# Forty Years Experience on Nuclear Data Evaluation
# (Personal View)

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Japanese Nuclear Data Committee (JNDC) was organized in 1963. Since then many activities have been made successfully by JNDC. The results of the activities were summarized in chronological table and some remarks based on the forty years experience in evaluation work were described.

## 1. Evaluation Activities

During the last forty years, JNDC has prepared and released several versions of general purpose neutron nuclear data file JENDL and special purpose data files such as FP decay heat data file, neutron dosimetry, neutron activation, (α,n) reactions and so on. And now JNDC is preparing high energy nuclear data files of neutron and proton incident reactions and photo-reaction data file. Several dozens of researchers, as the JNDC members, attended to the development of evaluation methods, evaluation work, verification of the evaluated data and compilation of the data files, almost as a side job.

Chronological table of these works is shown in Table 1. In the third column of the table, names of main software for the nuclear data evaluation developed or prepared in JNDC are given. These codes were utilized productively to evaluate the nuclear data files shown in the fourth column of the table. Besides these codes, experimental data supplied by several domestic universities and national organizations are great help for JENDL evaluation. These experimental data are

DDX by /Osaka Univ./ Tohoku Univ.
Fission Cross Section by /Tohoku Univ./ Kyoto Univ.
(n,γ) Cross Section by /Tokyo Inst. of Tech./Kyoto Univ./ JNC/ JAERI
Charged Particle Production by /Tohoku Univ../ JAERI,
Charged Particle Reaction by Kyushu Univ.
Resonance Parameter by JAERI
Activation Cross Section by /JAERI/ Nagoya Univ.
FP Decay Heat by Univ. of Tokyo
KERMA Factor by JAERI

## 2. Some remarks on evaluation work

In the course of evaluation work, some interesting problems are recognized personally in nuclear physics aspects and evaluation support aspect. But, at present, these problems are not solved and left untouched because of lack of ability and spare time. Some of them are described below;

<u>Nuclear physics aspect</u>:

- Resonance analysis,

An approximated R-matrix theory was applied successfully to analyze total cross section of neutrons incident on $^{14}$Nand $^{16}$O[2]. The theory also applied to analyze the (α, n) reaction of light nuclides[3]. In the analysis, total width, incident channel width and outgoing channel width are given as parameters besides other resonance parameters. Principally, total width is not a parameter, but determined by sum of all outgoing channels. So, all experimental data of outgoing channels are required for the analysis. For almost cases, it is not practical to acquire all open channel data. Some approximation should be made to obtain partial width for channels of which experimental data are not available.

● Deformed optical potential and single particle states.

Next stage evaluation is planned for fission product nuclides and minor actinides. For these nuclides, optical model potentials will be resurveyed. Structure of reaction cross section is reflected by single particle shell states of the optical model real part potential. As an example, neutron single particle states are surveyed for $^{90}$Zr+n. The results are shown in Fig.1. Similar survey will be effective to determine deformed potential depth and deformation. For deformed potential, is there correspondence with Nilsson orbits?

● More elaborate gamma-ray transition model.

Gamma-ray transition probability called Weisskopf units is used frequently in calculation of capture cross section, gamma-ray energy spectrum and so on. However, it is well known that Weisskopf units are differing from experimental transition probability by some order of magnitudes. Empirical distributions of the difference were studied by Wilkinson[5] in 1956. Since then many good experimental data have been accumulated. New study of the empirical distributions would contribute to the development of more elaborate model. If the development of elaborate model will not be attained, new empirical distributions will be integrated in calculation codes of capture cross section and so on.

● Photoreaction sum rule

Though there are plentiful experimental data for photo-neutron production, experimental data of photo-absorption cross section are scarce. With resonance parameters obtained by analysis of photo-neutron cross section, photo-absorption cross section can be calculated assuming photon widths. Photon widths are estimated to reproduce integral of photo-absorption cross section. Integral of photo-absorption cross section are known to be proportional to N*Z/A. Preliminary result is shown in Fig.2. More careful study on the relationship should be made.

● Fission cross section analysis.

JNDC has not yet cross section calculation code including fission process with double humped fission barrier.

● Calculation of number of fission neutron ($\nu_p$ and $\nu_d$).

For high energy file and photo-reaction file, $\nu_p$ and $\nu_d$ should be estimated in the incident energy region over 20 MeV. Is there simple model or systematics to estimate the quantities?

<u>Evaluation work aspect</u>:

● Automatic reading of experimental data shown in figures

For neutron incident data, EXFOR file includes almost experimental data as numerical data. But for charged particle incident data, in many cases, we must read the values in a figure.

● Dialogue type easy system to make ENDF format files.

ENDF format is complicated and to make the file, we must consult with the manual and it is very time consuming and tedious labor.

● More effective and rapid accomplishment of evaluation work.

To attain this problem, some system, management and/or tools should be studied.

Table 1 Chronological Table of JNDC （an abbreviation of table of ref. 1 ）

| Year | JNDC | Codes for Eval. | Evaluation |
|---|---|---|---|
| 1963 | organized by JAERI and AESJ* | ELIESE | |
| 1965 | 1st seminar on ND | | |
| 1966 | 1st JNDC News | | 1st eval.( $\sigma_{total}$ of C+n) |
| 1968 | ND Lab. | | |
| 1969 | Sub-Com.on ND, and Reactor Const. | | |
| 1970 | | | JENDL eval. started |
| 1972 | | | 28FPND |
| 1973 | Sub-Com.on N.Fuel Cycle | CASTHY,SPLINT | JENDL-1planned |
| 1974 | | (DWUCK4) | JENDL-0 |
| 1976 | ND center | | 1st Chart of Nuclides, Benchmark test of JENDL-1 |
| 1977 | Mass Chain eval.took part | (GNASH) | JENDL-1 released(72nuclides), JENDL-2 planned |
| 1978 | 1st Nuclear Data symposium | NDES | |
| 1979 | | | JENDL-3 planned |
| 1981 | | ASREP | FP decay data file 1 |
| 1982 | | CLUSTR, Simul.CS.eval.code | JENDL-2 released(89nuclides) |
| 1984 | | | 100FPND |
| 1985 | JENDL-2 awarded by AESJ(special prize) | | |
| 1987 | | PEGASUS | ( $\alpha$,n) data eval.started |
| 1986 | Special Purpose File Promotion Report | | |
| 1988 | Mito Int.Conf. on Nuclear Data | (ECIS88),SINCROS | FP decay data file 2 |
| 1989 | | (GMA) | JENDL-3 released(171nuclides) |
| 1990 | | | JENDL-3.1(324) |
| 1991 | Standardization of FP decay data awarded by AESJ | | Dosimetry file, Gas prod.file released |
| 1993 | High Energy File WG | ALICE-F | |
| 1994 | | | JENDL-3.2released(340nuclides) |
| 1995 | ND Center home page | | |
| 1996 | | | Activation file96 |
| 1997 | | KALMAN | |
| 1999 | | | Fusion File99 |
| 2000 | | SOC,DSD | FP decay data File 2000 |
| 2001 | Tsukuba Int.Conf. on Nuclear Data | QMD/JAM | |
| 2002 | | | JENDL-3.3released(337nuclides) |
| 2003 | | | ( $\alpha$,n) data file released, Photo-react.,HE File in preparation. |

* AESJ: Atomic Energy Society of Japan

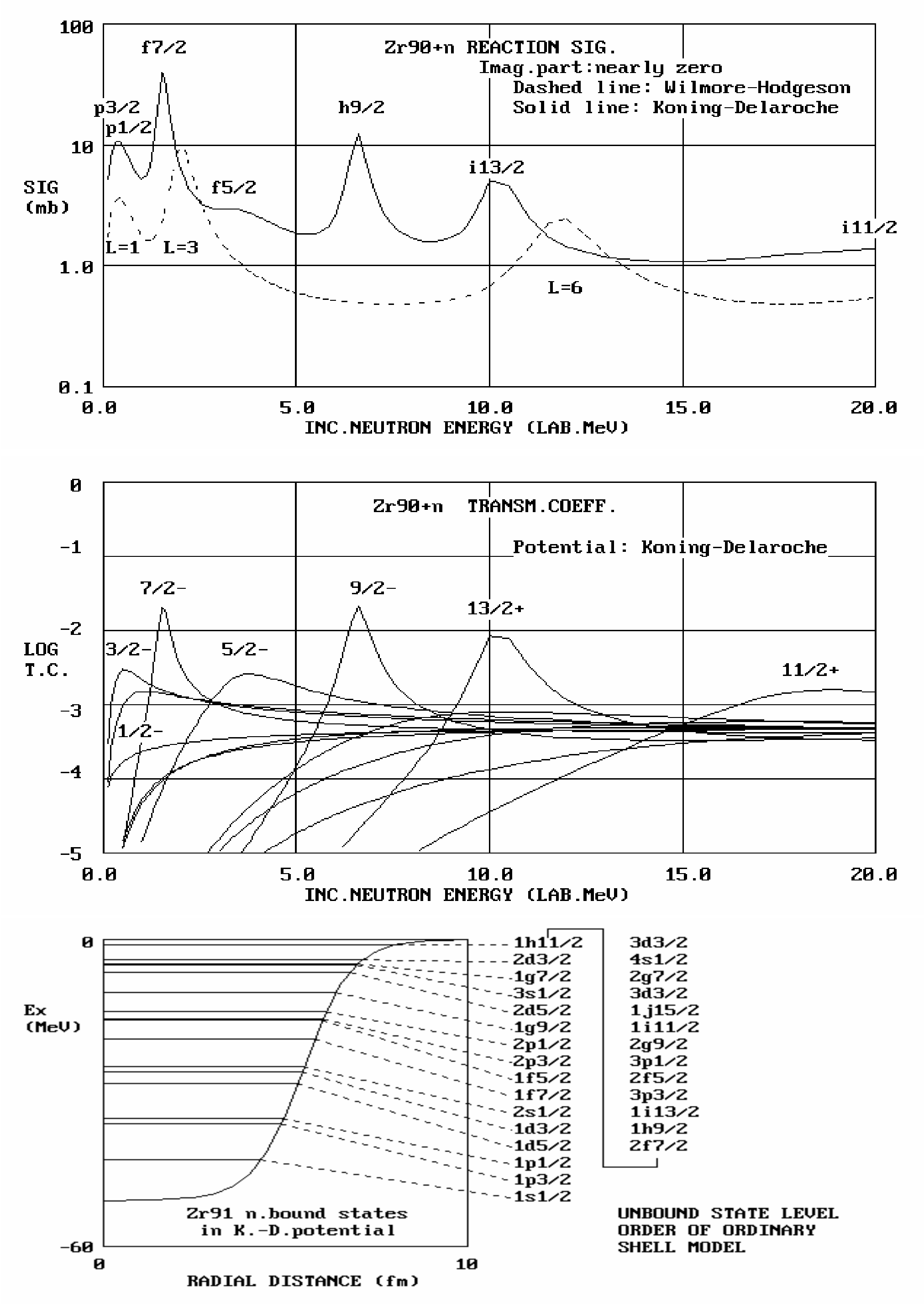


Fig.1 Top: Compound nucleus formation cross section calculated with Koning-Delaroche[4] and Wilmore-Hodgson (no $\ell \cdot s$ term) potential for imaginary potential nearly zero.
Middle: Transmission coefficients for Koning-Delaroche potential for determination of shell model states of peaks in the top figure.
Bottom: Shell model states of bound states in Koning-Delaroche potential and unbound ordinary shell model states with $\ell^2$ term. Some correspondences are recognized with the states in the top figure.

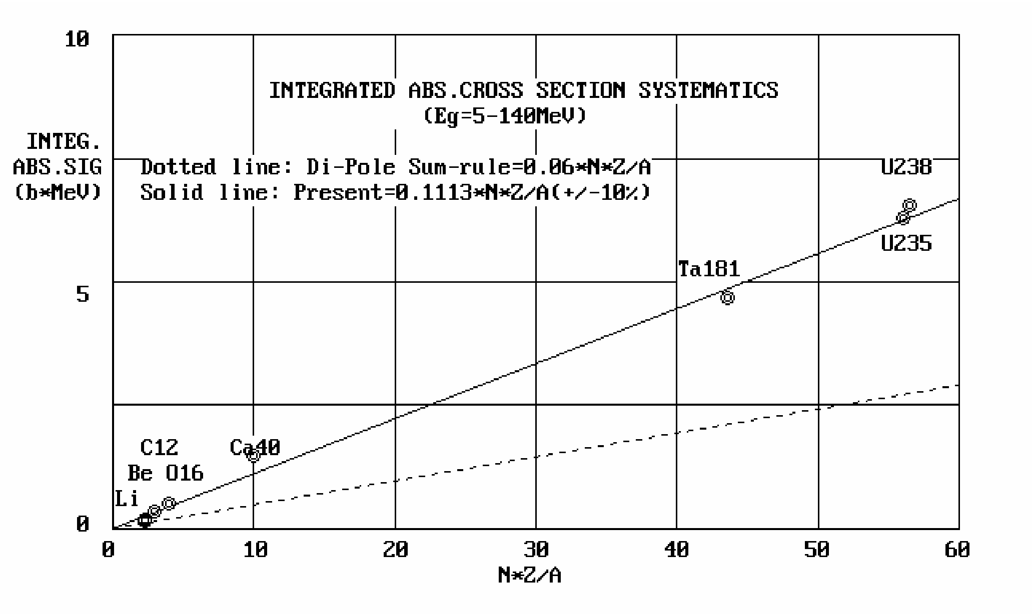


Fig.2 Integrated photo-absorption cross section systematics, In abscissa N, Z and A are neutron, proton and mass number of target nucleus, respectively.


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