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## PROGRESS REPORT

## HUNGARY

1974

#### PROGRESS REPORT

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### HUNGARY

### 1974

### Compiled by

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## CENTRAL RESEARCH INSTITUTE FOR PHYSICS OF THE HUNGARIAN ACADEMY OF SCIENCES

Budapest

#### EXPERIMENTATION FACILITIES OF THE NUCLEAR PHYSICS DEPARTMENT

1. / Van de Graaff-accelerator with the following parameters:

energy range: 0,8 - 5,0 MeV accelerated ions:  $H^+$ ,  $D^+$ ,  ${}^{4}He^+$ long-time energy stability:  $\Delta E/E = 2 \times 10^{-4}$  FWHM short-time energy stability:  $\Delta E/E = 1,2 \times 10^{-4}$  FWHM target places: 3 max. target current: 5  $\mu$ A working time: 4000 hours/year type: EG-2R /home made/

2./ Neutron-generator

max. voltage: 200 kV working voltage: 150-180 kV accelerated ions:  $H^+$ ,  $D^+$ max. ion current: 500  $\mu$ A neutronflux: 3 x 10<sup>9</sup> n/cm<sup>2</sup>.s /1 cm distance from the target at 10  $\mu$ A deuteron current/ target places: 2 working time: 2500 hours/year type: NG-200 /home made/

3./ A fast-slow coincidence unit for positron annihilation lifetime measurements with time resolution 0,6 ns /PAN/

4./ A setup for positron annihilation angular correlation measurements /PANNI/

5./ A fast-slow coincidence unit for the investigation of nuclear fission /gas-scintillation chambers, vacuum-system, etc./

6./ An automatically controlled three-detector system with fast-slow coincidence circuits for the differential and integral perturbed angular correlation /PAC/ measurements

7./ Three-axis goniometer for channeling and back-scattering experiments.

8./ 2 small computers /developed by the electronic department of CRIP/ with memory capacity 4k and 8k respectively /type TPA-1001/ for on-line measurements and for preliminary data analysis

9./ 4096-channel analyser with matrix analog-digital 'converter

10./ 1024-channel analysers /NTA-512 B/

11./ 512-channel analysers /NTA-512 A/

12./ 2 Mössbauer-spectrometers, cryostats and furnaces

13./ Ge/Li/ semiconductor detectors  $/4 \text{ cm}^3 - 80 \text{ cm}^3/$ 

14./ Ge/Li/ X-ray detector /Ne-5290/

15./ Multiwire proportional chambers.

KINEMATICALLY COMPLETE MEASUREMENT ON THE REACTION  ${}^{2}H/n,np/$  at  $\vartheta_{n}=0^{\circ}$ .

T. Czibók, J. Kecskeméti

Report KFKI-73-59 Phys. Rev. Letters, <u>32</u>, **1**063 (1974)

The differential cross section of the reaction  ${}^{2}$ H/n,np/ was measured in terms of the energy of the forward going neutron  $/\vartheta_{n} = 0^{\circ}$ / and of the proton detected in  $4\pi$  solid angle. Because of the applied special geometry the experimental data extend over a large fraction of the phase space, including several final-state interaction regions as well as regions far from the dominance of the quasi-two-body processes. This offers the possibility of extracting neutron-neutron scattering parameters and obtaining simultaneously additional information on the N-N potentials and three-body forces in the frame of an exact three-body calculation.

ON THE RECOMMENDED VALUES OF (n,2n) CROSS SECTIONS

L. Jeki

Report KFKI-73-68 (1973)

The cross section data of /n,2n/ reactions predicted by different empirical formulae are compared with each other and with the experimental data. The predictions from the Adám-Jéki formula with refitted parameters show an improved agreement with the measured cross section values. ISOBARIC ANALOGUE STATES IN THE 1f7/2 - 2p3/2 SHELL

I. Fodor, I. Szentpétery, J. Szüce

The investigation of gamma spectra of analogue resonances in /p, gamma/ reactions are extended to the odd-even target nuclei. Measurement on  $^{63}$ Cu is going on.

Higher-lying analogue states were investigated as well. A detailed study were performed on  ${}^{58}$ Ni/p,gamma/ ${}^{59}$ Cu,  ${}^{58}$ Ni/p,p/ ${}^{58}$ Ni reactions looking for d<sub>5/2</sub> analogue states.

TEMPERATURE SPIKE EFFECT FOLLOWED COULOMB-EXCITATION OF <sup>56</sup>Fe NUCLEI

I. Demeter, Z. Szőkefalvi-Nagy, L. Varga

According to the theoretical expectations, the recoil energy of the Coulomb-excited nuclei may cause a large increase in temperature in the neighbourhood of the path of slowing down. There are some indications from Mössbauer experiments, that a strong movement exists at the moment of deexcitation of the short-living nuclear states produced by Coulomb-excitation.

To get some idea about the order of magnitude and time evolution of the temperature the 847 keV energy level of <sup>56</sup>Fe was Coulomb-excited with protons of 2.5 MeV energy. In the experiment a thick iron target polarized with external magnetic field was used. The  $\omega \tau_{PADCE}$  precession of the excited state has been determined to be 6.5 ± 0.6 mrad. From comparison of this value with the static one measured by radioactive source we can get information on the time period during which the temperature spike deteriorates the perturbation caused by the ferromagnetic environment. The present value of  $\omega \tau_{static}$  is 8.4 ± 1.6 mrad. The big statistical error prevent us to draw strict conclusions. The improvement of the accuracy of  $\omega \tau_{static}$  is in progress.

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#### COULOMB-EXCITATION OF Cd ISOTOPES

#### I. Demeter, J. Sziklai, Z. Szőkefalvi-Nagy, L. Varga

To check the old experimental data of McGowan and Stelson, we started to measure the B/E2/ reduced transition probabilities in <sup>111,113</sup>Cd isotopes using Ge/Li/ detectors instead of scintillation counters. The preliminary data show, that the mixing parameter of the  $\frac{3}{2} + \frac{1}{2}$  transition of 298 keV energy in the <sup>113</sup>Cd nucleus probably has to be changed. Our other results are in agreement with the earlier data.

### g-FACTOR MEASUREMENT OF EXCITED STATES IN 197 Au NUCLEI

#### I. Demeter, Z. Szőkefalvi-Nagy, J. Vita\*, L. Varga

The measurement of g-factors of the 279 and 548 keV states in  $^{197}$ Au has been started. These short-living excited states with spins  $5/2^+$  and  $7/2^+$ , respectively, are Coulomb-excited by  $^{16}$ O ions of 42 MeV. The backscattered bombarding particles are detected by a ring counter. The perturbed angular distribution of gamma rays emitted by atoms repelled from the thin Au layer, evaporated onto the iron backing polarised till saturation are detected with scintillation counters in coincidence with backscattered  $^{16}$ O ions. This measurement is performed at the Tandem accelerator of the Institute of Atomic Physics in Bucharest.

Institute of Atomic Physics, Bucharest

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#### STUDIES OF T=2 LEVELS IN MASS -36 NUCLEI

#### J. Szücs\* and D.J. Martin

The lowest T=2 level in  ${}^{36}$ Ar has been found in /p,t/ reaction at 10858 <u>+</u> 35 keV excitation energy. This O<sup>+</sup>, T=2 level is expected to decay through 1<sup>+</sup>, T=1 levels which are analogues of low-lying states in  ${}^{36}$ Cl and which has not been identified yet. A search was performed to locate this T=2 level as a resonance in  ${}^{35}$ Cl/p,gamma/ ${}^{36}$ Ar and  ${}^{32}$ S/alfa, gamma/ ${}^{36}$ Ar reactions. Although in the relevant energy region several resonances were found until now none of them was identified with certainty to be the O<sup>+</sup>, T=2 state.

Since the T=2 in  ${}^{36}$ Ar is expected to decay the same way as the T=2 state in  ${}^{36}$ Cl /which is its parent state/ we have investigated the gamma--decay of this level. It was populated by / ${}^{3}$ He,p/ reaction at  $E_{3He} = 13$  MeV. The level at 4295  $\pm$  2 keV 0<sup>+</sup>, 2 was found to decay to two levels at 1160 keV /1/<sup>+</sup>, 1 and 1601 keV /1/<sup>+</sup>, 1 with branching ratios /49  $\pm$  3/% and /51 $\pm$ 3/%, respectively. A 100 fsec limit was set on the lifetime of the state.

\*This work was partly performed during the stay of the author at the Tandem Accelerator Laboratory of McMaster University /Hamilton, Ont., Canada/ in 1973.

#### GAMMA-DECAY OF THE LOWEST T=2 STATE OF 24 Mg

J. Szücs<sup>#</sup>, B.Y. Underwood, T.K. Alexander and N. Anyas Weiss Nuclear Physics A212 293 (1973)

The lowest T=2 state in <sup>24</sup>Mg was observed as a resonance in the gamma--ray yield from the <sup>23</sup>Na/p,gamma/<sup>24</sup>Mg reaction at  $E_p$ =3905±3 keV. The gamma decay of this  $J^{\pi}=0^+$ , T=2 state at 15434±3 keV was investigated by Ge/Li/ detectors; it was found to decay to the two lowest lying  $J^{\pi}=1^+$ , T=1 states at 9967±2 keV and 10711±2 keV with branching ratios /83±2/% and /17±2/%, respectively. The branching ratios for the decay of the /1<sup>+</sup>,1/ levels were also measured: 9967 + ground /63±3/%, 9967 + 1368 /32±6/% and 10711 + ground /91±7/%, 10711 + 1368 was not observed and a limit of <23% was set for this decay.

The resonance strength was found to be  $\omega\gamma=1.9\pm0.5$  eV. Using the known  $\Gamma_p/\Gamma$  ratio this enabled us to deduce transition probabilities for the primary transitions:  $\Gamma\gamma/15434 + 9967/_{M1} = 0.8 \pm 0.3$  Weisskopf units and  $\Gamma\gamma/15434 + 10711/_{M1} = 0.27 \pm 0.89$  W. u.

These values were compared to transition probabilities obtained from analogue beta-decays.

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This work was partly performed during the stay of the author at the Nuclear Physics Laboratory of University of Oxford in 1972.

ON THE ROLE OF EXCHANGE EFFECTS IN THE QUASI-ELASTIC KNOCK-OUT OF DEUTERONS\* V.I. Markov\*; L. Pocs

Dubna Report, 7298(1973)

The ratio of cross sections for scattering of protons on singlet and triplet quasi-deuterons is calculated in pole and triangle diagram approximation. In both cases the ratio was found to be near unity. This results show, that according to Balashov's idea, in the calculation of the effective number of deuteron clusters from cross section data, the singlet quasi-deuteron clusters must be taken into account, too.

\*This work was partly performed during author's stay at the Joint Institute for Nuclear Research, Dubna, USSR.

Institut for High Energy Physics, Alma-Ata, USSR

INELASTIC SCATTERING OF 40 MeV HELIONS FROM EVEN Sm-ISOTOPES\*

G. Palla and C. Pegel\*\*

Differential cross sections have been measured over an angular range  $/20^{\circ}-130^{\circ}/$  for the inelastic scattering of helions from the low lying collective states of Sm nuclei. The quadrupol and octupol, one- and two-phonon states in  $^{144,148,150}$ Sm nuclei and the members of the ground state rotational band in  $^{152,154}$ Sm are discussed using the coupled channel method.

<sup>\*</sup>This work was performed partly during the author's /G.P./ stay at University Hamburg /I. Institut f.Experimentalphysik/

<sup>\*\*</sup> Universität Hamburg, I. Institut f. Experimentalphysik

INVESTIGATION OF THE COLLECTIVE EXCITATIONS IN INELASTIC SCATTERING OF 25 MeV PROTONS FROM EVEN Sm-ISOTOPES\*

G. Pålla and C. Pegel\*\*

Differential cross sections for 25 MeV protons of the quadrupole and octupol states of spherical Sm isotopes and of the members of the ground state rotational band of the deformed Sm nuclei up-to  $6^+$  state have been measured. The data were analyzed using the collectiv model by coupled channel method. Higher order component  $-Y_4$ - in the nuclear shapes are determined.

He-3 ELASTIC SCATTERING FROM THE EVEN Sm-ISOTOPES AT E = 40.9 MeV\*

G. Pålla and C. Pegel\*\*

To be published in Zeitschrift f. Physik

Differential cross-sections of the elastic scattering of  ${}^{3}$ He-particles were measured from  ${}^{144,148,150,152,154}$ Sm nuclei at E = 40.9 MeV. The scattering data has been analysed with the simple optical model. The ambiguities of the real central potential and some trends depending on the target mass in the  ${}^{3}$ He optical potential parameters are discussed.

\*This work was performed partly during the author's /G.P./ stay at University Hamburg /I. Institut f. Experimentalphysik/

Universität Hamburg, I. Institut f. Experimentalphysik

SMALL ANGLE ELASTIC SCATTERING OF NEUTRONS BY LIGHT DEFORMED NUCLEI\*

G. Palla and C. Pegel\*\*

Published in "Nuclear Structure Study with Neutrons" Akad. Kiadó Ed. by J. Erő and J. Szücs

It has recently been suggested that a long-range component of the neutron-nucleus optical potential may be responsible for the "anomalous" small angle neutron scattering at 80-130 MeV energy. It is shown that the differential cross-section can be interpreted taking into account the effect of nuclear deformation on the basis of a generalised optical model.

This work was performed partly during the author's /G.P./ stay at University Hamburg /I. Institut f. Experimentalphysik/

Universität Hamburg, I. Institut f. Experimentalphysik

MEASUREMENT OF GAMMA-RAY SPECTRA FROM THE SPONTANEOUSLY FISSIONING ISOMER OF 236

A. Lajtai,L. Jeki, Gy. Kluge, I. Vinnay, F. Engard, Yu.P. Gangrsky,\* B.N. Markov\*

Symp. on Phys. and Chem. of Fission, Rochester, IAEA-Sm-174/31 (1973) Report KFKI-74-20 (1974)

The energy spectrum from 200 keV to 1 MeV of gamma-rays from  $^{235}$ U(n<sub>th</sub>, gamma f) reaction were studied to observe single lines corresponding to transitions preceding the spontaneous fission of the isomeric state  $^{236m}$ U. Excess gamma yields in several energy interval can be attributed to prefission gamma transitions.They appear in the following intervals: 234-240, 312-315, 402-406, 418-423, 445-455, 473-478, 574-580, 622-628, 650-660, 682-691, 740-748, 769-785, 805-815, 880-890 keV.

The measurements give in each of the covered intervals the limit  $\leq 10^{-5}$  on the ratio of the rate of isomeric fission events with prefission gamma rays to the rate of prompt fission events. The lifetime of the isomeric state was estimated as 100 nsec.

\*Joint Institute for Nuclear Research, Dubna, USSR

MEASUREMENT OF PERTURBED ANGULAR DISTRIBUTION OF GAMMA-RAYS FROM THE SPONTANEOUS FISSION OF  $^{\rm 252}{\rm Cf}$ 

A. Lajtai, L. Jėki, Gy. Kluge, I. Vinnay, F. Engard, P.P. Dyachenko<sup>\*</sup>, B.D. Kuzminov<sup>\*</sup>

Symp. on Phys. and Chem. of Fission, Rochester, IAEA-SM-174/32 (1973)

The angular and energy distribution of the gamma-rays emitted from fission fragments on the spontaneous fission of  $^{252}$ Cf were measured using platinum or iron source backing and NaI/Tl/ or Ge/Li/ detectors. The average anistoropy of the gamma rays relative to the direction of fragment flight, expressed as  $A = \frac{I/180^{\circ}/ - I/90^{\circ}/}{I/90^{\circ}/}$  is  $11 \pm 1$ % in the gamma energy interval from 120 keV - 1.5 MeV, and 18-22 % at energies from 350 to 850 keV if platinum backing and NaI/Tl/ detector are used. For iron backing the anisotropy value decreases under the same conditions to 5.2  $\pm$  0.1 % at energies from 120 keV to 1.5 MeV and to 5.1  $\pm$  0.2 % if a magnetic field is applied in the direction normal to the plane of fission in which the fragments and gamma rays are being counted.

Assuming a set of most plausible values for the life-time of fission gamma-rays and for the internal magnetic field at the iron site involved, average g-factor for the fission fragments were evaluated from the measured attenuation.

The measurements with Ge/Li/ detector show anisotropies which can be determined for about 30 gamma peaks and also the g-factors for specific gamma transitions seem to be evaluable. This work is still in progress.

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

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#### STUDY OF CONDENSED SYSTEMS BY MEANS OF THE MÖSSBAUER EFFECT

I. Dézsi, T. Lohner, D.L. Nagy

The systematic study of frozen solutions has been continued and extended to further materials as well as to new sample preparation technique.

The investigation of the water-dioxan-ferrous perchlorate system indicated that once the glass-like structure has been brought about the material no longer melts at about  $-90^{\circ}$ C nor does it crystallize. The Mössbauer parameters of a sample containing 35, 62 and 92 p.c.w. dioxan were measured and the temperature dependence observed supports the above statement. In addition, differential thermoanalytic measurements were performed on waterdioxan and water-dioxan-ferrous perchlorate systems. The phase diagram obtained in these measurements exhibits more phase transitions for the water-dioxan system than have been found by other authors.

A very rapid carrier-free freezing was achieved by injecting solution spray into liquid nitrogen. An interesting and significant shift relative to the case of medium cooling rate was observed in the intensity v. temperature diagram and the line width v. temperature diagram obtained from the measured Mössbauer spectra. One possible explanation is the formation of a structure which is now less stable than that obtained at medium cooling rate.

The effect of the electron spin relaxation upon the Mössbauer spectra has been investigated. Particular cases of the phenomenological theory developed by A.M. Afanasiev and V.D. Gorobchenko were experimentally verified. The measurements performed on  $NH_4Fe(SO_4)_2 \cdot 12 H_2O$ ,  $Fe(ClO_4)_3 \cdot 6 H_2O$ ,  $Fe(ClO_4)_3 \cdot 9 H_2O$  and  $Fe(NO_3)_3 \cdot 9 H_2O$  polycrystallic samples as well as on  $Fe(ClO_4)_3$  frozen solution samples can be very well fitted by the line shape function predicted by the theory.

The intramolecular magnetic exchange interaction in binuclear and trinuclear iron complexes were studied. The Mössbauer spectra of two binuclear complexes  $C_2N_2H_{10}$  (Fe - HEDTA) $_20.6H_20$  and  $Na_4$  (Fe EDTA)0.12  $H_20$  and their frozen solutions showed quadrupole split doublets. Asymmetries in the peak heights or areas of the doublets could not be observed. It can therefore be concluded that the asymmetry of the Debye-Waller factor or the relatively long spin relaxation times observed in some binuclear iron complexes are not general characteristics of these complexes.

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The Mössbauer spectra of trinuclear iron complexes /ferric acetate, benzoate, citrate and fumarate/ showed only quadrupole split doublets. Contrary to the former studies no paramagnetic hyperfine splitting could be observed down to 80 K. A possible non-equivalence of the three ferric ions in the molecule may be hidden under the broadened lines but their clear indication cannot be detected.

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#### STUDY OF POSITRON ANNIHILATION

#### I. Dézsi, D. Horváth, Zs. Kajcsos

NaCl single crystals of different concentration of  $Ca^{2+}$  impurity ions were studied in order to clarify the effect of the built-in bivalent impurities on the annihilation parameters. The impurity ion concentration was extended, for the first time in the literature, over the interval  $10^{-6}-10^{-3}$  Mol dope/Mol NaCl. An analysis of the results led to a quantitive relationship, expressible with a power function, between the positron capture probability  $I_2$  and the  $Ca^{2+}$  concentration.

Measurements on the NaCl /Ba/ system proved that the precipitates from the impurities do not exert any effect on the annihilation parameters and thus do not perturb the study of the effect of the built-in ions.

Measurements of the positron lifetime were carried out in specially purified liquid and solid state hydrocarbons. Following the work on hexane and dodecane, phase transitions of the eicosan and the 3-metilpentan were investigated. The lifetime parameters were found to change rapidly around the melting point.

The effect of the speed of the freezing, as well as of the quenching material  $O_2$  was studied for the solid phase. The results obtained have proved indirectly that there is no free positronium formation in solid phase.

Biophysical investigations have also been carried out on the simplest biomolecules: the positron lifetime was measured in different optical isomers of 9 aminoacids.

The measuring technique has been developed further; the so-called double-gate fast-slow coincidence method was realized; thus the amount of information was doubled with no change in resolution and measuring times.

Demonstrating considerable progress in the technique of data processing, a computer program was written which fits the convolution of exponential sum describing the positron decay and the resolution curve for the equipment to the measured spectrum.

#### PUBLICATIONS

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<sup>\*</sup>Research Group for Crystal Physics of the Hungarian Academy of Sciences, Budapest

#### MULTIWIRE PROPORTIONAL COUNTER

#### L. Valyi, Zs. Kajcsos

The group is working on the development and study of multiwire proportional counters /MWPC/ with detector surfaces of various sizes. Counters of 300 x 400, 300 x 800, 600 x 1000 mm<sup>2</sup> detector surface, with 200, 400, 500 wires along the X-coordinate and 150, 150, 300 along the Y-coordinate, respectively, were constructed. The planes of the signal wires, which are made of  $20\mu$  diam. gold-plated tungsten filaments spaced 2 mm apart, are separated from the high-tension wire planes by a gap of 8 mm. The windows consist of  $50\mu$  thick Mylar foil. The operating parameters of these counters were examined for several gas mixtures /argon, CO<sub>2</sub>, ethanol/, using the electron and gamma radiations of 90Sr and 55Fe. The efficiency of the MWPC is in the range 95-99,8 % for  $\beta^-$  particles emitted by 90Sr. The tension required by the instrument for each particular gas mixture is adjustable to any desired value in the range 3600-5400 V, and signals of 40-80 mV can be produced.

The counter proved stable and gave reproducible results under constant conditions.

## INSTITUTE OF EXPERIMENTAL PHYSICS, KOSSUTH UNIVERSITY

,

DEBRECEN

#### EXPERIMENTAL FACILITIES

- 1./ A 0,65 mg Cf<sup>252</sup> /fission/ neutron source;
- 2./ 200 kV /2 mA/ neutron generator /home made/;
- 3./ 180 kV /1.2 mA/ Activatron-111 neutron generator, it can be pulsed, pulse period: down to 10 microsec;
- 4./ Associated-particle system for  ${}^{3}$ He and  ${}^{4}$ He; this can be mounted onto any of the neutron generators;
- 5./ Pneumatic transport system for quick /0.8 sec for 2.4 m/ automatic sample transfer;
- 6./ Pu-Be neutron sources from 0.5 to 5 Ci;
- 7./ 40 cm<sup>3</sup> Ge/Li/ detector with 3 keV FWHM at 1332 keV, and a  $\sim$  10 cm<sup>3</sup> Ge/Li/ with  $\sim$  4.0 keV FWHM;
- 8./ 4000 channel DIDAC /Intertechnique/ analyser; three 100 channel analysers;
- 9./ Tally tape perforator, printer, tape-reader, X-Y plotter, spectrum-stabilizer;
- 10./ Lorenz telex with tape-punching and punched tape reading units in five hole CCIT code;
- 11./ <sup>6</sup>LiJ/Eu/ crystal spectrometer;
- 12./ <sup>3</sup>He proportional counter;
- 13./ Low-background proportional counter for measuring weak beta and/or gamma rays, e.g. tritium, with a sensitivity of a few pCi;
- 14./  $4\pi-\beta$  counter;
- 15./ Time of flight system with associated particle and klystron bunching method for fast neutrons is under construction;
- 16./ Si/Li/ X-ray spectrometer is under construction.

### USE OF THE CE-252 NEUTRON SOURCE FOR THERMAL NEUTRON ACTIVATION ANALYSIS S. Darbery, S. Nagy and P. Raics

The thermal, resonance and fast neutron flux distributions in a large water moderator surrounding a 660  $\mu$ g Cf-252 source were measured for planning activation analysis experiments.

A programme was started to investigate the possibilities for quantitative analysis of the elements of aluminium alloys. Amounts of Mn from 100 to 20000 ppm were determined in 1 g Al samples by absolute method, using a 40 cm<sup>3</sup> GeLi detector. The absolute thermal neutron flux was measured with In and Au foils. The experimental sensitivity of 3.5 ppm was estimated for quantitative determination with 10 % relative standard deviation at optimal timing /7.5 h irradiation, 1 h cooling, 5 h counting./ This sensitivity will be 20 ppm for a 1 hour irradiation - cooling - counting procedure.

#### INVESTIGATION OF 14.4 MEV NEUTRON INDUCED FISSION AND RELATED PROBLEMS

#### S. Darbezy, S.Nagy, P. Raics

The evaluation of the measurement on 14 MeV neutron, induced U-238 fission yields, mentioned in the Progress Report, Hungary, 1973, was completed. Absolute cumulative yields for 20 fission fragments were determined using the direct GeLi gamma-spectrometry of 39 gamma-lines from a 30 hour irradiated natural uranium sample. The results were submitted to the IAEA NDS.

To extend the investigations to the short-lived fragments /down to 10 min/, two independent 5 min irradiations were performed. It is possible to determine about 10 new cumulative and about 5 independent yields as well as to check the data obtained by the 30 hour irradiation. The evaluation of the measured 50 gamma spectra is in progress.

The cross section of  $^{238}$ U/n,2n/ reaction was investigated in the energy range of 13.5 - 14.8 MeV with GeLi gamma-spectrometry. This experiment makes it also possible to determine some fission yields in the same energy interval. The evaluation of about 100 gamma spectra measured with 8 natural uranium samples at 5 different neutron energies is in progress.

#### Cf-252 FISSION AVERAGE CROSS-SECTIONS

G. Pető, J. Csikai and I. Józsa

Continuing the programme for determining average cross sections by laboratory neutron sources [1], further 14 fission average cross-sections were measured by Cf-252 source. The results will be published in the near future.

[1] Pető, G., Csikai, J., Shuriet, G.M., Józsa, I., and Asztalos, V., Acta Phys. Hung., <u>33</u>, 363 /1973/

CALCULATION OF AVERAGE (n, 2n) CROSS SECTIONS FOR <sup>235</sup>U THERMAL FISSION SPECTRUM

#### Z.T. Bödy and J. Csikai

Using experimental /n, 2n/ excitation functions [1] as well as recommended /n, 2n/ values at 14.7 MeV [2] the normalization constants and nuclear temperatures /T/ were determined in the Weisskopf formula. Average cross sections for the neutron spectrum from the thermal fission of  $^{235}$ U, were calculated with these as well as with the Cranberg and Watt formulae, respectively /third and forth rows in the Table/. The results are compared with experimental and systematics values of Calamand [3].

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target nuclid@	T Gran e /MeV/ /1	nberg Wat nb/ /mb	t exp. //mb/	syst. /mb/	<u>exp.</u> Gran	<u>exp.</u> Watt	<u>syst.</u> Gran	<u>syst.</u> Watt
	1.46 0.000			0.030			 37	
F-19	2.50 0.000	63 0.0076	•0073 <sup>+</sup> •0007	0.050	1.16	0.96	7.90	6,58
Na-23	1.75 0.002	25 0.0032	.0022±.0002	0.008	0.88	0.69	3.20	2,50
P-31	1.64 0.00	0.0008	_	0.013		_	21.7	16.3
K-39	1.00 0.000	02 0.0003	_	0.007	-	· ·	35.0	23.3
Sc-45	0.90 0.034	48 0.0425	-	0.050	. –	_	1.44	1.18
Ti-46	1.42 0.00	30 0.0038	•0078 <sup>±</sup> •0009	<b>0.008</b>	2.60	2.05	2.70	2.11
Cr-50	1.59 0.00	17 0.0021	0.006±0.001	0.011	3.53	2.86	6.47	5.24
Cr-52	1.11 0.02	46 0.0306		0.028	-	_	1.14	0.92
Mn-55	1.20 0.18	58 0.2217	0.258 <sup>±</sup> 0.013	0.18	1.39	1.16	0.97	0.81
Fe-54	1.10 0.000	08 0.0010	0.005±0.0025	0.007	6.30	5.00	8.75	7.00
Co-59	1.05 0.162	24 0.1946	0.40±0.004	0.15	2.46	2.06	0.92	0.77
Ni-58	1.31 0.00	22 0.0027	-0049±0014	0.026	2.23	1.81	11.8	9.63
Cu-63	1,64 0.06	78 0.0824	0.124±0.011	0.11	1.83	1.50	1.62	1.33
Cu-65	1.30 0.259	98 0.3078		o.28	-	-	1.08	0.91
Zn-64	1.92 0.01	36 0.0170	-	0.040			2.94	2.35
Zn-66	1.27 0.08	74 0.1064	-	0.091	-	<u> </u>	1.04	0.86
Ga-69	1.31 0.20	33 0.2431	-	0.20		_	o.98	o.82
Ge-70	1.24 0.06	02 0.0739	1.8/±0.9/	0.059	30.0	24.4	0.98	0.80
Ge <b>-</b> 76	2.36 0.31	30 0.3685	-	0.51	-		1.63	1.38
As-75	1.30 0.24	40 0.2910	0.33 0.02	0.23	1.35	1.13	<b>0.</b> 94	o.79
Se-74	1.09 0.03	06 0.0380	-	0.036	_	-	1.17	o.95
Se-76	0.91 0.12	06 0.1464	-	0.091	-		o.75	o.62
Br-79	1.14 0.17	71 0.2132	-	0.15		-	o.85	0.70
Br-81	1.30 0.25	12 0.2995	-	o.26	-	-	1.03	o.87
Rb-85	1.17 0.26	85 0.3219	0.2 /±0.1/	0.20	0.74	0.62	0.74	o.62
Rb-87	1.08 0.57	lo 0.6746	· _	o.35	· _	-	0,61	0,52
Sr-84	1.20 0.01	64 0.0204	<del>-</del> .	0.042	-	-	2.56	2.06
Y-89	0.93 0.111	9 <b>0.</b> 1368	0.156±0.011	0.076	1.39	1.14	0.68	0.56
Zr-90	1.06 0.05	93 0.0734	0.076±0.01	<b>o</b> .048	1.28	1.04	o.81	0.65
Mo <b>-</b> 92	0.70 0.01	10 0.0137	-	0.023	-	-	2.10	1.68
Rh-103	0.90 0.53	39 0.6206	-	0.74	-	-	1.40	1.19
Ag-107	1.72 0.47	52 o.5593	. –	0.60	-	-	1.27	1.07
Ag-107	ml.29 o.1	899 0.2242	0•46±0•09	· _	2,42	2.05	-	-

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target nuclid	T /MeV/	Granberg /mb/	Watt /mb/	exp. /mb/	syst. /mb/	<u>exp.</u> Gran	<u>exp.</u> Watt	<u>syst.</u> Gran	<u>syst.</u> Watt
 Cd-106	0.94	o.1446	o.1743		o.15			1.04	0.86
Cd-116	0.97	1.3555	1.5543	-	1.5	<del>.</del>	_	1.11	o•97
In <b>-11</b> 3	1.12	0.8007	0.9352	-	0.70		-	0.87	0.75
In <b>-11</b> 5	1.22	1.0106	1.1711		1,1	-	-	1.10	o•94
Sn-112	0.91	o.2674	0.3213	. –	<b>o.</b> 18	-	_	0.67	0.56
56 <b>-</b> 121	1.32	o.7855	o.9148		0.89		-	1.12	0.97
SD-123	1.17	0.9719	1.1250	-	1.2		_	1.23	1.07
I <b></b> 127	1.26	0.8811	1.0233	0.9 <u>+</u> 0.1	1.0	1.02	<b>o</b> •88	1.13	0.98
Ce-140	1.19	0.8979	1.0444		1.0			1.11	0.96
Pr-141	1.18	0.7828	0.9146	-	0.86	-	-	1.10	0.94
5m-144	1.30	0,2708	0.3254	-	0.27	-	·	1.00	0.83
ſm <b>-1</b> 69	1.14	2.6156	2.9688	· - · `	3.7	, <del></del>	-	1.42	1.25
Au-197	0,87	3.3985	3.8436	3.0 <u>+</u> 0.3	4.0	o.88	0.78	1,18	1,04
F1-203	2.83	1.4580	1.6569	3.0 <u>+</u> 0.5	5,8	2.07	1.81	4.00	3.50
Pb-204	1.02	2.1007	2.3955	2.45 +0.4	3.0	1.17	1.02	1.42	1.25

EFFECT OF ELECTRONS AND X-RAYS ON ALPHA-PARTICLE REGISTRATION IN T - CELLIT DETECTOR

M. Varnagy, J. Csikai and S. Szegedi

To be published in Nuclear Instruments and Methods

Alpha-irradiated cellulose acetate /T-Cellit/ foils were exposed to 1.7 MeV electrons as well as to X-rays from a 60 kV X-ray tube. The exposures caused marked changes in the bulk etching rate of the polymer and in the diameter of the alpha particle tracks. These changes depend on the etchant as well as on the electron and X-ray doses. The possible consequences of the results are discussed.

APPLICATION OF T - CELLIT DETECTOR FOR THE STUDY OF <sup>6.7</sup>Li/p,a/<sup>3.4</sup>He REACTIONS M. Várnagy, J. Csikai, J. Szabó, S. Szegedi and J. Bánhalmi 2nd. Meeting of Hungarian Nuclear Physicists, Debrecen, 4-8 June 1973

The possiblity of mass discrimination <sup>3</sup>He and <sup>4</sup>He particles of about the same energy investigated using cellulose acetate /T-Cellit/ Solid State Nuclear Track Detector /SSNTD/. A method has been developed for the simultaneous determination of the angular distributions of <sup>3</sup>He and <sup>4</sup>He particles from the <sup>6,7</sup>Li/p, $\alpha$ /<sup>3,4</sup>He reactions in the low energy region. Cross sections for the reaction <sup>6</sup>Li/p, $\alpha$ /<sup>3</sup>He between 100 keV and 180 keV proton energies have also been determined. A FEW PROPERTIES OF THE SOLID STATE NUCLEAR TRACK DETECTORS /SSNTDs/

M. Varnagy, J. Csikai, S. Juhasz and S. Szegedi

Making use of fact that the limit of registration  $J_c$  of the SSNTDs depends on the etching conditions, a polycarbonate /Lexan/ detector has been found to be suitable for proton detection [1,2].

In order to investigate how the characteristic features of the T-Cellit detector change with the environmental effects, heat treatments as well as electron and X-ray exposures were performed on T-Cellit sheets irradiated with light  $/Z \leq 2/$  nuclei. Measurable changes have been found in the sensitivity and efficiency of the detector as well as in the track- and bulk-etch-rates above  $100^{\circ}C$  and 1 Mrad doses, respectively [1,2,3]. On the basis of our investigations a new geometrical model has been proposed to describe the track evolution process during etching. According to this model the bulk-etch-rate on the detectors surface differs from that in the interrior wall of the etched track [1].

#### REFERENCES

- M. Várnagy, 2nd. Meeting of Hungarian Nuclear Physicists Debrecen, 4-8 June 1973.
- [2] M. Várnagy, J. Csikai and S. Szegedi, to be published in Nuclear Instruments and Methods
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## INSTITUTE OF ISOTOPES

## OF THE HUNGARIAN ACADEMY OF SCIENCES

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## BUDAPEST

#### EXPERIMENTATION FACILITIES

- 1./ Station for irradiation with 80000 Ci <sup>60</sup>Co activity
- 2./ 6 MeV transportable betatron
- 3./ 1000 channel ND-2400 analyser /Nuclear Data/, with printer, puncher and x-y plotter
- 4./ 512 channel analyser /KFKI/
- 5./ TPAi computer /KFKI/
- 6./ Ge/Li/ detectors: 1.5 cm<sup>3</sup>, 30 cm<sup>3</sup> /Canberra/
- 7./ NaI/Tl/ low background detector /Nuclear Enterprises/  $\phi$ 5" x 5" in 20 cm iron shielding with a background index of 0.3 cpm/cm<sup>3</sup>
- 8./ GM and proportional planchet counters with anti-coincidence guard counters
- 9./  $4\pi \beta \gamma$  coincidence spectrometer

The Physics Department is engaged in the investigation of photonuclear reactions, namely of the inelastic resonance scattering of gamma-rays. By using high-activity <sup>60</sup>Co and other gamma sources, nuclear parameters - as integral cross-section, activation energy levels, partial widths of nuclear levels - of some nuclear isomers has been determined. The possible use of this technique for the determination of the activity of high intensity gamma sources and for activation analysis has also been investigated.

Recently, by extending the range of radioactive sources, new cross-section values were measured. An exact numerical method has been developed for the determination of the flux of Compton-scattered gamma rays of cylindrical sources.

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#### NUCLEAR EXCITATION BY GAMMA-RAYS OF RADIOACTIVE SOURCES

A. Veres, I. Pavlicsek, M. Csürös and L. Lakosi

Acta Phys. Hung., <u>34</u>, 97 (1973)

Nuclear isomers of stable nuclei were excited by inelastic resonance scattering of Compton-scattered gamma-rays from high-activity  ${}^{46}$ Sc,  ${}^{60}$ Co,  ${}^{142}$ Pr and  ${}^{24}$ Na radioactive sources. By counting the isomeric transition rates, thirty-five activation cross-sections were determined. Values of these crosssections were determined. Values of these cross-sections lie between 0.003 and 214 µbarn. The nuclides investigated are  ${}^{77}$ Se,  ${}^{79}$ Br,  ${}^{87}$ Sr,  ${}^{107-109}$ Ag,  ${}^{111}$ Cd,  ${}^{113}$ In,  ${}^{115}$ In,  ${}^{117}$ Sn,  ${}^{123}$ Te,  ${}^{107}$ Er,  ${}^{176}$ Lu,  ${}^{183}$ W,  ${}^{191}$ Ir,  ${}^{193}$ Ir,  ${}^{195}$ Pt,  ${}^{197}$ Au,  ${}^{199}$ Hg. The partial level widths for transitions leading from the activation to the metastable levels, estimated for twelve activation levels belonging to eight nuclei, are between  $4.10^{-6}$  and  $2.10^{-4}$  eV.

### ISOMER ACTIVATION DATA FROM EXPERIMENTS BY HIGH ACTIVITY 60 CO SOURCES

L. Lakosi, M. Csürös, A. Veres

#### Nucl. Instr. Meth. 13, 114 (1974)

The flux of Compton scattered gamma-rays of  $^{60}$ Co sources has been calculated in the unit energy interval at direct energy values on the symmetry-axis and at the points of the generatrix of the source cylinder. Using the numerical method and estimating the correction for multiple Compton scattering, we have reevaluated some isomer activation experiments. Integral cross-sections obtained by measuring  $^{111}$ Cd<sup>m</sup>  $^{115}$ In<sup>m</sup> activities excited by  $^{60}$ Co sources, are listed and compared with results of other authors in Table below:

Level	Aut Cauchois et al.	hor Booth et al.	Evaluated from earlier data	Present experiment
<sup>111</sup> cd	80 + 40 - 5	60 <u>+</u> 20	92 <u>+</u> 23	102 <u>+</u> 26
1300 keV 115 <sub>In</sub>	300 + 400 - 200	71 <u>+</u> 23	93 <u>+</u> 23	105 <u>+</u> 27
1078 keV		115 <u>+</u> 40		

Investigation of the reactions on elements yielding two nuclear isomers with energy levels and life-times close to each other is in progress. The individual cross-sections /for each isotope, like  $10^{7}$ Ag and  $10^{9}$ Ag/ are going to be determined by high-resolution gamma-spectrometry.

Preliminary measurements have been carried out in order to investigate photonuclear reactions induced by betatron radiation.

## INSTITUTE OF NUCLEAR RESEARCH OF THE HUNGARIAN ACADEMY OF SCIENCES

DEBRECEN

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#### EXPERIMENTATION FACILITIES

- 1./ A Van de Graaff accelerator with 5 MV nominal voltage, with proton-, deuteron- and alpha-beams. The measuring center of the generator is a Nuclear Data 50/50 data-acquisition and handling system.
- 2./ A Van de Graaff accelerator with 1 MV nominal voltage

Fundamental nuclear reaction researches /reaction mechanisms and collection of nuclear data/ are carried out on these generators.

Development of methods based on these accelerators in nuclear microanalysis is in progress.

- 3./ An instrument /with a superconducting magnet/ connected to the Van de Graaff /5MV/ is under development for the in-beam measurement of conversion electrons.
- 4./ A Cockroft-Walton accelerator up to a voltage of 700 KV

This accelerator is applied to generate proton-, deuteron- and electron beams for reaction studies and for irradiation purposes.

5./ Neutron generator

To produce D+T neutrons at a voltage of 150 KV, in the case of  $D^+$  ions with 500  $\mu$ A ion-current max. /analysed beam/.

6./ An ODRA 1013 Computer and the UT-200 to the CDC 3300 computer

> The evaluation of our experimental data and also their comparison with the theoretical calculations concerning nuclear reactions are carried out on these computers.

7./ Beta-, gamma- and X-ray-spectrometers of different types are available in the Institute to carry out different investigations in the field of nuclear spectroscopy and in the applications of it, in different other branches of sciences and partly in the practice.

## INVESTIGATION OF FAST-NEUTRON REACTIONS OF Pt

S. Szalay, I. Uray, P. Kováce

The fast neutron reactions of <sup>198</sup>Pt were investigated [1,2,3]. A further identification of <sup>198</sup> Ir new isotope is in progress by  $\beta - \gamma$  coincidence measurements.

#### REFERENCES

[1] A. Szalay, S. Uray, Radiochem. Radional. Letters, 14, 135 /1973/

[2] I. Uray, ATOMKI Bull. 15, 161 /1973/

[3] I. Uray, Progress Report

### THE DECAY PROPERTIES OF 198m

P. Kovács, I. Uray

The investigation of decay properties of <sup>190m</sup>Re is in progress. Measurements of branching ratios,  $\gamma$  transitions of de-excitation of <sup>190</sup>Os, and the cross sections of  $190_{OS} / n, p / 190_{m,g}$  Re reactions are under way.

THE INTERNAL BREMSSTRAHLUNG FROM THE SECOND FORBIDDEN ELECTRON CAPTURE DECAY OF  ${}^{36}$ C1 AND  ${}^{59}$ Ni

A. Ménes, D. Berényi, G. Hock, Cs. Ujhelyi and G. Székely

The internal bremsstrahlung from the second forbidden electron capture decay of  ${}^{36}$ Cl and  ${}^{59}$ Ni was, studied in the low background chamber of the ATOMKI by means of a 20 cm<sup>3</sup> Ge/Li/ detector.

The preliminary values for the total decay energy obtained from the analysis of the spectra are 1140  $\pm$  5 keV for  $^{36}$ Cl and 1058  $\pm$  3 keV for  $^{59}$ Ni.

The evaluation of the spectrum-shapes and the comparison of them with the Cutkosky and with the Rapoport-Zon theory as well as with the predictions of the virtual beta decay supposition are under way.

INTERNAL CONVERSION RATIOS AT THE L, M, N AND O SHELLS FOR THE 80,2 keV transition in the decay of  $^{131}{\rm I}$ 

Å. Köver, D. Berenyi and Cs. Ujhelyi

Some ratios of the internal conversion coefficients at the higher atomic shells have been studied for the 80,2 keV transition in the decay of  $^{131}$ I by means of a beta-ray band-spectrograph of 75 cm maximum radius.

The preliminary results, obtained by using nuclear emulsion as detector, are as follows

 $L_{II}/L_{I} = 0,084 /0,074/$  $M_{II}/M_{I} = 0,086 /0,083/$ N/M = 0,22 /0,29/M/L = 0,25 /0,206/.

In brackets the theoretical values are given. The study of the same ratios using scintillation detector in the band spectrograph is under way now, and a comparison of the two detecting methods will be carried out. A STUDY OF INTERNAL BREMSSTRAHLUNG FROM THE ALLOWED BETA DECAY OF <sup>35</sup>s D. Berényi, S. Mészáros, D. Varga and Cs. Ujhelyi

The internal bremsstrahlung from the allowed beta decay of  $^{35}$ S was measured at better conditions than in earlier works. A Ge/Li/ detector was used to take the IB spectrum and the radioactive source was placed in a special magnetic field to transport the electrons from the source and so to eliminate the contribution of the external bremsstrahlung to the spectrum.

As a result of the measurement, a better agreement with the Coulomb corrected KUB theory has been obtained as it was found at the earlier two studies.

The publication is in preparation.

#### ANALYSIS OF RESONANCE REACTIONS USING THE R-MATRIX THEORY

#### L. Vegh

Following the short description of the R-matrix theory [1] used to calculate cross sections, some illustrative examples are given [2].

#### REFERENCES

[1] A.M. Lane and R.G. Thomas, Rev. Mod. Phys., <u>30</u>, 257 /1958/

[2] L. Végh, Atomki Közlemények, 15, 229 /1973/

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INVESTIGATIONS OF THE EXCITED STATES OF  $^{41}$ SC WITH ELASTIC SCATTERING OF PROTONS ON  $^{40}$ Ca

E. Koltay, L. Meskó, L. Végh

Measurements have been performed on the elastic scattering of 1-5 MeV protons on 40Ca using the accelerated beam of the 5 MV Van de Graaff generator in this Institute. Altogether 30 resonances were observed. A comparison between the observed shape of the resonances and the calculated ones obtained in the framework of the R-matrix theory results in the assignment of spin and parity values to the excited states.

## THE INVESTIGATION OF 27 AL/p, a/ 24 Mg REACTION

I. Hunyadi, E. Koltay and L. Zolnai

Using solid state track detector technique [1] the excitation functions of the  $\alpha_0$  and  $\alpha_1$  groups from the  ${}^{27}\text{Al/p}, \alpha/{}^{24}\text{Mg}$  reaction are under investigation in the bombarding energy range 1,60 - 1,80 MeV at 80° and 150° laboratory angles. Angular distributions for both  $\alpha_0$  and  $\alpha_1$  groups are measured at the resonances. An extension of the measurements is planned to higher energies.

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G. Somogyi , B. Schlenk, M. Várnagy, L. Meskó and A. Valek: Nucl. Instr. Methods, 63, 189 /1968/

#### K/B<sup>+</sup> RATIOS OF NON-UNIQUE TRANSITION

#### E. Vatai

 $K/\beta^+$  ratio gives an equation for the nuclear matrix elements, which is linearly independent from the equation for the L/K ratios. This makes possible to determine all the three dominant nuclear matrix elements using the lg ft value, L/K ratio and  $K/\beta^+$  ratio for second and higher forbidden nonunique decays. Detailed evaluations will be presented for second forbidden transitions.

INVESTIGATION OF THE  ${}^{14}N/d_{,\alpha}/{}^{12}C$  REACTION AT  $E_d = 640-310$  keV DEUTERON ENERGIES

M.H.S. Bakr<sup>\*</sup>, I. Hunyadi, B. Schlenk, G. Somogyi and A. Valek

Angular distributions of the  $\alpha_0$ ,  $\alpha_1$ ,  $\alpha_2$  and  $\alpha_3$  groups from  $^{14}N/d, \alpha/^{12}C$  reaction have been measured at deuteron energies 640, 510 and 350 keV using solid state track detectors. Semiconductor detector was used to measure the excitation functions of the  $\alpha_0$  and  $\alpha_1$  groups from the same reaction in the energy range 640-310 keV at  $\theta_{1ab} = 90^{\circ}$ . The absolute cross section values are given for the alpha groups investigated. The experimentally obtained angular distributions have been analysed in terms of Legendre polynomials. The measured relative intensity ratios of the  $\alpha_0$ ,  $\alpha_1$  and  $\alpha_3$  groups could be reproduced by a simple calculation assuming statistical compound reaction mechanism [1].

#### REFERENCES

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\*Permanent address: Atomic Energy Establishment, Cairo, Egypt.

#### FURTHER INVESTIGATION ON NON-UNIQUE ELECTRON CAPTURE RATIOS

E. Vatai

To be puslished in ATOMKI Közlemények Triangle Seminar on "Weak Interactions at Low Energies", Debrecen, Hungary 1974

Ratios of nonrelativistic to relativistic nuclear matrix elements calculated from second forbidden experimental L/K electron capture ratios are discussed. Using the relations from the CVC theory the model dependent parameter  $\Lambda_1$  is calculated for  ${}^{36}$ Cl as  $1,2 \leq \Lambda_1 \leq 1.4$  or  $1.4 \leq \Lambda_1 < 1.6$ . This is smaller than the value  $1.9 \leq \Lambda_1 \leq 2.4$  predicted by different models. Further experimental and theoretical investigations are needed to clear up this discrepancy.

#### IMPACT IONIZATION CROSS SECTIONS FOR RELATIVISTIC POSITRONS

S. Seif el Nasr, D. Berényi and Gy. Bibók

Inner shell ionization cross sections by impact of positrons with 490 abd 670 keV energy for Ni, Y, Ag /K-shell/ and Yb, Ta, Pb, /L-shell/ have been measured. A radioactive source and a beta-ray spectrometer is used as a source of monoenergetic positrons. The measurements and the evaluation is in progress.

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#### INNER SHELL IONIZATION CROSS SECTIONS FOR RELATIVISTIC ELECTRONS

S.A.H. Seif el Naer, D. Berenyi and Gy. Bibok

2. Physik 267, 169 (1974)

The cross section of electron impact ionization was determined for the K-shell in the case of the elements Ni, Y, Ag, Yb, Ta, Au and Pb at 670 and 490 keV as well as for the L-shell in the case of the elements Yb and Pb at 670, 490 and 350 keV and in the case of Ta at 670 and 490 keV. The results are compared with the theoretical calculations and the earlier experimental results.

## INVESTIGATION OF THE <sup>191</sup>T1+<sup>191</sup>Hg+<sup>191</sup>Au DECAY<sup>+</sup>

Vandlik J.,\* Zaitseva N.G.\*, Máté Z., Mahunka I., Tyrroff H.\*, Fényes T. Preprint, Joint Institute for Nuclear Research, P6 - 7582 Dubna, 1973

The  $\gamma$  and internal-conversion-electron spectra from the decay of <sup>191</sup>Tl were measured with Ge/Li/ and Si/Li/ spectrometers. The  $\gamma$  spectrum of <sup>191</sup>Hg, the daughter isotope of <sup>191</sup>Tl, was also studied.

In the  $\gamma$ -spectrum of  $^{191}$ Tl  $/T_{1/2} = 5.22 \pm 0.16$  min/ 17  $\gamma$ -transitions were observed, from which 11 are new. The multipolarity of 5 transitions and the  $\epsilon/\beta^+$  branching rate of the  $^{191}$ Tl decay were also determined. On the basis of the  $\gamma$ -spectrum study of  $^{191}$ Hg we can conclude, that in the  $^{191}$ Hg nucleus, in addition to the known  $13/2^+$  state, there exists another long-lived 7probably  $(3/2^-)$  ground/ state too, with  $49\pm10$  min half-life.

\* This work has been performed in JINR, Dubna
\* Joint Institute for Nuclear Research, Dubna, USSR

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STUDY OF THE 192 T1 DECAY

T.B. Vandlik<sup>\*</sup>, J. Vandlik<sup>\*</sup>, N.G. Zaitseva<sup>\*</sup>, Z. Måte<sup>\*</sup>, I. Mahunka, M. Mahunka, H. Tyrroff<sup>\*</sup>, T. Fenyes

With the aim of producing  $^{192}$ Tl PbF<sub>2</sub> target was irradiated with 660 MeV protons. The extraction of thallium from the target was made with gas-thermochromatographic method during the irradiation.  $\gamma$  and conversion electron radiations of mass-separated  $^{192}$ Tl samples were studied using Ge/Li/ spectrometers. 49  $\gamma$ -transitions were observed, from which 40 are new. Multipolarities of 22 transitions were determined. The /2<sup>-</sup>/ ground state /T<sub>1/2</sub> = = 10.6 ± 0.5 min/ and /7<sup>+</sup>/ metastable state /T<sub>1/2</sub> = 10.8 ± 0.2 min/ of <sup>192</sup>Tl decay with e<sup>-</sup>-capture /98.2 %/ and  $\beta^+$ -emission /1.8 %/. A decay scheme of  $^{192g+m}$ Tl is proposed with the following energy levels of  $^{192}$ Hg: 0 keV 0<sup>+</sup>; 422.8 2<sup>+</sup>; 1057.9 4<sup>+</sup>; 1113.8 2<sup>+</sup>; 1592.9 /3<sup>+</sup>/; 1733.4 /3, 2<sup>+</sup>/; 1803.6; 6<sup>+</sup>; 1844.5 /5/<sup>-</sup>; 1977.6 /7/<sup>-</sup>; 2187.1 /6, 5/<sup>-</sup>.

THE DECAY SCHEME OF 193T1+

Vandlik T.B.\*, Vandlik J.\*, Zaitseva N.G.\*, Måte Z., Mahunka I., Mahunka M., Tyrroff H.\*, Fenyes T., Fominykh V.I.\*

Preprint, Joint Institute for Nuclear Research, P6 - 7581 Dubna, 1973

 $\gamma$ -, conversion-electron and  $\gamma\gamma$ -coincidence spectra from the decay of <sup>193</sup>Tl monoisotope preparations were measured with Ge/Li/ and Si/Li/ detectors. 48  $\gamma$ -transitions were observed, from which 40 are new. The multipolarity of 19 transitions, the half-life and  $\epsilon/\beta^+$  branching rate of <sup>193</sup>Tl were also determined. The proposed <sup>193</sup>Tl decay scheme contains the following new levels: 50.0 keV (1/2<sup>-</sup>); 324.4 keV (3/2)<sup>-</sup>; 374.6 keV (3/2, 5/2)<sup>-</sup>; 725.5 keV 3/2, 5/2, 1/2<sup>-</sup>; 1523.4 keV (3/2, 5/2, 1/2)<sup>-</sup> and 1580.0 keV.

<sup>+</sup>This work has been performed in JINR, Dubna

\*Joint Institute for Nuclear Research, Dubna , USSR

### DECAY SCHEME OF 195 T1

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Izv. AN SSSR, ser. fiz. XXXVII, 1804 (1973)

The  $\gamma$ -ray, conversion electron and  $\gamma\gamma$ -coincidence spectra of mass separated <sup>195</sup>Tl sources were measured in the Dubna YASNAPP programme. The energy, relative intensity and multipole order of the observed 103  $\gamma$ -transitions /from which 97 are new/ are tabulated. In the proposed level scheme of <sup>195</sup>Hg 26 new levels were introduced /in comparison with [1]/: 300.66 keV /5/2/¯; 595.61 3/2, 1/2, 5/2 /-/; 600.68 3/2, 1/2¯; 764.7 /5/2, 3/2/¯; 892.9 3/2, 5/2¯; 921.68 /1/2/¯; 952.6 ? 3/2, 5/2, 1/2 /-/; 1004.6 /3/2, 5/2/¯; 1188.5 /3/2, 5/2/¯; 1400.80 /3/2/¯; 1403.7 /3/2, 1/2/¯; 1548.55 /3/2/¯; 1663.7 ? /1/2, 3/2¯/; 1714.0 3/2, 1/2, 5/2 /-/; 1735.6 /3/2, 5/2¯/; 1742.7 3/2, 1/2, 5/2 /-/; 1831.1 /3/2¯/; 2014.8 /3/2, 1/2¯/; 2057.5 /3/2, 1/2¯/; 2283.5 ? 3/2, 1/2, 5/2<sup>/-/</sup>; 2363.3 /1/2, 3/2<sup>−</sup>; 3017.7 3/2, 1/2. A value of 140 ± 70 was obtained for the EC/β<sup>+</sup> branching ratio of <sup>195</sup>Tl.

#### REFERENCE

[1] M.J. Martin, Nucl. Data Sheets, <u>B8</u>, 431 /1972/

<sup>+</sup>This work has been performed in JINR, Dubna
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DECAY SCHEME OF 197T1+

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Izv. AN SSSR, ser. fiz., XXXVII, 1796 (1973)

With the aim of producing <sup>197</sup>Tl PbF<sub>2</sub> targets were irradiated with 660 MeV protons. After gas-thermochromatographic extraction and mass-separation of thallium isotopes  $\gamma$ -ray, conversion electron and  $\gamma\gamma$ -coincidence spectra of <sup>197</sup>Tl were measured using Ge/Li/, Si/Li/ and Ge/Li/ - Ge/Li/ spectrometers.

50  $\gamma$ -transitions were observed, from which 32 are new. The multipolarities of 33 transitions were determined. The EC/ $\beta^+$  branching rate of <sup>197</sup>Tl was found to be 205 ± 92. In the proposed level scheme of <sup>197</sup>Hg the following new levels were introduced: 307.74 keV I<sup>T</sup> = /5/2/<sup>-</sup>; 853.7 ?; 892.50 3/2<sup>-</sup>; 982.61 /3/2<sup>-</sup>; 1009.30 1/2, 3/2<sup>-</sup>; 1436.86 /1/2<sup>-</sup>; 1562.86 /3/2<sup>-</sup>; 1693.00 /1/2/<sup>-</sup>. A review of earlier experimental results see in [1].

REFERENCE

[1] M.B. Lewis, Nuclear Data Sheets, <u>B7</u>, 129 /1972/

<sup>+</sup>This work has been performed in JINR, Dubna <sup>\*</sup>Joint Institute for Nuclear Research, Dubna, USSR NEW SOURCE OF DECOUPLING OF E1 STRENGTH FROM THE GDR: BOUNDARY CONDITION MIXING FOR s- AND p-WAVE NEUTRON STATES NEAR THRESHOLD

B. Gyarmati, A.M. Lane\*, J. Zimanyi\*\*

Non-statistical effects in neutron capture reveal that El strength of neutron orbits of low *l*-value is partially decoupled from the GDR. Particlehole diagonalisations with realistic forces do not show this effect. We show that it can arise from a new source, boundary condition mixing, which operates when fine-structure states are introduced. This may also explain the "pygmy dip" in El strength reported for masses ~195.

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MODEL CALCULATIONS FOR FORM AND SPECTROSCOPIC FACTORS IN STRIPPING TO RESONANT STATES

#### R.G. Lovas

By some model calculations it is shown that for narrow resonances the single-particle and coupled channel resonance functions defined by different prescriptions /scattering, Gamow, Weiberg solutions/ are nearly identical. Only those stripping processes might or do distinguish the resonant functions whose final state is a broad resonance or a resonance in a surfacecoupled or complex coupled channel process or the contribution to the transition matrix element from the region outside the nucleus is important. A definition for the spectroscopic factor of a Gamow state is given. According to some numerical examples it satisfies physical expectation. EC/β<sup>+</sup> RATIOS IN THE DECAY OF <sup>191,193,195,197</sup>Tl Mahunka I., Máté Z., Tárkányi F. ATOMKI Közlemények, 16, 133 (1974)

Using gamma-detection technique /Ge(Li); KX,511<sub>ann</sub>/ the EC/ $\beta^+$ ratios were measured in the ground state decay of light Tl isotopes. In the cases of  $^{195,197}$ Tl, where the decay schemes had been known, the minimum values of the (EC/ $\beta^+$ )<sub>g</sub> ratio were determined for the transition  $\frac{1/2^+}{1/2^-}$  between ground states. This experimental value for  $^{195}$ Tl is 6 times higher than the theoretically calculated (EC/ $\beta^+$ )<sub>g</sub> for allowed transition.

### DECAY SCHEME OF 190 T1

T.B. Vandlik<sup>\*</sup>, J. Vandlik<sup>\*</sup>, N.G. Zaitseva<sup>\*</sup>, Z. Mate<sup>'</sup>, I. Mahunka, M. Mahunka, H. Tyrroff<sup>\*</sup>, T. Fenyes

γ and conversion electron spectra of mass-separated <sup>190</sup>Tl samples were measured with the aid of Ge/Li/ and Si/Li/ detectors. 21 γ-transitions were observed, from which 13 are new. Multipolarities of 9 transitions were determined. A decay scheme of <sup>190</sup>Tl is proposed with the following energy levels of <sup>190</sup>Hg: 0 keV 0<sup>+</sup>; 416.5 2<sup>+</sup>; 1041.9 4<sup>+</sup>; 1099.9 /2<sup>+</sup>/; 1557.6 /3<sup>+</sup>/; 1772.9 6<sup>+</sup>; 1881.5 /5/<sup>-</sup>; 2078.2 /7/<sup>-</sup>. From the energy level systematics of even thallium isotopes and from the decay scheme of <sup>190</sup>Tl one can draw the conclusion that in the <sup>190</sup>Tl nucleus exist two isomeric states with similar half-lives: /2<sup>-</sup>/, T<sub>1/2</sub> = 3.4 ± 0.3 min and /7<sup>+</sup>/, T<sub>1/2</sub> = 3.4 ± 0.2 min. The isomeric states decay mainly with e<sup>-</sup>-capture /97.4 %/, the intensity of the β<sup>+</sup> branch is only 2.6 %.

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# ROLAND EÖTVÖS UNIVERSITY DEPARTMENT FOR ATOMIC PHYSICS, BUDAPEST

#### MAIN EXPERIMENTATION FACILITY

.

NG-200 /200 keV/ neutron-generator

#### INELASTIC SCATTERING OF 14.7 MeV FAST NEUTRONS ON LIGHT NUCLEI

F. Deak, S. Gueth, A. Kiss

The aim of this work is to investigate the collective properties of light nuclei in the mass region of 12 < A < 30. An associated particle - fast neutron time-of-flight spectrometer with the time resolution of about 1.2 nsec is used. The angular distribution of the cross-sections are evaluated in the framework of the collective model.

#### INVESTIGATION OF SHORT-LIVED ACTIVITIES EXCITED BY FAST NEUTRONS

A. Kiss, F. Deak, S. Gueth

The production of short lived activities /10 nsec - 10  $\mu$ sec/ is investigated by 14.7 MeV fast neutrons. A combined alpha particle-pulsedbeam method is used to measure the distribution of  $\gamma$ -rays produced in the de-excitation process. Properties of statistical nuclear processes are investigated and the half- lives of isomeric levels can be deduced from the measurements.

#### FAST NEUTRON ACTIVATION ANALYSIS

S. Gueth, F. Deak, A. Kiss

Some research work is made to find economical and simple methods for the determination of small quantities of the elements N. O, F and Si in samples of materials produced in industrial processes.

Kiadja a Központi Fizikai Kutató Intézet Felelős kiadó: Pócs Lajos, a KFKI Részecske és Magfizikai Tudományos Tanácsának szekcióelnöke Példányszám: 85 Törzsszám: 74-10.040 Készült a KFKI sokszorositó üzemében Budapest, 1974. junius hó