Progress of Nuclear Data Evaluation and Related Studies in CNDC and CNDCN

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The following progress are obtained in collaborating with China Nuclear Data Coordination Network(CNDCN).

1. Nuclear data evaluation works

■ Neutron data evaluation

Light nuclides: The updated evaluations of H, D, and T have been finished. The whole set of neutron data including the MF-6 of ^{9}Be, ^{12}C have been calculated and evaluated based on new reaction model LUNF series codes for light nuclei and experimental data. **Structure nuclides:** ^{28,29,30,nat}Si, ^{50,52,53,54,nat}Cr, ^{64,66,67,68,70,72,73}Zn, ^{182,183,184,186,nat}W, ^{197}Au 22 structure material nuclides have been calculated and evaluated on the basis of the experimental data, the output file contained MF=1-6 in ENDF/B-6 format. **Fission product nuclides:**^{75,77,79}As, $^{70,71, 72,73,74, 75, 76,77,78,nat}$Ge, ^{174m}Lu, ^{148m}Pm, ^{85,87,nat}Rb, ^{69,71,nat}Ga, ^{86}Kr, ^{129}I, ^{89}Sr, ^{125}Sb, ^{123,133,135}Xe, ^{89}Y, ^{92,94,95,96,97,98,100,nat}Mo, ^{113,115,123,nat}In, ^{120,122,124,125,126}Sn, ^{93}Nb evaluations have been completed. The 101 FP evaluations of CENDL-3.0 have been selected to join in the international comparison of FP and recommend by WPEC Subgroup 21. **Actinides:** On the basis of the new model code FUNF for fission nuclei and the new experimental data adjusting the model parameters carefully, the new evaluations of ^{233,234,235,236}U, ^{241,242}Am, ^{236,237,238,239}Np and ^{232,233,234}Th have been performed.

■ **Structure and decay data**

CNDC and CNDCN have taken permanent responsibility for evaluating and updating NSDD for A=51, and 195-198.The mass chain A=197 have been revised using available experimental decay and reaction data, and A=196 is being updated. Updated evaluation of A=197 has been sent to NNDC, USA and will be published in NDS in 2004. The evaluations of mass chain A=52-56 were being updated at Jilin University. Decay data of ^{232}Th, ^{231,233}Pa, ^{232,233,234,236}U have been intercompared and checked. The decay data of ^{233}U were being evaluated on the basis of the new measured data.

2. Nuclear model study and related codes development

- **Nuclear reaction model study**

  A new model was improved and completed for 1p shell light nuclides, which contains the dynamics and kinematics of nuclear reactions.

  A method to set up file-6 of light nuclei for evaluated neutron data in ENDF/B-6 format below 20 MeV has been established and the energy balance was strictly considered. This method has been used in the evaluation of n+^{12}C.

  The possibility of ^{5}He emission has been investigated in the light nuclear reactions, and the formulation for calculating of the ^{5}He emission was developed. Also the double differential cross sections of ^{5}He emission, as well as the spectra of neutron and alpha particle from the breakup of ^{5}He, were set up and used in the series codes of LUNF.

- **Covariance study**

  A code for evaluating the covariance matrix of experimental data was developed. The covariance data are output in ENDF/B-6 format. The code together with the spline fitting code for multi-sets of correlative data was used to practically evaluate the covariance data for ^{58,60,61,62,64,nat}Ni and ^{63,65,nat}Cu and the reasonable results have been got. A program RAC for calculating covariance data of light nuclide was developed, based on the R matrix theory. The program has been tentatively used to calculate the covariance data for ^{6}Li and ^{10}B, the reasonable results have been got for the cross sections up to 5 MeV.

- **The systematic study of fission yield data**

  Based on the mass distribution data up to 200 MeV measured by Zoller, the systematic on dependence of chain yield on incident neutron energy for each mass number A was studied. And also the systematics of mass distribution on mass A and incident neutron energy was investigated by using 5 (or 3) Gaussian model. The calculated results could reproduce the experimental data used well. The investigation also shows that the correlation between the parameters of the systematic and the yields calculated with the systematics is quite complicated and, in general, is quite strong.

- **The study on the dependence of yield on energy**

  Taken some typical important fission products from $^{235, 238}$U fission, and the dependences of fission yield on incident neutron energy were studied. The covariance data were evaluated for each set of experimental data and the correlation among the data due to the error of fission rate (or normalization), detector efficiency, decay data etc. was taken into account in the fitting and the covariance matrix was obtained for the fit. The results show that the data for most of product nuclides, can be fitted with a linear function. But for some special product nuclides, the data have to be fitted with a spline function.

- **UNF, PREUNF**

  The UNF code (Version 2003) for nuclear data model calculations with the unified Hauser-Feshbach and exciton model has been completed. An interface code PREUNF with RIPL database has been developed, and used as the key code in the CENDL-3 nuclear data evaluations.

- **FUNF, PREFUNF**

The updated version of code FUNF, used for actinides model calculation, was improved compare with previous version. The code has been validated by using for some actinides calculations. The related interface code PREFUNF with RIPL database has been finished too.

- **APMN**

  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. One set of optical potential parameters may be suitable from 1 to 40 target nuclei obtained based on their experimental data simultaneously.

- **TT**

  Powerful software designed for nuclear data evaluation under Windows™ and Linux platforms. The main function of TT included the retrieving and plotting the evaluated data from the ENDF/B-6 format libraries and EXFOR database. The cross sections (MF=3), angular distributions (MF=4) can be plotted. TT also can be used for plotting the free format data.

3. **Nuclear data benchmark testing and validation works**

   The benchmark testing of CENDL-3 was continued. The testing of Pu, U isotopes, ^{232}Th , ^{237}Np, Cu, Al, Pb, Fe, D, C and some actinides of CENDL have been performed with available benchmarks. The NJOY system was used for generating the libraries for calculations. According to the benchmark testing results, improvements have been introduced into revaluations of some nuclei.

   The multigroup cross section libraries based on the CENDL-3, several multigroup cross section libraries of WIMS: WIMS 69, WIMS 82, CPM 69, CWIMS 69 and 123 groups library used for SCALE-4 were set up for the reactor physic performances and ADS project. A MCNP Monte Carlo library of CENDL-3 were generated and used in the benchmark testing of CENDL-3.

4. **The nuclear data work for ADS project**

   A library of continuum cross sections (at temperature 500K，850K，1200K，1500K，2000K) for MCNP code was established, which contains light nuclides H，^{9}Be, O, Al , material nuclides Cu, Fe, Cr and fissile nuclides ^{233,234,235,236,238,239}U, ^{238,239,240,241,242}Pu.

   A code MEND used for nuclear data calculations in the medium-high energy is being developed. Investigate the international experimental, theoretical nuclear data and relevant evaluation tools for the study of nuclear data in medium-high energy. The fission spectrum and number of prompt neutron per fission were calculated using the Quantum Molecular Dynamics (QMD), Statistical Decay Model (SDM) and fission statistical models in energy 100~3000MeV for nuclides ^{232}Th, ^{233,235,236,238}U, ^{235}Np, ^{242,243}Am, $^{240\sim250}$Cm, ^{249}Cf, ^{247}Bf and $^{237\sim242,244,246}$Pu

5. **Nuclear data library works**

   - The third version of China Evaluated Nuclear Data Library (CENDL-3) contains the data about 200 nuclides in the energy range from 10^{-5}eV to 20MeV. The benchmark testing and validation for most important structure material,

actinides nuclides have been done. Related technical documents for CENDL-3 are being prepared.

- By the support of Ministry of Science and Technology of China, Nuclear Basic Data Library is being constructing. This library contains the basic information, characters of nucleus and nuclear reaction model parameters, a series of special nuclear databases. This project will be finished in two or three years and will be available for the world through the Internet.