INTERNATIONAL NUCLEAR MODEL CODES COMPARISON STUDY

Following the distribution of the document "Nuclear Model Code Intercomparison" (NEANDC 118 "L"), many questionnaires were returned to the NEA Data Bank showing considerable interest in this exercise by both Nuclear Physicists and Evaluators.

The following areas of interest emerged from the replies:

- Coupled channel theory
- Optical model
- Statistical model
- Pre-equilibrium and particle emission spectra
- Fission channel
- Semi-direct capture mechanism

The first two exercises were suggested and prepared by Dr. Augustus Prince of BNL/NNDC and are the following:

1. Coupled Channel Exercise: Low energy neutrons exciting the lowest levels of U-238. Calculation of inelastic cross sections and neutron angular distributions.

2. Spherical Optical Model and Statistical Model Exercise: Calculation of all possible neutron-induced reactions for $E \leq 20$ MeV on Co-59.
   Depending on the energy of the incident neutron, several modes (with and without width fluctuations, with and without pre-equilibrium) may be used.

Exercies on pre-equilibrium model and emitted particle spectra, and on the fission-channel will be prepared during 1981.

Attached with this document you will find the detailed problem specification for the Coupled Channel Exercise.

From the responses to our previous questionnaire, we expect the following computer codes will be used; solutions from other codes are also welcome:

- CCROT/CCVIB (FEI Obninsk, USSR)
- CHUCK (Kunz, University of Colorado, USA)
- ECIS (Raynal, CEA/CEN Saclay, France)
- JUPITOR (several versions) (Tamura, ORNL, USA)

In order to better identify the version of your program, especially if you have made changes to the original version, we would like you to add a qualifier to the program name in point 1.

Replies to point 9 will help us to gather information on the speed and performance of the program you are using.

In point 10 we would like to gather information on particular problems you ran into when using the specified input parameters and other comments that might help during the analysis of any discrepancies.

We would like to receive the solution as a computer listing or as printed tables. When sending computer print-outs please explain abbreviations and/or symbols that appear in the listing. If possible we would like a copy of the listing on magnetic tape so that we could then easily recover information for analysis.

The solutions submitted will be analysed, comparative plots will be prepared, and conclusions given in the form of a report to be distributed to the participants, and to members of NEANDC.

In the event of large discrepancies for particular solutions, we will contact the participant to better understand the problem, and to help correct obvious mistakes.

In order that the experience with this first comparison can be presented to NEANDC at their 21st meeting in April 1981, solutions should be submitted as soon as possible, preferably before

<u>February 15, 1981</u>

Solutions should be returned to:

Dr. E. Sartori
NEA Data Bank
F-91191 GIF SUR YVETTE
France

The specifications for the Spherical Optical Model and Statistical Model Exercise will be distributed shortly.

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1. **Comparison for:**

   Coupled channel calculations

   Name of code: ....

2. **Physical process:**

   n + U-238

   with U-238 states: 0^+(ground st.), 2^+(0.044), 4^+(0.148), 6^+(0.308) energy levels (MeV) and with neutron energies E_n = 0.001, 0.01, 0.1, 0.5, 1.0 and 2.5 MeV.

3. **Quantities to be compared:**

   a. Total cross section.
   b. Integrated cross section for $0^+, 2^+, 4^+, 6^+$.
   c. Reaction cross section
   d. Angular distribution for $0^+, 2^+, 4^+, 6^+$ (from 2^o to 178^o in steps of 2^o).
   e. Scattering coefficients (C-matrix) for each partial wave.
   f. Transmission coefficients (if possible).

4. **Model specification:**

   Non-adiabatic coupled channel (relevant for JUPITOR).
   Including reorientation (self-coupling).
   Rotational model of deformed target nucleus.
   Woods-Saxon interaction with spin-orbit (optical model).

5. **Numerical method:**

   Legendre polynomial expansion of the coupled potential (to λ = 4).
   Complex radial form factors.
   Deformation for both real and imaginary potential (neglect it for spin-orbit).

6. **Numerical parameters:**

   First mesh size: 0.0125 F (relevant for JUPITOR).
   Second mesh size: 0.100 F.
   Matching radius: normally automatically chosen by code ($\sim$16 F).
   Number of partial waves: 6

7. <u>Model parameters:</u>

$V_R = 46.2 - 0.3\ E$ (Lab) $\quad r_r = 1.26$ F $\quad a_r = 0.63$ F

$W_S = 3.6 + 0.4\ E$ (Lab) $\quad r_i = 1.26$ F $\quad a_i = 0.52$ F

$V_{SL} = 6.2$ $\quad r_s = 1.12$ F $\quad a_s = 0.47$ F

(E in MeV)

$$\beta_2 = 0.198,\ \beta_4 = 0.057$$

parameters are defined by:

$$V(r) = -V_R f_r - i4a_i W_S \left(-\frac{df_i}{dr}\right) - \left(\frac{\hbar}{m_\pi c}\right)^2 \frac{V_{SL}}{r}\left[-\frac{d}{dr} f_s\right] \vec{\ell}\cdot\vec{\sigma}$$

where

$$f_x = \left[1 + \exp\left(\frac{r-R_x}{a_x}\right)\right]^{-1} \text{ and } R_x = r_x A^{1/3}\left(1 + \sum_\lambda \beta_\lambda Y_{\lambda 0}(\Theta)\right)$$

8. <u>Cases to run:</u>

for E_n = 0.001,0.01 and 0.1 MeV include only the 0^+ and 2^+ states
for E_n = 0.5,1.0 and 2.5 MeV include $0^+,2^+,4^+,6^+$

9. <u>Resources:</u>

Computer:

Optimization during compilation:

CPU time needed for the calculation:

10. <u>Comments:</u>