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INDC INTERNATIONAL NUCLEAR DATA COMMITTEE

Progress Report on Nuclear Data in Brazil

Compiled by

L.T. Auler

May 1981

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PROGRESS REPORT ON NUCLEAR DATA IN BRAZIL

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Readers are requested not to quote results contained herein without first consulting the appropriate authors.

Compiled by

L.T. Auler

Brazilian Liaison Officer

of the

International Nuclear Data Committee

Introduction.

This progress Report on Nuclear Data in Brazil consists of abstracts received by the Liaison Officer to the INDC, upon request to a number of scientists that in his judgement could be doing work related to nuclear data.

To submit or not an abstract was, of course, a choise of the scientists addressed. The abstracts received are reproduced in what follows.

Further information as well as permission to reproduce quoted data should be addressed to the authors.

NUCLEAR DATA CENTER AT THE CENTRO TĒCNICO AEROESPACIAL

The Nuclear Data Center in the Division of Advanced Studies of the Institute for Space Activities (IAE) at the Centro Tēcnico Aeroespacial was created with the objective of maintaining complete nuclear data files and multigroup processing programs with a view to furnishing basic or processed data to the nuclear scientists in the country.

Several evaluated nuclear data files along with corresponding utility programs and various multigroup processing codes, have been implemented in the division's CDC CYBER 170/730 system.

Preparatory to developing the capability of updating the data files, programs are being initiated in the areas of calculation and evaluation of microscopic neutron cross sections. In this context, several nuclear model codes are in the process of being implemented and tested.

Evaluation of the ressonance data of some of the actinide elements are in progress, with a view to investigating the discrepancies between the ENDP/B-IV data and the other published results.

PHOTONUCLEAR MEASUREMENTS NEAR THRESHOLD FOR ^{237}Np, USING MONOCHROMATIC GAMMA-RAYS

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Using monochromatic gamma rays produced by neutron capture reaction in targets placed near IEA-R1 reactor core, we are measuring the (γ,f) and (γ,n) cross sections for ^{237}Np, in 5.43 to 10.83 MeV energies.

The Neptunium sample was provided by IAEA and consists of six plates of titanium with 10mg NpO_2 deposited on each one.

The photofission cross section is been measured using a solid state track detector-the Makrofol KG. This material is placed in contact with the neptunium sample and after the irradiation is developed by chemical etching. The number of fission tracks obtained is counted in a spark chamber and a detection total efficiency of 38% was found for this method.

To determine the (γ,n) cross section, the total neutron emission is been measured by a 60 He-3 long counter. The efficiency obtained for this detector was 43% and it was constant around 10cm of the center, in the beam direction.

The fission fragments angular distribution also will be determined at 6.61 MeV energie, using a three chamber assembly, that will contain two plates each one, in order to use all the available sample. During the irradiation the sample will be rotating at the chamber center to avoid the geometry problems due to the sample form.

g-FACTOR OF THE 587 KeV STATE IN ^{117}In

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The integral perturbed angular correlation technique has been used to measure the g-factor of the 587 keV ($3/2^-$) state in ^{117}In. The measurements were made in an external magnetic field of 26kG. The 1303 - 276 keV gamma cascade in ^{117}In populated from the beta decay of ^{117}Cd was utilized for the measurement. The result is g(587 keV)= 0.233 ± 0.057. The experimental result is discussed in terms of nuclear models applicable for nuclei in this mass region.

THE HALF LIFE AND THE g-FACTOR OF THE 248 keV STATE IN ^{77}Se

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The half life of the 248 keV state in ^{77}Se was determined by the delayed gamma-gamma coincidence method. The gamma cascades 572-248 and 750-248 in ^{77}Se populated from the electron capture decay of 57h. ^{77}Br were utilized for the measurement. The resulting value of the half life is

$$T_{1/2}(248\ \text{keV}) = (9.56 \pm 0.20) \times 10^{-9}\ \text{sec}$$

The g-factor of the 248 keV state has been measured by the time differential perturbed angular correlation (TDPAC) method in an external magnetic field of 25kG. The(755-248) keV gamma cascade was utilized for the measurement. The g-factor is determined to be g(248 keV) = 0,486±0,020. Further detailed measurements of the gamma-gamma directional correlations for several transitions in ^{77}Se are in progress.

ELETRIC QUADRUPOLE GIANT RESONANCE IN THE PHOTOFISSION OF ^{233}U.

A.Vannucci, J.D.T.Arruda Neto, S.B.Herdade, B.L.Berman, I.C.Nascimento, and Maria de Fátima B.M.Vannucci (Instituto de Física, Universidade de São Paulo, São Paulo, Brazil)

The absolute cross-section for the electrofission of ^{233}U has been measured, in the energy range 5.5 to 31.0 MeV using the beam of the University of São Paulo Electron LINAC. The fission fragments have been detected by means of mica foils. Experimental details have been published elsewhere[1,2]. The E2 component of the photofission cross-section has been obtained by a combined analysis of electrofission and photofission experimental data, using virtual photon spectra calculated in DWBA[3,4]. Preliminary results show a broad peak, located at aproximately 10 MeV, that has been atributed to the E2 (T = 0) giant resonance in ^{233}U.

1) J.D.T.Arruda Neto, S.B.Herdade, B.S.Bhandari, and I.C.Nascimento, "Electrofission and Photofission of ^{238}U in the energy range 6-60 MeV", Phys. Rev. C14 (1976) 1499.

2) J.D.T.Arruda Neto, S.B.Herdade, and I.C.Nascimento, "Formalism and Applications of electrofission and photofission fragment angular distributions", Nucl.Phys. A334 (1980) 297.

3) J.D.T.Arruda Neto, S.B.Herdade, B.S.Bhandari, and I.C.Nascimento, "Electric quadrupole giant resonance in the photofission of ^{238}U", Phys.Rev. C18 (1978) 863.

4) J.D.T.Arruda Neto, B.L.Berman, S.B.Herdade, and I.C.Nascimento, "E2 giant resonance and M1 component in the photofission of ^{236}U", Phys.Rev. C22 (1980) 1996.

STUDY OF LOW-LYING LEVELS OF ^{232}Th TRANSITION NUCLEUS BY ELECTROFISSION.

Maria de Fátima B.M.Vannucci, J.D.T.Arruda Neto, S.B.Herdade , A.Vannucci, and I.C.Nascimento (Instituto de Física, Universidade de São Paulo, São Paulo, Brazil)

Thin targets (~ 70μg/cm^2) have been irradiated with the electron beam of the University of São Paulo LINAC, in the energy range 5.9 to 8.0 MeV. The fission fragments have been detected by mica foils located at angles from 10° to 90° with respect to the incident beam direction. Details on the experimental procedure and data analysis have been published elsewhere[1]. It is expected that, for energies below 7.0 MeV, only the K=0 band of the transition nucleus (saddle point) is important, the fission fragment angular distributions giving inormation on the competition of the $(J^\pi,K) = (2^+,0)$ and $(1^-,0)$ channels. From the analysis of: (a) ratio of the coefficient c and b of the angular distribution; (b) the absolute coefficient C_e, that is proportional to $\sigma_\gamma, f(2^+,0)$, for energies near the fission barrier, and (c) the anisotropy, evidences have been found that the first excited state of the nucleus in the saddle point would be a 1^- state. This result does not follow the systematics presented by other even-even actinide nuclei, for which the first excited state in the saddle point is a 2^+ state[2].

1) J.D.TArruda Neto, S.B.Herdade, and I.C.Nascimento, "Formalism and Applications of electrofission and photofission fragment angular distributions", Nucl.Phys.A334 (1980) 297.

2) J.D.T.Arruda Neto, S.B.Herdade, B.L.Berman, and I.C.Nascimento , "Electrofission of $^{234,236,238}U$: E2 strength function and angular distributions", to be published.

FISSION DECAY OF THE GIANT QUADRUPOLE RESONANCE FOR $^{234,236,238}U$: STRENGTH FUNCTIONS AND FISSION PROBABILITIES.

J.D.T.Arruda Neto, S.B.Herdade, B.L.Berman, and I.C.Nascimento (Instituto de Física, Universidade de São Paulo, São Paulo, Brazil)

The absolute electrofission cross sections for $^{234,236,238}U$ have been measured through the electron beam of the University of São Paulo Linear Accelerator in the energy range 5.5-25 MeV; details concerning the Accelerator and experimental set-up have been described elsewhere[1,2]. The strength functions $\frac{dB}{d\omega}$ (E2,ω) of the Giant Quadrupole Resonance fission decay have been delineated by means of a simultaneous analysis of the electrofission (present work) and photofission cross sections (measured at Livermore), and the virtual photon formalism[1-3]. The most striking features of the results are: a substantial concentration of E2-strength for excitation energies (ω) near the fission barrier (5.5-6.5 MeV) and around ω=8.5 MeV; it should be noted that the E2-strength function for the ^{238}U as deduced from hadron induced fission experiments peaks at $\omega\cong$10.5 MeV and goes to zero at $\omega\cong$8.5 MeV.

1) J.D.T.Arruda Neto, S.B.Herdade, B.S.Bhandari, and I.C.Nascimento, "Electric quadrupole giant resonance in the photofission of ^{238}U", Physical Review C18, 863 (1978).

2) J.D.T.Arruda Neto, B.L.Berman, S.B.Herdade, and I.C.Nascimento, "E2 giant resonance and M1 component in the photofission of ^{236}U", Physical Review C22, 1996 (1980).

3) J.D.T.Arruda Neto, B.L.Berman, S.B.Herdade, and I.C.Nascimento, "A test for the E2 virtual photon spectrum in DWBA", Physical Review C22, 1794 (1980).

STUDY OF LOW-LYING LEVELS OF THE TRANSITION NUCLEUS FROM ELECTROFISSION ANGULAR DISTRIBUTION FOR $^{234,236,238}U$.

J.D.T.Arruda Neto, S.B.Herdade, B.L.Berman, and I.C.Nascimento (Instituto de Física, Universidade de São Paulo, São Paulo, Brazil).

We have been measured the electrofission fragments angular distributions for $^{234,236,238}U$ between 5.5 and 8 MeV using the electron beam of the University of São Paulo Linear Accelerator and mica foils as fission detectors placed at twelve angles between 10^{o} and 100^{o}. The experimental details have been published elsewhere[1,2]. The analysis of the E2-coefficient of the angular distributions[3] allowed to obtain informations about energy position and strength of the saddle point (transition nucleus) rotational levels $(J^{\pi},K) = (2^{+},0)$ and $(2^{+},1)$, for excitation energies below the pairing gap. The K=0 channel alone concentrates more than 10% of the E2-energy weighted sum rule. The energy position of the $(2^{+},1)$ level is 0.5-0.7 MeV above the $(2^{+},0)$ level for all the investigated nuclei.

1) J.D.T.Arruda Neto, S.B.Herdade, B.S.Bhandari, and I.C.Nascimento, "Electric quadrupole giant resonance in the photofission of ^{238}U", Physical Review C18, 863 (1978).

2) J.D.T.Arruda Neto, B.L.Berman, S.B.Herdade, and I.C.Nascimento, "E2 giant resonance and M1 component in the photofission of ^{236}U", Physical Review C22, 1996 (1980).

3) J.D.T.Arruda Neto, S.B.Herdade, and I.C.Nascimento, "Formalism and applications of electrofission and photofission fragment angular distributions", Nuclear Physics A334, 297 (1980).

FISSION PRODUCT YIELDS FOR ^{238}U FISSION INDUCED BY FISSION SPECTRUM NEUTRONS

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The radiochemical method consist in irradiating samples of depleted and natural uranium, in small cadmium boxes and at the same time, with fission spectrum neutrons at the IEN-Argonaut reactor.

After irradiation, the samples are chemically divided in two fractions: one containing yttrium and lanthanide nuclides (fluoride precipitation) and the other containing the rest of fission products. The identification and activity measurements of the different fission products are done by γ-ray spectrometry using a high resolution Ge(Li) detector in conjunction with a 4096 multichannel analizer and a PDP-11 computer.

The cumulative yields are calculated by substraction of the ^{235}U fission contribution and relation of the saturation activities for each nuclide, in depleted and natural uranium, with the activities of the reference nuclides. The reference nuclides are: ^{142}La (yield: 4.95) for the lanthanide fraction and ^{92}Sr (yield: 4.10) for the non-lanthanide fraction.

The work is in progress.

HE-JET TRANSPORT SYSTEM

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A He-jet transport system is being developed at the IEN to transport recoil nuclei produced by bombardment with charged particles accelerated by the CV-28 cyclotron. The recoil nuclei will be transported from the cyclotron vault by a cappilary tube 21m long and about 1 mm o.d. to a region of low background where measurements are possible.

Efficiency of transport measured through the $^{27}Al(\alpha,2p)^{29}Al$ reaction is being studied as a function of a number of parameters. Best results so far give an efficiency of 20% in transport, this being the ratio of what escapes from the target, to what is effectively transported through the cappilary.

Improvements and modifications are being made in order to increase the transport.

Even with the present low efficiency some experiments are being done with this system such as:

- excitation functions and isomer ratio for $^{103}Rh(^{3}He,3n)^{103m}As$ (5.8s), ^{103g}Ag(1.1h) reaction.
- isomer ratio for $^{90}Zr(^{3}He,2n)^{91m}Mo$ (64s), ^{91g}Mo(15.5m) reaction.
- decay scheme and internal conversion coefficients of ^{92}Tc(4.4m) formed by $^{93}Nb(^{3}He,4n)$ reaction.

INTERNAL CONVERSION ELECTRON SPECTROMETER

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The internal conversion electron spectrometer built in this laboratory[1] is being adapted to be used with nuclides of shorter half-life. A first improvement, keeping the original geometry, was made by the adaptation of a system including a gate valve that allows a frequent change of sources without having to bring the whode chamber to atmospheric pressure and room temperature.

A still better improvement is one that will allow the spectrometer to be used together with the He-jet transport system being developed at the same time. With this new geometry in which the source will be external it will be possible to study angular correlations and also to use the spectrometer in beam to make measurements of prompt transitions.

A baffle system to cut down positrons that otherwise would also be transmitted to the detector, was also developed according to reference[2].

1) F. WENDLING, Master's Thesis, Coppe, UFRJ (unpublished)
2) R. WIENER., C. CHASMAN., P. HARIHAR and C.S. WU., Phys. Rev. 130, 1069 (1963).

EXCITATION FUNCTIONS AND ISOMER RATIOS IN $^{197}Au(^{3}He,xn)^{200-x}Tl$ REACTIONS WITH $X \leq 4$.

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Experimental determinations are being made of the excitation functions and isomer ratios of $^{197}Au(^{3}He,xn)$ reactions. Results will be compared to predictions of the hybrid model of nuclear reactions[1] which includes pre-equilibrium emission of particles. The ALICE code[2] will be used to obtain the calculations with this model.

Irradiations are being made at the CV-28 cyclotron of IEN using the stacked foil method. The stack is made of Au foils separated by Al degraders. Beam monitoring is done using the well known cross sections for the reactions $Cu(^{3}He,pxn)^{65}Zn$ and $^{65}Cu(^{3}He,2n)^{66}Ga$[3] as well as current integrator developed in this laboratory[4]. The cross sections for isomeric production will be calculated by the activation equations and for this end gamma-ray spectra of the irradiated foils were obtained using Ge-Li detectors.

The spectra stored in a MCA are transferred to a magnetic tape and post-processed by a computer code[5].

Irradiations in 9 energies from 21 to 36 MeV are being analysed and new ones at lower energies being prepared.

1) M.BLANN., Phys. Rev. Lett. 21, 1357 (1968).

2) M. BLANN, UR-NSRL-181

3) E. LEBOWITZ and M.W. GREENE, Int. J. Appl. Radiat. Isotopes, 21, 625 (1970).
E.A. BRYANT et al., Phys. Rev., 130, 1512 (1963)

4) J.A.D.FURLANETTO, presented at the Cambuquira Conference (1980)

5) L.T. AULER, Internal Report DEAT/DF/SFN-02/77.

EXCITATION FUNCTIONS AND ISOMER RATIOS IN $^{103}Rh(^{3}He,xn)^{106-x}Ag$ REACTIONS WITH $x \leq 4$

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Excitation functions and isomer ratios are being measured up to 36 MeV for the reactions $^{103}Rh(^{3}He,xn)^{106-x}Ag$. Following the line of other work in progress[1] or finished[2] in this laboratory, results will be compared with calculations performed by the ALICE code[3].

Starting from the sulphate, Rh foils are electrodeposited on Cu which is dissolved afterwards by tri-chloroacetic acid, leaving self-supported foils of about $4mg/cm^2$. Such Rh foils are irradiated in the ^{3}He beam of the IEN CV-28 cyclotron and the decay of the radioisotopes formed is followed with a high-resolution gamma-ray spectrometer. The spectra are dumped into magnetic tape and post-processed in a computer with an automatic gamma spectrum analysis code[4] to determine the activities formed.

In order to be able to study some of the short-lived nuclides formed, such as the 5.8 s ^{103m}Ag, a He-Jet transport system will be used.

An interface between the He-Jet system and a H.P. multichannel analyser is being prepared that will allow to control the motion of the source as well as the routing of the MCA so that the half-life of this short-lived nuclide can be followed.

1) U.M.Vinagre Fº et. al., "Excitation functions and isomer ratios in $^{197}Au(^{3}He,xn)^{200-x}Tl$. reactions with $X \leq 4$", private comunication.

2) L.T. Auler, A.G. da Silva and G.W.A. Newton, "Excitation functions and isomer ratios in $^{93}Nb(^{3}He.xn)$ reactions with X=2 and 3", to be published in J. Inorg. Nuclear Chem.

3) M. Blann, UR-NSRL - 181

4) L.T. Auler, internal report DEAT/DF/SFN/-2/77.