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Some of the Nuclear Data Research Projects Conducted by Soviet Scientists

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SOME OF THE NUCLEAR DATA RESEARCH PROJECTS CONDUCTED BY SOVIET SCIENTISTS

B.D. Kuz'minov and G.B. Yan'kov

(This paper is a review of the nuclear data research by Soviet scientists published over the period 1977 - July 1978)

A conference of experts from the Member States of CMEA (Council for Mutual Economic Assistance) for evaluation of nuclear data on the structure of the nucleus and nuclear reactions with charged particles was held in Moscow at the I.V. Kurchatov Atomic Energy Institute from 16 to 19 May. Those present included delegations of experts from Bulgaria, Hungary, the German Democratic Republic, Poland, USSR, Czechoslovakia and the Joint Nuclear Research Institute (Dubna).

The following subjects were considered at the conference:

- The collection, evaluation and dissemination of non-neutron nuclear data;
- The requirement for non-neutron nuclear data;
- Bibliographic services for evaluation work;
- Cross-section data for nuclear reactions with charged particles and photons;
- Data on the structure of nuclei and their radioactive transformations;
- Evaluation techniques;
- Some nuclear and atomic data.

Fifteen papers were presented at the conference.

Some of them are summarized in brief below.

A paper presented by the Data Centre of the USSR State Committee on the Utilization of Atomic Energy (Director of Centre - F.E. Chukreev) described the use of international exchange formats by the Centre [1]. Consideration was given to the formats of the international Evaluated Nuclear Structure Data File, the Generalized EXFOR and the Bibliographic File. Those attending the conference were informed of the centres taking part in the compilation and exchange of nuclear data in the EXFOR system, and a brief description of the data contained in the EXFOR dictionaries was given, together with an example of the coding of a publication into an edited format, plus a number of explanations with regard to the bibliographic file.

On the basis of an analysis of modern experimental data, G.M. Zhuravleva and co-workers [2] described evaluations of radioactive decay constants for the mass chain A = 242. Evaluations, energies and intensities of beta and gamma transitions have been obtained and the structure of levels, together with the radioactive properties with respect to alpha decay of isotopes of the elements with mass 246, which are the "parents" of the mass cahin A = 242, has been considered. There are considerable differences with regard to measurement data on the half-lives of plutonium-242 and californium-246. Analysis of the data has made it possible to co-ordinate the experimental data and obtain evaluated data. The results of the evaluation have been transmitted for incorporation into the international Evaluated Nuclear Structure Data File (ENSDF).

On the basis of bibliographical sources an evaluation has been made [3] of data on the structure of lithium-9, beryllium-9, boron-9 and carbon-9 nuclei. The following nuclear characteristics have been obtained: mass defects, neutron and proton binding energy, alpha particles, electron and positron decay energy, level energies for nuclei with A = 9 and their spin characteristic, parity, level width, data on the ways of level decay and data on the gamma decay of states. Evaluated data on the structure of nuclei in the A = 9 mass chain have been recorded on magnetic tape and a program has been developed in FORTRAN for handling them.

The paper by Yu.V. Medvedev and co-workers [4] gives a brief outline of the problems of working out standard nuclear data on cross-sections for interactions between neutrons and elements making up the atmosphere and earth's crust which are essential for users in the fields of health physics, nuclear geophysics, dosimetry, biophysics, neutron radiation metrology, and similar subjects.

The paper presented by the Leningrad Nuclear Physics Institute (LIYF) Data Centre (USSR Academy of Sciences) reported on work that had been done; in particular, the Centre has been working on the compilation of an evaluated data file on the structure of nuclei from radioactive decay and nuclear reactions for the nuclear chain with A = 134. These data have been recorded on magnetic tape in the ENDF format. This format has also been used in a program for expansion of a three-dimensional matrix of gamma/gamma coincidences [5] for the input of data on the decay scheme for excited states of the investigated nucleus. A reference list of nuclear moments has been published as an LIYF preprint [6]. The LIYF Data Centre Bulletin has published tables of experimental and theoretical rotational band energies for uneven-uneven and even-even nuclei [7].

It follows from these reports that the priority requirements are as follows:

1. Data on the structure of the nucleus and radioactive decay;

2. Data on nuclear reactions with charged particles over a broad range of targets and bombarding nuclei, and also their energies;

3. Atomic data on interactions between charged particles and matter as well as between nuclei and their atomic shells, required in nuclear research and in the application of nuclear-physical techniques to other scientific disciplines.

To increase the energy and types of accelerated ions with the possibility of regulating the energy over a broad range and improving the parameters of ion beams, the 1.5 m cyclotron at the I.V. Kurchatov Atomic Energy Institute has been reconstructed and made isochronic. It accelerates ions of all the basic stable isotopes from hydrogen to neon, for example, alpha particles up to 60 MeV, three-charge lithium-6 ions up to 90 MeV, and six-charge oxygen ions up to 130 MeV. The mean currents (in microamps) of the external beam are as follows: ${}^{6}Li^{3+}$-2, ${}^{7}Li^{3+}$-2, ${}^{9}Be^{3+}$-2, ${}^{12}C^{4+}$-30, ${}^{14}N^{5+}$-13, ${}^{16}O^{6+}$-1.

On the basis of the LIYF synchrocyclotron and mass separator a system has been set in operation for studying the alpha spectra of rare-earth isotopes on line [19]. The proton beam of the accelerator, which has an energy of 1 GeV, is directed on to a target placed together with the ion source of the mass separator - this makes it possible to maintain the target at a high working temperature (3×10^{3}°K) and to ensure high efficiency together with fast action. In this way it is possible to obtain an optimum on-line yield of the products under study for a small mass of target material (1-3 g). Used together with silicon detectors, the system can measure activities with a half-life of up to 0.1 sec. Studies of the alpha spectra of isotopes with masses ranging from A = 151 to A = 157 and at a distance from the beta stability band have been made.

The cyclotron belonging to the Physico-Technical Institute of the USSR Academy of Sciences has been used [10] to obtain stable acceleration conditions and ion beam extraction over a broad range of masses (p, α, ^{12}C, ^{14}C, ^{16}O) with an intensity of 1 microamp in the energy range of 0.1 ± 0.5 MeV. These beams are being used increasingly for many purposes, especially for ion alloying to alter the properties of semiconductors with a complex structure, or for intensive ionization of atomic shells of interest for astrophysical research and for thermonuclear fusion studies.

Techniques involving the growth of monocrystals from the vapour phase, from a melt solution and from a stoichiometric melt by means of vertical zonal fusion [11] have been used to produce semi-insulating cadmium telluride. The initial material is compensated by the B, A, I and C donors. A procedure has been developed for manufacturing gamma detectors using this semiconductor as a base. Material alloyed with chlorine has been used to manufacture spectrometric detectors with a sensitive area of 2 cm^2. The best resolving power has been obtained in the case of detectors with a C.Te.A base and constitutes 6 keV for E = 60 keV.

Mössbauer spectroscopy with ^{57}Fe nuclei has been used to study [12] the effect of the thickness of a sample on ordering and direct martensitic transformation in ferro-nickel alloys of different compositions (36, 30.3 and 29.5% nickel). The thickness of the specimens varied from 3 to 30 μm. The Mössbauer spectra provided a means of determining the temperature dependence of the amount of martensite formed when the specimen is cooled.

A magnetic alpha spectrograph and semiconductor gamma detectors have been used to study [13] alpha and gamma radiation occurring in the process $^{236}U \xrightarrow{\alpha} {}^{232}Th$; a uranium sample highly enriched in the isotope of mass number 236 ($T_{\frac{1}{2}\alpha}$= 2.34 x 10^7 years) was used. The alpha particle energies, their intensities, the energy levels of the daughter nucleus and the quantum characteristics of these levels, and also the gamma line energies were given.

An attempt has been made [14] to detect the hypothetical superdense nuclei with higher binding energy in the core of the pulsed fast reactor at JINR (Joint Institute for Nuclear Research) by observation of the gamma quanta and neutrons with abnormally high energy escaping from it. By the use of scintillation detectors placed in the reactor beam it has been found that the

30-100 MeV gamma and 40-200 MeV neutron yields do not exceed 3×10^{-8} and 9×10^{-7} per fission event, respectively. It has also been demonstrated, by using the reaction (n,γ) in superdense nuclei as an indicator of their presence in a neutron-irradiated substance, that the atomic concentrations of these nuclei in the water moderator, tungsten reflector and fissile reactor material are less than 2×10^{-12}, 2×10^{-8} and 5×10^{-7}, respectively.

An alalysis has been made [15] of the interference effects in the reaction "B$(p,3\alpha)$, namely two-dimensional energy distributions of alpha particles for proton energies of 2.0-4.0 MeV have been analysed by means of the P-matrix theory. A selection of optimum contributions to the reaction cross-section by various orbital moments in the alpha particle-beryllium-8 nucleus system has been made.

A study has been made [16] of P uneven symmetry during fission of uranium-233 induced by polarized thermal neutrons. The asymmetry is equal to $\alpha(^{234}U) = (2.8 \pm 0.3) \times 10^{-4}$. The positive sign of the asymmetry means that the light fragment moves predominantly in the direction of spin of the captured neutron.

Absolute measurements have been made [17] of the cross-sections for fission of ^{233}U, ^{235}U, ^{238}U and ^{239}Pu induced by neutrons from the fission spectrum of ^{252}Ca, and by 14.8 MeV neutrons. The following fission cross-section values have been found in the case of uranium-235: 1266 ± 19 (in the californium spectrum) and 2187 ± 37 mbarn (at 14.8 MeV).

In their paper [18] A.N. Davletshin and V.A. Tolstikov analyse all the stages of the measurement of fast mono-energetic neutron fluxes with proportional recoil proton counters, and suggest a programme of studies for further improving the reliability and accuracy of fast neutron measurements by using hydrogen gas counters. Their work is published in the collection of articles entitled "Problems of atomic science and engineering", Nuclear Constant Series, <u>24</u> (1977) 37. Analyses and evaluations have been made for measurements of 100 radionuclides (ranging from tritium to californium) used in the national economy. An evaluation of approximately 20 characteristics and their errors is given for each nuclide [19].

Absolute measurements have been made [20] of neptunium fission cross-sections induced by fission spectrum neutrons for californium-252. The following cross-section value has been obtained: 1442 ± 23 for $T_{\frac{1}{2}}(^{237}Np) = (2.14 \pm 0.01) \times 10^{6}$ y.

The energy spectrum of spontaneous fission neutrons for californium-252 has been studied [21] by the time-of-flight method, using two neutron detector crystals ^{6}LiI(Eu) and a fast ionization chamber with uranium-235 layers. With the first detector the spectrum was studied over an energy range 15 keV-2 MeV; the experimental points lie along a Maxwellian curve with the parameter T = 1.38 with a spread of 5-7%; for ^{6}Li(n,α)T the authors of Ref. [21] used evaluated data from the ENDF/B file. With the second detector, the measurement interval was 10 keV-7 MeV, and $T = 1.41 \pm 0.03$ MeV. The evaluated fission cross-sections for uranium-235 obtained by V.A. Kon'shin's group were used for processing the experimental data.

On the basis of multidimensional measurements of the mean number of neutrons emitted by fragments with a fixed mass and total kinetic energy, the authors of Ref. [22] discuss the features of neutron emission from separate spontaneous fission fragments for californium-252.

Tables which have been compiled [23] for the nuclear physics characteristics of gamma-emitting isotopes provide a means, when used in conjunction with gamma spectroscopic methods, of making operative studies of the composition and activity levels of process materials used in various sections of the nuclear-energy facilities at nuclear power stations.

Research is now being conducted with the 680 MeV accelerator at the Nuclear Problems Laboratory (JINR) in order to set up a medico-biological unit with two treatment rooms for proton therapy and one room for π-meson therapy [24]. The therapeutic proton rays are obtained by slowing down the beam of protons coming from the accelerator at an initial energy of 700 MeV and current of up to 50 μA to a final energy of 200 MeV, which makes it possible to shape the beam, in two therapy rooms, using a modified Bragg curve with a flat top stretching 5-6 g/cm^2 in soft tissue and with a sharp cut-off. The Bragg curve maximum ensures a dose rate of about 100 rad/min for an irradiation area with a diameter of up to 6 cm. The negative π-meson beam has the following parameters: up to 80 MeV energy, beam intensity of $1.5 \times 10^{+9} s^{-1}$, mean flux density of 2×10^7 cm^{-2}, and a dose rate at the maximum dose distribution of up to 100 rad/min.

Preparations containing platinum are being successfully used for the chemical treatment of cancer. The joint research conducted by the

Kurchatov Atomic Energy Institute and the Oncological Centre of the USSR Academy of Medical Sciences includes an activation analysis study [25] of the pharmacokinetics of platinum in laboratory animals. Experimental data have been obtained for several platinum-containing preparations.

Scientific research work carried out at the Kurchatov Institute on problems of safety in connection with the growth of nuclear power production is proceeding in two basic directions:

- Ecological problems of nuclear power;
- Engineering problems of IAEA safeguards.

Work on the first of these themes includes a study of the effect on the environment of nuclear fuel cycle plants on a local, regional and global scale, taking into account the anticipated development of power engineering and the quest for economically and technologically acceptable solutions designed to reduce this effect. The work is intended to ensure an optimum level of safety at nuclear power plants for human beings and the environment, both during normal operation and in the event of possible accidents [26, 27].

Ways are being studied [27, 28] to arrive at an optimum solution to the problem of radioactive waste disposal, including possible utilization, transmutation and economically effective isolation by burial in geological formations.

The second line of research includes a study of engineering problems entailed in applying Agency safeguards at water cooled and moderated reactor fuel cycle plants [29]. These studies [29] are aimed at ensuring non-proliferation of nuclear weapons in the export of nuclear technology.

In both types of research a number of nuclear constants [27, 29] associated with the reactor core are of importance. These are essential for calculating the isotopic composition of nuclear fuel, which is vital from both the ecological and the safeguards point of view.

The final results of measurements of fission cross-section ratios for ^{233}U and ^{241}Pu relative to ^{235}U [30] have been obtained. The measurements relate to the energy range 0.024-7.4 MeV at varying intervals from 20 keV in the lower energy region to 200 keV in the upper region. The error in the relative measurements is 1.3-2.2%, and the fragment detectors are ionization chambers and glasses. The acceleration conditions are constant. For the

^{233}U and ^{235}U cross-section ratios good agreement has been attained with the results of work by Pfletschinger and Gwin. The results obtained by Meadows, Lamphere and Lehto are 3-5% higher. Those obtained by White, Allen and Smith are systematically lower than those of the work in question. For the ^{241}Pu and ^{235}U fission cross-section ratio we observe, on the whole, agreement with the results obtained by Keppler, although there are differences in some of the energy areas. The spread of the data in work by other investigators in many cases exceeds the specified measurement errors.

Additional measurements of the fission cross-section ratios for ^{238}U and ^{235}U have been made and summary results have been obtained in the 1-7 MeV neutron energy range at intervals of 100-200 keV [31]. The older data reported by investigators in the energy range higher than 5.4 MeV have proved erroneous. The evaluated errors in measurement are 0.5-2%.

An electrostatic accelerator has been used for making measurements of the cross-sections for 0.3-1.8 MeV neutron-induced fission of ^{244}Pu relative to the ^{239}Pu fission cross-section [32]. The dependence of the cross-section on energy is the threshold type. The fission threshold is 0.75 MeV. On the plateau the cross-section is 1.1 barn which is considerably higher than what might be expected from the systematics based on consideration of the Z and A of the fissile nuclei. The cross-section does not show any noticeable irregularities close to the threshold.

Measurements have been made of the fission cross-section for ^{235}U and ^{239}Pu, the fission being induced by neutrons with energies of 2, 24, 55 and 144 keV [33]. Neutron beams with the above-mentioned energies were obtained using scandium, iron and silicon filters, as well as additional filters made of aluminium, boron, sulphur and titanium. The measurements were made with respect to the fission cross-section at a neutron energy of 0.0253 eV. Thermal and fast neutron flux ratios were determined from the reaction $^{10}B(n,\alpha)^{7}Li$. The results of the measurements are shown below in the table.

The VVR-M reactor at the Nuclear Research Institute of the Ukrainian Academy of Sciences has been used in conjunction with a neutron time-of-flight spectrometer [34] to study the neutron resonances of the radioactive isotope ^{125g}Eu ($T_{\frac{1}{2}}$ = 12.4 years). More than 20 resonances have been discovered, 12 of which can be satisfactorily described by the Breit-Wigner single-level formula. The radiation width varies from one resonance to another over a range of 80–270 MeV. The mean radiation width of the isotope ^{152g}Eu is considerably higher than for the isotopes ^{151}Eu and ^{153}Eu, being equal to 160 ± 25 MeV. The mean observed distance between levels D_{obs} = 0.25 ± 0.04 eV; S_o is a strength function equal to (3.6 ± 1.2) x 10^{-4}.

TABLE

E_n (keV)	σ_f (^{235}U), barns	σ_f (^{239}Pu), barns
2	6.69 ± 0.13	3.97 ± 0.08
24	2.26 ± 0.05	1.73 ± 0.04
55	1.92 ± 0.04	1.58 ± 0.03
144	1.49 ± 0.03	1.50 ± 0.03

An LNF neutron spectrometer at JINR (Dubna) with a resolution between 11 and 3.5 nsec/m has been used for making measurements of the gamma yield from neutron capture and transmission for several samples of ^{159}Tb [35]. The parameters of the neutron resonances in the region up to 580 eV have been determined, and the mean distance between the resonances D = 4.4 ± 0.4 eV, together with the strength function S^o = (1.25 ± 0.18) x 10^{-4} have been derived.

The SM-2 reactor neutron beam has been used in conjunction with a selector with a rotor on a magnetic suspension to measure total neutron cross-sections and to determine the parameters of resonances in the neutron energy region from thermal neutrons to 3 eV for ^{230}Th, up to 1 keV for ^{226}Ra [36], up to 200 eV for $^{175, 176}$Lu [37], and in the energy region 1-30 eV for ^{245}Cm [38].

Measurements of resonance parameters in the energy region up to 400 eV for ^{133}Cs and up to 170 eV for ^{134}Cs [39] have been made by using the transmission method with the SM-2 reactor beam together with a selector.

Measurements have been made of the thermal cross-sections and resonance integrals for radiative neutron capture by $^{244-248}$Cm and ^{250}Cf nuclei [40]. The cross-sections were determined from the filling of the daughter elements during irradiation of samples in the SM-2 reactor channel. The results are shown below:

TABLE

Element	Mass number	(barns) = 2200 m/sec	Resonance integral
Cm	244	15.2 ± 1.2	626 ± 53
	245	350 ± 18	108 ± 81
	246	114 ± 0.3	118 ± 15
	247	60	490
	248	10.7 ± 1.5	250 ± 24
Cf	250	1800	5000

The final results of measurements of capture and fission cross-section ratios for ^{239}Pu in the 0.1-30 keV energy range, which were obtained by a team from the ITEF (Theoretical and Experimental Physics Institute) using the IBR-30 (JINR) reactor spectrometer, have been published. The mean measurement error for the entire energy range is about 15% [41].

F.N. Belyaev and co-workers have studied grouping in the distribution of distances between levels [42]. They have made a statistical analysis of the random occurrence of these features, and it has been demonstrated that the probability of random occurrence of groupings is found at the level 10^{-2}-10^{-3} for the individual nucleus.

A number of research projects relating to the spectrometry of fast neutrons and elucidation of the mechanism by which nuclei emit neutrons has been completed.

On the basis of the exciton model, which takes into account pre-equilibrium nuclear decay, expressions have been derived for the energy and angular distributions of particles originating from two-particle and three-particle nuclear reactions [43]. The hypotheses leading to symmetry and asymmetry of the angular distributions are being examined.

Measurements have been made of the spectra and angular distributions of neutrons emitted during the reaction $^{109}Ag(p,n)^{109}Cd$ [44]. The measurements were carried out by the time-of-flight method at proton energies E_p = 6 and 7 MeV. The spectra and angular distributions of neutrons in the reactions $^{181}Ta(p,n)^{181}W$ and $^{181}Ta(n,n')$ have been studied [45]. It has been demonstrated that in the case of the reaction (p,n) the hard part of the spectrum attributed to non-equilibrium processes is considerably suppressed. This fact is evidence that the present models of pre-equilibrium processes are untenable and is interpreted as a manifestation of direct processes.

The double differential scattering cross-section for 9.1 ± 0.2 MeV neutrons for ^{7}Li nuclei have been measured [46]. Spectra and angular distributions have been obtained for scattered neutrons (for five angles). The measurement technique is based on the time-of-flight. The neutrons were obtained with the FEI (Physics and Energetics Institute) cyclotron, using an interruption system.

The time-of-flight method has been used to measure differential elastic and inelastic scattering cross-sections for neutrons with excitation of the first two or three levels by the even isotopes $^{50, 52, 54}Cr$ and $^{64, 66, 68}Zn$ at neutron energies of 1.5, 2.0, 2.5 and 3.0 MeV [47, 48].

The same method has been used to measure the mean energies of neutron spectra for thermal neutron-induced fission of ^{233}U, ^{235}U and ^{239}Pu [49]. The measurements were made with respect to the spontaneous fission neutron spectrum of ^{252}Cf. The interval between the measured energies of the secondary neutrons was 0.6–10 MeV. The fission fragments were recorded by a gas scintillator. The neutron detector used was a plastic scintillator 170 mm in diameter and 50 mm high. The recording threshold was 0.4 MeV and the following mean neutron energies were obtained over the 0.6–8 MeV range: $\bar{E} = 1.996 \pm 0.040$ (^{233}U), 1.926 ± 0.030 (^{235}U) and 2.050 ± 0.040 (^{239}Pu).

Measurements have been made of the energy spectra of neutrons forming during the irradiation of thick targets made of Be, C, Al, Mo, Pb, Ni, Cu and Ta by deuterons with 13 MeV energy. The accelerated deuteron beam was obtained with the cyclotron belonging to the ITI (Institute of Theoretical Research) of the Ukrainian Academy of Sciences [50].

Measurements have been made of the reactions (n,p), (n,α), their systematics analysed and compilations made of data relating to them.

The (N–Z) dependence of the (n,p) reaction cross-sections for a neutron energy of ~5 MeV [51] has been analysed and supporting evidence for it has been found. On the basis of conventional statistical relationships for nuclear reaction cross-sections and the Weizsäcker equation for the binding energy of the nucleus, a simple relationship between the cross-section for the reaction (n,p) and the number of protons and neutrons in the nucleus has been derived. It has been demonstrated that the (N-Z) dependence is a corollary of the exponential dependence of the (n,p) reaction cross-sections on the proton binding energy in the nucleus. The relationships derived for the (n,p) reaction can be extended to cover other reactions, i.e. (n,α), (n,t) and (n,2n). The results of this research are recommended for use in the evaluation of nuclear data.

An empirical relationship has been derived for the computation of the maximum cross-section for the reaction (n,p) as a function of the parameter (N-Z + 1)/A [52]. Comparison with experimental data shows that the theoretical values are fairly close to the measured ones. Deviations range between 5 and 30%.

V.T. Shchebolev and co-workers have determined (n,p) and (n,α) reaction cross-sections for ^{28}Si, ^{29}Si and ^{30}Si for 14.8 MeV neutrons [53]. The isotopic composition of the sample was determined with a mass spectrometer. The reaction cross-section was determined from the induced activity of samples placed in a neutron flux of known density (~ 1%). The measurement data are shown in the table below:

Reaction	^{28}Si(n,p)	^{29}Si(n,p)	^{30}Si(n,α)
Cross-section (b)	269.4 $\pm$ 6.3	98.5 $\pm$ 23.0	90.7 $\pm$ 28.2

Melent'ev et al. have measured the cross-sections for the reaction ^{27}Al(n,p)^{27}Mg by activating aluminium in a 14.9 MeV neutron flux and recording the induced activity by means of an NaI(Tl) detector [54]. The measurements were carried out with respect to the cross-section for the reaction ^{27}Al(n,α). The value obtained was $\sigma_{(n,p)} = 71 \pm 5$ mb.

Measurements of the reaction cross-section for ^{56}Fe(n,p) for 14.8 MeV neutrons have been made by Ramendyuk et al. [55]. The flux was determined by the associated particle method (n-α coincidences) and from scattering by hydrogen. The activity of the foils was measured in a β-α coincidence device, in a counter and in a scintillation gamma spectrometer. The following cross-section for reaction $^{56}Fe(n,p)^{56}Mn$ for 14.8 MeV neutrons was obtained: $\sigma = 110.9 \pm 1.7$ mbarn.

Cross-sections of the $^{28}Si(n,\alpha)$ and $^{29}Si(n,\alpha)$ reactions have been determined for 14.1 MeV neutrons for transitions to the ground and excited states of the residual nucleus [56]. The alpha particle energies were measured with a silicon semiconductor detector. The detector mass contained in the sensitive region acted at the same time as the target. The resulting data are shown in the following table:

Reaction	Cross-section (mb)				
	α_0	α_1	α_2	α_3	α_4
$^{28}Si(n,\alpha)^{25}Mg$	14.3 ± 0.7	6.6 ± 0.3	9.0 ± 0.5	12 ± 1	13.8 ± 0.7
$^{29}Si(n,\alpha)^{26}Mg$	2.4 ± 0.3	7.3 ± 0.9			

V.G. Vorob'eva and co-workers have analysed experimental data on the mean kinetic energies of fragments [57]. The numerical data are referred to a single standard. In the first part the investigators analyse the existing experimental data on the mean kinetic energies of fragments for a fixed nucleon composition and fissile nucleus excitation energy. Reference values are selected and their error evaluated. In the second part they analyse the experimental data obtained in fission reactions permitting preliminary emission of nucleons. Compilation and evaluation work on the reactions (n,α), (n,p) and $(n,2n)$ for $Z > 20$ [58] is in progress.

Under an agreement with the IAEA the evaluation of nuclear data for ^{241}Am is in progress at the Institute of Heat and Mass Transfer in Minsk [58]. Evaluation of nuclear data for ^{242}Pu has been completed [58], and nuclear data evaluations for ^{240}Pu and ^{241}Pu (1977) have been completed and sent to the IAEA. A large number of measurements and evaluations completed in 1977 are presented in the papers of the Fourth All-Union Conference on Neutron Physics held in Kiev from 18 to 22 April 1977 [59].

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