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INDC INTERNATIONAL NUCLEAR DATA COMMITTEE

PROGRESS REPORT ON NUCLEAR DATA IN BRAZIL

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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.

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EXCITATION FUNCTIONS AND ISOMER RATIOS IN THE $^{89}Y(^{3}He,3n)^{89}Nb$ REACTION

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The $^{89}Y(^{3}He,3n)$ reaction yields an isomeric pair characterized by the following nuclear properties[1]; ^{89A}Nb, $t_{1/2}$ = 1.10 h, s = - 1/2 and ^{89B}Nb, $t_{1/2}$ = 2.03 h, s = + 9/2. Which one is the ground or the metastable state it is not yet known due to the lack of transitions between the members of the pair. Auler et al.[2], and Cabral et al.[3] studying ^{93}Tc and ^{91}Mo, respectively, observed as a systematic behavior that, after an initial fall the isomeric ratio increases as the energy of the bombarding particles decreases below a certain value.

To explain this behaviour, Auler and col.[2] suggested that, in the mentioned isomeric pairs since the ground state is the state of high spin, in the last stage of de-excitation by a neutron cascade it is easier for the decaying mealei to populate the state of lowest energy (high spin) with a small exchange of angular momentum in transitions in which the centrifugal barrier is low.

To test this hypothesis, it was decided to measure the excitation function and isomer ratios of ^{89}Nb (whose levels have the same spins as those of ^{93}Tc) produced in the reaction $^{89}Y(^{3}He,3n)^{89}Nb$.

Y_2O_3, powder pressed between aluminum foils, and metallic Y foils were irradiated with ^{3}He accelerated in the IEN CV-28 cyclotron and preliminary results are shown in Figs. 1 and 2. Irradiation at energies lower than 21 MeV are being now carried out, as well as investigations to clear out the discrepancies observed when the targets are Y_2O_3 or metallic Y.

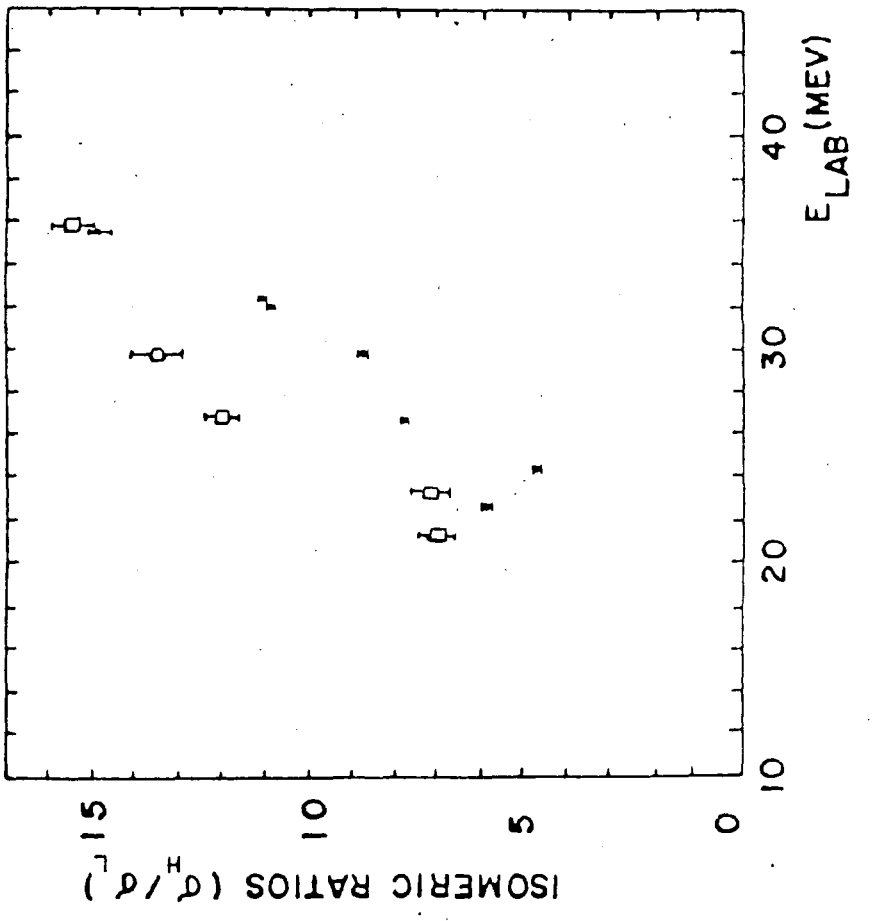
ISOMERIC RATIOS (σ_H/σ_L)
0
5
10
15
10
20
30
40
E_{LAB}(MEV)

Fig. 2

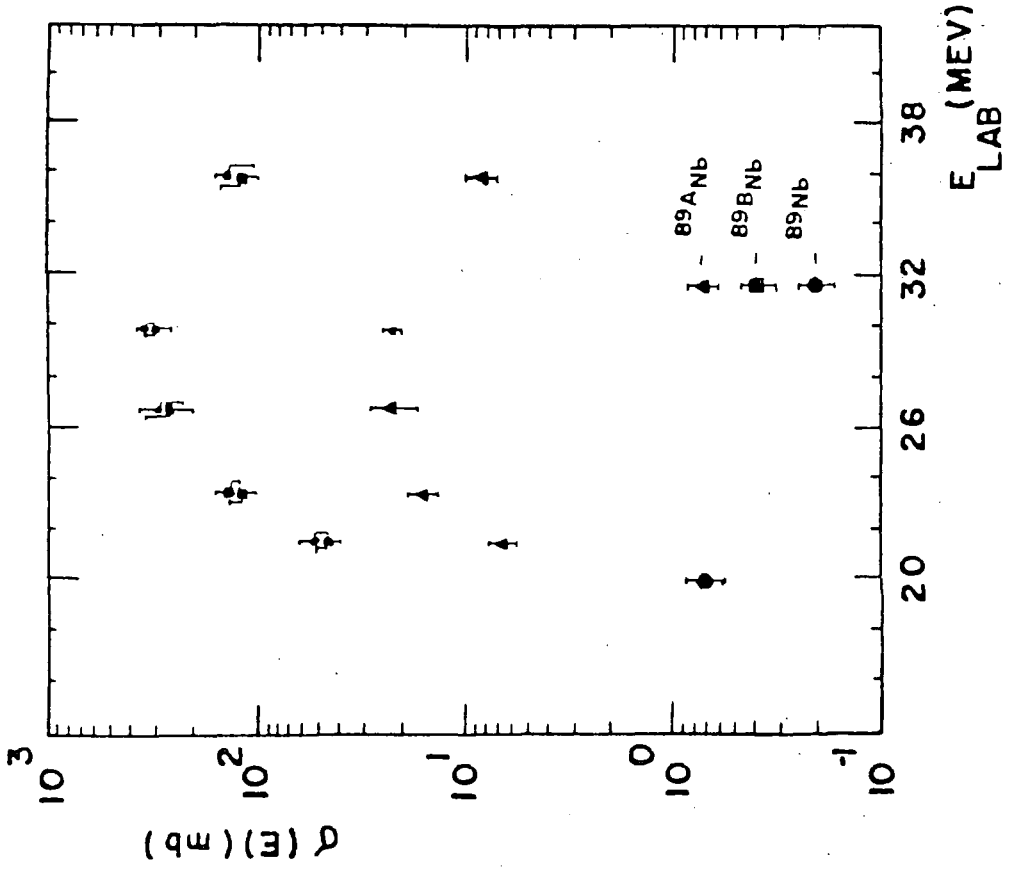
σ (E) (mb)
10^{3}
10^{2}
10^{1}
10^{0}
10^{-1}
20
26
32
38
E_{LAB}(MEV)
^{89A}Nb
^{89B}Nb
^{89}Nb

Fig. 1

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FISSION PRODUCT YIELDS AND DECAY SCHEMES IN ACTINIDES FISSION INDUCED BY CHARGED PARTICULES.

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The research project has been commenced by studying the ^{238}U fission by 20 Mev protons. UF_4 targets are bombarded with the CV-28 variable energy cyclotron external proton beam and the recoiling fission products are quickly transported, from the irradiation chamber to the counting station, in a helium jet transport system.

Detection of the fission product gamma rays is carried out in a hyper-pure Ge detector and the spectra are accumulated in a microcomputer - MCA LeCroy 3500. Analysis and spectra resolution is performed with the Gamalta computer programme at the CNEN Cii Honeywell Bull computer.

Identification of the fission products is done taking into account the energy of their gamma rays and their half-lives, which are measured accompanying the radioactive decay for an appropiate length of time. In preliminary experiments, of short time irradiations and short time counting periods, about 170 γ-rays have been sorted out and assigned - only for their energies - to 56 fission products.

GAMMA-RAY AND NEUTRON LIGHT OUTPUT OF A NE-213 DETECTOR

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The light output of a NE-213 scintillator detector (1,5" lenght by 1,5" diam.) for gamma-rays and neutrons has been measured. The output for Compton electrons as obtained using calibrated gamma-ray sources is linear as expected. The non-linear proton recoil response was measured in the energy range from 2 MeV to 16 MeV using monoenergetic neutrons from the $T(p,n)^3He$ and $D(d,n)^3He$ reactions. Strict control of experimental parameters has allowed neutron energy determinations with low errors. Data points were fitted in the whole energy range by a third degree polynomial.

Precise knowledge of this response is of fundamental importance as input data in the Monte Carlo computer code NRESP[1] which will generate a number of responses to monoenergetic neutrons for use in the unfolding code FANTI[2]

The accompanying figure shows the light output as function of energy both for electrons and for protons. One light unit has been set arbitrarily egual to one for a 1 MeV Compton electron. Limitations in our experimental set-up has prevented to go below 2 MeV protons.

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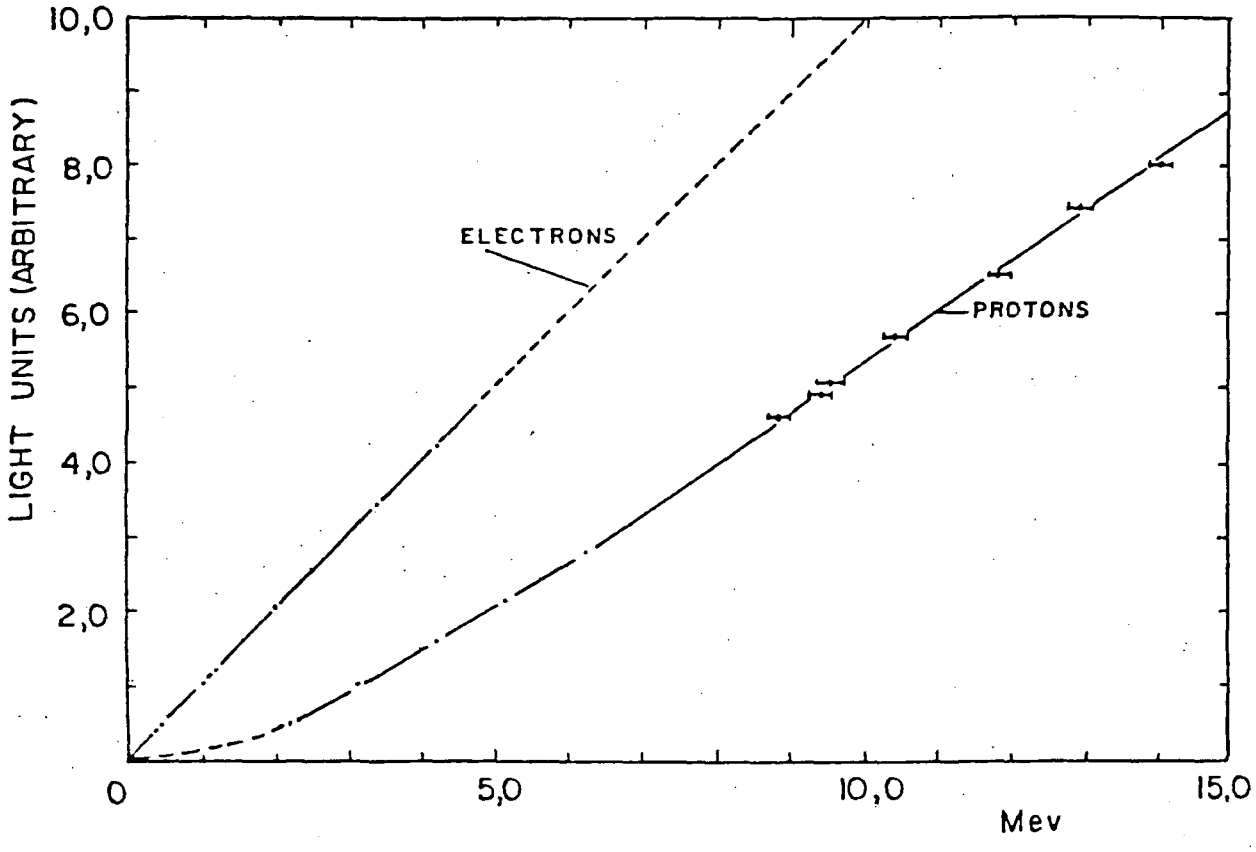

Light output response of NE213 for electrons and protons.

DOUBLE DIFFERENTIAL NEUTRON EMISSION SPECTRA OBTAINED BY A DOUBLE GAMMA DISCRIMINATION TECHNIQUE

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Renewed interest in nuclear level density measurements has recently aroused[1] due to the possibility of using modern methods of data acquisition and analysis. Double differential continuum neutron emission spectra, mainly through a method pioneered by Grimes[2] is now used to obtain precise values of the level density parameter.

TOF is the technique of choice for this type of measurement but an alternative technique can be used by laboratories, such as our own, where the full equipment necessary for TOF is not available. The technique devised consists in a double gamma-ray discrimination of the NE-213 detector output pulses to get a pure neutron spectra. The gamma-rays are discriminated, once by the pulse shape analysis method, and once by a time correlation of the detector pulses with the cyclotron RF. Gamma-rays which have escaped pulse shape discrimination are further discriminated by the time correlation since their flight time is well separated from the neutron flight time. A pure neutron light spectrum will result from the detector pulses which satisfy three requirements: 1) being above a certain threshold; 2) having a certain pulse shape; and 3) having a certain time correlation with the RF.

Comparison of the energy resolution obtainable by the technique just described[3] (which necessarily requires spectra unfolding) with TOF energy resolution estimated from data of published work[4] has shown that under certain conditions this technique can give results as good as, or even better, than conventional TOF.

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PHOTODESINTEGRATION OF ^{233}U AND ^{239}Pu NEAR SHRESHOLD

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The photofission and photoneutron cross section are being measured using neutron capture gamma rays produced in several targets. The range of gamma rays energies is from 5.43 MeV to 10.83 MeV.

The phofission fragments are recorded by a solid state nuclear track detector, Makrofol. The neutrons produced in (γ,n) and (γ,f) reactions are detected by a "long counter" with 60 ^{3}He detectors disposed in a polythene cube.

The samples, in oxide form, are deposited in titanium plates. The ^{233}U total mass is 51,4 mg and the ^{239}Pu mass is 51,4 mg, both were supplied by the IAEA.

Few data are available on these parameters and it is very important that some results be obtained near threshold.

MEASUREMENTS OF THE GROUND STATE SPONTANEOUS FISSION HALF LIFE FOR THE ISOTOPES: ^{233}U, ^{235}U, ^{238}U, ^{237}Np AND ^{239}Pu.

Luiz Paulo Geraldo and Marilia T.F. Cesar

Studies of spontaneous fission half lives for odd-A nuclei have shown a deviation from the even-even nuclei systematics by orders of magnitude. However it has been possible to obtain a measure of this retardation of spontaneous fission rates for odd-A nuclei by defining a hindrance factor analogous to that employed in α-decay systematics. Unfortunately the experimental data available on this parameter are still limited and with much uncertainties to have a clear idea of this behaviour for odd-A nuclei.

On this project a systematic investigation of spontaneous fission for odd-A nuclei has been undertaken, in a effort to obtain a comprehensive picture of the phenomenon for these nuclei.

Measurements of the ground state spontaneous fission half life for the isotopes $^{233,235,238}U$, ^{237}Np and ^{239}Pu are being simultaneously performed by the fission track registration technique in Makrofol KG(8μ). The experimental procedure consist in irradiating the Makrofol foils in contact with the fissile samples by a period of about one year. In order to minimize the interferences by cosmic ray induced reactions, the fissile samples together the Makrofol foils, were shielded by 30 cm boron (5 wt%) water.

The spontaneous fission half life for ^{238}U is known, at the present moment, with an uncertainty of about 1%. So, the present measurement for this nucleus will be also useful as an experimental consistence test for the other results of this work.

DIRECTIONAL CORRELATION MEASUREMENTS OF GAMA TRANSITIONS IN ^{101}Tc

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The directional correlation of coincident gamma transitions in ^{101}Tc have been measured from the β^- decay of ^{101}Mo ($T_{1/2}$ = 15 min). Radioactive sources of ^{101}Mo were produced by the irradiation of ^{100}Mo (97% enriched) with neutrons from IEA-R1 reactor in a flux of approximately 5 X 10^{12} n/cm^{2}s.

A total of fifteen gamma cascades in ^{101}Tc were studied using either a Ge(Li)-NaI(Tl) or a Ge(Li)-Ge(Hp) spectrometer. Spin values for the majority of levels involved have been determined or confirmed. Multipole mixing ratios δ(E2/M1) for fifteen γ-transitions have also been determined.

PHOTOFISSION OF ^{209}Bi IN THE ENERGY RANGE 30-250 MeV

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and

Laboratory of Nuclear Science, Tohoku University, Sendai, Japão

The electrofission cross section $\sigma_{e,f}$ of ^{209}Bi was measured from 30 to 250 MeV, using the electron beam of the Tohoku University (Japan) Linear Accelerator - the raw data were analized at São Paulo. The photofission cross section was deduced from the electrofission data by means of the virtual photon technique. The deduced fission probability P_f of ^{209}Bi shows a strong dependence with the nuclear excitation energy — for example, P_f changes 6 orders of magnitude from 50 to 250 MeV. Above the photopion threshold (~ 140 MeV) the photoexcitation mechanism leading the ^{209}Bi to fission can be described by the Levinger's Modified Quasi-Deuteron model.

FAPESP, CNPq, FINEP

PHOTOFISSION OF ^{237}Np IN THE ENERGY RANGE 6-60 MeV

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The photofission cross section $\sigma_{\gamma,f}$ of ^{237}Np, in the energy range 6-60 MeV, was deduced from the unfolding of the bremsstrahlung-induced fission cross section $\sigma_{B,f}$. The cross section $\sigma_{B,f}$ was measured with the electron beam of the University of São Paulo Linear Accelerator. Our (γ,f) cross section of ^{237}Np agrees well with the data from Livermore, obtained with monoenergetic photons in the energy range 6-18 MeV. There are no (γ,f) data for ^{237}Np above 18 MeV, so, this work represents the first experiment in this energy region. The integrated (γ,f) cross section from threshold to 60 MeV is (3.8 ± 0.2) b.MeV, and the relative fission probability of ^{237}Np is nearly 100% at 30 MeV and above.

FAPESP, CNPq, FINEP

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The current activities of CDN 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 ^{232}Th and ^{56}Fe is under way. The more recent data available in literature have been added to those from the EXFOR files. Optical model analysis has been performed with JUPITOR, CIRCE and SCAT2 codes. In the low energy region, the Hauser-Feshbach calculations are being performed with the POLIFEMO code using the coupled channel transmission coeficients obtained from the optical model analysis. The GNASH and STAPRE codes will be employed to analyze the higher energy region. The higher excited states of ^{56}Fe, and possibly ^{232}Th, will be analyzed through DWBA calculations.

The resonance data analysis will be undertaken once the analysis of the continuum is complete.

2. Multigroup Processing

CDN is presently engaged in developing an advanced code for generation of group constants for fast reactor applications. The code proposes to generate pointwise neutron spectrum in a fast reactor cell using the transport equation along with the interface current concepts.

The code uses a reconstructed pointwise cross section library previously prepared. The first phase dealing with the calculation of the source terms through processing the ENDF data is complete. Procedures and routines for the solution of the transport equation are being developed.

An updated library for the HAMMER system for the calculation of thermal reactor cells is being prepared and tested. An extensive intercomparison of several codes that process the ENDF data was realized with a view to rectifying the errors observed in the codes ETOG and FLANGE. Completion o this work is expected shortly.

An ENDF/B-4 based library is being prepared also for the XSDRN code for cell calculations using transport theory.

3. Integral Analysis

Procedures and software developed for sensitivity analysis using diffusion theory are being employed in the analysis of the fast reactor design parameters. The sensitivity analysis package employing transport theory - FORSS, is also being utilized in the analysis of fast reactor benchmark problems.

4. The Data Bank

The Data Bank has added to its collection several new multigroup libraries. These are now available to acreditted users.

Qualification of the actinides in the INDL, ENDL, ENDF/B-4 and ENDF/B-5 (dosimetry) files through numerical and graphical comparison of the cross section and resonance integrals is in its final phase. This is being performed as a part of a Coordinated Research Project of the IAEA/NDS.