The Progress of CENDL (May 2002)

Yu Hongwei
China Nuclear Data Center

From 2001, we began a new five years plan of CENDL, and continue test the data of CENDL-3, improved for the problems found in the test.

□□ The progress of the data measurements

1. Precise measurements of the emission probabilities for the low energy γ-rays of ^{161}Tb

The emission probabilities for the low energyγ-rays following the decay of ^{161}Tb were measured precisely by using a 4πβ-γ coincidence apparatus and low energy photon spectrometer. Determined results and comparison are showing in the table. The uncertainty of the present measurement is lower than previous data.

Emission probabilities for the low energy γ-rays of ^{161}Tb

E_γ(keV)	Probabilities □□□		
	Present work	Ref.1	Ref.2 *
25.667	23.27±0.53	23.2±1.0	21.0±2.1
48.930	17.00±0.31	17.0±0.4	16±3
74.597	10.01±0.19	10.2±0.2	9.8±2.0

Ref.1: R.G.Helmer, Nucl. Data Sheets, 1990,59(1) p40-41
Ref.2: Edgardo Browne and Richard B. Frestone, Table of Radioactive Isotopes, New York, John Wiley & Sons, Inc. 1986, 161-2

2. Excitation functions of (n, γ) reactions

The cross sections of ^{186}W(n, γ) ^{187}W reaction were measured in neutron energy range from 0.5 to 1.5 MeV by the activation technique. Neutrons were produced through the T (p, n) ^{3}He reaction, and the cross sections of the ^{197}Au(n, γ) ^{198}Au reaction were used to determine the absolute neutron flux. Experimental results agreed with the previous time-of-flight measurements but did not agree with the previous activation measurements. Without the tungsten resonance absorption foils, the measured cross sections of the ^{186}W(n, γ) ^{187}W reaction by the activation method were shown to be larger than the corrected ones because of the interference of the low energy neutrons (See publication NSE 137, 107-110(2001)).

3. Excitation functions of reactions from d+Ti, d+Mo, p+Ti and p+Mo

In present work, the excitation function for the products of ^{48}V, from p+Ti and d+Ti and of ^{95m,g}Tc, ^{96g}Tc, and ^{99}Mo from p+Mo, and d+Mo in the incident energy 6-22 MeV were studied.

4. Spectroscopic(□□□) studies of highly ionized atoms

A 2.2-meter grazing incidence VUV to soft X-ray

(2) The cross sections for the ^{174}Hf (n, γ) ^{175}Hf reaction were measured relatively to the ^{197}Au(n, γ)^{198}Au reaction for neutron energies from 162 to 1200 keV at Sichuan University , with high resolution HPGE gamma ray spectroscopy.

(3) The cross section of ^{114}Cd(n,2n)^{113m}Cd reaction was measured relatively to ^{93}Nb(n,2n)^{92m}Nb reaction at neutron energy of 14.7±0.3MeV at Lanzhou University. The activities were measured with high resolution HPGe detector. The error of the measured cross section is 9.4%.

8. Measurement of Thermal Neutron Capture Cross Section

The thermal neutron capture cross sections of ^{71}Ga(n,γ)^{72}Ga, ^{94}Zr(n,γ)^{95}Zr and ^{191}Ir(n,γ)^{192}Ir$^{m1+g,m2}$ reactions were measured by using activation method and compared with other measured data. Meanwhile the half-life of ^{72}Ga was also measured. The samples were irradiated with the neutron in the thermal column of heavy water reactor of China Institute of Atomic Energy. The activities of the reaction products were measured by well-calibrated Ge(Li) detector.

9. Measurement of Isomer Cross Section for the ^{197}Au(n,2n)^{196m2}Au Reaction at around 14 MeV

The intensity of ^{196m2}Au 148keV γ-ray and time relation of intensity of ^{196g}Au 356keV γ-ray was measured with a HPGe detector. The cross section of ^{197}Au(n,2n)^{196m2}Au was obtained to be 182±15mb, by two methods with DT neutrons

□□ The progress of the evaluation

The Benchmarks testing of CENDL-3 has been done at CNDC. The comparisons of calculated results with different evaluated nuclear data libraries were also made.

In most thermal and fast uranium□U□ criticality benchmarks, the calculated K_{eff} values with CENDL-3 are in good agreements with experimental results. In small fast cores with ^{233}U fuel□□□□, good results of K_{eff} values are given with CENDL-3, due to reevaluation of ^{233}U fission cross sections.

In the plutonium□Pu□ fast cores, the K_{eff} values were improved significantly with CENDL-3. This is duo to reevaluation of the fission spectrum and elastic angular distributions of ^{239}Pu and ^{240}Pu from CENDL-2 to CENDL –3.

Benchmark testing for beryllium has been done. The results were improved considerably compared with CENDL-2.1. But it's necessary to do further improvement for the data of beryllium from CENDL-3.

Benchmark testing for some structure materials has been done. It can be seen that further improvement for data of iron is needed, and further benchmarks testing will be done with these material.

The data testing for fission product nuclides has been done. The reactor spectrum averaged (n, γ) cross sections were calculated and compared with the measured ones. Good results are given for most fission product nuclides compared with other nuclear data libraries. This is because of using the newest experimental data for the evaluated data.

From 2001, we began a new five years plan of CENDL. The data of total 21 nuclides were evaluated in 2001:
(1) ^{0}Ga, ^{85}Rb, ^{87}Rb, ^{0}Rb, ^{204}Pb, ^{207}Pb, ^{75}As, ^{9}Be, ^{209}Bi, ^{232}Th, the file 1,2,3,4,6,12-15 are included.
(2) ^{125}Sb, ^{129}I, ^{89}Sr, ^{174m}Lu, ^{86}Kr, ^{95}Mo, ^{97}Mo, ^{233}Th, ^{234}Th, ^{204}Pb, ^{207}Pb, the file 1,2,3,4, 5 are included.

The new function were developed in UNF code:
(1) the kerma factors from every reaction channels, including elastic scattering process, can be calculated.
(2) DPA calculation of the damage crosses sections.

A Code APMN for Automatically Searching Optimal Optical Potential Parameters below 300 MeV was developed. APMN is a program for automatically searching a set of optimal optical potential parameters in $E \leq 300$ MeV energy region by means of the improved fastest falling method, which is suitable for non-fissile medium-heavy nuclei with the light projectiles, such as n, p, d, t, ^{3}He, and α. One set of optical potential parameters may be suitable from 1 to 40 target nuclei obtained based on their experimental data simultaneously□□□□.

The number of prompt (ν_p) and delayed (ν_d) neutrons emitted per fission event was evaluated for ^{239}Pu based on absolute measurements and relative to the spontaneous□□□□□□ fission υof ^{252}Cf. The dependence of prompt neutron number on incident neutron energy for ^{239}Pu was given from 10^{-5} eV to 20 MeV.

□□Future plans of CENDL

We have three main projects in CNDC from 2001: general purpose file;

nuclear physics basic database ; nuclear data for ADS

(1) General purpose file

A new five years plan from 2001 to 2005 has been determined, we will get more fund from our government in the plan. The data of total 281 nuclides will be evaluated.

The new five years plan

Nuclides	Fissile Nuclides	Structure material	Fission products	Light Nuclides	Total
Planned	44	58	166	13	281

More files will be included in the general purpose data file and the new methods of evaluation will be **developed:**

1. Covariance data files
2. The resonance parameters will be investigated and evaluated.
3. The methods of Unstable nuclear evaluation.
4. Improvement of the Light Nuclides calculation.

(2) Nuclear physics basic database:

The project is supported by China Ministry of science and technology, and it will contain the following data base:

1. Nuclear structure and Nuclear Decay database
2. Nuclear Model Parameters and computing programs library
3. Special Purpose database
4. Exfor Database
5. Evaluation Nuclear data library

Besides setting up the data files , we will setup online service system at CNDC.

(3) Nuclear data for ADS

This work is a part of the project of ADS system of China, and is supported by China Ministry of science and technology .The project include the following parts :

1. **Intermediate energy files**
2. **Study of Spallation target**
3. **Multi-group cross section generated**

monochromator□□□□□ was established at the HI-13 tandem accelerator at CIAE a couple of years ago. This spectrometer□□□□□ has been used for beam foil studies. New results for transitions of Mg-like Br XXIV, Ne-like Br XXVI, Ne-like Ge XXIII have been published (See publication: Physica Scripta 61, 464-467, (2000), Physica Scripta 61, 443-448, (2000)).

5. Angular Distribution and Cross Section Measurement Using a gridded ionization chamber □□□□□□□

(1) The differential cross section for $^{10}B(n,\alpha)$ ^{7}Li reaction were measured at 4.0, 5.0, 5.7 and 6.7MeV . The neutrons were produced through D (d, n) ^{3}He reaction.

(2) The differential cross section for $^{64}Zn(n,\alpha)$ ^{61}Ni reaction was measured at 5.0, 5.7and 6.7MeV. The neutrons were produced through D (d, n) ^{3}He reaction.

(3) The differential cross sections and integrated cross sections of the $^{6}Li(n,t)^{4}He$ reaction were measured at 1.85 and 2.67 MeV . Neutrons were produced through the $T(p,n)^{3}He$ reaction

Absolute neutron flux was determined through $^{238}U(n, f)$ reaction. The differential cross sections are obviously backward peaked in the center of mass reference system.

6. Fission Product Yields

(1) The chain yields of 28 product nuclides were determined for the fission of ^{235}U induced by 22 MeV neutrons

(2) Fission yields of 32 chains were determined for the fission of ^{238}U induced by 22.0MeV essentially mono-energetic neutrons.

(3) 35 chain yields were determined for the fission of ^{235}U induced by 19.1 MeV neutrons

(4) 36 chain yields were determined for the fission of ^{238}U induced by 19.1 MeV neutrons

Absolute fission rate was monitored with a double-fission chamber. Fission product activities were measured by HPGe γ-ray spectrometry. Time of flight technique was used to measure the neutron spectrum in order to estimate fission events induced by break-up neutrons and scattering neutrons. A mass distribution curve was obtained and the dependence of fission yield on neutron energy is discussed.

7. Measurement of Cross Section using the activation technique

(1) The cross sections for the $^{75}As(n,\gamma)$ ^{76}As reaction were measured relatively to that of ^{197}Au in neutron energy range from 29 to 1100 keV. Neutrons were produced via the $^{7}Li(p, n)$ ^{7}Be and T (p, n) ^{3}He reactions with a 2.5 MV Van de Graaff accelerator at Sichuan University. The activities after irradiation were measured with a calibrated high resolution HPGe detector. The errors of the measurements are 6.7%~7.8%.

nuclear physics basic database ; nuclear data for ADS

(1) General purpose file

A new five years plan from 2001 to 2005 has been determined, we will get more fund from our government in the plan. The data of total 281 nuclides will be evaluated.

The new five years plan

Nuclides	Fissile Nuclides	Structure material	Fission products	Light Nuclides	Total
Planned	44	58	166	13	281

More files will be included in the general purpose data file and the new methods of evaluation will be **developed:**

1. Covariance data files
2. The resonance parameters will be investigated and evaluated.
3. The methods of Unstable nuclear evaluation.
4. Improvement of the Light Nuclides calculation.

(2) Nuclear physics basic database:

The project is supported by China Ministry of science and technology, and it will contain the following data base:

1. Nuclear structure and Nuclear Decay database
2. Nuclear Model Parameters and computing programs library
3. Special Purpose database
4. Exfor Database
5. Evaluation Nuclear data library

   Besides setting up the data files , we will setup online service system at CNDC.

(3) Nuclear data for ADS

This work is a part of the project of ADS system of China, and is supported by China Ministry of science and technology .The project include the following parts :

1. Intermediate energy files
2. Study of Spallation target
3. Multi-group cross section generated