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INDC INTERNATIONAL NUCLEAR DATA COMMITTEE

Second Research Co-ordination Meeting on

DEVELOPMENT OF REFERENCE INPUT PARAMETER LIBRARY FOR NUCLEAR MODEL CALCULATIONS OF NUCLEAR DATA

Vienna, Austria, 30 October - 3 November 1995

SUMMARY REPORT

Prepared by

Pavel Obložinský
IAEA Nuclear Data Section
Vienna, Austria

March 1996

IAEA NUCLEAR DATA SECTION, WAGRAMERSTRASSE 5, A-1400 VIENNA

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Abstract

The present report contains the summary of the Second Research Co-ordination Meeting on "Development of Reference Input Parameter Library for Nuclear Model Calculations of Nuclear Data", held in Vienna, Austria, from 30 October to 3 November 1995. The library should serve the input for theoretical calculations of nuclear reaction data induced primarily with neutrons in the incident energy range below 30 MeV. Summarized are conclusions and recommendations of the meeting together with a detailed list of actions and deadlines. Attached is the agenda of the meeting, list of participants, and titles and abstracts of their presentations.

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Pavel Obložinský
IAEA Nuclear Data Section
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Table of Contents

Summary of the Meeting

Introduction

The 2nd Research Coordination Meeting on "Development of Reference Input Parameter Library for Nuclear Model Calculations of Nuclear Data (Phase I: Starter File)" was held in the IAEA Headquarters, Vienna, from 30 October to 3 November 1995. The meeting was convened as a part of the IAEA Coordinated Research Programme (CRP) aimed to develop a Starter File of the Reference Input Parameter Library (RIPL). This library should serve the input for theoretical calculations of nuclear reaction data induced primarily with neutrons in the incident energy range below 30 MeV. Extensions to reactions with light charged particles are also considered as are the incident energies exceeding the above limit.

The purpose of the meeting was to review the status of work performed under the CRP, to provide a forum for discussion of related problems and to coordinate future activities. Prof. A.V. Ignatyuk of the Institute of Physics and Power Engineering, Obninsk, Russia acted as a chairman of the meeting. The detailed Agenda is attached (*Appendix 1*) along with short abstracts of scientific and technical presentations (*Appendix 2*).

The meeting was attended by chief scientific investigators of 8 laboratories participating in the project, by 1 consultant and 4 observers. Participating laboratories were represented by M.B. Chadwick (Livermore, USA), A.V. Ignatyuk (Obninsk, Russia), T. Fukahori (Tokai-mura, Japan), A. Kumar (Bombay, India), G. Molnár (Budapest, Hungary), G. Reffo (Bologna, Italy), Su Zongdi (Beijing, China) and P.G. Young (Los Alamos, USA). J. Kopecky (Petten, Netherlands) attended as a consultant, and B. Strohmaier (IRK Vienna, Austria), V.M. Maslov together with E. Sh. Sukhovitskij (both Minsk, Belarus) and D.W. Muir (Los Alamos, USA) attended as observers. (For details see *Appendix 3*).

An overall strategy of the RIPL project is to develop the library in two major steps, Phase I and Phase II. The two Phases were discussed as summarized below. Other observations/conclusions of a general nature are also summarized below. Detailed conclusions and recommendations relevant to individual segments of the RIPL can be found in the next Chapter of the present Report.

Phase I: Starter File

The objective of the present CRP is to create a Starter File of the RIPL. The Starter File should be composed of 7 segments with a single data file for each segment of the Library. In addition, each segment should be accompanied by a short readme file and a text file with full supporting information. The data file can contain several selected options for data from various sources. The file should however always contain a single set of recommended data.

An overall structure of the Library agreed at the 1-st Meeting in Cervia proved to be useful. Format of the Starter File was discussed, but no particular recommendation on it was made at this stage.

Progress was achieved in developments of all segments of the RIPL. In a good shape are the following 4 segments: Atomic Masses including Shell Corrections and Deformations, Optical Model Parameters, Gamma-Ray Strength Functions, and Angular Distributions. Particularly complicated segments are Discrete Level Schemes, Average Neutron Resonance Parameters, and Level Densities. It seems realistic that starter files should be completed for all segments by the spring of 1997.

The Starter File should be collected at the NDS DEC Alpha computer. It should be accessed through the electronic networking system via ftp. In addition, a hardcopy document (Handbook or TECDOC) should be produced that should contain a full description of the Starter File. The following major actions have been agreed upon:

* *Action on segment coordinators, produce text files for each segment, deadline end 1996*
* *Action on M.B. Chadwick, produce complete text file in LaTeX, deadline 31 April 1997*

Phase II: Final File

Phase II of the RIPL project, foreseen for the period 1998-2000, was discussed. The objective of the Phase II should be validation and improvement of the Starter File, development of retrieval codes, and development of modules for generation of complete input data sets tailored for several selected nuclear reaction model codes.

It was stressed that a possible approval of the Phase II depends on the success of the current Phase I of the project. It was noted that the IAEA International Nuclear Data Committee expressed its wish to be duly informed about this CRP at the next INDC meeting to be held in spring 1997.

Other observations

It was noted that 7 diskettes with data files were received from the CRP participants during the meeting:

- Updated Chinese Evaluated Nuclear Parameter Library, CENPL, 4 diskettes (received from Su Zongdi)

- Bologna Nuclear Level File, BNLF, new file, 1 diskette (received from G. Reffo). Note: The BNLF file is available for CRP participants under the understanding that it will be not published by them.

- Updated segment Angular Distributions, 1 diskette (received from M.B. Chadwick)

- Smirenkin and Obninsk fission barriers, 1 diskette (received from A.V. Ignatyuk).

The following data sets were distributed at the meeting:

- Full Reference Input Parameter Library, RIPL (given to A.V. Ignatyuk, G. Reffo, Su Zongdi)

- Selected parts of RIPL (given to J.Kopecky), optical model parameters of RIPL (given to A. Sh. Sukhovitskij)

It was noted with satisfaction that the additional support to the CRP will be given through 2 individual Research Contracts (M. Avrigeanu, Bucharest - partial level densities and V. Maslov, Minsk - fission level densities).

A final meeting of the present CRP (Phase I) is foreseen to be held in 1997. Two options were discussed, to hold the meeting (i) well before the next International Conference on Nuclear Data for Science and Technology (Trieste, May 1997) or (ii) adjacent to it. The second option was found to be preferable. It was agreed that results of the CRP should be presented at this conference:

* *Action on P. Obložinský, prepare presentation for the Trieste Conference, deadline May 1997*

It was further recommended that a Consultants' Meeting is convened in 1996, if possible, to support development of the most critical segment of the RIPL.

CONCLUSIONS AND RECOMMENDATIONS

I. ATOMIC MASSES, SHELL CORRECTIONS, AND DEFORMATIONS

Coordinator: M.B. Chadwick, LLNL Livermore, U.S.A.

Achievements

In accordance with the previous recommendations P.G. Young supplied a README file for the Möller file to the Agency.

Recommendations

We recommend that the Möller file [1] be used for B_n, Q-value calculations, shell corrections, and deformations. Where experimental values of masses exist, they should be used. In other cases the calculated values should be used. We recommend that for nuclides lighter than oxygen (which were not considered by Möller), the recommended Möller file should be supplemented by experimental values from Audi et.al. [2].

It was noted that NUBASE, a Database of Nuclear and Decay Properties is being setup [3]. The mass excesses used in NUBASE are those values from the most recent evaluation [2] and by the time the database is published in full, they will be replaced by the values from the 1995 update.

[1] P. Möller, J.R. Nix, W.D. Myers and W.J. Swiatecki, "Nuclear Ground-State Masses and Deformations", Atomic and Nuclear Data Tables **59** (1995) 185.

[2] G. Audi and A.H. Wapstra, "The 1993 Atomic Mass Evaluation", Nucl. Phys. **A565** (1993) 1, and **A565** (1993) 66.

[3] G. Audi, O. Bersillon, J. Blachot and A.H. Wapstra, "NUBASE: A Database of Nuclear and Decay Properties", Nucl. Instr. Meth. **A369** (1996) 511.

Actions

1. Experimental mass values for $A < 16$ should be added into the Möller file.
   * *Action Chadwick, deadline December 1996*

2. New mass estimates from the Chinese group for selected nuclei should be sent to M.B. Chadwick for possible inclusion in RIPL.
   * *Action Su Zongdi, deadline December 1995*

3. The Starter File for segment Masses should include README, text, and data files.
   * *Action Chadwick, deadline December 1996*

II. DISCRETE LEVEL SCHEMES

Coordinator: G. Molnár, IKI Budapest, Hungary

Information concerning low-lying (bound) discrete levels is required for two main purposes. First, a complete set of discrete levels with full characteristics, i.e., spins and parities, is needed to specify outgoing channels in nuclear reaction calculations. Second, the cumulative number of discrete levels and the corresponding cutoff energies have to be established for testing level density models and determining their parameters. It is essential that the new discrete levels library is based on the latest data from the ENSDF and it is compared with older similar libraries, created independently.

Achievements

A new discrete level file has been created at Budapest, containing data for nuclei with mass between 50 and 150. Correction of errors and statistical tests of the ENSDF data have also been performed.

A comparison of the Bologna file LIVELLI has been performed with the Budapest file for nuclei mass in the range $50 < A < 150$ and with the two JAERI files for the nuclei they contain.

A new discrete level file from Beijing containing data for all nuclei has been sent to the Agency's Nuclear Data Section.

In addition, a new version of the Bologna Nuclear Level File (BNLF) has been delivered at the meeting. This file is a translation of the whole relevant data set in the ENSDF.

Recommendations

The recommendations of the first Research Co-ordination Meeting are reinforced, in that a single file of discrete levels has to be created including all nuclei. This file should be based on data from the ENSDF file and it should keep the format of the Bologna discrete levels file.

Histograms of the cumulative number of levels against energy (staircase plots) have to be created for **all** nuclei for which ENSDF data are available.

The cutoff energy U_{max} and the cumulative number N of levels up to this energy have to be determined from exponential fits to the staircase plots for **those** (~300) nuclei for which average resonance data are available. This energy should be considered as a cutoff value up to which the discrete level scheme is complete, with respect to missing states.

A second energy cutoff U_c , corresponding to the upper energy limit of levels characterised by an unique spin and parity, has to be determined for **all** nuclei on the basis of ENSDF data alone.

The Bologna file format should be extended to accommodate for the storage of additional information in the following way:

1) Extend the line length to 132 characters in order to introduce further columns for
   - up to 8 more gamma rays (8x4 integers, positions 81-112)
   - level half-life in seconds (1 floating point number, positions 113-122)
   - blank column for further use (positions 123-132)

2) Include additional rows for as many levels as needed.

3) Include one line after the comment line for each isotope to indicate the cutoff energies U_{max} and U_c by the corresponding level numbers. In the future other parameters, such as the spin cutoff σ^2, level density parameter a and effective temperature T, may be added as well.

It appeares that these changes will cause no serious difficulties in codes that read the existing Bologna format.

Additional definitions and modifications suggested:

- Use the isomer flag for level half-lives larger than 1 *s*. This definition can be changed any time, since the half-lives are now included.

- Include the original branching percentages for gamma rays instead of the values renormalised due to the truncation to 10 gammas. The 1% lower limit of a branching remains in effect, as it is sufficient for practical applications.

Actions

1. Hardcopies of staircase plots for ~300 nuclides, as specified in the Recommendations, will be reproduced for CRP participants and distributed. A possibility of distributing postscript files will be considered.
   * *Action Molnár, deadline 1 April 1996*
   * *Action Obložinský, deadline 15 April 1996*

2. New upper energy limits and cumulative numbers of levels for those 300 nuclides will be deduced independently at Budapest and Beijing. The new data sets will be compared with each other and with old data from Beijing and Obninsk.
   * *Action Molnár, Su Zongdi, deadline 1 April 1996*

3. Staircase plots of number of levels will be created by Budapest group for all nuclides.
   * *Action Molnár, deadline 1 June 1996*

4. A new discrete levels file will be created by Budapest group for all nuclei in the extended Bologna format. This file also includes both cutoff energies (when available), half-lives, as well as gamma ray placements and branchings.
   * *Action Molnár, deadline 1 June 1996*

5. The new file of discrete level schemes will be compared with existing older files from JAERI, Beijing and Bologna.
   * *Action Fukahori, Molnár, deadline standing*

III. AVERAGE NEUTRON RESONANCE PARAMETERS

Coordinator: G. Reffo, ENEA Bologna, Italy

Present Status

Tables of average resonance parameters have been provided by Beijing, Bologna and Obninsk. These were derived from statistical analysis of neutron resonance schemes.

Bologna has prepared combined tables of average resonance parameters one for each of the relevant parameter D_{obs}, Γ_γ and S_0 , S_1 separately. Each table includes the information from Obninsk and Beijing.

Obninsk has recompiled the tables to computer readable format eliminating part of misprints and other errors including several interpretation errors. This work is providing a working basis for detailed comparison and discussions.

Many discrepancies appear from the tables. When the associated uncertainties are considered, however, the number of severely discrepant cases is greatly reduced. In any event these discrepancies raised questions about how to remove them in order to arrive at a recommended set of average resonance. For large discrepancies it has been accepted to mean the cases where discrepancies exceed the quoted confidence intervals.

Thorough discussion of the discrepancies lead to the clarification of the following points:

- The values quoted under the column headed Γ_γ-Bologna are the expectation (rather than the mean) values of the χ^2 distribution obtained by least square fit to the distribution of the experimental Γ_γ per spin state, while the values associated to the Γ_γ give the half maximum width of the distribution and ν gives the effective number of degrees of freedom.

- The uncertainty quoted with the D_{obs}-Bologna represent the spread of the results of different statistics as applied to the same sample.

- The number of resonances and the associated error, as given in the Bologna table, give the presumed size of the sample as inferred after statistical analysis.

To better understand the nature of discrepancies, a restricted number of participants have analyzed the different methods used at Bologna at the example of ^{243}Am. This has clarified the different philosophies adopted as well as the significance of the quoted quantities. In particular Obninsk turned out to be more inclined to optimism and tends at providing guesses where statistical method results are complemented with experience and intuition to yield educated guesses both of physical quantities and of the associated errors. Bologna appears more conservative and prefers to provide the objective information as coming out of adopted calculation methods. On the whole Bologna estimates are more conservative in the sense that the quoted uncertainties represent the intrinsic limit and deficiency of the statistical sample and therefore are in general larger than the other confidence limit estimates.

It is to be reminded, however, that pure statistical methods apply only to very few cases, which is why Bologna is using an iterative procedure over 6 different statistics, while in any event an evaluation criterion is always necessary. To this end it was recommended to perform a similar analysis for a number of selected cases where discrepancies are particularly high. For large discrepancies it has been accepted to mean cases where discrepancies exceed the quoted confidence intervals.

It is agreed that the information presently made available constitutes a good basis of working material from which to derive a unique set of average resonance parameters.

Phase 2 starting now will of necessity need much closer cooperation because calculations for selected nuclei will have practically to proceed in parallel while one envisages for particular cases the necessity of specific discussions for each individual case. This is the phase where evaluation criteria have to be used rather than calculation methods and in doubtful cases they will have to be complemented with additional information other than resonances as well as additional tests, like systematic considerations or tests against radiative widths and cross sections calculations.

Recommendations and actions

1. Identify the list of isotopes to be run together.
   * *Action Ignatyuk, deadline 31 December 1995*

2. Obninsk will make available their resonance file to Bologna. This will be useful to repeat calculations for discrepant cases based on the same data set.
   * *Action Ignatyuk, deadline 31 December 1995*

3. Misprints will be removed from the tables. A. Ignatyuk will send to G. Reffo the corrected version of the tables initially originated in Obninsk and Beijing. These will include the number of resonances for those samples not taken from Mughabghab compilation. G. Reffo will correct the Bologna file and compile new tables to be sent to NDS in computer readable format.
   * *Action Ignatyuk, deadline 31 January 1996*
   * *Action Reffo, deadline 29 February 1996*

4. The different laboratories should clearly state the physical meaning of the listed quantities and also specify or reference the analysis method and illustrate it at least at the example of few cases which must be the same for all laboratories. (This will be useful also for the NEA Nuclear Model Validation project).
   * *Action Ignatyuk, Reffo and Su Zongdi, deadline 31 March 1996*

5. Beijing will prepare new tables of average resonance parameters that will include errors.
   * *Action Su Zongdi, deadline 31 March 1996*

6. Bologna, Beijing, Minsk and Obninsk will perform new analysis for the selected cases to solve the systematic discrepancies.
   * *Action Reffo, Su Zongdi, Sukhovitskij and Ignatyuk, deadline 15 April 1996*

7. Starter files will be prepared of the recommended average resonance parameters, based on the final conclusions after reanalysis and corrections. this will include README, RESONANCE.DAT and RESONACE.TEX. The files will be sent to NDS for wide distribution.
   * *Action Reffo and Ignatyuk, deadline December 1996*
   * *Action Obložinský, deadline 15 January 1997*

IV. OPTICAL MODEL PARAMETERS

Coordinator: P.G. Young, Los Alamos, U.S.A.

Achievements

During the year following the 1st Research Coordination Meeting on Development of Reference Input Library at Cervia, a trial computer format for storing optical model parameterizations was devised and a collection of potentials were converted to the trial format at Bombay and Los Alamos. Additionally, optical parameters used in evaluations at Livermore, JAERI, and the Chinese Nuclear Data Center were provided for the library.

Recommendations

1. The provisional format for storing optical parameters is approved with modifications as noted below.

2. Optical model potentials developed at Obninsk, Kiev, and Minsk should be added to the library.

3. The "SUMMARY" string in the provisional format should be extended from 2 to 4 lines of descriptive comments.

4. The possibility of coupled vibrational potentials should be included in the format.

5. Consideration should be given to including quadrupole nonaxiality and deformability (softness) parameterizations.

6. The final library should be blocked by reference number into sections for neutrons, protons, deuterons, tritons, ^{3}He and ^{4}He.

Actions

1. Include optical model parameterizations from Obninsk, Kiev, Minsk, China, and JAERI in the library. [References for Obninsk, Kiev, and Minsk potentials should be obtained from previous nuclear data and technology conferences. CRP participants are requested to provide references or parameters to Young or Kumar for cases they consider to be important.]
   * *Action Kumar, deadline 31 August 1996*

2. Modify the format specifications to include 4 lines for the SUMMARY string.
   * *Action Young, deadline 31 December 1995*

3. Extend the format to include coupled vibrational potentials and softness parameters.
   * *Action Young, deadline 30 April 1996*

4. Send available parameters for structural materials to Young.
   * *Action Sukhovitskij, deadline 31 March 1996*

5. Investigate possibility of assessing the potentials from various laboratories. We recommend that a consultancy agreement be established by the IAEA for Dr. Kumar to spend time at Los Alamos National Laboratory to carry out this task. Graphical comparisons of cross sections calculated from various optical model parameterizations should be compared to experimental data in order to provide a basis for parameter recommendations.
   * *Action Kumar, 31 March 1997*

6. Prepare initial version of starter file describing format, contents, and retrieval possibilities.
   * *Action Kumar and Young, deadline 31 March 1997*

7. Provide text file to Chadwick for descriptive report.
   * *Action Young, deadline 31 December 1996*

8. Send Young Beijing optical model parameterizations.
   * *Action Su Zongdi, deadline 31 December 1996*

V. LEVEL DENSITIES

Coordinator: A.V. Ignatyuk, FEI Obninsk, Russia

This segment is composed of three parts as discussed below.

V.1. Total Level Densities

Coordinator: A.V. Ignatyuk, FEI Obninsk, Russia

The files of the level density parameters presented to the Nuclear Data Section from Obninsk, JAERI, Beijing and Bombay were discussed. It was confirmed that the parameters of the three level density models (the back-shifted Fermi gas model, Gilbert-Cameron approach and generalized superfluid model) should be selected for the starter file of RIPL. Differences of parameters recommended by different groups are mainly connected with disagreements of input data on the neutron resonance spacings and cumulative numbers of low-lying levels. It was decided that the updated versions of the level density parameters will be prepared for the starter file based on the revised sets of D_{oi} and $N(U_{max})$.

Recommendations and Actions

1. The parameters of JAERI for the mass region $160 < A < 230$ together with possible changes of recommended parameters for other nuclei will be prepared.
   * *Action Fukahori , deadline 15 April 1996*
2. The Bologna group will provide their set of the parameters recommended for RIPL.
   * *Action Reffo, deadline April 1996 (pending action from the previous meeting)*
3. The Budapest group will prepare their recommendations for the cumulative numbers of low-lying levels at least for nuclei for which the neutron resonance spacings are available.
   * *Action Molnár, deadline 1 April 1996*
4. Updated versions of the parameters consistent with updated recommendations of the neutron resonance spacings will be prepared by the Chinese and Obninsk groups.
   * *Action Su Zongdi, deadline 15 April 1996*
   * *Action Ignatyuk, deadline 15 June 1996*
5. Activity of the Bombay group in the selection of recommended parameters from prepared compilations will be welcomed.
   * *Action Kumar, deadline 15 June 1996*
6. The starter files of the level density parameters (README, DENSITIES.DAT and DENSITIES.TEX) based on the recommendations of all groups should be prepared and presented to the Nuclear Data Section. Files will be distributed by the Nuclear Data Section to all participants for remarks and corrections.
   * *Action Ignatyuk, deadline 31 December 1996*
   * *Action Obložinský, deadline 15 January 1997*

V.2. Fission Level Densities

Coordinator: A.V. Ignatyuk, FEI Obninsk, Russia

The fission barriers recommended by the Chinese, Obninsk and Minsk groups were discussed. It was noted that barriers recommended independently from the fission level densities may be applied for rough estimations of fission cross sections only. Accurate calculations of the cross sections for wide energy range require consistent modeling of the barriers and fission level density parameters. Rather sophisticated models that take into account the shell and pairing together with changes of nuclear shapes for two-hump barriers should be used for such tasks. So the Minsk-Obninsk approach is recommended as the more accurate one

Recommendations and Actions

1. Starter file of the fission barriers and fission level densities will be prepared in collaboration with the Minsk and Obninsk groups. The barriers recommended by other groups will be included in the starter file for a completeness.
   * *Action Maslov, deadline 15 April 1996*
   * *Action Ignatyuk, deadline 31 December 1996*

2. The analysis of the recommended barriers will be performed by Chinese group and any other volunteers will be welcomed (may be M.B. Chadwick). Proposals on the updated fission barrier parameters should be sent to A.V. Ignatyuk before 1 October 1996.
   * *Action Su Zongdi, deadline 1 October 1996*

V.3. Partial Level Densities

Coordinator: M.B. Chadwick, LLNL Livermore, U.S.A.

Achievements

During the last year, as recommended at the 1st CRP meeting, Chadwick has started writing a review document for RIPL summarizing the status of partial level density models for use in preequilibrium model calculations. This document refers to a useful source of references reflecting the state-of-the-art (the Proceedings of the 1989 Bologna Level Density Meeting), and summarizes the most widely-used equidistant-single-particle formulas.

Additionally, M. Avrigeanu (Bucharest, Romania) should receive an individual IAEA research contract to compile useful partial level-density formulas. It is assumed that the work of the Bucharest group will be coordinated by M.B. Chadwick and the results should be included into the Starter File.

Actions

1. The development should continue of a text file describing useful partial level density approaches, such as those including shell model and pairing effects.
   * *Action Chadwick, deadline December 1996*

2. FORTRAN subroutines should be provided for the computation of some of these formulas. Contributions from M. Avrigeanu are expected. These will be included in the RIPL starter file.
   * *Action Chadwick, deadline December 1996*

VI. γ RAY STRENGTH FUNCTIONS

Coordinator: J. Kopecky, ECN Petten, The Netherlands

The content of the starter file was discussed and its final structure, slightly differing to the previous recommendation, was finalized. The inclusion of the experimental data base of E1(M1) gamma ray strength functions (papers by J. Kopecky and M. Uhl quoted below) has been approved.

The development of this segment of RIPL has originally been coordinated by M. Uhl (IRK, Vienna, Austria) in a close cooperation with J. Kopecky (ECN Petten, Netherlands). Usefulness of this cooperation was underlined by the fact that Gamma-Ray Strength Functions are of importance also for the ongoing CRP on "Measurement, Calculation and Evaluation of Photon Production Data" of which J. Kopecky is a regular participant. In view of the death of M. Uhl, it was felt very important that J. Kopecky will directly continue to maintain a close link between the two CRPs.

Recommendations and Actions

1. Formulas to calculate Lorentzian parameters will be provided by Su Zongdi (CNDC) and forwarded to J. Kopecky. Formulas based on the hydrodynamic model will be made available by G. Reffo after finishing the publication (pending actions from the previous meeting).
   * *Action Su Zongdi, deadline 31 December 1995*
   * *Action Reffo, deadline immediately after publication*

2. J. Kopecky will provide the starter file with the following content:

   - README file
   - Formulas for calculating giant resonance Lorentzian parameters for E1, M1 and E2 γ-ray multipolarities.
   - Formulas for systematics of f(E1), f(M1) and f(E1)/f(M1). The experimental data base of f(E1) and f(M1) will be included.
   - Formulas for enhancement factor k_0 to be applied on f(E1) in rare earth deformed region.

   * *Action: Kopecky, deadline 31 December 1996*

3. The following documents are recommended as a basic information on the strength function models and experimental data.

   - M. Uhl and J. Kopecky, Gamma-Ray Strength Function Models and their Parameterization, INDC(NDS)-335 (May 1995) p. 157.
   - J. Kopecky and M. Uhl, Present Status of Experimental Gamma-Ray Strength Functions, NEA/NSC/Doc(95)1, p. 119.

VII. CONTINUUM ANGULAR DISTRIBUTIONS

Coordinator: M.B. Chadwick, LLNL Livermore, U.S.A.

Achievements

Evaluated nuclear data files usually require a description of the angular distributions of emitted particles. The Kalbach systematics provide a very successful characterization of these distributions, and have been widely used in data files. A drawback of the Kalbach systematics is that they were not originally designed to include photon-induced reactions. During the last year, we have extended the Kalbach systematics to include photon projectiles. These new results have been incorporated into a computer code for RIPL, ANGELMC.FOR, allowing angular distribution systematics to be computed.

During the last year, an alternative method for calculating angular distributions based on the Chadwick-Obložinský theory has been further studied, and compared with experimental data and other theoretical approaches, including quantum molecular dynamics (QMD).

Recommendations

1. For data evaluations, including photonuclear reactions, the Kalbach systematics (including recent modifications for photon projectiles) can often be used successfully to determine preequilibrium and equilibrium continuum angular distribution. We encourage further work into the systematics of photonuclear reactions at low energies, where a dipole-shaped distribution often occurs.

2. The above Kalbach approach is useful for data evaluation work. However, in some cases it may be desirable to calculate preequilibrium angular distributions using a more sophisticated theoretical approach. In such cases we recommend the use of the Chadwick-Obložinský theory.

Actions

1. The above approaches should be documented in a text file for the RIPL final summary report.
   * *Action Chadwick, deadline December 1996*

2. FORTRAN subroutine should be provided to calculate preequilibrium angular distributions according to the Chadwick-Obložinský theory.
   * *Action Chadwick, deadline December 1996*

Appendix 1

Second Research Co-ordination Meeting on
"Development of Reference Input Parameter Library (RIPL) for Nuclear Model Calculations of Nuclear Data (Phase I: Starter File)"

IAEA Headquarters, Vienna, Austria
30 October to 3 November 1995

Meeting Room A19-72

Scientific Secretary: P. Obložinský

AGENDA

Monday, 30 October

09:30 - 10:00 Opening (P. Obložinský - IAEA)
Election of Chairman
Adoption of Agenda

10:00 - 12:30 **Regional Approaches to the Input Parameter Library**

- P. Obložinský: "Status of RIPL Files Collected at the NDS VAX Computer"
- T. Fukahori: "Present Status of INDES and its Parameter Database"
- Su Zongdi: "Progress and Activities on Reference Input Parameter Library at CNDC (Chinese Evaluated Nuclear Parameter Library CENPL)

14:00 - 17:00 **Status of the Reference Input Parameter Library**

I. Atomic Masses, Shell Corrections and Deformations
(Coordinator and discussion leader: **M.B. Chadwick**)

- Su Zongdi: "Updated Edition of Atomic Masses and Characteristic Constants of Nuclear Ground States (CENPL.MCC 1.1)"
- Accomplishments, review of actions, status, discussion, recommendations

II. Discrete Level Schemes
(Coordinator and discussion leader: **G. Molnár**)

- G. Molnár: "Status of Discrete Level Schemes of Medium-Heavy Nuclei"
- Su Zongdi: "Discrete Level Schemes, their Gamma Radiation and Branching Ratios (CENPL.DLS)"
- Accomplishments, review of actions, status, discussion, recommendations

17:30 **Welcome Drink** (in front of the NDS Library, A23-40)

Tuesday, 31 October

09:00 - 12:30 **Status of the Reference Input Parameter Library** (cont'd)

III. Average Neutron Resonances
(Coordinator and discussion leader: **G. Reffo**;
if absent **A.V. Ignatyuk**)

- A.V. Ignatyuk and G. Reffo: "Analysis of Main Differences between Neutron Resonance Density Evaluations"
- Accomplishments, review of actions, status, discussion, recommendations

14:00 - 17:30 *IV. Optical Model Parameters*
(Coordinator and discussion leader: **P.G. Young**)

- P.G. Young: "Status of Optical Model Activities at Los Alamos National Laboratory"
- A. Kumar: "Starter File of Optical Model Potential Parameters and Nuclear Data Computations of Nd-Isotopes"
- E.Sh. Sukhovitskij: "Deformed Optical Potentials for Applied Purposes"
- Accomplishments, review of actions, status, discussion, recommendations

Wednesday, 1 November

09:00 - 12:30 **Status of the Reference Input Parameter Library** (cont'd)

V. Level Densities (Coordinator **A.V. Ignatyuk**)

1. Total Level Densities
(Coordinator and discussion leader **A.V. Ignatyuk**)

   - A.V. Ignatyuk: "Sublibrary of Level Density Parameters"
   - Su Zongdi: "Sublibrary of Nuclear Level Densities" (CENPL.NLD)
   - Accomplishments, review of actions, status, discussion, recommendations

2. Level Densities for Fission
(Coordinator and discussion leader **A.V. Ignatyuk**)

   - M.V. Maslov: "Fission Level Density and Barrier Parameters for Actinide Neutron-Induced Cross Section Calculations"
   - Accomplishments, review of actions, status, discussion, recommendations

3. Partial Level Densities
[Includes also VII. Angular Distributions]
(Coordinator and discussion leader **M.B. Chadwick**)

   - M.B. Chadwick: "Photonuclear Angular Distribution Systematics in the Quasideuteron Regime"
   - Accomplishments, review of actions, status, discussion, recommendations

14:00 - 16:30 **VI.** ***Gamma Ray Strength Functions***
(Coordinator and discussion leader **J. Kopecky**)

- J. Kopecky: "Recent Experimental Work on Gamma Ray Strength Functions"
- Su Zongdi: "Giant Dipole Resonance Parameters for A < 50 and Sublibrary of Giant Dipole Resonance Parameters (CENPL.GDP-1.1)"

- Accomplishments, review of actions, status, discussion, recommendations

18:30 **Dinner** at the typical Viennese Wine Pub, Heuriger "Dorfschenke" (favourite place of Mario Uhl), Dreimarktsteingasse 1, Vienna - Salmannsdorf/Neustift

Thursday, 2 November

09:00 - 12:30 **Discussion**

- General review of the RIPL
- Steps toward creation of the Starter File

14:00 - 17:30 **Drafting of the Report**

Friday, 3 November

09:00 - 12:30 **Adoption of the Report**

14:00 Summary of the Meeting
Adjournment

Appendix 2

Abstracts

Regional Approaches to Input Parameter Library

Status Report on RIPL Files Collected at the NDS VAX Computer

P. Obložinský
Nuclear Data Section, IAEA Vienna

Current status of files of the Reference Input Parameter Library (RIPL) for nuclear reaction model calculations is described. Details are given on access, structure and composition of (sub)directories, and their actual contents in terms of files. The files were submitted by the CRP participants and they are collected at the UD4:[RIPL] directory of the VAX computer at the IAEA Nuclear Data Section. Totally, 27 MBytes of information is available.

Present Status of INDES and its Parameter Database

T. Fukahori and T. Nakagawa
Nuclear Data Center, JAERI
Tokai-mura, Naka-gun
Ibaraki-ken, 319-11 Japan

The Integrated Nuclear Data Evaluation System (INDES) is being developed in JAERI main frame computer. The main frame version of INDES will be frozen as this stage. Development of a UNIX version of INDES will be started from 1996. The parameter database files in INDES have informations described in Table 1. They have been already sent to IAEA/NDS. The brief manual for the format has been also attached.

Table 1. Parameter Databases Included in INDES

Deformation Parameter:	88 isotopes, 462 parameters
Level Density Parameter:	462 isotopes
Discrete Level Scheme:	174+503 isotopes, 2857+7092 levels
Basic Nuclear Information:	2585+3111 isotopes
Optical Model Potential Parameter:	35 parameter sets

+: separated into two files

Progress and Activities on Reference Input Parameter Library at CNDC (Chinese Evaluated Nuclear Data Library CENPL)

Su Zongdi, Ge Zhigang, Zhang Limin, Sun Zhengjun, Wang Baojin
(Chinese Nuclear Data Center, CIAE, P.O. Box 275-41, Beijing)

Huang Zhongfu
(Dept. of Phys., Guangxi Univ.)

Liu Jianfeng
(Dept. of Phys., Zhengzhou Univ.)

Zuo Yixin, Yu Ziqiang
(Dept. of Phys., Nankai Univ.)

Ma Gonggui
(Inst.Nucl.Sci.& Tech., Sichuan Univ.)

Chen Zhenpeng
(Dept.of Modern Applied Phys., Tsinghua University)

The progresses on the Reference Input Parameter Library for nuclear model calculations of nuclear data , i.e. the Chinese Evaluated Nuclear Parameter Library (CENPL) at the past period are presented . The work of setting up the CENPL was continued, and some sub-libraries were updated and expanded. The relevant nuclear model parameters, such as the level density parameters, giant dipole resonance parameters , average neutron resonance parameters and so on , have been developed. In addition, the activities on the CENPL at the past period and plan on the CENPL-2(Version 2) at CNDC are present in this paper.

Status of RIPL
I. Atomic Masses, Shell Corrections and Deformations

Updated Edition for Sub-library of Atomic Masses and Characteristic Constants of Nuclear Ground States(CENPL.MCC 1.1)

Su Zongdi, Sun Zhengjun, Ma Lizhen
Chinese Nuclear Data Center, CIAE, P.O.BOX 275-41, Beijing

The sub-library of the atomic masses and characteristic constants of nuclear ground states(MCC-1.1, Version 95), which is a sub-library of the Chinese Evaluated Nuclear Parameter Library (CENPL) has been finished. The mass excess, atomic mass and total binding energy have been updated in the MCC-1.1 sub-library.

Status of RIPL
II. Discrete Level Schemes

Status of Discrete Level Schemes of Medium-Heavy Nuclei

G. Molnár
Institute of Isotopes, Budapest

The first working version of a Discrete Level Schemes Sublibrary has been created for medium-heavy nuclei with mass $50 < A < 150$ by our group. The original data have been retrieved from the Evaluated Nuclear Structure Data File, exported into a database management system and carefully checked for consistency. The resulting library has been compared with a similar file created earlier at Bologna. The new database is substantially larger than the old one and is virtually free of errors. More work has to be done, however, in order to assess completeness of level scheme for each nucleus and introduce reasonable cutoff energies. In the course of the work utilization of a relational data base management system has proved most useful, if not inevitable.

Discrete Level Schemes, their Gamma Radiation and Branching Ratios (CENPL.DLS)

Zhang Limin, Su Zongdi, Sun Zhengjun
Chinese Nuclear Data Center, CIAE, P.O.Box 275-41, Beijing

The sub-library of the discrete level schemes, their gamma radiation and branching ratios (DLS) is presented . The data of DLS data file were translated from the Evaluated Nuclear Structure Data File (ENSDF). These data have further been checked and corrected, and its format has further been refined at the past a year. The DLS management retrieval code has been completed at the CNDC. This code can cut off and select the required levels and gamma rays from whole discrete level scheme according to user's demand.

Status of RIPL
III. Average Neutron Resonances

Analysis of Main Differences between Neutron Resonance Density Evaluations

A.V. Ignatyuk and G. Reffo
FEI Obninsk and ENEA Bologna

No Abstract given

Status of RIPL
IV. Optical Model Parameters

Status of Optical Model Activities at Los Alamos National Laboratory

P.G. Young
Theoretical Division, Los Alamos National Laboratory

An update will be given of activities at Los Alamos National Laboratory aimed at developing optical model potentials for applied calculations. Recent work on a coupled-channels potential for neutron reactions on 241,243Am and a spherical neutron potential for 59Co will be presented, together with examples of their application in nuclear reaction calculations with the GNASH code system. Additional potentials from earlier analyses will be described and made available for possible inclusion in the Reference Input Parameter Library (RIPL) for nuclear model calculations of nuclear data. Specific activities directed at development of the optical potential segment of the RIPL will be summarized.

Starter File of Optical Model Potential Parameters and Nuclear Data Computation of ND-Isotopes

S.B.Garg and Ashok Kumar

Bhabha Atomic Research Centre
Trombay, Bombay-400 085 (India)

It is well known that the optical model forms the backbone of generating nuclear data for the scientific and technological applications. Optical model has evolved into a variety of different forms and formulations which include spherical, non-local, dispersive, folding and coupled channels. The potential parameters pertaining to all these different forms are required by the data evaluators. We have attempted to compile these parameters for a large number of nuclides according to a new format set up for this purpose , which covers the above listed different potential forms. The parameters have been compiled for the incident projectiles, namely, neutron, proton, deuteron, triton, He-3 and alpha particles in a 'Starter File' which is constituted of OMSUB, NEUT, DEUT, PROT, ALPHA, CCNEUT and CCPROT sub-files. The bases of deriving the potential parametrizations are explicitly recorded in these Files.

(N,2N) and (N,3N) cross-sections of Nd-146,Nd-148 and Nd-150 have been computed by making use of the compiled potential parametrizations and compared with the corresponding measured cross-section data. The analysis has been carried out with the Wilmore-Hodgson and Rapaport-Kulkarni-Finlay potentials by taking into account neutron, proton, alpha and gamma-ray decay channels in the framework of statistical-cum- preequilibrium exciton model. Comments about suitability of potential parameters and other relevant information concerning the computation and data compilation are given in the paper.

Deformed Optical Potentials for Applied Purposes Determined in Nuclear Data Evaluation Laboratory

E.Sh. Sukhovitskij, Yu.V. Porodzinskij
Radiation Physics and Chemistry Problems Institute
220109, Minsk-Sosny, Belarus

Coupled channels calculations appear to be reliable method for prediction of optical cross-sections, provide wave function for direct, transmission coefficients for statistical and preequilibrium models. Deformed optical potentials for actinides developed and used for nuclear data evaluation and other applied purposes in Nuclear Data Evaluation Laboratory in Minsk are presented and suggested to be included in RIPL. The deformed potential for 238-U with saturated coupling allowing to predict optical cross-sections for excited nucleus is given. This can be important for calculations in the vicinity of level excitation thresholds. The differences appearing in the predicted optical cross-sections for actinides by the proposed potentials and others commonly used are discussed.

Status of RIPL
V. Level Densities

Sublibrary of Level Density Parameter

A.V. Ignatyuk
FEI Obninsk, Russia

No Abstract given

Sub-Library of Nuclear Level Density (CENPL.NLD)

Su Zongdi
Chinese Nuclear Data Center, CIAE, P.O.Box 275(41), Beijing

Huang Zhongfu, Dong Liaoyuan
Department of Physics, Guangxi Univ., Lanlin, Guangxi

A data file of the nuclear level density sub-library , the level density parameter data file (LDP), are described . It contains eight sets of level density parameters for three kinds of the popular level density formulas.

Fission Level Density and Barrier Parameters for Actinide Neutron-Induced Cross Section Calculations

V.M. Maslov
Radiation Physics and Chemistry Problems Institute
220109, Minsk-Sosny, Belarus, CIS

Fissioning nucleus level densities are one of the key ingredients in actinide fission cross section calculations. It is well-recognized that fission level density and barrier parameters are interdependent. The level density depends rather sensitively on the pairing, collective and shell effects. These effects are easily introduced within generalized superfluid model both at equilibrium and saddle-point deformations. Step-like structures in fission cross sections below 1 MeV incident neutron energies are interpreted as being due to pairing effects. Pairing strength parameters are used to fit the fission cross section slope with energy in the first plateau region. The collective contribution to the level density of deformed nucleus is determined by the order of symmetry of nuclear saddle deformation, which was derived with shell correction method calculations of Howard-Moller. The shell effects dumping is manifested as consistent fit of fission data above emissive fission threshold. We apply this approach for the analysis of actinide (U, Np, Pu, Am, Cm) neutron-induced reaction data from 1 keV up to 20 MeV. Resulted fission level density and barrier parameters are presented.

Photonuclear angular distribution systematics in the quasideuteron regime

M.B. Chadwick
Livermore National Laboratory, Livermore, USA

We describe an applications-oriented method for determining continuum photonuclear angular distributions for emission of light particles (n, p, d, t, 3He, and alphas) in the quasideuteron regime ($40 < E_inc < 140$MeV).

Based on theoretical considerations by Chadwick and Oblozinsky for the angular forward-peaking in preequilibrium reactions, Kalbach's 1988 angular distribution systematics for a neutron projectile can be straightforwardly modified for use in photon-induced reactions. This results in photonuclear angular distributions which are less forward-peaked than their nucleon-induced counterparts, due to the small momentum carried by a photon. Our predictions are compared against double-differential monochromatic 12C(gamma,xp) data at 60 and 80 MeV and are seen to describe the measurements fairly well.

Status of RIPL
VI. Gamma Ray Strength Functions

Recent Experimental Work on Gamma Ray Strength Functions

J. Kopecky
ECN Petten, The Netherlands

- Review of recent BNL and INP (Rez) experiments -

Results of recent sum-coincidence measurements of two-step cascade gamma-ray spectra is reviewed. The method is sensitive to both primary and secondary transitions involved. The results were analysed with a series of model calculations employing different models for gamma ray strength functions and level densities. Conclusions on preferred gamma ray strength function models will be discussed.

Giant Dipole Resonance Parameters For A < 50 and Sub-Library of Giant Dipole Resonance Parameters for Gamma-Ray (CENPL.GDP 1.1)

Liu Jianfeng
Department of Physics, Zhengzhou University, Zhengzhou, China

Su Zongdi
China Institute of Atomic Energy, P.O.Box 275(41),Beijing, China

Zuo Yixin
Department of Mathematics, Nankai University, Tanjin, China

The experimental data of the photonuclear reactions for the nuclides 12-C , 14-N , 16-O , 27-Al and 28-Si have been fitted with the Lorentz curves describing the giant dipole resonances of the photonuclear reactions and the GDRP of these nuclides have been extracted. These GDRP have been compiled in the sub-library of the giant dipole resonance parameters for gamma-ray (GDP). An updated edition GDP-1.1 (Version 95) has been completed and used in the nuclear model calculations widely.

Appendix 3

Second Research Co-ordination Meeting on
"Development of Reference Input Parameter Library (RIPL) for Nuclear Model Calculations of Nuclear Data"

IAEA Headquarters, Vienna, Austria
30 October to 3 November 1995

Scientific Secretary: P. Obložinský

LIST OF PARTICIPANTS

CHINA
SU Zongdi (7431/RB)
Chinese Nuclear Data Center
China Institute of Atomic Energy
P.O. Box 275 (41)
Beijing 102413
Tel.: +86 10-935-7275
Fax: +86-10-935-7008
E-mail: ciaednp@bepc2.ihep.ac.cn

HUNGARY
Gábor MOLNÁR (8068/RB)
Institute of Isotopes
Hungarian Academy of Sciences
P.O. Box 77
H-1525 Budapest
Tel.: +36 1-275-4347
Fax: +36 1-275-4349
E-mail: molnar@alpha0.iki.kfki.hun

INDIA
Ashok KUMAR (8067/RB)
Theoretical Physics Division
5th Floor, Central Complex
Bhabha Atomic Research Centre
Trombay, Bombay 400 085
Tel.: +91 22-551-9946
Fax: +91 22-556-0750
E-mail: krsrini@magnum.barct1.ernet.in

ITALY
Gianni REFFO (7914/CF)
Nuclear Data Center
E.N.E.A.
Via Martiri di Monte Sole, 4
I-40129 Bologna
Tel.: +39 51-609-8522
Fax: +39 51-609-8785
E-mail: reffo@rin365.arcoveggio.enea.it

JAPAN
Tokio FUKAHORI (8069/CF)
Nuclear Data Center
Department of Reactor Engineering
Japan Atomic Energy Research Institute (JAERI)
Tokai-mura, Naka-gun
Ibaraki-ken 319-11
Tel.: +81 292-82-5907
Fax: +81 292-82-6122
E-mail: fukahori@cracker.tokai.jaeri.go.jp

RUSSIA
Anatoly V. IGNATYUK (7914/CF)
Institute of Physics and Power Engineering (IPPE)
Bondarenko Sq. 1
249020 Obninsk, Kaluga Region
Tel.: +7 084-399-8035
Fax: +7 095-883-3112
E-mail: igantyuk@cjd.obninsk.su

UNITED STATES OF AMERICA
Mark B. CHADWICK (8002/CF)
Nuclear Data Group, L-412
Lawrence Livermore National Laboratory
P.O. Box 808
Livermore, CA 94551
Tel.: +1 510-422-5879
Fax: +1 510-422-2851
E-mail: mbchadwick@llnl.gov

Phillip G. YOUNG (7916/CF)
Group T-2, MS-B243
Theoretical Division
Los Alamos National Laboratory
Los Alamos, NM 87545
Tel.: +1 505-667-7670
Fax: +1 505-667-9671
E-mail: pgy@lanl.gov

I.A.E.A.
Pavel OBLOŽINSKÝ (Scientific Secretary)
IAEA Nuclear Data Section
Wagramerstrasse 5, P.O. Box 100
A-1400 Vienna, Austria
Tel. (43-1)2060-21712
Fax: (43-1)20607
E-mail: oblozinsky@iaeand.iaea.or.at

CONSULTANT:
Jura KOPECKY (8001/CF)
ECN Nuclear Energy
Netherlands Energy Research
Foundation (ECN)
P.O. Box 1
NL-1755 ZG Petten
Tel.: +31 2246-4483
Fax: +31 2246-3490
E-mail: kopecky@ecn.nl
research1@pi.net (private e-mail)

OBSERVERS:
B. STROHMAIER
Institut für Radiumforschung und
Kernphysik
Boltzmanngasse 3
A-1090 Vienna, Austria
Tel.: +43 1-31367 ext. 3508
Fax: +43 1-310-2338 or 310-2683
E-mail: brigi@pap.univie.ac.at
a8251dac@awiuni11.edvz.univie.ac.at

Vladimir M. MASLOV
Radiation Physics and Chemistry
Problems Institute
Belarus Academy of Science
220109 Minsk-Sosny, Belarus
Tel.: +375 172-467-341
Fax: +375 172-467-341
E-mail: maslov@ndel.basnet.minsk.by

E. Sh. SUKHOVITSKIJ
Radiation Physics and Chemistry
Problems Institute
Belarus Academy of Science
220109 Minsk-Sosny, Belarus
Tel.: +375 172-467-935
Fax: +375 172-467-341
E-mail: maslov@ndel.basnet.minsk.by

Douglas W. MUIR
Group T-2, MS-B243
Los Alamos National Laboratory
P.O. Box 1663
Los Alamos, NM 87545, U.S.A.
Tel.: +1-505-665-8819
Fax: +1-505-667-9671
E-mail: dwm@lanl.gov

MS. MAGGIN AVEDIKIAN
EXT. ROOM: A2418
INTERNATIONAL ATOMIC ENERGY
AGENCY
P.O. BOX 100
A-1400 VIENNA
AUSTRIA

Nuclear Data Section
International Atomic Energy Agency
P.O. Box 100
A-1400 Vienna
Austria

e-mail, INTERNET: SERVICES@IAEAND.IAEA.OR.AT
e-mail, BITNET: RNDS@IAEA1
fax: (43-1) 20607
cable: INATOM VIENNA
telex: 1-12645 atom a
telephone: (43-1) 2060-21710

online: TELNET or FTP: IAEAND.IAEA.OR.AT
username: IAEANDS for interactive Nuclear Data Information System
username: NDSOPEN for FTP file transfer