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PROGRESS REPORT FOR HUNGARY FOR THE PERIOD 1989/90

Institute of Experimental Physics
Kossuth University, Debrecen

Institute of Nuclear Research
of Hungarian Academy of Sciences

Institute of Nuclear Technics
Technical University Budapest

Compiled by Gy. Kluge

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IAEA NUCLEAR DATA SECTION, WAGRAMERSTRASSE 5, A-1400 VIENNA

INSTITUTE OF EXPERIMENTAL PHYSICS
KOSSUTH UNIVERSITY
DEBRECEN

EVALUATION PROCEDURE FOR NUCLEAR RMS CHARGE RADII

I. Angeli

Data sources are listed and an evaluation procedure is described that have been used recently to derive best values of nuclear root-mean-square (RMS) charge radii measured by fast electron scattering and muonic atom X-rays. The evaluation procedure which is a revised version of that used in evaluating total neutron cross sections by a semiclassical optical model[1], consists of two algorithms. The first one performs a search for discrepant data -"outliers"-, together with an eventual reassignment of their errors; this algorithm is active only for groups containing at least n=5 data. The second algorithm forms a weighted mean and its error for each data group; it takes into account both external and internal consistencies. An illustrative table of input data as well as a table of "1990 best values" of nuclear RMS charge radii are also included[2].

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EFFECT OF VALENCE NUKLEONS ON RMS CHARGE RADII

I. Angeli

The nucleonic promiscuity factor $P=N_pN_n/(N_p+N_n)$, where N_p (N_n) is the number of valence protons (neutrons) or holes[1], is shown to be a useful and physically meaningful parameter in the description of RMS charge radii[2]. The empirically found mass number dependence of the average strength of this interaction is in agreement with the qualitative theoretical expectation[1]. The limitation of the parametrisation in terms of P only, requires the inclusion of the polarising effect of individual valence nucleons. As a by-product, a positive correlation between surface diffusity and promiscuity is pointed out. Different formulae for the mass number dependence of RMS radii are compared; the introduction of nucleonic promiscuity factor in the radius formula $R\approx R_c+0.075P/R_c$ (R_c: "closed-shell radius") reduced the χ^2/n' value by a factor of two. The fit can be further improved by taking into account the mass number dependence of proton-neutron overlap probability.

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THE $^{115}In(n,n')^{115m}In$ REACTION AS A POSSIBLE FLUENCE MONITOR OF D-D NEUTRONS

J.Csikai and P.Raics

The D-D and D-T neutrons produced by low voltage accelerators are widely used for the determination of reaction cross-sections. The angular yield of neutrons emitted in D-T reaction is measured mainly by the $^{93}Nb(n,2n)^{92m}Nb$ reaction[1]. In spite of the significant anisotropy in the angular distribution of D-D neutrons[2] a good agreement was found between the measured relative activity of ^{115m}In and the calculated angular yield of neutrons at 200 keV bombarding deuteron energy (see Fig.1). The details of calculations for thin and thick TiD targets have been described elsewhere[3]. The calculated neutron energy and the energy spread vs. emission angle is shown in Fig.2. The flatness of the excitation function of $^{115}In(n,n')^{115m}In$ reaction between 2 and 3 MeV neutron energy can be checked by comparison to the $\sigma_{n,f}(E)$ curve of the ^{238}U fission. Figure 3 shows the recommended[4] $\sigma_{n,f}(E)$ curve and its relative change between 2 and 3 MeV incident neutron energy. The measurement of $\sigma_{n,n'}(E)$ to $\sigma_{n,f}(E)$ is in progress using the activation method and a fission chamber.

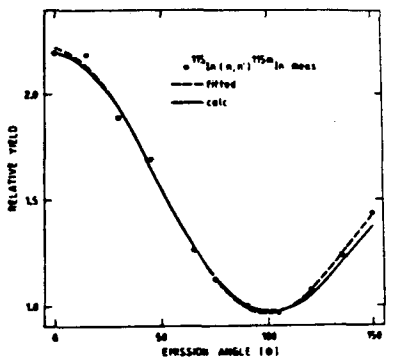

Fig. 1.

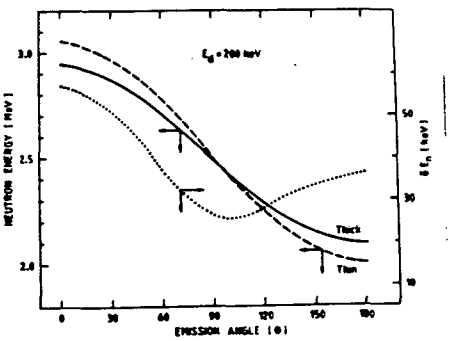

Fig. 2.

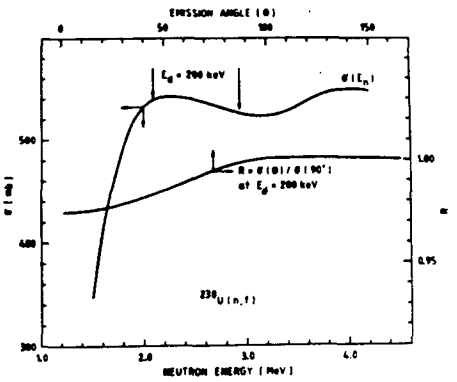

Fig. 3.

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EXCITATION FUNCTION OF NEUTRON INDUCED REACTIONS ON Zr ISOTOPES IN THE NEUTRON ENERGY RANGE FROM 5 TO 12 MeV

P.Raics, S.Nagy, S.Szegedi,
N.V.Kornilov*, and A.B.Kagalenko*

Natural zirconium samples were irradiated at the MGC-20E cyclotron in Debrecen at 12 different neutron energies in the neutron energy range from 5 to 12 MeV using neutrons around zero degree from D+D reaction on a gas deuterium target. The neutron flux density was monitorized by a fission chamber containing thin depleted ^{238}U layer. The neutron flux density as well as energy distribution were also checked by Al, Fe and In foils activated together with the Zr samples. The deuterium beam was analysed by a calibrated analyzing magnet, the energy and energy spread of neutrons were calculated and checked by a stilbene neutron detector as well as by the scanning of the resonance absorbtion curve around 6.3 MeV on ^{12}C.

The activities of the irradiated Zr and monitor samples were measured by calibrated HPGe and Ge(Li) detectors. The evaluation of the measured gamma-spectra as well as the determination of excitation functions are in progress.

The available data from literature will also be analyzed critically.

* Institut of Physics and Power Engineering, Obninsk, USSR.

MEASUREMENT OF SOME REACTION CROSS-SECTIONS NEEDED FOR DOSIMETRY

Cs.M.Buczkó, T.Chimoye*, B.Jimba**, K.Usman**
and S.M.Al-Jobori***

Activation cross sections of threshold reactions to unfold the spectral density of neutrons in different media by multiple-foil analysis have, mostly, not been measured with the required 3-5 % accuracy[1]. Standard reference data are needed for $^{115}In(n,n')$, $^{113}In(n,n')$ and $^{58}Ni(n,p)$ reactions around 14 and 3 MeV neutron energies to normalize the excitation functions, similarly to the $^{115}In(n,n')^{115m}In$ reaction studied[2] at around 14 MeV. Measurements are in progress by using the activation method for the 2.1-2.9 MeV and 13.5-14.8 MeV incident neutron energy ranges produced in D-D and D-T reactions. In addition, the determination of the excitation functions of $^{58}Ni(n,p)^{58}Co^{m,g}$ reactions at eleven energy points between 5 and 12.3 MeV in progress using the MGC-20 cyclotron in Debrecen.

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Permanent address:* Faculty of Science and Technology, Thammasat University, Bangkok, Thailand. ** Centre for Energy Research and Training, Ahmadu Bello University, Zaria, Nigeria. ***Nuclear Research Center, Tuwaitha, Baghdad, Iraq.

EXCITATION FUNCTIONS OF $^{63}Cu(n,p)^{63}Ni$ AND $^{63}Cu(n,\alpha)^{60}Co$ REACTIONS BETWEEN 5.5 AND 15 MeV

F.Cserpák, G.Stöcklin*, S.M.Qaim*, Cs.M.Buczkó, J.Csikai
S.Sudár and R.Pepelnik**

The accuracy of the existing cross-section values for the $^{63}Cu(n,p)$ and $^{63}Cu(n,\alpha)$ reactions cannot satisfy the data needs [1,2], therefore, measurements are in progress between 5.5 and 15 MeV incident neutron energy range in twelve points.

Samples were irradiated at the MGC-20 cyclotron in Debrecen and at the KORONA generator in Geesthacht. For the determination of the activity of ^{63}Ni by the detection of soft betas the radiochemical separation technique is applied.
Results will be compared with the existing data and the model calculations.

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* Institut für Chemie 1 (Nuclearchemie), Kernforschungsanlage Jülich GmbH, D-5170 Jülich, FRG.

** GKSS Forschungszerntrum Geesthacht GmbH, Institut für Physik, 2054, Geesthacht, Pf. 1160, FRG.

INVESTIGATION OF THE $^{60}Ni(n,p)^{60}Co$ REACTION FOR 5.3-14.8 MeV NEUTRONS

S.Sudár, J. Csikai, S.M. Qaim*, G.Stöcklin*

Recent measurement [1] for the $^{60}Ni(n,p)^{60}Co$ reaction shows a significant deviation from the earlier data. The aim of this investigation is to check the excitation function of this reaction between 5 and 15 MeV neutron energy range.

The approximately monoenergetic neutrons 5.3-12 MeV were produced by bombarding D_2 gas target assembly with 3-9.5 MeV deuterons of the MGC cyclotron in Debrecen. The neutron fluences were measured by $^{238}U(n,f)$, $^{27}Al(n,\alpha)$, $^{58}Ni(n,p)$ and $^{56}Fe(n,p)^{56}Mn$ reactions. Corrections for neutron production in the window and beam stopper material and the D(d,np) reaction will be considered.

Neutrons in the 13.5-14.8 MeV energy range will be produced by a neutrongenerator using the D+T reaction.

The activity of the ^{60}Co isotope is measured by an intrisic Ge gamma-ray detector.

The excitation function of the $^{60}Ni(n,p)^{60}Co$ reaction will be calculated by the Hauser-Feshbach and the preequlibrium models. The results will be compared with those investigations which are in progress in Jülich.

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*Institut für Chemie 1 (Nuclearchemie), Kernforschungsanlage Jülich GmbH, D-5170 Jülich, FRG.

$^{10}B(n,t)$ CROSS-SECTION MEASUREMENTS AT 400 keV AND THERMAL NEUTRON ENERGIES USING DIFFERENT METHODS FOR TRITIUM DETERMINATION

F.Cserpák, S.Sudár
N.V.Kornilov*, A.V.Balitskij*, V.Ya.Baryba* and A.B.Kagalenko*

The $^{10}B(n,t)$ reaction cross-section below 2.5 MeV neutron energy is hardly known. Only a few experimental data are available and they are rather contradictory especially at thermal energy.
Measurements at 400 keV and thermal neutron energies as well as at 5 MeV for checking purposes have been done. Two different methods were used to determine the amount of tritium produced in this reaction:

1. beta-counting by a proportional counter after tritium extraction;
2. beta-counting by a boron-filled liquid scintillator.

In addition, the description of experimental techniques and data, error analysis, model calculations as well as comparison of experiments to theory are also planned in this work.

*Institute of Physics and Power Engineering, Obninsk, USSR.

ANALYSIS OF (n,t), (n,p) and (n,α) EXCITATION FUNCTIONS

K.Mihály*, J.Frank** and Z.T.Bődy

A systematic testing of the codes of SCAT2 (optical model code by O.Bersillon) and STAPRE (statistical-preequilibrium code of H.Uhl et.al) was carried out. These codes were taken for the implementation for PC (Triest ICTP Workshop Applied Nuclear Theory and Nuclear Model, Calculations).

After having corrected different mistakes (division by zero, mixing of global and local variables, missing and wrong input data, subscript out of range, etc.), the SCAT2 code has been transformed to C language, which resulted in 40% reduction in running time. Different tests of this improved SCAT2 code are under way by comparing the present results to former ones by calculating e.g. ^{115}In(n,2n), ^{56}Fe(n,p), ^{27}Al(n,t) cross-sections. The results of comparisons agree well with the excitation functions calculated by mainframe computer. The aim of the investigation is to determine a good theoretical model for calculation of (n,t) cross-sections on the basis of experimental data available up-to-date.

The method described in Ref.[1] is applied in our present work, which is a part of a joint programme of Obninsk, Dubna (USSR) and Debrecen (Hungary).

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* Institute of Nuclear Technics, Technical University, Budapest,

**Central Research Institute for Physics, Hungarian Academy of Sciences, Budapest.

MEASUREMENT AND THEORETICAL ANALYSIS OF THE GENERALIZED "FLUX ALBEDO"

A.Boufraqech*, J.Csikai, K.M.Dede,
A.Ait Haddou* and L.Szabados

The principle of the flux albedo and its measuring method for homogeneous media has been introduced by Amaldi and Fermi[1]. This method was generalized by Csikai[2] for two media of different neutron diffusion properties which is the most cammon case in the practice. The flux albedo has been determined for Al, Fe, Pb and paraffin reflectors. Spherical harmonics approximation was used for the interpretation of the experimental data. Measurements on matrices of geological samples are in progress to improve the neutron reflection method used for the determination of water content[3].

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*Permanent address: Université M^{ed} V., Faculté des Sciences, Rabat, Maroc.

MEASUREMENTS OF NEUTRON DIFFUSION PARAMETERS BY PULSED ALBEDO METHOD

A.Demény, K.M.Dede, J.Kuti-Darai and L.Vas

The neutron pulse reflection method developed for measuring neutron diffusion parameters of non-moderating media [1] is being modified into an arrangement allowing serial measurements on geological samples and structural materials. Taking into account the considerations on the evaluation of primary measured data[2,3] the moderator layer is modified from water to plexiglass assuring more reliable geometry, and one side reflectors are used (instead of two faces) for better statistics. Control measurements on iron and boron poisoned sands are in progress.

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DETERMINATION OF SPECTRUM AVERAGED REMOVAL CROSS SECTIONS

M.Váradi, J.Csikai and J.Kuti-Darai

The macroscopic removal cross-sections (Σ_R) of primary 14 MeV neutrons have been determined for different construction and shielding materials [1-4]. A method for the determination of the spectrum averaged removal cross sections based on a long-counter detector was also developed[5]. The analysis of analytical expressions to deduce the attenuation parameters in the case of various elements and compounds is in progress. Relations between the attenuation parameters and the microscopic neutron data for different geometrical arrangements are planned to study. On the basis of the measured average removal cross sections and relaxation lengths, the possible replacement of ironshot and heavy concrete shielding by combinations of natural minerals is intended to investigate. Results will be compared with the model calculations.

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DETERMINATION OF BULK OXYGEN CONCENTRATIONS IN HIGH T_c CERAMICS

Cs.M.Buczkó, T.Chimoye*, B.Jimba**, K.Usman**
and L.Desdin***

The recent developments in the production of different types of high T_c ceramics require the knowledge of the oxygen contents in the samples. The 14 MeV NAA is applied via the $^{16}O(n,p)^{16}N$ reaction for the measurement of oxygen by using a double pneumatic transfer system[1]. The high energy gammas from the ^{16}N produced in the samples and standards are detected by NaI scintillators. The dependence of the physical parameters on the oxygen concentrations[2] of various types of high T_c ceramics obtained in different technological phases will be investigated.

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Permanent address: *Faculty of Science and Technology, Thammasat University, Bangkok, Thailand. **Centre for Energy Research and Training, Ahmadu Bello University, Zaria, Nigeria. ***Centro de Estudios Aplicados al Resarrolló Nuclear, P.B. 6122. Habana, Cuba.

INSTITUTE OF NUCLEAR RESEARCH
OF
HUNGARIAN ACADEMY OF SCIENCES

STRUCTURE OF ^{116}Sb NUCLEUS

Z. Gácsi, Zs. Dombrádi, and T. Fényes
Institute of Nuclear Research of the Hungarian Academy
Of Sciences, H-4001 Debrecen, Hungary

V. Paar
Prirodoslovno-Matematicki Fakultet, University of Zagreb,
41000 Zagreb, Yugoslavia

The γ-ray and internal conversion electron spectra of the ^{113}In (α,nγ) ^{116}Sb reaction were measured at 14.5 and 16.0 MeV bombarding α-particle energies with Ge(HP) γ and superconducting magnetic lens plus Si(Li) electron spectrometers. The energies and relative intensities of 189 ^{116}Sb γ rays (including 117 new ones), as well as internal conversion coefficients of 59 ^{116}Sb transitions have been determined. $\gamma\gamma$-coincidences were also measured at E_α = 16 MeV. Both low-spin and high-spin level schemes have been deduced, which contain 61 (among them 32 new) levels. Multipolarities of transitions and γ-ray branching ratios have been determined. The level energy spectrum and electromagnetic properties were calculated on the basis of the interacting boson-fermion-fermion / odd-odd trancated quadrupole phonon model (IBFFM/OTQM) and satisfactory agreement was obtained between the experimental and theoretical results.

LEVEL SCHEME OF ^{116}Sb FROM (p,nγ) REACTION

Z. Gácsi, T. Fényes, and Zs. Dombrádi

Institute of Nuclear Research of the Hungarian Academy of Sciences, H-4001 Debrecen, Hungary

The γ-ray and internal conversion electron spectra of the ^{116}Sn(p,nγ)^{116}Sb reaction were measured at E_p = 6.3, 6.7, and 7.2 MeV bombarding energies with Ge(HP), Ge(HP, LEPS) γ and superconducting magnetic lens plus Si(Li) electron spectrometers. The energies and relative intensities of 90 ^{116}Sb γ rays, as well as internal conversion coefficients of 21 ^{116}Sb transitions were determined. Angular distribution data have been obtained for 37 γ rays. A more complete level scheme of ^{116}Sb has been deduced, which contains 38 levels below 1500 keV excitation energy. Multipolarities of transitions and γ-ray branching ratios have been deduced. Calculated Hauser-Feshbach (p,n) cross sections were compared with experimental values. Level spins and parities have been determined on the basis of Hauser-Feshbach analysis, internal conversion coefficients, and γ-ray angular distribution data. The energies of several ^{116}Sb proton-neutron multiplets were calculated using the parabolic rule. Members of different multiplets have been identified.

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TECHNICAL UNIVERSITY OF BUDAPEST

THE USE OF NUCLEAR DATA IN RADIATION DAMAGE CALCULATIONS FOR ASSESMENT OF THE SERVICE LIFE OF NPPS

E.J. SZONDI , E.M. ZSOLNAY

The Institute of Nuclear Technics of the Technical University of Budapest, in co-operation with the Netherlands Energy Research Foundation, Petten, has continued the works of the REAL-88 project of the IAEA Nuclear Data Section in the period 1989/90.

IAEA NDS has organized the REAL-80, REAL-84, AND REAL-88 interlaboratory exercises in order ot improve the quality of the results of radiation damage calculations for the service life assessment of nuclear facilities. The output of the exercises resulted in a neutron metrology file /NMF-90/ which will be available at the end of 1990 at IAEA NDS for distribution to interested laboratories.

The NMF-90 contains the following information in separate modules:
1. User's guide and help module
2. Reference data file for neutron spectrum adjustment and related radiation damage calculations
3. Relevant cross section libraries
4. Neutron spectrum adjustment code packages and utility programs.

Two cross section libraries, IRDF-85 and IRDF-90, are given in the NMF-90.

The International Reactor Dosimetry File IRDF-85, Version 2 contains the cross sections and their uncertainty information to be used in the calculations on the reference spectra for testing the user's practice. The library has the ENDF-5 format.

The International Reactor Dosimetry File IRDF-90 is partly based on the ENDF/B-VI data and it contains improved information extended with several dosimetry reactions as compared with the IRDF-85. This library is written in the ENDF-6 format. The IRDF-90 has not yet been widely tested by neutron metrology calculations. The first calculations were carried out in the Spring 1990, and they show important differences between the IRDF-85 and IRDF-90. The validation /consistency check/ of the new library using the benchmark data of the NMF-90 will be finished in 199o only.

The new cross section library processing program X333 calculates weighted, group averaged, self-shielded cross sections and their relative covariance matrix in the user's energy grid, starting from the files No. 3 and No. 33 of the ENDF-5 or ENDF-6 format data sets. It calculates the damage and gas production cross sections as well. The output of the cross section codes can directly be used by neutron spectrum adjustment codes and utility programs.

ANALYSYS OF (n,t) , (n,p) and (n,α) EXCITATION FUNCTIONS

K.Mihály ♥, J.Frank ♣ and Z.T.Bödy ♦

A systematic testing of the codes of SCAT2 (optical model code by O.Bersillon) and STAPRE (statistical-preequilibrium code of H.Uhl et.al) was carried out. These codes were taken for the implementation for PC (Triest ICTP Workshop Applied Nuclear Theory and Nuclear Model, Calculations).

After having corrected different mistakes (division by zero, mixing of global and local variables, missing and wrong input data, subscript out of range, etc.), the SCAT2 code has been transformed to C language, which resulted in 40% reduction in running time. Different tests of this improved SCAT2 code are under way by comparing the present results to former ones by calculating e.g. 115-In (n,2n), 56-Fe (n,p), 27-Al (n,t) cross-sections. The results of comparisons agree well with the excitation functions calculated by mainframe computer. The aim of the investigation is to determine a good theoretical model for calculation of (n,t) cross-sections on the basis of experimental data available up-to-date.

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[1] A.V.Ignatyuk, K.Mihály, O.T.Grudzevich and Z.T.Bödy, An analysis of the 27-Al (n,t) 25-Mg excitation function, Rep.INDC(HUN)-025/L,Vienna,1988.

♥ Institute of Nuclear Technics, Technical University, Budapest.
♣ Central Research Institute for Physics, Hungarian Academy of Sciences, Budapest.
♦ Institute of Experimental Physics, Kossuth University, Debrecen.