± 0.34[3]	2.90	1.8 ± 0.4 [4]	1.41	5.9 ± 0.5 [5]	4.17
24					2.0 ± 0.4 [4]	1.48		
25			4.07 ± 0.42[3]	3.64	2.4 ± 0.5 [4]	1.55	8.0 ± 2.0 [5]	4.03
26			3.88 ± 0.40[3]	3.58				
27			3.55 ± 0.38[3]	3.46	1.8 ± 0.4 [4]	1.66		
28			2.99 ± 0.31[3]	3.28	2.0 ± 0.4 [4]	1.70	3.7 ± 1.0 [5]	3.12
29			1.75 ± 0.20[3]	2.93	2.0 ± 0.4 [4]	1.75	5.3 ± 1.0 [5]	2.96
30			1.81 ± 0.19[3]	2.87				
31			1.86 ± 0.19[3]	2.80	3.37 ± 0.34[4]	1.81		

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SUPERCONDUCTIVITY AND OTHER NUCLEON PHASES INVESTIGATED WITH NEUTRON RESONANCES.

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Abstract: The possible existence of acoustic waves [1] in nuclides indicated in the neutron resonance spectra permits the application of the classical BCS-equations developed in solid state physics. Accordingly the coupling strength between nucleons and phonons is in excellent agreement with the coupling strength between electrons and phonons in a superconductor. Additionally *the critical nuclear temperature* T_C *is close to the neutron separation energy.* The reduced pairing gap near T_C is also indicated with the experimental level density parameter 'a' above the 'base line' defined in the level density systematic [2]. The phase transition is studied with the neutron level densities at neutron separation energy obtained for isotopic nuclides and is compared with Bethe level density expressions using three different ground state shifts, a) the Fermi free gas, b) *the superconductive phase and c) the energy dependent* ground state shift including the phase transition. Accordingly the pairing gap near T_C changes as sharply as for a superconductor in spite of the limited number of nucleons in a nucleus. Beyond the critical temperature the nucleon phase corresponds to the free Fermi nucleon gas. Therefore the introduction of a condensation energy and a phase transition of the second kind become superfluous while the excitation energy is *counted from the 'correlated ground state'* instead of the 'fictive normal ground state'. On the other hand it is very well known that the superconductivity characterised by Cooper-pairs is the only nucleon phase due to the nucleon-phonon interaction that is present in the ground state of the nucleus. The study of the excited nuclear states provides also other parts of the nucleon-phonon interaction namely many-nucleon co-operative (cluster) correlation and a many-nucleon repulsion correlation. The first one is indicated by a level density parameter below the base line and is observed for closed shell nuclei with energy gaps larger than that for paired nucleons. However this type of nucleon correlation has not yet its equivalent in solid state physics. The second correlation is indicated by a negative ground state shift and is observed for nuclei at A=150 (N=90) and at A=230 (Z=90). The reduction of pairing energy and the presence of a nucleon repulsive force are strongly correlated with the deformation of the nucleus and consequently affects also the energy of shape collective excited bound states.

This study provides therefore a level density formula with only one parameter, including the temperature dependence of the transition from superconductive to the normal nucleon phase as well shell effects, which are relevant for numerous applications of the statistical theory of nuclear reactions. Furthermore a method is proposed, based on the systematics of the nuclear temperature, that predicts the level density parameter for nuclei far off from the stable mass region.

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LEVEL DENSITY RESEARCH AT OHIO UNIVERSITY

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Level densities remain an area where both theoretical and experimental work is needed. The talk will describe a Monte-Carlo - based moment calculation procedure which can be used in very large systems. Two - body forces can be included in the calculation and bases as large as 10^{12} have been used. A new technique removes the need for orthogonal polynomial expansions and assures a positive definite expansion. Not only the level density but also the parity ratio and spin-cutoff factor can be obtained from such calculations.

A separate study has used single particle states based on Hartree - Fock calculations to examine level densities off of the stability line. These results indicate that level densities do not change dramatically as we move off of the stability line, although some effects which could be of importance in astrophysics are described, Some experimental work has also been completed recently. Ericson Fluctuations yielded considerable information about level densities twenty years ago. The difficulty of obtaining good statistics at a number of bombarding energies with a very thin target made these experiments quite challenging, Modern white neutron sourses can be used for such measurements, and we also have found a quick and efficient method for doing such measurements on an electrostatic accelerator with charged particle beams. Some results for nuclei in the sd shell will be described.

ENERGY DEPENDENCE OF s- AND p- NEUTRON STRENGTH FUNCTIONS AND POTENTIAL SCATTERING RADIUS OF ^{238}U

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The neutron strength functions of heavy nuclei in the isolate resonance region usually are supposed independent on the neutron energy E_n. At the same time some of microscopic models predict an intermediate structure in the distribution of one-particle strength not only for the small nuclear excitations, but even higher than neutron binding energy. If such structure is observed, it would lead to revision of some model-dependent calculations, for example, the calculations of neutron cross sections of nuclei in excited states, needed for the astrophysical estimations.

In this connection the analysis of energy dependence of s- and p- neutron strength functions S_{n0}, S_{n1} and potential scattering radius R′ of the ^{238}U in the energy interval $E_n < 0.5$ MeV was carried out. The local values of S_{n0} (Fig.1) and R′ for s- wave were found from the data on average total cross sections and its resonance self-shielding effects [1]. The values of S_{n1} (Fig.2) were obtained from analysis of the existing data on neutron cross sections of inelastic scattering with excitation of the first level 2^+, 45keV.

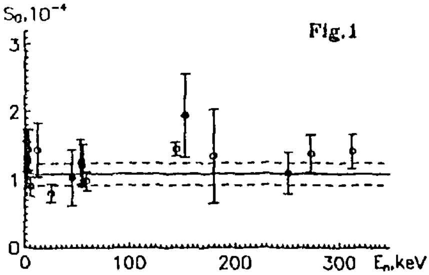

Fig.1

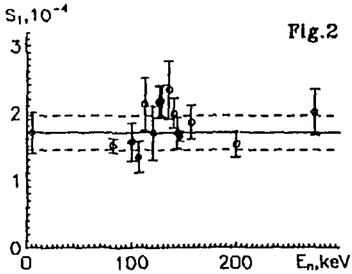

Fig.2

As seen from the Fig.1,2, there is no energy dependence of S_{n0} and S_{n1} out of the experimental errors (~ 12% and 15% respectively). The same result was obtained for R′ also.

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NEUTRON RESONANSES IN ^{113,115}In INVESTIGATION

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ABSTRACT

Gamma rays in the range of 150 1500 keV have been studied for s wave neutron resonances of ^{113}In and ^{115}In, selected by the time of flight in the range 1-100 eV. The measurements were carried out at the pulsed neutron booster ***IBR-30*** of the Joint Institute for Nuclear Research (JINR) in Dubna on the 60 *m* flight-path. The capture gamma rays were detected by 75 cm^3 coaxial HP Ge crystal with a resolution of 2.7 keV at 1.33 MeV. The samples of In_2O_3 enriched in ^{113}In to 87.2 % and in ^{115}In to 99.9 % were positioned in the center of the detector in the thin *Al* containers. A ^{113}In target thick was 60.71$*10^5$ nuclei/barn and 67.98$*10^5$ nuclei/barn for ^{115}In respectively. In experiment the spins for 6 resonances of ^{115}In have been assigned by measuring intensity variation of some strong low-energy transitions. On the basis of the previous experiment statements [1,2] we determined the spins from the ratios between the intensities of the transitions at 273 and 186 keV and of the triplet at 171-175 keV. In the case of ^{113}In we chose under consideration the ratios line intensities at 307, 287.4keV, and 341 keV. In this way the information on the spins for eight resonances of ^{113}In was obtained for the first time.

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"The New Neutron Source FRM-II"

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The research reactor FRM, which has been in operation at the Technical University of Munich since 1957, is no longer competitive in all fields of research and will be replaced by a high-performance neutron source, the FRM-II, with state-of-the-art scientific installations.

The design of the FRM-II provides for a particularly compact core, which consists of a single fuel element, using the new high-density silicide fuel in combination with high-enriched uranium. Unperturbed thermal neutron fluxes as high as $8x10^{14}$ n/cm^2 s can be generated with a relatively low reactor power of 20 MW.

A description of the design concept and of special features including some experimental devices (hot and cold source, converter facility) will be presented as well as a short report about the present statue of the project and future perspectives.

SFERC-method for the estimation of stable intervals of super-fine structure

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Grouping effect in neutron resonance positions was found in 60-tis and now has been checked by analysis of the total distribution of the positions of 10 the most strong levels of each isotopes . This data is contained in the relevant Table of BNL-325 Compilation (1981) and was used without any selection. Small probability of simultaneous grouping of the values $E_n = E^* - S_n$ for many nuclei at the integer numbers (n) of the common intervals 5.5 eV and 11 eV=2×5.5eV with n=2,13,14 and 17 is supported by the appearance of such intervals in the spacings distributions for certain isotope (D=44 eV in nuclei with Z=46-50 and 72, D=142 eV in arsenic, D=154 eV and D=187 eV in isotope with Z=60 and 62-66 etc.). Grouping effect in E_n -distribution means very accurate attenuation between large effects in E^* and S_n-values that are usually attributed to electromagnetic and strong interactions. So the presence of the same super-fine structure in the spacing and in resonance positions signals about fundamental tuning effect and gives unique possibility to study interplay of seemingly independent parts of Standard Model.

The intriguing aspect of these structural effects consists in possibility to relate them by the help of single scaling factor close to $\alpha/2\pi$-radiation correction of QED (SFERC-method) with fine-structure intervals multiple to ε'=1.2 keV and with few-nucleon parameter ε_o=1022 keV. Besides groupings of E_n- values at $2\varepsilon'$ and $4\varepsilon'$ the great amount of new data from ORELA-spectrometer permits observation of fine-structure effects in nuclei situated near the closing shells (D=$3\varepsilon'$ by Z=26-30, D=1190 eV =ε' by Z=41-43, D=594 eV =$\varepsilon'/2$ by Z=51,53 and D=2375 eV =$2\varepsilon'$ by Z=52). Simultaneously at the same shells Z_o=20,28,38,50 and N_o=82 excitations of the phonon-type have the values close to ε_o and they manifest themselves in the groupings of the values of excitation energies E^*, in the groupings of spacings as well as in the proximity of the positions of O^+-levels to $2\varepsilon_o$.

Recently Ohkubo has noticed in ^{183}W correlation in neutron level positions with period 173 eV (including strong level at 695 eV =4 × 173eV). Interval D=173 eV is clearly seen in the ORELA-data for neighbor nuclei ^{178}Hf and ^{180}Hf and intervals D=691 eV, 690 eV and 689 eV are seen in levels of nuclei with even Z=60,62-66 and 68 (as well as in levels of ^{199}Hg and of N-even tangsten isotopes). The values of the intervals D=77 eV in ^{180}Hf, D=154 eV=E_n mentioned above and D=690 eV form ratio 1 : 2 : 9 . Analogous effect with D=143 eV=E_n was discussed earlier by Ideno and Ohkubo and was shown in previous paper (Proc.Sem.Inter.Neutr. with Nuclei,Dubna,1994,p 326). The second important aspect of SFERC-methods results consists in establishing of integer-type relations between stable nuclear intervals (in each of different energy ranges interconnected by $\alpha/2\pi$-parameter). Unexpectedly many of the particle mass values turned to be located near these fixed positions of SFERC-model.

Large Solid-Angle Spectrometers for Studies of Double-differential Charged-particle and Neutron Emission Reactions

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Double-differential cross sections (DDX) for (n, charged-particle) and (n,xn') reactions are of great importance in various applied and basic fields. They are important data in the design of fusion and accelerator-based reactors, and provide useful information on reaction mechanism. Measurements of these DDX data require spectrometers having large geometrical efficiency as well as good energy and angular resolution. We have developed large solid-angle spectrometers for (n, charged-particle) and (n,xn') reactions.

The charged-particle spectrometer is based on a gridded-ionization chamber and applied to studies of energy-angular distributions of (n,xalpha) and (n,p) reactions up to 20 MeV and 6 MeV, respectively [1,2,3]. This spectrometer permits measurements of secondary charged-particles with very high geometrical efficiency close to 4π and a good signal-to-background ratio owing to employment of high-Z elements for structural elements and a counting gas. Examples of applications are presented on DDX measurements of (n,xalpha) reactions for 4-14 MeV neutrons and (n,p) reactions for MeV incident neurons, as well as design parameters of the spectrometer.

The neutron spectrometer is a long liquid scintillation detector, 80 cm long x 6 cm thick x 10 cm wide, enclosed in a pyrex glass cell and viewed by two fast photomultipliers from both ends [4]. The detector can be used either as a large single detector or a position-sensitive detector. As a single detector with a large solid-angle, the detector is applied to DDX measurements for 11.5 MeV neutrons via the 15N(d,n) reaction and for 18 MeV neutrons via the T(d,n) reaction with limited source strengths. The position- sensitive capability of the detector will enable neutron scattering measurement over wide scattering angle in a single run. Experimental data are presented with the performance of the detector.

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A New Method for Generation of the Maxwellian Neutron Spectra with Stellar Temperatures in a Moderator

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- The role of neutron reactions in element synthesis in the Universe (particularly for the mass region A>60) is crucial. To verify the modern scenario of nucleosynthesis it is necessary to know the neutron capture cross sections for every isotope in the neutron energy region of about several tens of keV, that is for Maxwellian neutron spectra for stellar temperatures.

- We propose a new method for generation of the Maxwellian-type neutron spectra with different temperatures from 10 to 50 keV in moderator. To form a Maxwellian spectrum we use ^{7}Li(p,n) and T(p,n) reactions as neutron sources and a special form of moderator (sometimes an absorber, too). The results of the moderator form and dimension calculations and its optimisation are discussed in the report. The experimental possibility to conform real neutron spectra are discussed, as well. The accuracy of reproducing the Maxwellian neutron spectrum for a definite point of moderator maybe about 1% at the spectrum maximum and several percent on the wings of the Maxwellian curve, according to our calculations.

- The new method allows direct measurement of the cross section for Maxwellian spectra, and use of the activation method for measurements of capture cross sections for nuclei with small neutron cross section or for very small samples. The latter may be important for rare isotopes which take part in s-and p-processes of stellar nucleosynthesis.

METHOD OF ANALYSIS OF DOUBLE-DIMENSIONAL SPECTRA OF α-PARTICLES REGISTERED BY IONIZATION CHAMBER.

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ABSTRACT

An α-particles spectrometer based on a Frisch gridded ionization chamber is described. The basic principles of ionization chamber operation during α-particles registration is considered. An algorithm of α-particles double-dimensional spectra processing and correction on grid inefficiency along with energy losses in a target and kinematic is described in detail. Description of the computer software for α-particles spectra processing, energy and angular spectra analysis is given.

A problem of a background resulted from $^{14}N(n,\alpha)$ reaction is discussed. Results of calculations for different conditions of measurements are given. It is shown, that investigations of $^{50,53}Cr$ and $^{54,56}Fe$ which have Q-reaction close to one of ^{14}N are possible.

ORIGIN OF LOW ENERGY "TAIL" FOR MONOENERGETIC NEUTRON SOURCES.

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Only two parameters i.e. average energy and its variance are needed for many neutron experiments. However in some cases (inelastic neutron scattering, cross section ratio measurement for different energy dependencies and so on) we need the detailed information on energy-angular distribution of the neutron. We faced this problem while investigating the 238U inelastic scattering cross sections. To unfold the experimental spectra and to determine the partial cross sections for separate levels the Response Function (RF) of the spectrometer must be constructed. All factors (the thickness spread of the target, "slit" scattering, source environment scattering, multiple scattering in the sample) produce low energy "tail", which complicate the experimental data evaluation.

In this report we present our results of the investigation of Li(p,n) neutron source properties. The neutron energy distributions were measured by time-of-flight method. The experimental data were supported by Monte-Carlo calculations. The following factors were taken into account: - reaction kinematics; - experimental geometric parameters; - Li-distribution into the target; - source environment scattering; - incident proton scattering on slit. This allows us to describe the RF of Li(p,n) source with high accuracy in energy region E0-(E0-0.3MeV), where the neutron yield varies more than 10**3 times. We used real parameters (but not the fitting procedure) such as target thickness, "slit" proton distribution and so on. Therefore we can predict RF for each angle and incident energy.

METHOD FOR DETERMINATION OF CENTER-OF-MASS VELOCITY WITH LABORATORY NEUTRON SPECTRA ANALYSIS.

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The prompt fission neutron spectra (PFNS) in laboratory system (LS) are usually estimated on the basis of the following assumptions: i) the spectrum in the center-of-mass system (CMS) may be described by Maxwellian distribution; ii) the neutrons have isotropic angular distribution in CMS, iii) the neutrons are emitted by fully accelerated fragments.

The third assumption is very important despite its last position in this set. If the CMS velocity is known then the first and the second assumptions may be investigated after the experimental data have been transformed into CMS. The CMS velocity is usually calculated on the basis of fragments masses and their total kinetic energy (TKE) on the assumption that all neutrons are emitted by fully accelerated fragments. So, our knowledge of CMS angular distribution and spectrum parameters depends on the validity of the third assumption.

Ref.[1] gives some evidence that fragment kinetic energy is less than TKE. The conclusion was made on the basis of the analysis of angular integrated spectra in LS. In paper [2] we found out that there was no experimental evidence against neutron emission during the fragment acceleration. Therefore the main task is to find the method which would allow us to determine CMS velocity directly. In the course of this activity we suggested the method of CMS velocity estimation based on the analysis of neutron energy-angular distributions in LS. The method does not apply any "a priori" information on spectrum shape. In this report we describe the method and demonstrate its reliability with a "numerical experiment".

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The Problem of the Neutron Charge Radius and the Proposal of New Experiments for the n,e-amplitude Estimation.

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The question of the neutron mean square charge radius value derived from the experimental estimates of the n,e-amplitude cannot be considered as solved. There are two groups of values, $b_{ne} = -1.59$ and -1.31 mfm, which differ by $4-5$ errors and lead to the values of $< r^2 >_n = -0.0105 \pm 0.0034$ and $+0.0137 \pm 0.0026$ fm^2 respectively. The last result from the ORNL experiment [1] is in good agreement with the second group of estimates for b_{ne} and $< r^2 >_n$. But the fact of contradictory estimates for b_{ne} and the absence of definite indications in theory to the possible existence of the positive $< r^2 >_n$ lent impetus to the search for new approaches to the n,e-amplitude measurement.

One of the main difficulties in deriving b_{ne} from the initial experimental data is connected with the necessity to correct for collective effects in the neutron scattering cross section and also for the thermal motion of atoms. Therefore it is of interest to repeat these experiments on noble monatomic gases. In this case the calculations of the mentioned corrections are more reliable and exact.

The modelling of the experiment to measure the energy dependence of the angular anisotropy following the elastic neutron scattering by the Xe isotopes in the low energy region shows the possibility to estimate the b_{ne} value with the accuracy which is known for the nuclear scattering amplitude, b_N. To obtain an accuracy for b_N better than 5% by additionally measuring the cross section in the ~ 10 eV region should present no problems.

The total cross section measurements for ^{86}Kr which has a small capture cross section ($\sigma_\gamma^{th} \simeq 3$ mb) are even more promising. The calculations show that from $\sigma_t(E)$, measured with an accuracy of 2.5 mb in the interval of $0.002 - 1$ eV at the IBR-2 reactor (and, perhaps, in addition at the IBR-30 booster), one can obtain b_{ne} with an accuracy better than 5%. The available beam intensities with the ^{86}Kr sample weighing 10g make it possible to obtain higher statistical accuracy.

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NEUTRON INTERFEROMETRY METHOD OF STUDY
OF PARITY VIOLATION IN COLD NEUTRON TRANSMISSION

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A possibility to use an extremely sensitive neutron interferometry technique to carry out precise measurements of the neutron spin rotation is discussed.

During the operation of the neutron interferometer set up in Hahn-Meitner Institute, Berlin [1] was achieved a rather high accuracy (~10^{-5}) of measurements of a phase shift

$$\varphi_{nucl} = \frac{2\pi}{\lambda} \cdot (1 - n_{nucl}) \cdot l \qquad (1)$$

introduced by a sample of nuclear refraction index n_{nucl} and thickness l placed in one of the interferometers' beams (here λ is the neutron wavelength).

The nucleus-neutron week interaction results in a helicity dependence of the neutron forward scattering amplitude, that can be written as $C \cdot \boldsymbol{\sigma}\, \boldsymbol{p}$, where $\boldsymbol{\sigma}$ is the neutron spin vector and $\boldsymbol{p}$ is the neutron momentum. The real part of constant C, that is a constant at low energy results in a helicity dependence of the neutron refraction index. The angle of the neutron spin precession about $\boldsymbol{p}$ is given by [2]

$$\varphi_{pnc} = -4\pi \cdot N \cdot l \cdot \mathrm{Re}(C).$$

The phase shifts introduced by a corresponding sample for two opposite neutron spin directions can be written as $\varphi_{nucl} \pm 1/2\varphi_{pnc}$, where φ_{nucl} is a nuclear phase shift of the sample (Eq. (1)). Therefore an interferometry experiment carrying out with the reverse of the spin direction can give the similar accuracy ~10^{-5} of the measurement of the parity non-conservation effect.

Such method being free from some systematic effects limiting present polarization techniques can be used as alternative one for the study of parity non-conservation effects in week interactions.

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Dispersion Law for Neutrons at Extremely Low Energy

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The behavior of superslow neutrons (SSN) with velocities less than ≈0.1m/s cannot be described by employing the notion of an average or optical potential. Owing to the existence of such a region, the wave vector in the medium becomes complex when the scattering length of an individual nucleus is positive,

$$k = k_r + ik_i;\quad k_r = \frac{1}{2}\sqrt[3]{\chi_0^2 k_0};\quad k_i = \frac{\sqrt{3}}{2}\sqrt[3]{\chi_0^2 k_0};\quad \chi_0^2 = 4\pi b|b|, \tag{1}$$

where $\mathbf{b}$ is the coherent scattering length, $\mathbf{n}$ the density of nuclei, and $\mathbf{k_0}$ is the wave number of the incident neutrons. The reason for this is the considerable rescattering effect at distances about $\rho_0 = a^2/b$, where $\mathbf{a}$ is interatomic distance. As a consequence, slow infiltration deep into a substance by ultracold neutrons with energies lower than the boundary energy takes place. The universal dispersion law for very cold neutrons was found

$$k_r = \sqrt{k_0^2 - \chi_0^2 - \frac{J_v}{k_0^2} + \sqrt{\left(k_0^2 - \chi_0^2 - \frac{J_v}{k_0^2}\right)^2 + \left(\frac{J_v}{k_0^2}\right)^2}},$$

$$k_i = \sqrt{\chi_0^2 - k_0^2 + \frac{J_v}{k_0^2} + \sqrt{\left(\chi_0^2 - k_0^2 + \frac{J_v}{k_0^2}\right)^2 + \left(\frac{J_v}{k_0^2}\right)^2}}, \tag{2}$$

$$k = k_r + ik_i,\qquad k_0^2 >> \chi_0^4 a^2 .$$

Taking into account the weak absorption results in the appearance of a second branch in the neutron wave spectrum. This second branch is characterized by a significantly longer damping length than predicted by the conventional theory for a complex potential. In the Conclusion possibilities of experimental verification of the theory are discussed.

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"Consistent Parameter Sets far Describing Neutron Nuclear Interaction"

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Sure values for neutron cross-sections and scattering lengths are fundamental properties, which are needed in a lot of basic and applied research questions, not only for elements, but also for isolated isotopes. Spin dependent scattering lengths, too, are of ever-increasing interest for many investigations, moreover, they are useful quantities as complement to the resonance parameters to describe totally neutron nucleus interaction ever a wide range of neutron energy.

It is necessary to have complete sets of resonance parameters for calculations of spin dependent scattering length, In most cases the contributions from unresolved resonances in high energy range and from unknown bound levels at "negative energies" are not negligible.

The presented method to fit one fictive bound state can adopt not only the measured values of coherent scattering lengths arid of total cross sections at various energies, but also the spin dependent scattering lengths and with this the incoherent cross-sections and the potential radii for s-wave scattering. For recent measurements on Thallium and its isotopes some bound level fits are presented and discussed to describe the low energy interaction in a homogeneous and consistent way.

PRECISE MEASUREMENTS OF σ_{tot} FOR ^{208}PB

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In order to get a new evaluation of the neutron electric polarizability the measurements of neutron total cross section σ_{tot} for ^{208}Pb are undertaken at the 70 m flight-- path of Dubna booster IBR- 30. The transmission sample (enrichment 98.3%) is metallic cylinder 15 mm in diameter and 20.8 mm in thickness. Neutron beam near the sample is 11 mm in diameter. 20 or 50 cm long 10 atm $^3He-$ counter is used as a neutron detector.

Combined filter- time- of- flight method of three kinds is used for the energy selection. Nine points of σ_{tot} between 1.7 and 60 eV are obtained with the Co, Br, W, Ag and Rh filters with black resonances being permanently present in the beam for the background isolation. Filters of 10 cm ^{60}Ni and $\sim$ 4 cm powdery Na_2CO_3 is used to give a broad peak of neutrons at $\sim 3-8$ keV with background on both edges of it. This kind of measurements allows to get some keV points of σ_{tot}. At last the third kind of measurements is carried out with filters of 24 cm Fe and 10 or 20 cm Al, what gives σ_{tot} at $\sim$ 24 keV.

Unfortunately accuracy of calculated σ_{tot} is limited now by the error of dead time $\Delta\tau \simeq 0.05$ mcs.

Preliminary results on σ_{tot} and polarizability are given.

ON THE NEUTRON MEAN SQUARE INTRINSIC CHARGE RADIUS

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In 1994, the physical community of the world continued discussing the issue of the value of the n-e scattering length, a_{ne}, and of the sign of the neutron mean square charge radius $< r_{in}^2 >_N$. With respect to neutron experimental data processing results physicists can be divided into two groups : those belonging to the first group believe that $< a_{ne} >= (-1.31 \pm 0.02) \times 10^{-3} fm$ (Krohn, Ringo (1973), Koester et al. (1988)) and, consequently, $< r_{in}^2 >_N > 0$, and the others who believe that $< a_{ne} >= (-1.58 \pm 0.03) \times 10^{-3} fm$ (Melkonian et al. (1959), Alexandrov et al. (1975 and 1986)) and, consequently, $< r_{in}^2 >< 0$.

Calculations performed in on the basis of the S-matrix of neutron scattering which take into account the phenomenon of inter-resonance scattering (Wigner (1946), Fogt (1958)), yielded an analytical expression for the inter-resonance interference term. It has also been shown that far from resonances the interference term is practically independent of neutron energies and thus cannot influence the value of a_{ne} obtained in Dubna. It has moreover been shown that the sum effect of resonance effects and inter-resonance interference is almost equal to zero for even-even nuclei, what means that for an even-even nucleus the resonance scattering should not affect the value of a_{ne}.

Reasons for a discrepancy in the determination of the a_{ne} value from transmission experiments performed in Garching (Koester et al. (1988)) and in Dubna (Alexandrov et al. (1986)) were also considered. It has been shown that the most probable reason for this discrepancy is the calculation methods by which the influence of negative energy resonances is accounted for.

A comparison was carried out between experimental and calculated values for a_{ne} and $< r_{in}^2 >_N$ on the basis of modern theoretical representations of the nucleon. It has been shown that the well-known theoretical ideas of the nucleon structure based on the old meson theory by Yukawa (Cloudy Bag Model, Skyrme model, Numbu-Jona-Lasinio model, Collective model etc.) disagree with the experimental value $< a_{ne} >= -1.31 \times 10^{-3} fm (< r_{in}^2 >_N > 0)$, and agree with the value $< a_{ne} >= -1.58 \times 10^{-3} fm (< r_{in}^2 >_N < 0)$.

This point of view has recently received positive response at the XVIII International Nuclear Physics Symposium at Oaxtepec (Mexico) held on January 4-7, 1995. At present there exists no adequate idea of the nucleon structure which would explain the value $< a_{ne} >= -1.31 \times 10^{-3} fm$.

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NEW PRESENTATATION FOR THE PHASE SHIFTS OF STRONG INTERACTION FOR THE EVALUATION OF NEUTRON FUNDAMENTAL PARAMETERS

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Theoretical expression of s-wave neutron-nucleus scattering cross section $\sigma_s^{th}(E_i)$ is presented using equation for imaginar part Im A(0) of scattering amplitude and taking into account resonance corrections. Then comparison of theoretical $\sigma_s^{th}(E_i)$ and experimental $\sigma_s^{ex}(E_i)$ values (where the last are corrected with respect to absorption, solid state, Schwinger and incoherent scattering effects) allows to calculate the total scattering phase shift $\delta'_0=\delta_0+\eta_0+\xi_0$ (where δ_0, η_0, ξ_0 are phase shifts of strong, neutron-electron and neutron electric polarizability scatterings, correspondingly) at low neutron energies E_i.

This procedure has been employed for δ'_0 calculation using the neutron scattering cross section results (ref.[1]) for ^{209}Bi at 1.26 eV. Then, using the equation for real part Re A(0) of scattering amplitude including the resonance corrections Σ_1, Σ_2

$$\mathrm{Re}\,A(0)+\frac{\sum_1\cdot\cos(2\cdot\delta_0')}{2\cdot k_i}+\frac{\sum_2\cdot\sin(2\cdot\delta_0)}{2\cdot k_i}=\frac{\sin(2\cdot\delta_0')}{2\cdot k_i}=-(R'-Z\cdot a_{ne}\cdot(f(E_i)-h(E_i))-\alpha_n\cdot g_n(E_i))$$

with the parameter values $R'=9.36(5)$ fm (ref.[2]) and $a_{ne}=-1.32(3)10^{-3}$ fm (ref.[1]) we obtain the neutron electric polarizability value $\alpha_n=(1.19\pm1.18)10^{-3}$ fm^3 in good agreement with its value $\alpha_n=(1.16\pm1.18)10^{-3}$ fm^3 which follows from an approximate low energy formula

$$R'=b_{coh}\cdot\frac{A}{A+1}+a_n-\frac{\sum_1}{2\cdot k_i}$$

where the experimental value $b_{coh}=8.532(2)$ fm (ref.[3]) and the above mentioned R' value have been used.

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THE CORRELATION EXPERIMENTS AT FREE NEUTRON BETA DECAY AS A VERIFICATION OF THE $V - A$ THEORY.

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$\lambda = G_A/G_V$ is the only parameter of the $V - A$ theory of the weak interaction. Therefore three coefficients of angular correlations

a_o (correlation between the electron and antineutrino momenta),

A_o (correlation between the neutron spin and electron) momentum,

B_o (correlation between the neutron spin and antineutrino momentum)

at neutron beta decay must lead to the same value of λ. That gives possibility to verify a fulfilment of the $V - A$ theory.

Three experimental results lead to three different values: λ_a, λ_A and λ_B. The average value λ_c corresponds to new values of the correlation coefficients which differ from a_o, A_o and B_o. It is possible to show that the $C\{a_c, A_c, B_c\}$ combination is the most probable one among combinations which are co-ordinated with $V - A$ theory.

The deviations of three λ's from λ_c characterize the fulfilment of the $V - A$ theory, but the accuracy of such verification should be poor because of the weak dependens of λ value on B.

It is better to compare $O\{a_o, A_o, B_o\}$ and $C\{a_c, A_c, B_c\}$ combinations directly. Let us use the three-dimension coordinate with the normalized deviation

$$\frac{a - a_o}{a_o}, \qquad \frac{A - A_o}{A_o}, \qquad \frac{B - B_o}{B_o}$$

for symmetrization of data. Then for each axis the deviation of x_c from x_o is deviation from unit of the normalize asymmetry. Hence the summary of three deviations is equal to distance between O and C:

$$\sqrt{(1 - \frac{a}{a_o})^2 + (1 - \frac{A}{A_o})^2 + (1 - \frac{B}{B_o})^2}.$$

Its error is equal to the average radius of the general ellipsoid of the 90% probability of experimental data $a_o \pm da_o$; $A_o \pm dA_o$; $B_o \pm dB_o$:

$$\sqrt{3 \times [(\frac{da_o}{a_o})^2 + (\frac{dA_o}{A_o})^2 + (\frac{dB_o}{B_o})^2]}.$$

Such verification shows that difference between the modern experimental results and $V - A$ theory is equal to $(0.5 \pm 7.5)\%$ with 90% c.l.

The large error of this result is connected with large relative error of the a_o measurement. If to exclude a_o from analysis and to use only the comparison of (A_o, B_o) with (A_c, B_c) combinations that gives the better accuracy. At this case the difference is equal to $(0.2 \pm 2.7)\%$ with 90% c.l.

ANTINEUTRINO-SPIN ASYMMETRY IN BETA DECAY OF THE NEUTRON AND RESTRICTION FOR MASS OF W_R

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Abstract

In this work we report on new results of measurements of antineutrino–spin asymmetry in beta decay of polarized neutrons. This work has been carried out on the polarized neutron vertical channel of the WWR–M reactor. From results of measurements of the experimental asymmetry, $x = BP = 0.6617 \pm 0.0044$, and from results of measurements of the beam polarization, $P = (66.88 \pm 0.22)\%$, the value of the antineutrino spin asymmetry coefficient was obtained: $B = 0.9894 \pm 0.0083$. This allows us to place restrictions on M_{W_R}: $M_{W_R} > 282$ Gev/c^2 (90% C.L.) .

P-ODD, LEFT-RIGHT AND FORWARD-BACKWARD ASYMMETRIES OF FRAGMENT ANGULAR DISTRIBUTIONS IN ^{233}U NEUTRON INDUCED FISSION AND FORWARD-BACKWARD ASYMMETRY IN ^{239}Pu FISSION

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Results of simultaneous analysis of different P-odd and P-even interference effects in ^{233}U fission fragment angular distributions are presented. P-even forward-backward asymmetry coefficients as a function of neutron energies $E_n \sim (0.1 \div 70)$ eV was measured at the pulsed reactor IBR-30. Measurements of P-odd and P-even left-right asymmetry coefficients inside neutron energy range 0.04 eV $< E_n <$ 2 eV was performed earlier using crystal diffraction monochromator of polarized neutrons at WWR-M reactor of PNPI RAS. All experimental results obtained have been found to be in a good mutual accordance within the frames of modern theoretical conceptions about the mechanisms of space parity violation effect and P-even interference effects forming in fission process induced by slow neutrons.

Results of the first measurements of P-even forward-backward asymmetry coefficient as a function of neutron energies in ^{239}Pu fission was presented in the range 0.5 eV $< E_n <$ 175 eV. Just as it was observed in ^{233,235}U, fission pronounced irregularities in neutron energy dependence of this asymmetry coefficient were observed in this case as well. Preliminary analysis of the experimental data gave possibility to get estimates of some main parameters of the weak p-resonances unvisible in fission cross sections.

This work was performed under support of RFFI (93-02-3979) and ISF (NOC000).

OBSERVATION OF DEFORMED NUCLEAR SHELL N=102 IN HIGH ASYMMETRIC FISSION PROCESS.

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ABSTRACT

A mass-energy spectrum of ^{236}U fission fragments was investigated in the mass region below 85 a.m.u. The yield of nickel and iron isotopes was observed to be approximately 10^{-3}% which is very high in comparison with the yield level determined for other fissile nuclei. We suggested the existence of a new mass channel associated with the proton shell P=28. Measured kinetic energy distribution being anomalously narrow was used to determine scission deformation spectrum of Gd isotopes. Corresponding β-deformation parameter was calculated to be centered around the value of β=0.84 in good agreement with the value predicted theoretically. The role of scission barrier was discussed. It was shown that the events analyzed are from definitely true binary fission process.

FRAGMENT ANGULAR ANISOTROPY FOR TERNARY FISSION OF 238U BY 1.6 MeV NEUTRONS

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Abstract

To search for effective K - values of channels of both ternary and binary fission, a simultaneous measurement of fragment anisotropy for ternary and binary fission of 238U induced by neutrons with energy 1.6 MeV was performed. The fission fragments were detected by a low pressure multiwire proportional chamber, while the long-range ternary alfa - particles recorded by an array of Si-diodes. The ratio of ternary-to-binary fragment anisotropy N(0°)/N(90°) was found to be 1.18 + - 0.08. The ratio is seen to deviate from unity at a confidence level of 95%. This result calls for further experiments aiming at a higher precision.

The present work has been supported by BMFT/Bonn (WTZ - Abkommen mit der GUS No. YI-30), NATO (CRG 921307) and Russian Program "Fundamental'naya Yadernaya Fizika" (134-06). Financial support by these funding organizations is gratefully acknowledged.

MULTILEVEL FITTING OF ^{235}U RESONANCE DATA SENSITIVE TO BOHR- AND BROSA-FISSION CHANNELS

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A re-evaluation of the low energy resonance fission, capture, and total cross sections of ^{235}U was carried out for the U.S Evaluated Nuclear Data File ENDF/B-VI. In this evaluation,[1] we did not consider any data on the variation of ν, the number of neutrons emitted per fission, or the total kinetic energy of fission fragments as a function of neutron energy. These are scission-point variables, which Hambsch et al [2] analyzed with a fission-channel representation suggested by Brosa et al [3]

We also did not specifically include in our evaluation the measurements of the energy variation of the angular distribution of fission fragments from aligned ^{235}U nuclei. Such measurements were carried out nearly 30 years ago by Pattenden and Postma,[4] and a remeasurement has very recently been reported by Furman et al[5] at Dubna. These measurements give the variation of K, J from resonance to resonance These are the Bohr fission channels, and they provide a description of the saddle-point configuration

It was first pointed out by Auchampaugh[6] that a two (or more) fission channel description of spin-dependent total, fission, and capture cross sections is not unique, there can be many solutions for the orientation of the fission-width vectors Physically, however, the relative fission-width vectors have a fixed orientation in channel space, i.e , only one of the many possible descriptions is physically the correct one We assert that this correct solution is the Bohr-channel representation, the one that fits the measurements of Refs 4 and 5 However, it appears that this solution does not describe the variation of the scission-point variables in the Brosa-channel representation

In the present study, we have modified the ENDF/B-VI parameter set in such a way that the predicted cross sections are the same as in Ref 1, and yet provide a reasonably good description of the Bohr-channel angular distributions This same parameter set also provides a description of the energy dependence of symmetric fission as given by the Brosa superlong channel. Furthermore, we find that a simple rotation in channel space can give an adequate description of the fragment kinetic-energy variation, in the framework of the two Brosa standard channels.

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NEW RESULTS ON THE REACTIONS $^{237}Np(n,f)$ AND $^{252}Cf(sf)$

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The experimental investigations of the reactions $^{237}Np(n,f)$ and $^{252}Cf(sf)$ have been finished recently. For $^{237}Np(n,f)$ we investigated the fission fragment mass, total kinetic energy ($\overline{TKE}$) and angular distributions as a function of incident neutron energy from E_n= 0.3 MeV to E_n= 5.5 MeV. For $^{252}Cf(sf)$ the correlation of the above mentioned fission fragment parameters with prompt γ-ray emission has been studied. In addition also theoretical calculations based on the multi-modal random-neck rupture model of Brosa, Großmann and Müller [1] have been accomplished.
In the case of $^{237}Np(n,f)$ the fluctuations observed in $\overline{TKE}$ could be explained, performing two-dimensional fits to the fragment mass-energy distribution. Only this approach was unambiguous for the interpretation of the experimental data in terms of sharing contributions or fission modes. The behaviour of the $\overline{TKE}$ as a function of the incident neutron energy, could be attributed to a change in $\overline{TKE}(A)$ as long as E_n is below the fission barrier. Above the barrier the mass-distribution changes, with higher mass yields for lower TKE's and therefore the $\overline{TKE}$ drops. Also structures observed in the number of prompt neutrons could be attributed to changes in the mass distribution and an increase of the total excitation energy. The changes of the fission fragment parameters under investigation are now fully understood.
In the case of $^{252}Cf(sf)$, the aim is to check whether an increased non statistical high energy γ-yield is found for fragment masses around A≈130 amu as compared to other mass regions, which has been reported by other authors [2,3,4]. Furthermore, for the determination of the excitation energy of the nascent fragments and of the level density parameters, it is necessary to know the average γ-energy as a function of mass and total kinetic energy. Also in the cold fragmentation region it will be checked whether it is possible to determine fragment charges via specific γ-ray transitions.
Having assayed only part of the data yet, indeed a difference in the γ-yield for energies from 2 MeV to 6 MeV is found comparing the mass range $126 \leq A < 136$ to $A \geq 136$. The γ-ray energy spectra for individual masses show several peaks located at different positions for light and heavy fragments.

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Fluctuations of γ-ray Yields in ^{237}Np Low Energy Fission Resonances

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Abstract

In order to perform some γ-ray yield fluctuation measurements with a higher accuracy, a new multiplate ionizing fission chamber was constructed and tested. The total amount of high purity ^{237}Np is about 1.5 g, deposited on two sides of 15 μm thin Al targets. All measurements were carried out on the Dubna IBR-30 pulsed reactor - based time-of-flight spectrometer. A large 6-section liquid scintillation detector was used for detecting 3 or more fission γ-quanta in coincidence with fission fragment pulses. The obtained data on the variation of ν_γ-dependent relative fission γ-ray yields are reported. .

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EXPERIMENTAL GROUNDS FOR NUCLEAR SHAPE ISOMERISM HYPOTHESIS

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Technique and experimental results to hint at and to support of the nuclear shape isomerism hypothesis are briefly discussed.

Among them :

⊙ the discovery of spontaneously fissioning isomers;
⊙ the effect of angular momentum transferred on spin and fission isomer yields;
⊙ the bumps in direct (d, pf) - and (t, pf) - reaction cross sections below barrier;
⊙ the shelf in actinide photofission cross section;
⊙ electron spectroscopy in the second well;
⊙ α - and γ - spectroscopy of fission isomers.

A set of the fission data getting their explanation beyond the frame of the shape isomerism hypothesis isreviewed.

It includes :

⊙ energetic dependence of the fission isomer yield in 241Am(n, γ) - reaction;
⊙ yields of the fission isomers in $^{238}U(n,n')$ - reaction;
⊙ fission isomer yeild in $^{241}Am(n,n')$ - reaction.

INFLUENCE OF THE DYNAMICAL EFFECTS ON PREFISSION NEUTRON MYLTIPLISITY IN HEAVY ION INDUCED REACTIONS

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In studying the nuclear processes included the large amplitude collective motion of nuclear matter an important role plays the experimental and theoretical investigations concerning to nuclear fission. The investigation of fission mechanisms of highly excited nuclei produced in the heavy ion reactions is connected with consideration of dynamical peculiarities of this process, dissipation processes, conservative potentials and statistical characteristics of excited nuclei (for example, the level density).

It is well known that the pre- and post-fission multiplicities of neutron and charged light particles are sensitive probes of the nuclear fission dynamics. The statistical model evaporation code used in analyses of the experimental data on light charge particle emission prior to fission is described. In this code the three effects of nuclear dissipation on light particle emission are incorporated: (1) Kramers's modification of the statistical model result for the fission width; (2) the transient time required to build up the quasistationary probability flow at the saddle point; (3) the mean time of the descent from saddle to scission. The possible effects of energy dependence of nuclear dissipation on the prefission neutron and light charged particles emission are discussed. It is shown that it is necessary to take into account the energy dependence of the nuclear dissipation coefficient to calculate the fission width in description of the experimental data on the energy dependence of fission probability of highly excited nuclei.

INVESTIGATION OF RESONANCE STRUCTURE AND DOPPLER-EFFECT OF CROSS-SECTIONS FOR ^{232}Th, ^{235}U AND ^{239}Pu

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Transmissions and their Doppler coefficients for ^{232}Th, ^{235}U, ^{239}Pu were measured on the 60 m, 123 m and 1006 m flight paths of the IBR-30 in the energy range from 1eV to 200 keV. Metal disks with the diameter 45 mm were samples-filters, which cooled to temperature of liquid nitrogen and heated to 293^0, 600^0 and 900^0. Similar data had been calculated from BROND-2, ENDF/B-6, JENDL-3 evaluated data libraries by means of the GRUCON computer program. Maximal values of Doppler coefficients for ^{235}U are in energy range 100-215 eV, for ^{239}Pu in range 215-465 eV, for ^{232}Th in range 2.15-10 keV. Experimental Doppler coefficients are agreement with calculated values for ^{232}Th and ^{239}Pu. Calculated coefficients for ^{235}U from BROND-2 and JENDL-3 are more than experimental results by a factor of two. Analogous measurements and calculations have been carried out earlier only for ^{238}U [1,2].

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Combined file for the analysis of nonstatistical effects in the spacing distributions

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Since the publication in 1981 of the last edition of Compilation of Neutron Resonance Parameters known as BNL-325 the great amount of data appeared in the literature and in Data centers. Performance of the analysis of different nonstatistical effects demands access for computer-based programs to these data files. In Nuclear Data Center of PNPI we come to conclusion that new evaluation of neutron resonance parameters and rearrangement of the data files, their updating and transforming all neutron data in a common format is needed besides the eliminating of systematic effects in the energy calibration in different data sets. About 30 000 data lines each containing 10 parameters for one neutron resonance (E_n-neutron resonance position, J-total moment, l-orbital moment, Γ_{total}, $\Gamma_{neutron}$, $\Gamma_{radiation}$,reduced neutron widths for l=0 and l=1, parameter $\Gamma_n \times \Gamma_\gamma/\Gamma$ and some of partial width) are accumulating now after the search of relevant literature (by CINDA and EXFOR). The analysis of energy calibrations of different spectrometers (ORELA,Columbia University,JAERI and GELINA) was performed by the data for iodine, arsenic, tantalum and some other elements and is now completed and will be reported. Most of the neutron resonance positions have been already inserted in the files and the search for the systematical effects in resonance positions in many heavy nuclei is underway. One case of the influence of isotopic impurity (^{141}Pr in ^{142}Nd) was found in data from BNL-325. All six the first neutron resonances of neodymium are situated exactly at the same energy as the strong resonances of praseodymium.

Some problem with estimation of errors may be seen from the distributions of the last numbers in the neutron resonance positions taken from BNL-325 compilation by S.Mughabghab et al . Recently adopted in files ENSDF (Evaluated Nuclear Structure Data File , Academic Press, N.Y.) procedure of data presentation avoids any unnecessary rounding up of the values. General policy of recent compilation consists in preservation of all known values (even from single experiment) and producing of evaluated values (were it is possible). It is preferably to have the common standard representation of all results including permanent relative position of the parameters in the Tables.

The second part of Combined File is now forming on the basis of ENSDF-values with addition of rough data not contained in it (states from strong gamma-ray transitions and from proton and neutron resonances in light nuclei). SFERC method of estimation of super-fine structure intervals is based on the assumption that common fundamental parameters of nucleon structure will dictate through the limited number of factors the intervals in the spectra of high-lying excitations thus giving nonstatistical effects in many level spacing distributions. The possible importance of that phenomenon (of the manifestation of parameters of electrodynimics) is connected with very accurate proximity to the $\alpha/2\pi$ of the mass ratios that involve leptons and Z-boson for example $m_e/(M_q = 3 \times \Delta M_\Delta$) or m_μ/M_Z. More detailed description of the problem and results is contained in the number of separate papers.

INVESTIGATION OF THE REACTION $^6Li(n,t)^4He$ AT THE C.M. ENERGIES BELOW 500 keV IN THE FRAMEWORK OF THE ALGEBRAIC VERSION OF RESONATING GROUP METHOD

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The reaction $^6Li(n,t)^4He$ are investigated in the framework of the algebraic version of the resonating group method [1]. We consider two channels with the cluster structures $^6Li + n$ and $t + ^4He$. The total wave function is taken in the form of antisymmetrized product of the internal claster functions and function of relative motion. The lowest wave functions of the oscillator shell model are used as the internal cluster functions. The function of relative motion is searched in the form of the expansion in the oscillator basis with the same oscillator radius. In this case the multiparticle Shrodinger equation is reduced to infinite set of linear algebraic equations for the expansion coefficients. Solving this set with allowance for scattering asymptotic conditions, we obtain the $S-$matrix elements.

The nucleon-nucleon potential in form [2] containing the central, spin-orbit and tensor forces are used in this calculations. All partial waves with total angular momentum $J \leq 7/2$ are taken into account. The calculated results indicate strong resonant behavior of the $5/2^-$ amplitude. Performing calculations without channels coupling, we show that this resonance is formed in the channel $^6Li + n$ with the total spin $S = 3/2$ and the orbital angular momentum $l = 1$. The amplitude with $J^\pi = 1/2^+$ provides the $1/v$ dependence of the total cross section at low energies. The contribution of the amplitude with $J^\pi = 3/2^+$, which also leads to the $1/v$ dependence, is smaller than the contribution of the $J^\pi = 1/2^+$ amplitude by two orders of magnitude. The calculations indicate that the amplitudes with $J^\pi = 1/2^-$ and $3/2^-$ give nonvanishing contribution to the total cross section in the c.m. energy region below 500 keV. The calculated total cross section agrees with the experimental data [3].

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COLLECTIVE EXCITATIONS INDUCED BY NEUTRONS IN THE QUASIPARTICLE-PHONON NUCLEAR MODEL

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Analysis of the spectra and angular distributions of nucleons in the elastic scattering reactions permits the determination of the role of various nuclear-reaction mechanisms over a wide range of nuclear excitation energies. It is known that with increase of the incident-nucleon energy the contribution of the statistical reaction mechanism is no longer dominant and this appears first of all in the shape of the angular distributions of the emitted protons and neutrons. The asymmetry of the angular distribution can be explained in terms of the theory of direct processes, but to obtain a self-consistent interpretation of the experimental data it is necessary to separate the direct processes correctly from other decay modes of the excited compound nucleus. For the description of the integral contribution of direct processes to the neutron inelastic-scattering spectra it is necessary to know the spectroscopic characteristics of all possible collective excitations. In the present work the description of such excitations has been carried out by the quasiparticle-phonon nuclear model /1/.

In this paper the possibilities of the semimicroscopic approach for a quantitative description of the observed differential spectra of elastic scattering of neutrons with energy 14 and 40 MeV by ^{208}Pb and ^{92}Zr nuclei are analyzed. It is shown that in formation of the integrated and differential spectra an important role is played the collective states of high multipolarity with complex structure.

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ANALYSIS OF FISSION FRAGMENT DATA FROM THE 238U(n,f) REACTION AT INCIDENT NEUTRON ENERGIES FROM 1 MeV TO 500 MeV

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