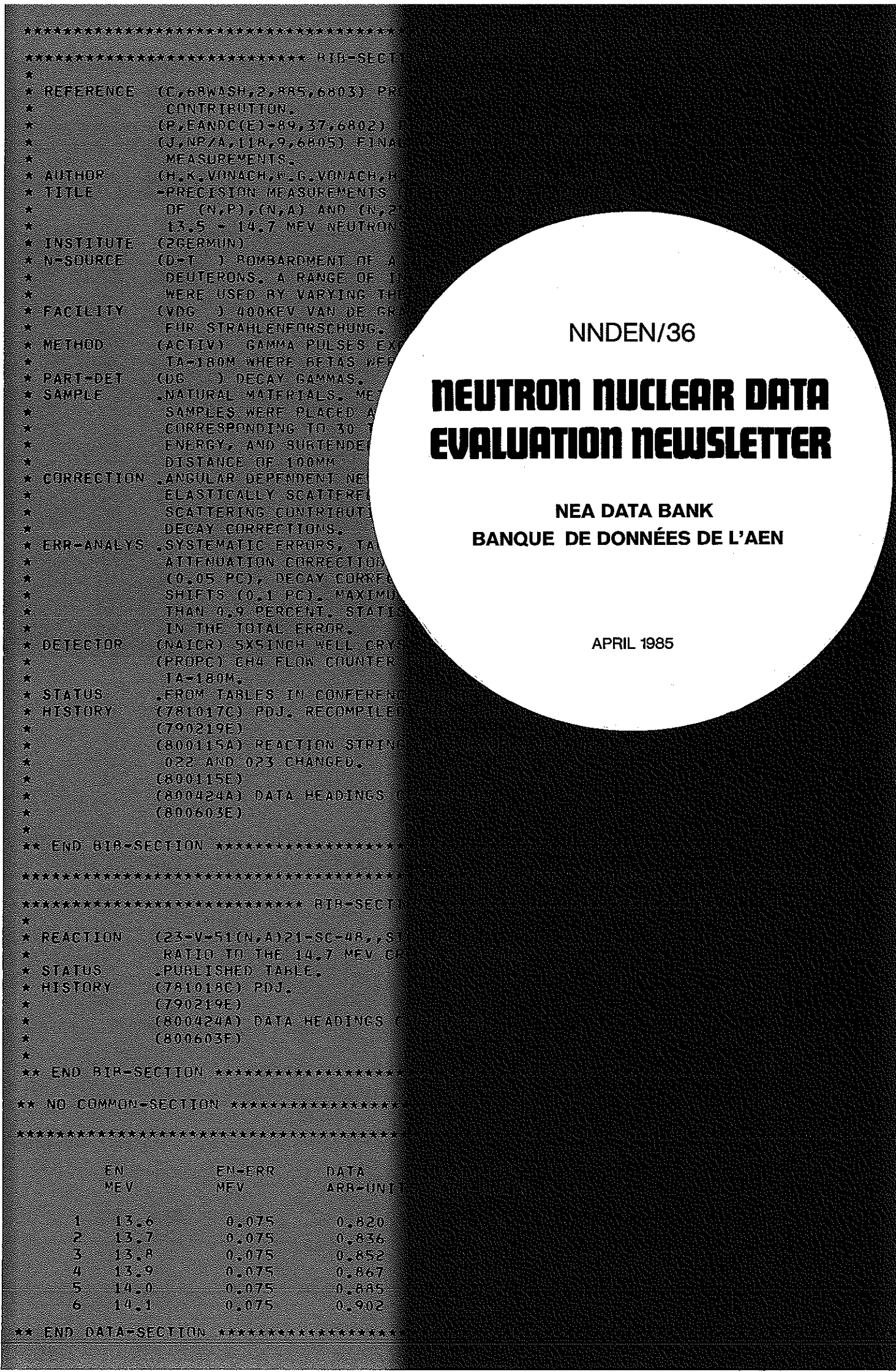

NNDEN/36

NEUTRON NUCLEAR DATA EVALUATION NEWSLETTER

NEA DATA BANK
BANQUE DE DONNÉES DE L'AEN

APRIL 1985

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NEUTRON NUCLEAR DATA EVALUATION NEWSLETTER

NNDEN/36

The Newsletter reports:

1. Evaluation work on particular nuclides.
2. Development of codes for nuclear model calculations, and other codes needed for nuclear data work.
3. Publications relevant to the neutron data field.

Contributions on evaluation activities and nuclear model codes have been received from:

This issue was originally scheduled for publication in December 1984, when it was also hoped to announce the completion of the JEF-1 file assembly and benchmark testing phase. The JEF work took longer to finish than we had expected, and the pressure to complete JEF-1 is at least partly responsible for the delay to NNDEN-36. We apologise, but we are now able to announce that the JEF-1 file is being distributed to participants in the project.

The next issue of NNDEN has been scheduled for December 1985, and contributors are asked to send in their reports by 31st October 1984.

NEA Data Bank, April 1985

1. NEW EVALUATIONS COMPLETED A) IN PROGRESS B), OR PLANNED IN THE NEAR FUTURE C)

NUCLIDE	DATA TYPE	ENERGY RANGE	PAGE A	PAGE B	PAGE C
Li-6	(n,t),(n,n)		22		
Be-9	(n,2n)		13		
B-10	many	0.0253eV -20MeV	16		
B-10	(n,α_0), (n,$\alpha_1\gamma$) (n,n)		22		
C-12	many	10^{-5}eV-20MeV	13		
Al	many			12	
Si	many			12	
Cr	many	10^{-5}eV-20MeV	12		
Fe-Nat	many				16
Ni-Nat	many	1KeV-500KeV	3		
Zr-Nat	many	1KeV-20MeV	16		
Mo	many	14.5MeV	23		
Mo-Nat	many	1KeV-20MeV	16		
Ru-101	many		15		
Ru-102	many			15	
Ru-104	many			15	
I-129	many		15		
Ta-181	many	1KeV-20MeV	16		
W-Nat	many				16
Au-197	many	1KeV-20MeV	16		
Au-197	(n,γ)		22		
Pb-Nat	many				16
Pb-Nat	many	10^{-5}eV-20MeV	4		
Th-230	(n,γ)		17		
Th-232	many	10^{-5}eV-20MeV			8
Pa-231	many			17	
Pa-231	(n,γ)		17		
U-234	decay data		17		
U-239	many			17	
U-235	(n,F)		22		
U-238	(n,γ),(n,F)		22		
U-233	many	10^{-5}eV-20MeV			8
Np-237	n,2n		3		
Pu-239	many	10^{-2}eV-660eV	3		
Pu-239	many	660eV-4KeV	3		
Pu-239	(n,2n)		3		
Pu-239	γp	10^{-5}eV-20MeV			
Pu-239	(n,F)		22		
Cm	many	10^{-5}eV-20MeV	12		
Cm-246	many		13		
Cm-247	many		13		
Bk-249	many	10^{-5}eV-20MeV			14
Cf-249	many	10^{-5}eV-20MeV			14

CONTRIBUTION A NNDEN 36

CEN, Bruyères-le-Châtel, France

- Work recently completed and publications :

  - Structure of low-lying states of ^{76,78,80,82}Se deduced from $(\vec{p},p')$ scattering at 16 MeV,
    J.P. DELAROCHE et al.,
    Nucl. Phys. A414 (1984) 113.

  - Complex spin-orbit potential for ^{208}Pb(n,n)^{208}Pb at 10 MeV,
    J.P. DELAROCHE et al.,
    Phys. Rev. C28 (1983) 1410.

  - Spin-orbit potential properties derived from measurements of analyzing powers for neutron scattering from ^{54}Fe and ^{65}Cu,
    C.E. FLOYD et al.,
    Phys. Rev. C28 (1983) 1498.

  - Cross sections and analyzing powers for fast neutron scattering to the ground and first excited states of ^{58}Ni and ^{60}Ni,
    P.P. GUSS et al.,
    Accepted for publication in Nuclear Physics.

  - Strong coupling and isospin effects in neutron scattering from ^{78,80}Se,
    R.G. KURUP et al.,
    Nucl. Phys. A420 (1984) 237.

  - Further extensions of the collective model for inelastic scattering from deformed nuclei,
    J.P. DELAROCHE et al.,
    Submitted to Nuclear Physics.

  - Nucleon-induced excitation of collective bands in ^{12}C,
    A.S. MEIGOONI et al.,
    Submitted to Nuclear Physics.

  - Semi-microscopic calculations of elastic, inelastic, and total neutron scattering by ^{239}Pu,
    Ch. LAGRANGE, D.G. MADLAND*, M. GIROD,
    GLOUSTER Conf., September 1984.

* LOS ALAMOS (USA)

- On the transofmration of angular scattering probabilities between reference systems,
  O. BERSILLON, A. SCHETT, B. CAPUT,
  Atomkernenergie Kerntechnich Vol. 45 (1984) n° 3.

- Calcul précis de l'angle moyen de diffusion du décrément logarithmique et de son carré moyen,
  O. BERSILLON, B. CAPUT,
  Note CEA-N-2393 (1984).

WORK IN PROGRESS :

- Calculations of neutron scattering cross sections based on IBA-2 model for some Os and Pt nuclei,
  J.P. DELAROCHE.

- Analysis of polarized neutron scattering from ^{40}Ca,
  J.P. DELAROCHE.

- Calculation of neutron scattering cross sections from Sn isotopes,
  J.P. DELAROCHE.

- Coherent optical and statistical model calculations of neutron cross sections for Gd isotopes,
  J.P. DELAROCHE, Ch. LAGRANGE.

- Calcul numérique des sections efficaces dans le domaine des résonances non résolues
  C. BERAT*, O. BERSILLON.

* Stagiaire Universitaire.

Contribution to NNDEN

H. DERRIEN, E. FORT, P. LONG (CEN Cadarache)

- WORK RECENTLY COMPLETED

  - Evaluation of ^{239}Pu neutron cross sections in the resolved resonance region from thermal to 660 eV (H. DERRIEN).

  - Evaluation of ^{239}Pu neutron cross sections in the unresolved region: 660 eV - 4 KeV. The average cross sections have been evaluated in 56 energy intervals from the available experimental data. The average parameters have been obtained in each interval from statistical model calculations using the FISINGA code (H. DERRIEN).

  - Reevaluation of natural Nickel neutron cross sections in the resonance region up to 500 KeV, taking into account the ORNL experimental results for ^{60}Ni (H. DERRIEN).

  - Reevaluation of ^{239}Pu $(n,2n)_{7}$ cross section to be compared to integral data and reevaluation of ^{237}Np $(n,2n)^{236}$ Np shortlived to take into account recent Russian data (E. FORT).

  - Evaluation of $\bar{\nu}_p$-of ^{239}Pu in the full energy range (E. FORT).

  - Calculation of integral parameters of the LOS ALAMOS bore spheres (JEZEBEL, JEZABEL-Pu, FLATTOP-Pu) with the transport theory and of the experiments R1, R2, R3, Z1, Z2, Z3 from the so-called French R-Z program using Sensitivity calculations in fundamental mode. These calculations have been performed in the context of phase 1 and 2 of JEF1 benchmark testing (E. FORT).

  - Participation to the NEACRP specilists' meeting on methods to treat the unresolved region in neutronics calculations (E. Fort)

- PUBLICATIONS:

  "Status of ^{239}Pu cross section evaluation in the resonance region, at Cadarache" (H. DERRIEN, P. LONG).

  Third Advisory group meeting on transactinium isotope nuclear data, UPSALA, 21-25 May 1984.

GERMAN DEMOCRATIC REPUBLIC

Name: D. Hermsdorf, H. Kalka, D. Seeliger

Address: Technische Universität Dresden
Sektion Physik
Mommsenstr. 13
DDR-8027 Dresden

Work recently completed:

Evaluation of neutron nuclear data for natural Pb for the Soviet Library SOKRATOR in ENDF/B format.

Advantages of this file:

- inclusion of energy-angle differential data for inelastic scattering (proposed File 6 of version VI)
- theoretically and experimentally based charged-particle and γ-ray emission cross sections
- inclusion of covariance matrices (File 33 of version V)

Recent publications:

Proc. Intern. Conf. on Neutron Physics, Kiev, 1983
Proc. Intern. Sympos. Gaussig, 1983

Work in progress:

Systematics of the anisotropy of neutron inelastic scattering at 14 MeV (experiments and theoretical description)

BHABHA ATOMIC RESEARCH CENTRE, TROMBAY, BOMBAY 400 085, INDIA

Names : S.B. Garg, Amar Sinha

Address : Neutron Physics Division
Bhabha Atomic Research Centre
Trombay, Bombay 400 085, India

Recent Publications

1. S.B. Garg, A. Sinha and V.K. Shukla; Evaluation of Neutron Cross-Sections for Thorium Fuel Cycle Elements, Work summarized in Reports NDE(BARC)-5, NDE(BARC)-6, NDE(BARC)-7, NDE(BARC)-8, NDE(BARC)-9, NDE(BARC)-12 (1982)

2. S.B. Garg, V.K. Shukla and A. Sinha; Multiparticle Reaction Cross-Sections of V, Mn, Fe, Cr & Ni, Nuclear Physics and Solid State Physics Symp., Varanasi, India, (1982)

3. S.B. Garg; Binary and Tertiary Reaction Cross-Sections of V,Cr,Mn,Fe, Ni,Cu, Zr,Nb, Mo, Ta,W, Pt and Their Isotopes, BARC-1155 (1982)

4. S.B. Garg and A. Sinha; Preequilibrium Particle Emission Spectra and Multiparticle Reaction Cross-Sections of Niobium, Nuclear Phys. and Solid St. Phys. Symp., MYSORE, India (1983)

5. S.B. Garg and A. Sinha; Proton and Alpha Particle Induced Reaction Cross-Sections of Carbon, Cobalt and Lead, International Nuclear Model Comparison Study Sponsored by NEA Data Bank, France (1983)

6. S.B. Garg and A. Sinha; BARC35-A 35 Group Cross-Section Library with P_3-Anisotropic Scattering Matrices and Resonance Self-Shielding Factors, BARC-1222(1984)

Work Recently Completed

1. Criticality Analysis of Some Selected Fast Multiplying Assemblies Using BARC35 Cross-Section Library.

2. Multigroup Photon Interaction Cross-Sections with P5-Anisotropic Scattering Matrices for 44 Elements

Work in Progress

Development and commissioning of computer codes required in the neutronics studies of accelerator-breeder spallation based concept.

Work Planned for the Future

1. Development of computer codes based on intranuclear cascade model to carryout cross-section studies in the high energy regions for accelerator-breeder applications.

2. Intercomparison of various preequilibrium and statistical models in determining the particle emission spectra and their angular distributions.

Computer Codes

1. STAPRE and SCAT2 codes obtained from IAEA have been added to our galaxy of codes employed for evaluating basic cross-sections using nuclear theory.

2. A code system to generate multigroup cross-sections for reactor and other scientific applications has been developed. Both neutron and photon multigroup cross-sections can be generated. Capability also exists for evaluating atomic displacement cross-sections used in the radiation damage studies.

REACTOR RESEARCH CENTRE, KALPAKKAM, INDIA

Names: S. Ganesan, M.M. Ramanadhan, V. Gopalakrishnan, R.S. Keshavamurthy

Address: Reactor Engineering Design Group
Reactor Research Centre
Kalpakkam 603 102
Tamil Nadu, India

Work recently completed

- Sensitivity studies with pre-processing codes have revealed that the temperature derivative of self shielded cross sections is significantly affected by interpolation error used in LINEAR-RECENT-SIGMA1 codes.

- Production of Indian Evaluated Nuclear Data File for Th-232 under Co-ordinated Research Programme of IAEA. The data for resolved resonance region is taken from JENDL file.

- Generation and comparisons of different complete multigroup cross section sets for Th-232. Different sets were derived from 1. ENDF/B-IV, 2. JENDL-1, 3. INDL/A-83 Rumanian file, 4. Indian file, 5. Adjusted 1969 French set.

- Analysis of THOR - a Pu fuelled thorium reflected fast critical assembly using five different multigroup sets for thorium.

- Commissioning of code RECOIL for calculations of displacement damage cross sections.

- Generation of multigroup sets using Kalpakkam processing code system for B-10, B-11, Sb-121 and Sb-123 from ENDF/B-IV files.

Work in progress:

- An assessment of available multigroup libraries for Fe, Cr and Ni, the structural elements and nuclear data status for fast reactor applications.

- Collapsing of covariance error matrix data from fine energy groups to broad energy groups.

Publications

1) S.Ganesan, V.Gopalakrishnan and M.M.Ramanadhan 'Problems and Experiences in Nuclear Data Processing in Developing Countries' Progress in Nuclear Energy (1984) In Print.

2) S.Ganesan, M.M.Ramanadhan, V.Gopalakrishnan and R.S.Keshavamurthy 'A Programme of Evaluation, Processing and Testing of Nuclear Data for Th-232'. Paper presented at Third IAEA Advisory Group Meeting on Transactinium Isotope Nuclear Data, Gustaf Werner Institute, University of Uppsala, Sweden, 21-25 May 1984.

3) S.Ganesan et al:, 'Effect of Interpolation Error in pre-processing Codes on Calculations of Self Shielding Factors and their Temperature Derivatives' (September, 1984) Preliminary Note.

Work Planned

Work under Co-ordinated Research Programme of IAEA on Validation and Benchmark testing of actinide nuclear data:-

1. Presentation of a compilation of details of specific integral experiments and measured integral values of parameters including uncertainties for benchmark testing purposes for Th-232 and U-233.

2. Updating of Indian Evaluated Nuclear Data File for U-233 and Th-232 in ENDF/B format.

E.N.E.A. - Centro Ricerche Energia "Ezio Clementel"
Laboratorio Dati Nucleari e Codici
Divisione Fisica e Calcolo Scientifico
Dipartimento Tecnologie Intersettoriali di Base
Via Mazzini, 2 - 40138 Bologna, Italy
tel. 051/498111 - telex 511578 ENEABO I

Names: V. Benzi, F. Fabbri, G. Longo, G. Maino, E. Menapace, G.C. Panini, M. Pescarini, G. Reffo, M. Rosetti, F. Saporetti, M. Vaccari, A. Ventura.

Publications

1) G. Maino, A. Ventura, "NBCS approach to the effective boson number in the interacting boson model", Lett. Nuovo Cimento 39, 89 (1984).

2) G. Reffo, "Particle and gamma-ray spectra calculations for the structural material in fission and fusion technology", Invited paper, Proceedings of the IAEA (UNESCO) Advisory Group Meeting on Structural Material, Vienna, Nov. 2-4, (1983), IAEA Report INDC(NDS).

3) G. Reffo, "Total gamma ray spectra and isomeric ratio calculations in thermal and fast neutron capture for U-238, Pu-240, -242 and Am-241", invited paper, at the 3rd IAEA advisory group meeting on "Transactinium Isotopes Nuclear Data", Uppsala, Sweden, May 21-25, 1984 and ENEA report in press.

4) K. Wisshak, F. Kaeppeler, R.L. Macklin, G. Reffo, F. Fabbri, "Neutron capture in s-wave resonance of Ni-64", extended version report KfK 3582, 1983. Reduced version in Nucl. Sci. Eng./87(1984)48.

5) K. Wisshak, F. Kaeppeler, G. Reffo, F. Fabbri, "Neutron capture in s-wave resonances of Fe-56, Ni-58, Ni-60", extended version report KfK 3516, 1983. Reduced version in Nucl. Sci. Eng. 86(1984)168.

6) G. Maino, A. Ventura, L. Zuffi and F. Iachello, "Properties of giant resonances in the interacting boson model", Physical Review C 30, 2101(1984).

7) L. Zuffi, G. Maino and A. Ventura, "Interacting boson description of the giant dipole resonance in the lanthanide region" contr. to Fifth Intern. Symp. on Capture Gamma-Ray Spectroscopy and related topics, Knoxville, Sept. 10-14, 1984.

8) F. Saporetti and R. Guidotti, "Finite-range nucleon-nucleon in the radiative capture of fast nucleons", Nucl. Phys., A431(1984)288.

9) G. Longo, F. Fabbri, C. Mazzotti, "Angular distributions of photons following the capture of 4-50 MeV neutrons", Proc. 6th Kiev Conference on Neutron Physics, Kiev (URSS), October 2-6, 1983, vol. 1, p. 277, Moscow (1984).

10) G. Reffo, C. Costa, F. Fabbri, "Effect of refraction and bound nucleon-nucleon scattering in preequilibrium angular distribution of (n,n') reactions", contribution to the 1984 Europhysics Study Conference on Nuclear Reactions. Crete-Greece, June 24-29, 1984 and ENEA report in press.

11) G. Reffo, F. Fabbri, not for publication.

12) R.R. Winters, F. Kaeppeler, K. Wisshak, G. Reffo, A. Mengoni, "Stellar neutron capture rate of Sm-148,-149,-150", report KfK 3827, Nov. 1984.

13) G. Reffo, "Target thermalization effect in OS-187 Neutron Capture", contributed paper to the 5th Int. Symp. on "Capture gamma ray sepctroscopy and related topics", Knoxville, Tenn. (USA), Sept. 10-14, 1984.

14) M. Herman, A. Marcinkowski, G. Reffo, "Fast neutron capture on IR isotopes", Acta Phys. Polonica, vol. B16, N. 1, in press.

15) G. Walter, B. Lengers, F. Kaeppeler, G. Reffo, F. Fabbri, "KeV-neutron capture cross sections of Krypton Isotopes" KfK report in press and submitted to Nucl. Sci. and Eng.

16) V. Benzi, "The (alfa,n) neutron yield and energy spectrum in oxide nuclear fuels", contributed paper to 3rd Advisory Group Meeting on transactinium isotope nuclear data. Uppsala, Sweden, 21-25 May, 1984.

17) G. Maino, M. Rosetti, M. Vaccari and A. Ventura, "Evaluation of Cm-248 neutron cross sections from 10^{-5} eV to 15 MeV", ENEA report RT/TIB/84/9 and INDC report INDC(ITY)-10, March 1984.

18) G. Maino, E. Menapace and M. Vaccari, "Complete evaluations of neutron nuclear data for Cm isotopes", contr. to IAEA Third Advisory Group Meeting on Transactinium Isotope Nuclear Data, Uppsala, Sweden, May 21-25, 1984.

19) F. Kaeppeler, K. Wisshak, G. Reffo, "The capture width of the 34.8 KeV s-wave neutron resonance in Al-27", accepted by Nucl. Sci. and Eng., 1984.

Work in progress or recently completed

I. Model and Methods

1) Nuclear Structure Models

a) Level density: energy and parity distributions of nuclear excited states have been investigated in the frame of a microscopic Nilsson-BCS formalism; preliminary results have been obtained for spherical nuclei in the mass range $48 \leq A \leq 65$ and for deformed nuclei in the lanthanide and actinide regions.

b) IBA model: calculations of collective spectra for even-even Nd and U isotopes have been performed in the frame of the interacting boson model. A microscopic Nilsson-BCS approach has been developed in order to estimate the effective number of valence bosons to be introduced in actual calculations (1).

2) Nuclear Reactions

a) Models for photon production and interaction data calculations.

- A model has been developed concerning E_1, M_1, E_2 gamma-ray cascades following particle capture and emission. Gamma-ray spectra, isomeric ratios and angular distributions can be estimated. Valence contribution in a interference term with C.N. capture is also included . (2,3,4,5)

- An extended version of the interacting boson model has been formulated for estimating giant resonance properties. Gamma-ray absorption and scattering calculations in the giant dipole resonance region were initiated with regard to Nd, Sm, Th and U nuclei. (6,7)

- The effect of the finite range nucleon-nucleon interaction has been investigated in the nucleon radiative capture process. (8)

- Direct-semidirect model calculations of 10 to 5 MeV photon production and angular distributions by neutron radiative capture were complet for Ca-40 and Sn-120. (9) Extension to further structural materials is in progress.

b) Preequilibrium: the effects have been investigated of nucleon reflection and refraction at the nuclear surface, as well as of the bound nucleon-nucleon scattering in the unified model for equilibrium and preequilibrium emissions with angular momentum conservation. (10)

c) Codes: the master code IDA (11), a modular system of codes for reaction data calculations of any particle induced reaction up to 50 MeV, has been improved, with account for nucleon reflection and refraction and bound nucleon-nucleon scattering in the preequilibrium cascades.

3. Evaluation

a) Fission products and isotopes for various technological applications

- Neutron capture cross sections have been measured and/or theoretically estimated for the following targets: Se-76,-78, -79,-80, Br-79,-81, Kr-78,-79,-80,-81,-82,-83,-84 (1KeV≤En≤1000 KeV), Sm-148,-149,-150 (1KeV≤En≤100 KeV), Os-127 (1KeV≤En≤70 KeV), Ir-191,193 (300 KeV≤En≤1.3 MeV) (refs. 12,13,14,15).

b) Actinides

- Model methods and results of recent theoretical investigations on neutron induced reactions for actinides have been reviewed at Uppsala IAEA-AGM on Actinide data, May 1984. (3)

- (alfa,n) reactions in fuel oxides have been theoretically investigated, in the energy range of interest for fission reactor purposes, and presented at the same IAEA-AGM. (16)

- Evaluations of neutron nuclear data for Cm isotopes were completed according to ENDF/B-V format and discussed as contribution to the same IAEA-AGM. (17,18)

c) Structural materials

- Neutron cross sections of Cr isotopes of relevance for fast reactor applications were evaluated in ENDF/B-V format.

- Neutron cross section data revision for Al and Si isotopes, relevant for fusion reactor studies, have been undertaken. The capture width of 34.8 KeV s-wave neutron resonance for Al-27 has been determined by combined experimental and theoretical methods. (19)

4. Activity on data management and processing

a) NJOY system has been successfully tested and used for producing different group libraries. The work is in progress for MATXS format data generation and interfacing.

b) VITAMIN-C library has been processed through AMPX-II modular system for the application to shielding calculations of PEC fast reactor. Similar processing is underway according to nuclear industry request and fusion reactor studies.

c) Processing through FOURACES code of:
   - activation data from the international dosimetry files for thermal power reactor purposes;
   - fission product and actinide data required for PEC fast reactor project;
   - Cu (ENEA evaluated file) data for fast TAPIRO facility applications.

Contribution to Neutron Nuclear Data Evaluation Newsletter-36

Japanese Nuclear Data Committee
(Nuclear Data Center, JAERI)

Work Recently Completed and Publications:

(i) Evaluation of Neutron nuclear Data for ^{12}C
Keiichi SHIBATA

(JAERI-M 83-221(1983))

Neutron nuclear data of ^{12}C have been evaluated for JENDL-3 in the energy range from 10^{-5} eV to 20 MeV. Evaluated quantities are the total, elastic and inelastic scattering, radiative capture, photon-production, (n,p), (n,d) and (n,α) reaction cross sections and the angular or energy distribution of neutrons and photons. The total cross section below the threshold energy of the inelastic scattering has been calculated on the basis of the R-matrix theory. Three discrete levels have been taken into account for the inelastic scattering.

(ii) Evaluation of Neutron Nuclear Data for ^{246}Cm and ^{247}Cm
Yasuyuki KIKUCHI

(JAERI-M 83-127(1983))

Neutron nuclear data of ^{246}Cm and ^{247}Cm have been evaluated. Evaluated quantities are the total, elastic and inelastic scattering, fission, capture, (n,2n), (n,3n) and (n,4n) reaction cross sections, the resolved and unresolved resonance parameters, the angular and energy distributions of the emitted neutrons, and the average number of neutrons emitted per fission. The fission cross section was evaluated mainly on the basis of measured data. The other cross sections were calculated with the optical and statistical models because of scarce measured data. Discussion is given on the nuclear model calculations.

Work in Progress:

(i) Neutron-induced fission cross sections of 24 actinide nuclides are analyzed by means of the double-humped barrier model. The deduced barrier heights are interpreted in terms of a two-part approach, in which the barrier heights are decomposed into liquid-drop and shell correction parts.

(from T. Ohsawa, KYU)

(ii) Evaluation of neutron nuclear data for ^{9}Be is in progress. The (n,2n) reaction cross section is given as a sum of the inelastic scattering and (n,α) reaction cross sections.

(from K. Shibata, JAERI)

Nuclear Model Code:

(i) Two codes FAIR-DDX and DDXPLOT have been developed to calculate the energy-angle double-differential cross sections from a library in the ENDF/B format and compare them with the measured data.

(from Y. Kikuchi, JAERI)

Work Planned for the Near Future:

(i) Evaluation of neutron nuclear data for ^{249}Bk and ^{249}Cf is planned in the energy range from 10^{-5} eV to 20 MeV.

(from Y. Kikuchi, JAERI)

S. Igarasi
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Japan Atomic Energy Research Institute
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Japan

May 10, 1984

NEUTRON NUCLEAR DATA EVALUATION NEWSLETTER-36

ECN-PETTEN, THE NETHERLANDS

1. Names

H. Gruppelaar, H.A.J. van der Kamp, A.J. Janssen, R.J. Heijboer and J.M. Akkermans, Netherlands Energy Research Foundation (ECN), P.O. Box 1, 1755 ZG Petten, The Netherlands.
Telephone: 02246-4083, telex: 57211 REACP NL.

2. Recent publications and reports

|1| H. Gruppelaar, Model calculations of double-differential cross sections, Proc. IAEA Consultants' Mtg. on Nuclear Data for Structural Materials, IAEA, Vienna, November 1983, INDC(NDS)-152/L (1984).

|2| H. Gruppelaar, Nuclear Data for Reactors, Semi-Annual Progress Report, 1st half year 1984, ECN-84-185 (available upon request).

3. Work recently completed (see |2|)

. Second phase of integral-data test of JEF-1 fission-product file (cooperation with CEA-Cadarache).
. Study of inelastic-scattering cross sections in the fission-product mass range.
. New evaluations for ^{129}I and ^{101}Ru.
. File management of European Fusion File (EFF).
. Definition of format for EFF-1 (EC-cooperation).
. Analysis of γ-ray emission in precompound-decay reactions.
. Analysis of precompound-model intercomparison.

4. Work in progress

. Third phase of JEF-1 integral data test (fission products).
. Re-evaluation of neutron cross sections for ^{102}Ru, ^{104}Ru.
. Revision of neutron-emission cross sections in natural lead.
. Assembling the EFF-1 file (release early 1985).
. Study of fundamental aspects of precompound models (transition rates, state densities, relation to hybrid models).
. Improvement of angular-distribution calculations in exciton models.

5. Computer codes

A new code system (GRAPE) for preequilibrium and equilibrium calculations with the exciton model has been completed. The main code GRYPHON and some auxilliary codes will be released in early 1985.

Chinese Nuclear Data Center

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Work recently completed

1) Complete evaluations of neutron nuclear data for ^{10}B, ^{Nat}Zr, ^{Nat}Mo, ^{181}Ta, ^{197}Au in the energy range from 1 keV to 20 MeV (for ^{10}B from 0.0253 eV to 20 MeV) were performed. The evaluated quantities are all possible reaction cross-sections, angular and energy distribution of secondary neutrons.

2) Fission yield for about seventy fission products of ^{233}, $^{235,238}U$, ^{239}Pu and some other.

3) Optical model (including spherical and deformed), direct interaction theory, statistical theory (including H-F theory and evaporation model) and pre-equilibrium theory have been adopted to calculate the data of specified reaction cross-sections; corresponding computer codes have been developed.

4) A computerized evaluation system was developed.

5) The processing codes CHECK4, SUMUP4, LIST4, DICT4, MERGE, RETRIEVAL were put into operation and are used for the work with data file in ENDF/B-IV format.

Work in progress

1) The evaluation of nuclear structure and decay data in cooperation with BNL.

2) The evaluation of neutron nuclear data for actinide in cooperation with NDS/IAEA.

3) Chinese Evaluated Nuclear Data Library CENDL.

Work planned for the near future

Re-evaluation of neutron nuclear data for ^{Nat}Pb, ^{Nat}W, ^{Nat}Fe is planned, the energy range will be extended to thermal energy.

AEE Winfrith

Compiled by R W Smith

1 Nuclear Data Evaluation and Validation

1.1 Fission Product Data (M F James and S Whitworth)

1.1.1 Fission Product Yields

The evaluation programmes by Crouch (recently retired from AERE) have been implemented at Winfrith, and further developed. Using the last database of yield measurements produced by Crouch, a revised evaluation has been made. Two libraries of independent yields and their standard deviations are available in ENDF/B5 format: C4U, containing unadjusted data from a straightforward evaluation of measured yields; and C4A, containing data obtained from a least-squares adjustment, forcing yields to satisfy several conservation laws. Yields of isomeric states are included. Data files will be prepared of the covariance matrices for the adjustment set C4A. A draft report describing the evaluation has been written and testing of the libraries, including comparison with the currently recommended set C3I and with the US ENDF/B5 library is underway.

1.1.2 Decay Heat

Further studies (primarily of the sensitivity of decay heat to branching ratios and to fission product isomer yields) have confirmed the difficulty of explaining all of the discrepancies between calculated and measured decay heat by deficiences in the decay data or yield libraries. Revised calculations using the new yield library C4A will be made shortly.

1.2 IAEA Co-ordinated Research Program on Transactinium Decay Data (A L Nichols)

In support of the IAEA/CRP the decay data evaluation for U234 has been completed and the evaluations for Pa231 and U239 should be available in early 1985.

1.3 Few group capture cross sections of Pa231 and Th230 in FISPIN (R W Smith)

An in-depth review of the three group (thermal, resonance and fast) capture cross sections of Pa231 and Th230, as used in FISPIN, has been completed. Significant changes to some of the existing data are proposed and error estimates have been derived by comparing the calculated values with an evaluation of all available experimental data.

1.4 **Three group actinide cross sections** (Mrs C R Eaton and C J Dean)

A library of irradiation independent actinide cross sections (129 actinides) has been produced for use in FISPIN to predict isotope inventories and activities in irradiated MAGNOX reactor fuel.

1.5 **Benchmark testing of the JEF-1 library** (Miss C Biles, C J Dean and M J Grimstone)

Benchmark testing of this library has continued during 1983.

2 Theoretical Methods

2.1 **Level statistics in the unresolved resonance region** (M F James)

Existing methods of generating ladders of resonances from statistical populations (eg *GENEX, RESP and TIMS*) do not assume any correlation between spacings of neighbouring resonances, although it has been known for some time that a strong correlation exists. A study has shown that the diagonalistion of relatively small random matrices (eg of order 50 x 50) will generate populations of levels that satisfy all statistical tests that appear relevant to the production of shielded multigroup cross-sections, and be still sufficiently rapid for practical purposes.

3 Cross section Processing Codes

3.1 **NJOY/SIGAR** (R W Smith)

During 1983 the implementation of the SIGAR7 option in NJOY for the generation of Doppler broadened cross sections was completed and tested. A comparison of NJOY and SIGAR7 broadened data has been made using the data files in the ENDF/B5 dosimetry library and the results, constituting stage two of the IAEA intercomparison exercise, are being sent to Vienna.

3.2 **NJOY/ACER** (Miss C Biles)

Extensive modifications have been made to the ACER module of NJOY on the ICL 2976 in order to produce cross section data for UK Monte Carlo codes.

3.3 **Code implementation and testing on the Harwell computers** (Mrs C R Eaton and S Whitworth)

TIMS has been successfully implemented on both CRAY and IBM computers (at AERE Harwell) and difficulties in running NJOY on the CRAY due to problems of character handling are the subject of current studies.

AEE Winfrith

January, 1985

USA Contribution to NNDEN-36
via The National Nuclear Data Center

Recent Publications

ANL/NDM-60 June 1984
"Gamma-Ray Detector Calibration Methods Utilized in the Argonne FNG Group Activiation Cross Section Measurement Program"
J. W. Meadows and D. L. Smith

ANL/NDM-84 November 1983
^{235}U and ^{239}Pu Sample-Mass Determinations and Intercomparisons
W. P. Poenitz and J. W. Meadows

ANL/NDM-85 June 1984
"Measurement of the $^{51}V(n,p)^{51}Ti$ Reaction Cross Section from Threshold to 9.3 MeV by the Activation Method"
D. L. Smith, J. W. Meadows, and I. Kanno

ANL/NDM-86 July 1984
"Energy-Differential Cross Section Measurement for the $^{51}V(n,\alpha)^{48}Sc$ Reaction"
I. Kanno, J. W. Meadows, and D. L. Smith

ANL/NDM-87 September 1984
Cross-Section Measurement for the $^{7}Li(n,n't)^{4}He$ Reaction at 14.74 MeV
Donald L. Smith, James W. Meadows, Manuel M. Bretscher and Samson A. Cox

BNL-19302-VolII December 1983
"Cross Section Evaluation Working Group Benchmark Specifications" Edited by P. F. Rose and R. W. Roussin

BNL-NCS-51694 June 1983
"IAEA Advisory Group Meeting on Basic and Applied Problems of Nuclear Level Densities"
Edited by M. R. Bhat

BNL-51778 October 1983
"NEANDC Specialists Meeting on Yields and Decay Data of Fission Product Nuclides" Held at Brookhaven National Laboratory, Upton, Long Island, New York 11973, October 24-27, 1983
Edited by R. E. Chrien and T. W. Burrows

ORNL/RSIC-46 December 1983
"Description of the DLC-99/HUGO Package of Photon Interaction Data in ENDF/B-V Format"
R. W. Roussin, J. R. Knight, J. H. Hubbell, and R. J. Howerton

ORNL/TM-9023 May 1984
"Report to the ^{238}U Discrepancy Task Force on SIOB Fits to the ORNL, CBNM, and JAERI Transmission Data"
D. K. Olsen

Recent Publications (cont.)

ORNL/TM-9083 August 1984
"Calculated Neutron-Induced Cross Sections for $^{63,65}Cu$ from 1 to 20 MeV and Comparisons with Experiments"
D. M. Hetrick, C. Y. Fu, and D. C. Larson

Evaluations Recently Completed or in Progress

Material	Laboratory	Status
^{1}H	LASL	Dodder-Hale R-Matrix analysis completed
^{6}Li	ANL	Simultaneous evaluation- (n,t), (n,n) reactions
	LASL	R-Matrix analysis-all reactions
^{10}B	ANL	Simultaneous evaluation-(n,α_0), $(n,\alpha_1\gamma)$ (n,n) reactions
	LASL	R-Matrix analysis-all reactions
^{197}Au	ANL	Simultaneous evaluation-(n,γ) reaction
^{235}U	ANL	Simultaneous evaluation-(n,f) reaction
^{238}U	ANL	Simultaneous evaluations-(n,γ),(n,f) reactions
^{239}Pu	ANL	Simultaneous evaluation-(n,f) reaction

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K. Okamoto, O. Schwerer

1) The EXFOR-VIEN file containing various International Evaluated Neutron data in EXFOR format has been supplemented with a number of Chinese evaluations of selected neutron reactions on U, Pu and Am isotopes in the keV and MeV range. - Furthermore, an unpublished evaluation from Poland for 14.5 MeV neutrons on Mo isotopes has been added. - The contents of the EXFOR-VIEN file is documented in IAEA-NDS-34 Rev. 2. The purpose of this file is to collect miscellaneous evaluations that are not (yet) available in ENDF format; or that contain quantities that are not defined in the ENDF format.

2) The validation of INDL/A (IAEA Nuclear Data Library for Actinides) continues in a coordinated program in which scientists from Brazil, Bulgaria, People's Republic of China, India, USSR and Yugoslavia participate.

NEA DATA BANK

A BRIEF REPORT ON THE JEF-1 FILE

I. Availability

Copies of the first two JEF-1 Library tapes have now been sent out to groups in Data Bank Member countries which are participating actively in the JEF project, and data will then be available to other users in those countries. The complete library will occupy three 6250 bpi high-density tapes, elements 1-99 (cross sections + resonance parameters), elements 1-99 (cross-sections in pointwise form), special files ($S(\alpha,\beta)$, fission yields, photon interaction and decay data).

In addition, certain group cross-section sets prepared for use in JEF-1 benchmark testing will be made available: for 31 nuclides, fast reactor spectrum: 71 groups, 50 groups, 25 groups, also 26 groups with the KFK-INR structure. Similarly a copy of the IKE Stuttgart '126 group plus epithermal fine structure' library, as used for thermal benchmarking, is being prepared for distribution to requesters entitled to receive JEF data.

II. Requests for JEF data

The full JEF-1 library, including the special files and the pointwise data, contains some two million records in all. Although copies of the full library can be supplied, and may be useful to laboratories with their own ENDF format storage system, we would suggest selective retrievals of only those materials required at the time of the request. The Data Bank is holding a "frozen" copy of JEF-1 on disk, and can make available data for other materials as and when they are needed (these data will be "compatible" in the sense that benchmark results apply to JEF-1 taken as a whole).

JEF data is available only to scientists in Data Bank Member countries, who are asked to treat the JEF-1 data and documents they receive as confidential.

III. The selection of data for JEF

The choice of data for inclusion in JEF-1 has proceeded on two levels: very careful reviews by specialists designated by the Scientific Coordination Group for the more important isotopes (110 materials so far) and more superficial choice of residual data from ENDF/B-IV or V pending extension of the rigorous selection procedures during construction of JEF-2. For comparison, the index to ENDF/B-V evaluations shows 112 materials in the General Purpose file (and which are covered by full evaluations). Where suitable new evaluations were available, these have been used in JEF-1; as a result of the benchmark tests already carried out, several new evaluations are planned.

Neutron balance in a reactor is controlled by relatively few isotopes out of more than 300 materials represented in ENDF, JEF or in other files with pretensions to "completeness". As an example, the JEF-1 file carries data for 200 fission products; sixty of them have been selected in comparisons between a series of new evaluations and are responsible together for more than 97 percent of the capture cross-section of the lumped fission products.

The rather exhaustive set of benchmark tests carried out with ENDF/B-V data, or the similar series calculated for JEF-1, allow cross-sections for about thirty materials (with the largest influence on the neutron economy) to be individually verified against integral measurements.

IV. Preparation of JEF-1, and initial data checking

The U.S. ENDF checking and data plotting codes were available to us, and were installed and run on the Data Bank VAX-11/780 computer, together with appropriate conversion codes. In building up the file for a new material, data was passed through the sequence:

Input 1 (+ Input 2... where the file is composite)
Format conversion using one of the programs E4TO5, KTOE, etc. ...
(Merge Input 1, 2 ... using program CRECTJ$)
Check: CHECKER for format, FIZCON for physical consistency
(In the resonance region convert to pointwise form: RECENT, RESENDD)
Plot using LINEAR, then EVALPLOT or COMPLOT.

While the FIZCON program was very useful in detecting local inconsistencies, systematic plotting of data for the most important materials proved invaluable as a means of showing up errors in data values themselves, and hence also in some of the translation, processing and even the checking codes. Where the unphysical appearance of a plot appeared to be attributable to the evaluation itself rather than to processing errors, this selection will be reconsidered for JEF-2.

Pointwise data covering the resonance region are available for all materials. Resonance parameter data for some fissile materials are expressed in Reich-Moore form. An integrated Data Base was constructed to store the JEF-1 data sets individually, and to keep a record of the successive versions of each during the file construction and testing/correction phase, and also of the data sent out to each outside user, so that corrections and new data can if necessary be supplied to update his personal files.

V. Benchmarking

The value of an evaluated library, but also its cost, is a function of the effort invested in benchmark testing. Before asking the laboratories taking part in the project to carry out complex benchmark calculations, it seemed essential to check that the JEF-1 data was free of gross errors, and during 1983-4, many simple preliminary integral calculations were made by Data Bank staff, while simple benchmarks were used to compare JEF-1 data with KFK-INR adjusted and JENDL fast sets.

Benchmarks in the national laboratories started in 1984 and are continuing into 1985. Results obtained by IKE Stuttgart, for a series of thermal assemblies and homogeneous solutions of Pu and U/Th, were considered good. Some well-known problems (for example, ^{238}U), appeared again for fast reactor spectra. In general, for fission products and secondary actinide isotopes JEF-1 data are judged as very satisfactory (minor revisions are planned for a few fission products). The main requirement is for improvements to selected reactions in the primary actinides and important structural materials. This evaluation work, together with extensions including covariance data, will provide a full programme for all participants in developing the file towards JEF-2.

International Nuclear Model and Code Comparison on Pre-equilibrium Effects

H. Gruppelaar and P. Nagel

Final results have been analysed of an international effort to compare statistical nuclear models and codes that calculate reaction cross sections, emission spectra and angular distributions, taking into account pre-compound or preequilibrium effects. These models are widely used in nuclear data evaluations and in predictions of neutron-induced reaction cross sections at energies of 5 to 50 MeV, i.e. in an energy-range that is of interest for technological applications. The participants were asked to calculate cross sections of neutron-induced reactions on 93 Nb at incident energies of 10, 14.6, 20 and 25.7 MeV. This nucleus was chosen because it is well-studied, both experimentally and theoretically, and because pronounced precompound effects were observed in neutron emission spectra at 14.6 and 25.7 MeV. At lower incident energies (below 5 to 10 MeV) precompound effects become of minor importance and the usual Hauser-Feshbach models with a correction for width fluctuation effects could be used.

The full report will be published by the NEA Data Bank later this year.

The contributions received are as follows:

CLASS A, Modified HF codes, unified models

STAPRE, GNASH, EMPIRE, PERINNI, HAUSER-V, TNG

CLASS B, Exciton-model codes (spin-independent)

PRANG, PEQGM, PREM, PREANG1, PRECO-D2, AMAPRE

CLASS C, Hybrid model

ALICE HYBRID + evaporation model, ALICE GDH + evaporation model, ALICE, GDH + evaporation model, SECDIST + evaporation model, EMPIRE.

The analysis showed that:

- There are no serious problems in the optical-model calculations (σ_t, σ_{el}, σ_r).
- There is quite good agreement in the calculation of σ_{nnx} (maximum standard deviation is at 25.7 MeV: $\pm$4%). The PREM results show the largest deviation, at least at 25.7 MeV (-8.7%). The ALICE results are inconsistent with σ_r. Note that the equilibrium results are in excellent agreement, except for the HAUSER-V results at low energy.
- With respect to the σ_{npx} data, there is not much agreement; the standard deviation is 40% to 50%. However, the equilibrium calculation is also quite uncertain: $\pm$50% at low energies up to 30% at 25.7 MeV.
- For the calculation of $\sigma_{n\alpha x}$, the situation is still worse: the standard deviations range from 30% to 60%; for the equilibrium results they vary from 30% to 80%. Extremely low cross sections are calculated by PREANG1.

- For the calculations of $\sigma_{nn'\gamma}$, $\sigma_{n2n\gamma}$ and $\sigma_{n3n\gamma}$, we find quite acceptable results, with a standard deviation of less than 10% for high values of these cross sections (>500 mb), except at E=10 MeV. In general the codes of Class A are superior, although reasonably good results can also be obtained with codes of class B as follows from the tables. We note that the differences between the PERINNI results and the other codes at 10 MeV is partly due to the renormalisation to the back-shifted Fermi-gas formula, rather than using the Gilbert-Cameron level density.

- The standard deviation of the calculated total neutron-production cross sections is less than 5%. However, the pre-equilibrium contribution in this quantity is rather small (at most 23% at 25.7 MeV). The hybrid model codes also give good results.

- With respect to the total photon-production data, we notice reasonably good agreement between the class A codes that calculate these quantities; STAPRE, GNASH, TNG and EMPIRE. The results of PEQGM are much higher. Again, the pre-equilibrium effect is not large in this lumped quantity.

- Some codes also calculate cross sections for the population of isometric states.

The calculation of σ_{nnx} is generally satisfactory, although in some codes there is no consistency with the total reaction cross section (the codes should automatically check and eventually correct this discrepancy). The calculation of the much weaker σ_{npx} and $\sigma_{n\alpha x}$ cross sections is unreliable. In particular the treatment of the α-emission needs more care. The calculation of multi-particle emission cross sections is difficult near thresholds: the energy grid is not always fine enough and perhaps no appropriate corrections are made if only part of a "bin" can be further emitted.

In codes of classes B and C, where the level density is described by a continuum over the whole energy range, it is important to utilise a realistic expression at low energies, otherwise the (n,2n) and (n,3n) cross sections cannot be calculated with high accuracy. Again it is necessary to check the consistency of the multi-particle emission with the first-emission cross sections. Some results of 10 MeV need to be better understood, mainly because the (n,2n) threshold is relatively low. Probably the γ-ray competition is important as well (it is neglected in most codes of classes B and C). We feel that most codes of classes B and C need further development in the following directions:

(1) Refinement of multi-particle emission treatment with respect to enery mesh and integration;

(2) More realistic description of the level density at low energies, in agreement with experimental level schemes (or introduction of discrete-level excitation).

(3) Introduction of γ-ray competition.

Our impression is that the neglect of angular-momentum conservation is not the prime reason for some differences between the results of classes A and B+C. This follows for example from a comparison of PERINNI and PRANG results.

International Nuclear Model Computer Exercise: Spherical Optical Model

In addition to the Coupled Channel, Spherical Optical and Statistical Model Comparison Exercise, the Charged Particle Optical Model Exercise has also now been completed (NEANDC-198U/INDC(NEA)5).

This latter exercise was organised in order to identify possible reasons for some important discrepancies that were found in the charged particle emission cross sections of the spherical optical model exercise.

The comparison covered calculations for protons and alpha-particles scattered at 5, 10, 15 and 20 MeV from Carbon-12, Cobalt-59 and Lead-208. The reaction cross-sections agreed reasonably well for practical purposes. It could be verified that the Coulomb functions used in the codes were essentially correct. A closer examination showed significant differences in detail. One code was found eventually to give erroneous results. Another iteration of the exercise was run in which the participants were asked to use the same mathematical parameters that control the integration of the radial wave equation and to use the same values of the wave number and Coulomb parameter. This exercise concentrated on neutron and proton as incident particles and Carbon-12 as target. Agreement could then be improved considerably.

One code was run on two different computers using the same word length both in single and double precision. On the average the agreement was of 0.1 percent for the differential cross section and about 0.7 percent for the polarisation. This can be considered as an estimation of the best agreement that can be obtained in this kind of exercises.

The results for the different codes in the last iteration agreed on the average to 1 percent in the differential cross-section and 2-3 percent in the polarisation.

The published results can be considered as a standard to check spherical optical model calculations.

Bibliographic note: ^{235}U and ^{239}Pu Sample Masses

A report in the ANL Nuclear Data and Measurements series received at the Data Bank may be of particular interest to evaluators:

^{235}U and ^{239}Pu Sample-mass determinations and inter-comparisons,
W. Poenitz and J. Meadows, ANL/NDM-84, Nov. 1983.

Abstract

In order to estimate the uncertainties on the fission cross-sections which come from the determination of the fissile sample masses, fifteen samples of ^{235}U obtained from seven laboratories and four samples of ^{239}Pu were studied. The masses were determined from absolute alpha counting and the relative 2π alpha and fission ratio measurements, and intercompared.

The results indicate that ^{235}U sample masses are well enough known ($\pm$0.3 percent) for the required high accuracy fission cross-section measurements. The comparison for the ^{239}Pu sample indicates problems in the order of 1-3 percent which are more likely to be related to counting efficiencies than to sample masses.

The absolute alpha decay rates and absolute masses of the ^{235}U samples can be used to determine the halflife of ^{234}U. This one was found equal to $(2.457 \pm 0.005)\ 10^5$ yrs.

EUROPEAN FUSION FILE (EFF)

(file management: ECN, Petten)

1. Introduction

In 1984 important progress has been made in the definition of the format and contents of a first version of the "European Fusion File" (EFF). This file is one of the tools that is developed for neutronics calculations of fusion reactors, in the framework of the B2 task force of the European Community. It contains nuclear data of important fusion materials with emphasis on the double-differential neutron-emission cross sections. A first version (EFF-0) of the file has been assembled.
The following evaluation groups are actively involved at present: KfK-Karlsruhe, ENEA-Bologna, ECN-Petten. Contributions are also obtained from other European laboratories. The B2 activity is coordinated by the NET-team at Garching and is supported by users groups at the above-mentioned laboratories and at CEA-Saclay, AERE-Harwell, ENEA-Frascati, KFA-Jülich, EIR-Würenlingen and by experimental groups from CBNM-Geel and SCK/CEN-Mol. The file-management is performed at ECN-Petten with assistance of the NEA Data Bank.

2. Starter file EFF-0

A preliminary file with 26 materials of interest for fusion-reactor technology has been selected from the Joint Evaluated File (JEF). This file serves as a "starter file" for further improvements, with emphasis on applications in fusion-reactor neutronics calculations. About 50% of the evaluations are "new" with respect to ENDF/B-IV.

3. Format for EFF-1

The format of the EFF-1 will be essentially the same as that of EFF-0 (ENDF-V) with the addition of the "continuum particle-emission" cross section (MT=10) of which the particle yields and angle-energy correlated distributions are given in the new MF6 format of ENDF-VI. This new quantity implicitly defines the total continuum neutron-production cross section. A special processing routine will be provided to calculate group constants and transfer matrices of this quantity.

4. Contents of EFF-1

Major revisions with respect to EFF-0 are being made for ^{7}Li, Al, Si and Pb. Minor updates will be applied for most of the other materials. The file will be completed early in 1985.

5. Plans for EFF-2

Further revisions of EFF-1 will appear in the EFF-2 file of which the format is ENDF-VI, probably with some additions (e.g. MT=10). The EFF and JEF-2 activities will be coordinated.

6. Documentation and distribution

The EFF is documented in a new report series (EFF-Doc), issued by the Netherlands Energy Research Foundation at Petten. The distribution of the file and its documentation are still restricted.

H. Gruppelaar

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