INDC(BZL)-011/GI
INT(84)-8

COMISSÃO NACIONAL
DE ENERGIA NUCLEAR

INSTITUTO DE
ENGENHARIA NUCLEAR

PROGRESS REPORT ON NUCLEAR DATA IN BRAZIL

August 1984

RIO DE JANEIRO
BRASIL

INDC(BZL)-011/GI
INT(84)-8

COMISSÃO NACIONAL DE ENERGIA NUCLEAR

INSTITUTO DE ENGENHARIA NUCLEAR

PROGRESS REPORT ON NUCLEAR DATA IN BRAZIL

August 1984

Compiled by

L.T. Auler

Introduction

This progress Report on Nuclear Data in Brazil consists of abstracts received by the editor, 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 choice of the addressed scientists. The abstracts are reproduced in the following pages, as received by the compiler.

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

FAST NEUTRON FACILITY

L.T. Auler, A.G. da Silva, J.C. Suita, S.C. Cabral and L.J. Antunes (Departamento de Física, Instituto de Engenharia Nuclear, Rio de Janeiro, Brasil)

A fast neutron facility is being installed at the Instituto de Engenharia Nuclear. This facility will use the available variable energy (3 to 14 MeV) deuteron beam from our CV-28 cyclotron, to produce "monoenergetic" neutrons by the $D(d,n)^3He$ reaction for use in differential cross section measurements by the activation method. Details on the facility are given in two recent reports (1,2).

In summary, status of this project is the following:

- The dedicated beam line extension is already assembled and tested for vacuum and beam transmission.

- Two BA1 type NE213 liquid scintillators were assembled in detector housings and their characteristics exaustively studied (see reference 2 for further details). Neutron response function of these detectors are being determined, one of them at the PTB - Braunschweig. These response functions are necessary for unfolding purposes.

- Several computer codes are being made available by adapting to our CII-HB L64 DPS 6 computer, for calibration of detectors (GRESP (3), NRESP (4)) and spectra unfolding (FORIST (5), LOUHI78 (6)).

REFERENCES

1 - A.G. da Silva and L.T. Auler, in "Nuclear Data for Science and Technology", K.H. Bockoff (ed.), D. Reidel, Dordrecht, Boston, London, p. 843 (1983).

2 - J.C. Suita, S.C. Cabral, L.J. Antunes, A.G. da Silva and L.T. Auler, "Progress Report on a Fast Neutron Facility", report DIFIS-02/84. Instituto de Engenharia Nuclear, Rio

de Janeiro, Brasil, 1984.

3 - G. Dietze and H. Klein, "Gamma Calibration of NE-213 Scintillation Counters", Nucl. Instr. and Meth. 193 (1982) 549.

4 - G. Dietze and H. Klein, "NRESP 4 and NEFF 4, Monte Carlo Codes for the Calculation of Neutron Response Functions and Detection Efficiences for NE-213 Scintillation Detectors", report PTB-ND-22 (1982).

5 - R.H. Johnson, D.T. Ingersoll, B.W. Wehring and J.J.Dorning, "NE-213 Neutron Spectrometry System for Measurements from 1.0 to 20 MeV", Nucl. Instr. and Meth. 145 (1977) 337.

6 - J.T. Routti and J.V. Sandberg, "General Purpose Unfolding Program Louhi 78 with Linear and Nonlinear Regularizations", Comp. Phys. Comm. 21 (1980) 119.

CHARGED PARTICLE NUCLEAR FISSION STUDIES

A.V. Bellido, L.T.Auler and S.C.Cabral

Departamento de Física
Instituto de Engenharia Nuclear
Rio de Janeiro - Brasil

A rapid transport of the fission fragments is being used to study nuclear fission reactions induced by charged particles.

The charged particle bombardments are carried out with a CV-28 variable energy cyclotron and the extraction of the fission products is done in a helium jet transport system [1,2] which uses naphtalene for cluster generation and allows the fragments to be brought from the irradiated target to the collection chamber in 0.5 s. The identification and measurements of the fission product yields is performed by high resolution gamma spectrometry [3-5].

References:

1. H. Dautet, S. Guirathi, W.J. Wiesehahn, J.M. D'auria and B.D. Pate, "A Gas Jet Transport System for the Radioactive Products of Fast Neutron Induced Fission", Nucl. Instr. and Meth. 107 (1973) 49.
2. S.C.Cabral, "Razão Isomérica dos ^{91g,m}Mo da Reação ^{90}Zr(^{3}He,2n) usando a Técnica de Transporte de Núcleos de Recuo por Jato de Helio", M.Sc, Thesis Coordenação dos Programas de Pós-Graduação de Engenharia, U.F.R.J. (1983).
3. G. Erdtmann and W. Soyka, Die γ -Linien der Radionuklide, Band 1-3, Jül-1003-AC (1973), KFA-Jülich.
4. M.E. Meek and B.F. Rider, "Compilation of Fission Product Yields", NEDO-12154-1,Vallecitos Nuclear Center, 1974.
5. B.F. Rider and M.E. Meek, "Compilation of Fission Product Yields", NEDO-12154-2 (D), Vallecitos Nuclear Center, (1977).

EXCITATION FUNCTION AND ISOMER RATIOS IN CHARGED PARTICLE INDUCED REACTIONS.

S.C.Cabral, U.M.Vinagre Fº, L.T.Auler and A.G.da Silva

INSTITUTO DE ENGENHARIA NUCLEAR
DEPARTAMENTO DE FÍSICA
RIO DE JANEIRO - BRASIL

Continuing studies on excitation functions and isomer ratios (1-3), experimental measurements using particles acelerated by CV-28 cyclotron are being made in the following reactions:

1) $^{90}Zr\ (p,xn)^{91-x}Nb\ (x = 1,2)$

2) $^{197}Au(^{3}He,xn)^{200-x}Tl\ (x = 2,3,4)$

3) $^{66}Zn\ (\alpha,2n)^{68}Ge$

4) $^{110}Pd\ (d,p)^{111}Pd \rightarrow\ ^{111}Ag$

The excitation functions for the (p,xn) and (^{3}He,xn) and the isomer ratios for $^{89g,m}Nb$, $^{198g,m}Tl$ and $^{197g,m}Tl$ are being compared with those predicted by the statistical model calculation using the ALICE code(4). The $^{89g,m}Nb$ isomer ratios measurements show the same type of behavior as verified with $^{93g,m}Tc$(1) produced by ^{93}Nb (^{3}He,3n) reaction and $^{91g,m}Mo$(3) from the ^{90}Zr (^{3}He,2n) reaction, both being different from those obtained by the ALICE code calculations at energies near the threshold.

The third reaction above is being studied to determine the optimum production condictions of 288 d ^{68}Ge which decays to 68 min ^{68}Ga, a radioisotope employed in nuclear medicine(5).

The last reaction is being studied aiming to produce a ^{111}Ag source for utilization in gamma-gamma time differential perturbed angular correlation experiments(6).

References:

1) L.T.Auler, A.G.da Silva and G.W.A. Newton, J. Inorg. Nucl. Chem, Vol 43, nº 11 (1981) 2611.

2) A.M.Borges, A.G.da Silva, L.T.Auler and O.F.Lemos Jr. - Revista Brasileira de Física - vol. especial - IV R.T. Fisica Nuclear no Brasil (1981) 106.

3) S.C.Cabral, L.T.Auler and A.G. da Silva, - Revista Brasileira de Física - Vol. Especial - V.R. T. Física Nuclear no Brasil (1982)

4) M. Blann, "Overlaid ALICE. A Statistical model computer code including fission and preequilibrium models" - Report COO-3494 29 (1978).

5) A. Karpeles, "Obtencion en ciclotron del Nuclido Ge-68", Preprint, Departament Radioisotopos, Comission Nacional de Energia Atômica, Buenos Aires, Republica Argentina, outubro 1969.

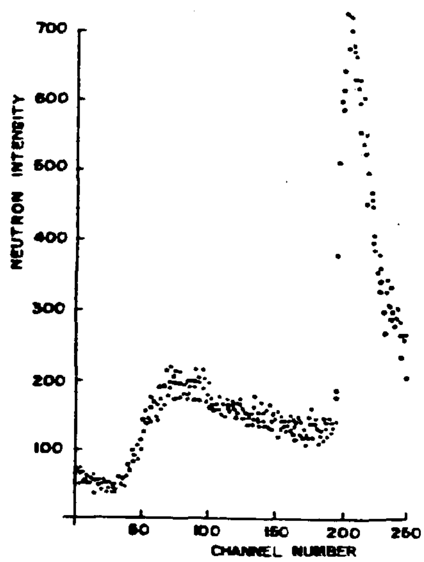
6) L.T.Auler, S. Jha, A.G. da Silva, U. M. Vinagre Fº, D.S. Chamma e V.L. da Costa, VI R.T. Física Nuclear do Brasil - Itatiaia - setembro/1983.

SLOW ENERGY DOUBLE DIFFERENTIAL SCATTERING CROSS-SECTION MEASUREMENTS OF BAQUELITE AT 800ºC.

Voi, D.L. (CNEN/IEN)

In way that the neutron scattering law could be determined from double differential scattering cross-sections, baquelite neutron spectrum have been measured with the time-of-flight experimental arrangement at CNEN-IPEN.

The sample emergent spectrum obtained at 45º from the 5 meV beam, shown below, permit that, by an appropriate formalism to obtain the neutron double differential cross-sections and the correspondent scattering law.



NEUTRON ESPECTRUM FROM BAQUELITE AT 800°C

MULTIPOLAR COMPONENTS IN THE ELECTROFISSION CROSS SECTION OF ^{235}U

Z. Carvalheiro, S. Simionatto, S.B. Herdade, J.D.T. Arruda-Neto (Instituto de Física, Universidade de São Paulo) and B.L. Berman (Lawrence Livermore National Laboratory, LLNL, University of California)

The electrofission cross section of ^{235}U has been measured in the energy range 5.83-34.66 MeV, with the electron beam of the University of São Paulo Linear Accelerator. The target has been provided by LLNL and was prepared by vaccuum evaporation of metalic uranium (99.7% enriched in ^{235}U) on a titanium backing with 5 μm thickness. The ^{235}U thickness was (211 ± 4) μg/cm^2. Fission fragments have been detected by means of mica foils[1]. The E2(T=0) and M1 components have been determined in the energy range 5.83-17.92 MeV. The experimental electrofission cross sections are shown as black circles in Figure 1. The continuous curve is the E1 component calculated by integration of the photofission cross section measured with monoenergetic photons at LLNL[2] over the E1 virtual photon spectra calculated in DWBA[3]. The open circles are diferences between the black circles and the continuous curve, and represent the components different of E1 in the electrofission cross section. Figure 2 shows the "non-E1" photofission cross section determined from the open circles in Figure 1, by a method described in reference 3.

Figure 3 shows the strength function $\frac{dB}{d\omega}\frac{\Gamma_f}{\Gamma}$, obtained from the data of Figure 2[4], as a function of photon energy. The strength concentrated between 5.0 and 7.4 MeV is attributed mainly to the M1 giant resonance and is equivalent to $11.0(^{+2.4}_{-3.3})\ \mu_0^2$. The strength concentrated between 8.0 and 18.0 MeV, with a peak at

10.4 MeV and $\Gamma \cong 4$ MeV (FWHM), is the E2(T=0) giant resonance, which exausts 80% of an E2 energy weighted sum rule.

REFERENCES

1) J.D.T. Arruda-Neto, S.B. Herdade, B.S. Bhandari, and I.C. Nascimento, Phys. Rev. C14 (1976) 1499.

2) J.T. Caldwell, E.J. Dowdy, B.L. Berman, R.A. Alvarez, and P. Meyer, Phys. Rev. C21 (1980) 1215.

3) J.D.T. Arruda-Neto, S.B. Herdade, B.S. Bhandari, and I.C. Nascimento, Phys. Rev. C18 (1978) 863.

4) J.D.T. Arruda-Neto, S.B. Herdade, I.C. Nascimento and B.L. Berman, Nucl. Phys. A389 (1982) 378.

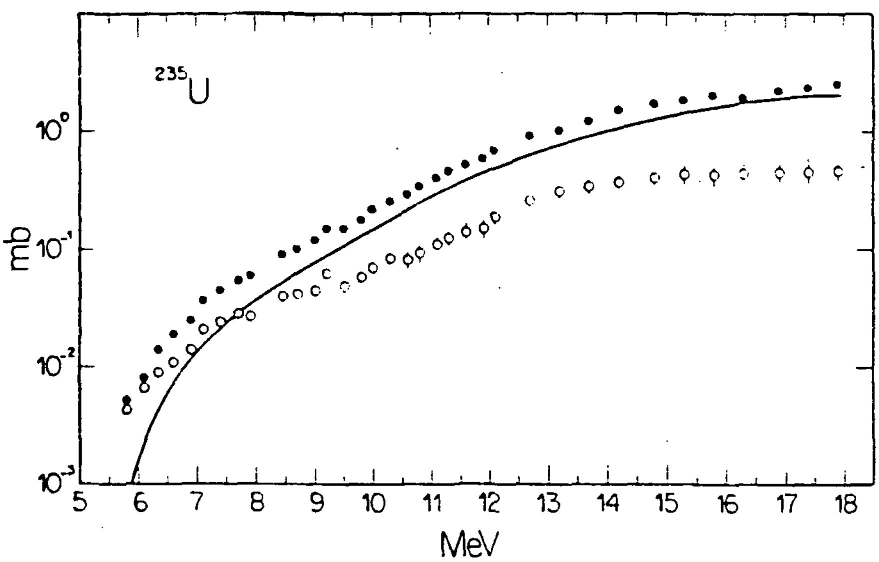


Figure 1

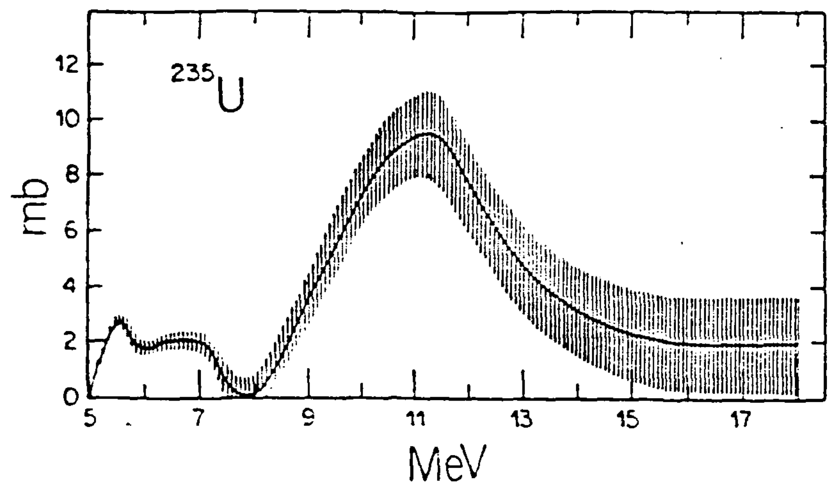


Figure 2

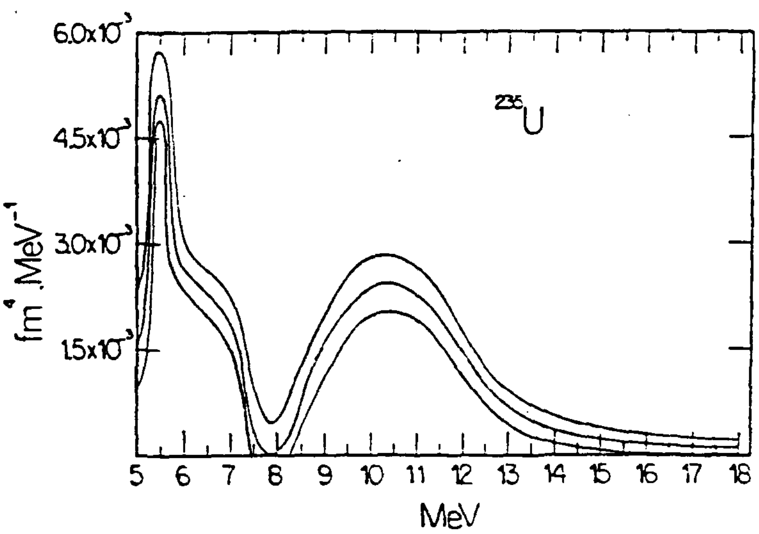


Figure 3

ELECTROFISSION OF ^{237}NP

S.L. Paschoal, S.B. Herdade, J.D.T. Arruda-Neto and M.C.P. Martins (Instituto de Física da Universidade de São Paulo)

The electrofission cross-section of ^{237}Np has been measured in the energy range 6.0-60.0 MeV with the electron beam of the University of São Paulo Linear Accelerator. The neptunium target, with a thickness $(750 \pm 6)\mu g/cm^2$, was provided by IAEA . Fission fragments were detected by means of mica foils(1). The experimental results, as a function of incident electron energy, are shown in Figura 1.

A preliminary analysis of the multipole components of the electrofission cross section has been carried out by means of the ratio $\sigma^*_{e,f}/\sigma_{e,f}$, where $\sigma^*_{e,f}$ is the E1 component determined by integration of the Livermore photofission cross section data(2) with the E1 virtual photon spectrum calculated in DWBA(3), and $\sigma_{e,f}$ is the experimental electrofission cross section. This ratio as a function of incident electron energy is shown in Figure 2. A pure E1 cross section should give a constant value for the ratio. E2 (T=0) and M1 giant resonances are expected to appear at photon energies ~ $63A^{-1/3}$ and ~ $40A^{-1/3}$ MeV, respectively , that for A = 237 corresponds to 10,1 MeV and 6,5 MeV. The minima observed at ~ 6.0 and ~ 10.0 MeV, in Figure 2, suggests the existence of E2(T=0) and M1 resonances in the electrofission cross section of ^{237}Np.

REFERENCES

1. J.D.T. Arruda-Neto, S.B. Herdade, B.S. Bhandari, and I.C. Nascimento, Phys. Rev. C14 (1976) 1499.
2. B.L. Berman "Atlas of Photoneutron Cross Sections Obtained with Monoenergetic Photons", Report UCRL-78482(1976) 160.
3. C.W. Soto-Vargas, D.S. Onley and L.E. Wright, Nucl. Phys. A288 (1977) 45.

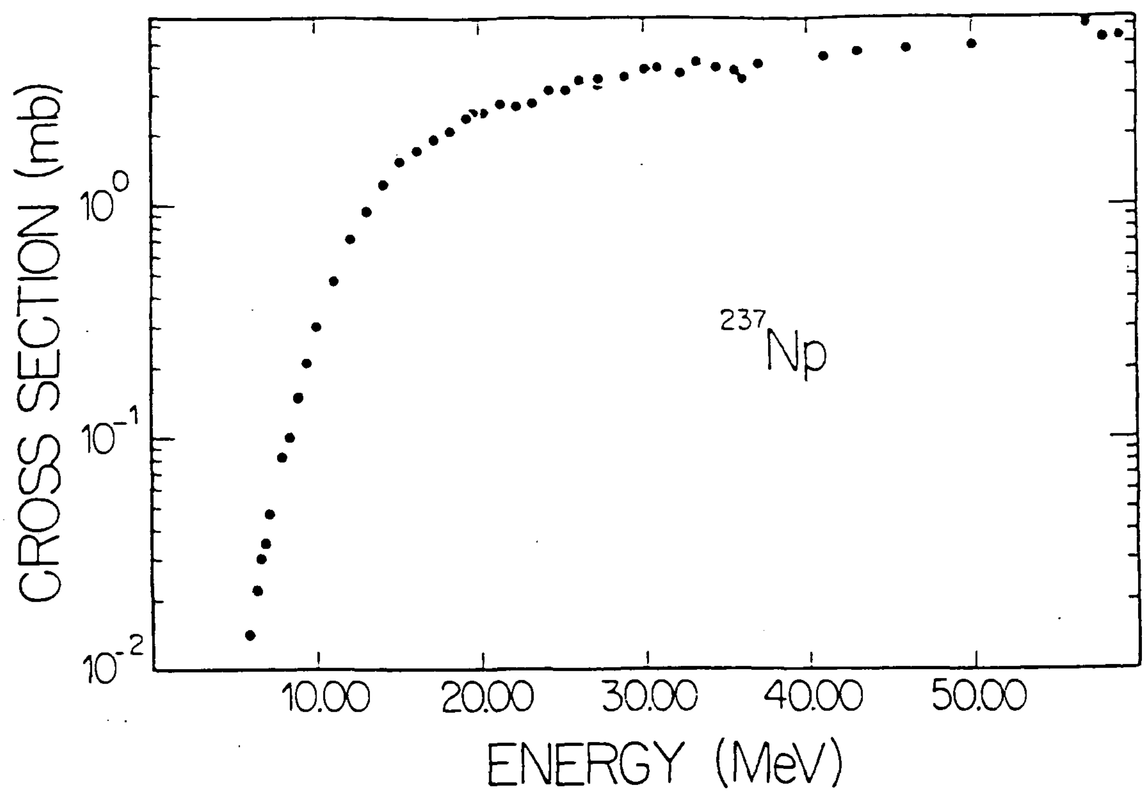


FIGURE 1

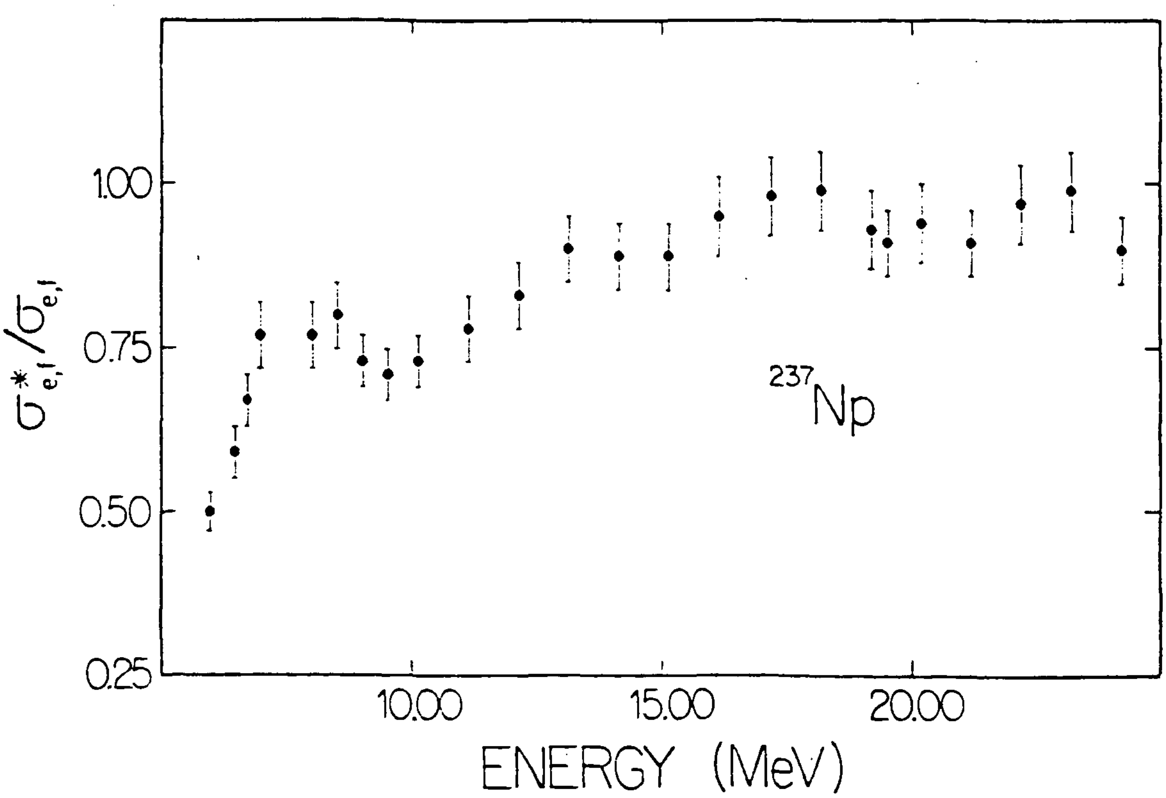


FIGURE 2

PHOTOFISSION OF ^{237}Np

M.C.P. Martins, J.D.T. Arruda-Neto, S.L. Paschoal, and S.B. Herdade (Instituto de Física, Universidade de São Paulo)

The "bremsstrahlung" fission cross section of ^{237}Np has been measured in the energy range 10-60 MeV, by utilizing the electron beam of the University of São Paulo Linear Accelerator, and a copper radiator with a thickness 0.624 g/cm^2 (4.85×10^{-2} radiation lengths). The ^{237}Np target, with a thickness (750 ± 6) $\mu g/cm^2$, was provided by the International Atomic Energy Agency. Fission fragments were detected by means of mica foils(1). Experimental details are given in reference 1.

The experimental results, as a function of incident electron energy, are shown as black circles with error bars in Figure 1. The continuous curve is the contribution of the ^{237}Np Giant Electric Dipole Resonance (GDR) to the "bremsstrahlung" fission cross section. This curve has been calculated by integration of the Lorentz lines representing the GDR photofission cross section, with the "bremsstrahlung" spectra. The photofission data used were those obtained with monoenergetic photons at Lawrence Livermore National Laboratory(2). The discrepancy between the data points and the continuous curve for $E_e \geq 20$ MeV is being analysed as an additional component of the cross section due to the interaction of photons with correlated nucleon pairs, on the basis of the Modified Quasi--deuteron Model(3).

REFERENCES

1) J.D.T. Arruda-Neto, S.B. Herdade, B.S. Bhandari, and I.C. Nascimento, Phys. Rev. C14 (1976) 1499.

2) B.L. Berman, "Atlas of Photoneutron Cross Sections Obtained with

Monoenergetic Photons", UCRL-78482 (1976).

3) J.S. Levinger, Phys. Lett. 82B (1979) 181.

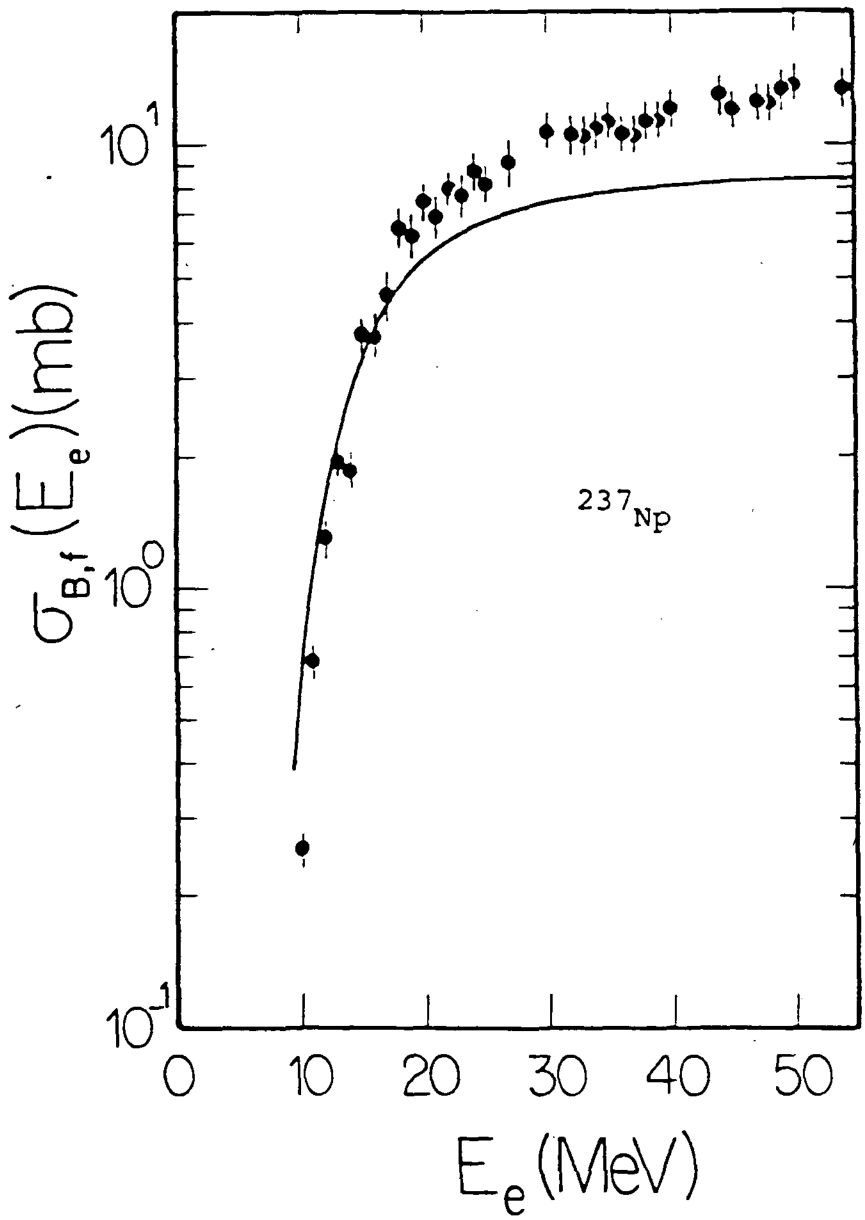


FIGURE 1

CENTRO DE DADOS NUCLEARES (CDN)
INSTITUTO DE ESTUDOS AVANÇADOS, CENTRO TÉCNICO AEROESPACIAL,
SÃO JOSÉ DOS CAMPOS, SP, BRAZIL

The activities of CDN in progress are summarized below:

1. Nuclear Data Evaluation:

Evaluation of the total, capture, fission, elastic, inelastic, (n,2n), (n,p) and (n,α) cross sections of U^{236} and Ti^{48} for the incident neutron energy range of 0.1 to 20.0 Mev is in the final stages. Evaluation of the cross sections of Fe^{56} and Th^{232} is being initiated.

Initial studies for definition of procedures for the resonance data evaluation are in progress.

2. Multigroup Processing

The CDN presently utilizes the available codes for preparing multigroup libraries for thermal or fast reactor applications according to the users' specifications.

Development of an improved code for generation of multigroup library for fast reactor applications is in early stages.

3. Integral Analysis

Procedures and software were developed for the calculation of sensitivity profiles of the integral parameters of fast systems. Application of these procedures for the analysis of sensitivity and errors in the benchmark problems is under way, with a view to determining the quality of evaluated and multigroup data.

4. The Data Bank

The Data Bank of the CDN has at its disposal several evaluated libraries obtained through the Nuclear Data Section of the IAEA as well as several multigroup libraries obtained from other institutions and some generated locally. These are available to Brazilian users.

The CDN also prepares data libraries according to the specifications of the users.

Analysis of the actinides in the INDL through the comparison of the resonance integrals and other integral parameters is being conducted as part of the Coordinated Research Project of the IAEA/NDS.

5. Experimental Measurements

Despite some delay due to funding and other difficulties, the design of the 20 Mev linear electron accelerator is in progress. This will be utilized for generation of neutrons cross section measurements.