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Development of a Module for the Evaluation of the Resonance Region

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1. Introduction

A new module has been developed to be added to a nuclear reaction model code EMPIRE [1] to allow for an evaluation of neutron cross sections in the resonance region. It automates most of the evaluation procedures and can be executed within EMPIRE or as a stand-alone program. The module performs an analysis of the available resonances, provides statistical distributions, and computes cross sections in the resolved and unresolved resonance regions. The module also provides an ENDF-6 formatted file [2] for the resonance region and various plots allowing for a verification of the procedure. The formatted file can be integrated later into the final ENDF-6 file as generated by the EMPIRE code. In the present paper, use of the resonance module and some sample cases are presented.

2. Calculation Method and Procedure

The resonance module consists of a graphic user interface (GUI) and a number of codes and scripts that read resonance parameters and other physical constants, perform an analysis of the available resonances, provide statistical distributions and compute cross sections in the resolved and unresolved resonance regions which are then compared with the available evaluated cross sections and experimental data.

At a startup, the module reads all the necessary data for the target nucleus including individual, as well as average, resonance parameters from the Atlas of

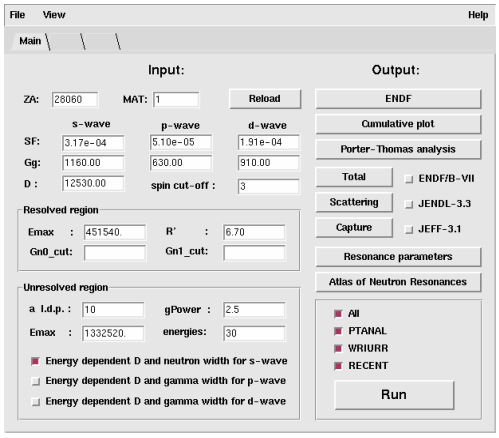

Figure 1. The screen shot of GUI main control panel.

Neutron Resonances [3] and other physical constants from RIPL-2 [4] and displays them on the screen. The user has the possibility to modify the nuclear parameters before performing the calculations in the resolved and unresolved regions. Figure 1 shows an example screen for Ni-60.

The PTANAL [5] and WRIURR [5] codes which have been modified for the resonance module are used for the calculation of resonance parameters in the resolved and unresolved energy regions, respectively. The Porter-Thomas distribution [6] is presented graphically by reading the output of the PTANAL code so that an user can easily determine the average level spacings and strength functions for the s- and p-waves

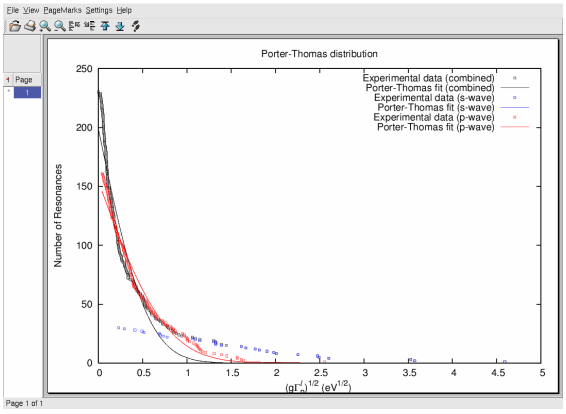

Figure 2. The Porter-Thomas distribution curves.

as shown in Figure 2. The SCANR code has been newly developed and is used for the graphical analysis of the resonance energies, which helps the determination of the upper boundary of the resolved resonance region

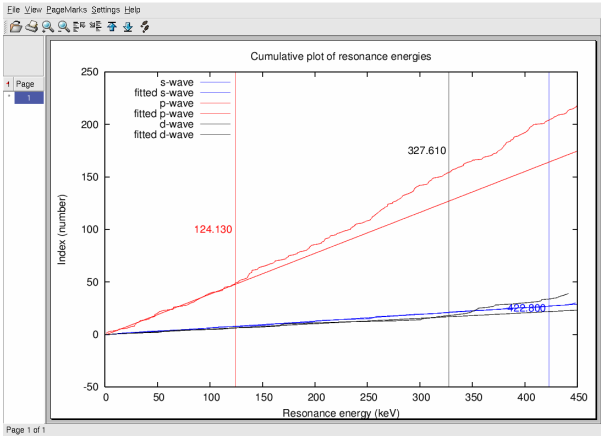

Figure 3. The cumulative plot of resonance energies.

(see Figure 3). The calculated resonance parameters can then be constructed as point-wise cross sections by calling the auxiliary codes such as RECENT [7] and

SIGMA1 [8] and compared with the experimental data and the available evaluated cross sections including ENDF/B-VII [9], JENDL-3.3 [10] and JEFF-3.1 [11] (see Figure 4).

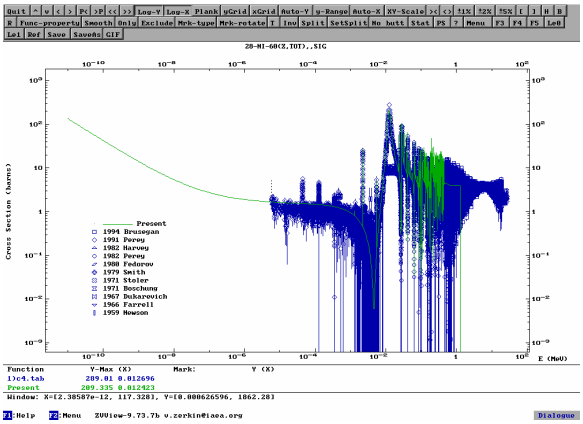

Figure 4. The screen shot of cross section comparison page.

All the jobs except the modification of default values for the standard resonance parameters and physical constants are executed with simple mouse clicks. The module also provides an ENDF-6 formatted file for the resonance region. The formatted file can be integrated later into the final ENDF-6 file as generated by the EMPIRE code.

3. Summary and Further Work

A new module has been developed for the evaluation of cross sections in the resolved and unresolved resonance regions. It automates most of the evaluation procedures and can be executed within EMPIRE or as a stand-alone program. When it is used as connected to the EMPIRE code, the single ENDF-6 formatted file can be obtained in the full energy region. As most of jobs are performed with a few simple mouse clicks on the GUI control panel providing various plots that help the user check the validity of the calculation results, it will minimize the possible human error factor and improve the productivity and efficiency of the evaluation tasks.

In the current version, the SCANR code searches and suggests the upper boundary of the resolved resonance region by comparing the chi squares between the experimentally determined resolved resonance energies and the fitted ones. While the sample evaluation works for some nuclides showed that the algorithm implemented in the SCANR code predicted the reasonable values, some other cases indicated the necessity for the improvement. The improvement to the algorithm will be made by inspecting the results in the future evaluation works for the more various nuclides.

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