NEANDC-228"U"
12th January 1987.

INTERNATONAL NUCLEAR MODEL CODE COMPARISON STUDY OF HAUSER-FESHBACH CALCULATONS

P.E. Hodgson
Nuclear Physics Laboratory, Oxford, U.K.

and

E. Sartori
NEA Data Bank, Gif-sur-Yvette, France

1. Introduction

Several intercomparisons [1],[2] of computer codes used to calculate nuclear cross sections show general agreement but significant differences in detail. Since these codes embody the same mathematical functions and the intercomparisons use the same input parameters one would expect, if the codes are indeed identical, that the results would be the same to a high degree of accuracy, limited only by the rounding errors of the computer used For most practical purposes the differences between the codes tested in previous intercomparisons are not important. It is however desirable to identify and, where necessary, correct the sources of these differences because they may well cause significant effects when the program is used in other domains of parameter space or when the code is used as a subroutine in a more extended calculation.

A previous report [3] contained the results of an intercomparison of nuclear optical model codes for charged and uncharged particles. The present study is devoted to Hauser-Feshbach calculations. In section 2 the specifications of the test calculations are given and section 3 sets out the forms to be used for sending in the calculated results.

2. Specification of the Calculations

The Hauser-Feshbach theory enables the cross-sections of compound nucleus reactions to discrete final states to be calculated from a knowledge of the transmission coefficients in all channels and the energies and total angular moments of the states of the residual nuclei.

Since the purpose of this intercompairson is to compare the computer codes, we calculate only inelastic neutron scattering from an imaginary nucleus 60Co (Z=27, N=33) with states at the follwing energies (MeV) : 0^+, 0; 2^+, 0.1; 4^+, 0.3; 0^+, 1.0. The calculations should be made at the following energies : 0.2, 0.5, 1, 2 MeV and the differential shape elastic, compound elastic and inelastic scattering cross-sections should be tabulated at 10^o intervals in the CM system.

The transmission coefficients should be calculated from optical potentials specified for all channels by

$$V(r) = Uf_u(r) + iWg(r)$$

where $$f_u(r) = \left[1 + \exp\left\{(r_u A^{1/3} - r)/a_u\right\}\right]^{-1}$$

$$g(r) = -4a_w \frac{df_w(r)}{dr}$$

with U=50 MeV, W=10 MeV, $r_u=r_w=1.2$ fm; $a_u=a_w=0.6$ fm. As in the optical model intercomparison, the wave number parameter is 0.218732. For consistency reasons, integer masses should be used.

Hauser-Feshbach calculations may differ in several respects, in particular concerning the method used to take account of the correlation between the incident channel and the outgoing compound elastic channel. This correlation affects the compounds elastic cross-section at low energies, and consequently the non-elastic channels open at these energies. Its magnitude can be calculated in two ways: (i) by the Moldauer width fluctuation correction (WFC) and (ii) by the HRTW formalism [5]. The Moldauer WFC requires the evaluation of an integral and the HRTW formalism in its simpler form requires an iteration calculation. Since earlier codes may have the Moldauer WFC and later codes the HRTW method, calculations should be made with whatever options are available, and included in the final tabulation.

In particular, the previous statistical model intercomparison exercise did not include differential cross-sections, and in some of the outgoing channels it is notable that the cross-sections differ by quite large factors. It therefore remains desirable to make a precise intercomparison of statistical model codes so as to establish the correct values, and that is the principal motivation of the present study.

REFERENCES

[1] E. Sartori, Report on the International Nuclear Model Code Intercomparison, Coupled Channel Model Study, NEANDC-182A, INDC(NEA)3, 1984.

[2] A. Prince, G. Reffo and E. Sartori, Report on the International Nuclear Model Code Intercomparison Spherical Optical and Statistical Model Study, NEANDC-152A, INDC(NEA)4, 1983.

[3] P.E. Hodgson, E. Sartori, International Nuclear Model Code Intercomparison of Spherical Optical Model for Charged Particles. NEANDC-198-U, INDC(NEA)5.

[4] P.A. Moldauer, Phys. Rev. 135, B642(1964) and Nucl. Phys. A344, 185 (1980).

[5] H.M. Hofmann, J. Richert, J.W. Tepel, H.A. Weidenmueller, Ann. Phys. (N.Y.), 90, 403 (1975)

Hauser-Feshbach Comparison Study

(n+Co-60)

To be returned by 15 March 1987 to:

E. Sartori, NEA Data Bank, F-91191 Gif-sur-Yvette CEDEX, France

Name: .....

Address: .....

.....

Computer code(s) used : .....

.....

Computer used : .....

Precision used : ..... single ..... double.....

Computing time :.....

Comments : .....

.....

.....

.....

.....

.....

.....

.....

.....

.....

Table I. Shape Elastic Cross Section (C.M.)

(Energies in MeV, Cross Sections in mbarn/sterad.)

E / θ	0.2	0.5	1.0	2.0
0 10 20 30 40 50 60 70 80 90				
Integral				

Table II. Compound Elastic Cross Section (C.M.)

(Energies in MeV, Cross Sections in mbarn/sterad.)

WFC __ HRTW __

E / θ	0.2	0.5	1.0	2.0
0				
10				
20				
30				
40				
50				
60				
70				
80				
90				
Integral				

Table III. Inelastic Cross Section 1st level (C.M.)
(2+ 0.1 MeV)

(Energies in MeV, Cross Sections in mbarn/sterad.)

WFC __ HRTW __

E / θ	0.2	0.5	1.0	2.0
0				
10				
20				
30				
40				
50				
60				
70				
80				
90				
Integral				

Table IV. Inelastic Cross Section 2nd level (C.M.)
(4+ 0.3 MeV)

(Energies in MeV, Cross Sections in mbarn/sterad.)

WFC __ HRTW __

E / θ	0.2	0.5	1.0	2.0
0				
10				
20				
30				
40				
50				
60				
70				
80				
90				
Integral				

Table V. Inelastic Cross Section 3rd level (C.M.)
(0+ 1.0 MeV)

(Energies in MeV, Cross Sections in mbarn/sterad.)

WFC __ HRTW __

E / θ	0.2	0.5	1.0	2.0
0				
10				
20				
30				
40				
50				
60				
70				
80				
90				
Integral				

Table VI. Total and Reaction Cross Section

(Energies in MeV, Cross Sections in mbarn)

E / σ	0.2	0.5	1.0	2.0
Total				
Reaction				