Development of a Master Library for the Transport Lattice Code LIBERTE

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1. Introduction

Korea Atomic Energy Research Institute (KAERI) has developed a transport lattice code called LIBERTE[1] which is the first domestic transport lattice code with a full capability. Since the LIBERTE code does not include its own library, the HELIOS[2] library has been used instead. Library of the transport lattice code includes multi-group microscopic cross sections and fission spectra, resonance integral tables, atomic masses, decay constants, and fission product yields. Since all these data are strongly related with the methodologies adopted in the transport lattice code, the library should be prepared considering those relationships.

Recently we have developed a procedure to generate the library for the transport lattice code LIBERTE and we have generated the master library to be a basis for the simplified libraries. The NJOY[3] code has been used to process the point-wise continuous and multi-group cross sections to be used in the following procedure. Other than the NJOY code we have developed various kinds of Fortran programs to generate all the data required by the library, which includes programs to generate the resonance related parameters, to edit burnup data and to reformulate multi-group cross sections. This procedure provides not only the library for the transport lattice codes and the whole-core transport codes, but the basis for a further research in the deterministic transport related areas.

2. Methods and Results

2.1 Overall procedure

Figure 1 shows the overall flow chart to generate a new library. Multi-group microscopic cross sections for all the nuclides are processed through the NJOY code developed by Los Alamos national laboratory. These cross sections are reformulated to be used in the transport lattice code by GREIDT developed at KAERI. Intermediate resonance parameters (λ) called hydrogen equivalent parameters and the resonance integral tables are generated by the MERIT code[4]. This code includes a solver for the ultra fine group slowing down calculation in the homogeneous and the heterogeneous 1-dimensional cylindrical geometries to obtain an effective resonance cross section from the fine group BROADR cross sections. This code also involves a solver to obtain the corresponding background cross sections to the effective resonance integral by using the method of characteristics. This code also includes a functionality to generate the hydrogen-equivalent parameters to be used in the resonance treatment.

We developed the GENEDIT program to edit atomic masses, decay constants, potential cross sections and fission product yields.

The LIBGEN program is to assemble all the prepared data in a specified format, and to collapse the multi-group data into a smaller number of group data by using the given neutron spectra. And this code is to generate subgroup data according to the resonance treatment methodology adopted in the LIBERTE code.

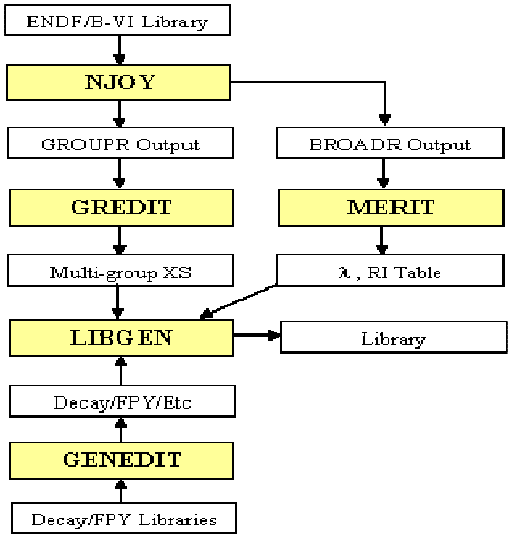

Figure 1. Flow chart for the library generation

2.2 NJOY processing

We developed a Fortran program to generate all the NJOY input files and a batch file to run these NJOY input files according to the main control deck automatically. Two different types of NJOY input files were generated. The first one is to generate multi-group cross sections and the second one is to generate cross sections at 2200 *m/sec* and resonance integrals. The LIBERTE code requires transport-corrected total, absorption, fission, fission-neutron production, fission-energy production, scattering cross sections and fission spectrum. Absorption and scattering cross section are adjusted with *(n,2n)* and *(n,3n)* ones. GREDIT reformulates multi-group cross sections

into the format required by the LIBERTE code. Cross section at 2200 *m/sec* and resonance integral will be used to identify a characteristic of a nuclide.

2.3 Resonance data

The LIBERTE code adopts a subgroup method[5] for the resonance treatment. Potential cross sections, hydrogen equivalent parameters and the subgroup data are needed in the subgroup method. Potential cross sections can be obtained simply from the nuclear radius in the ENDF/B file for each nuclide by using GENEDIT. Group dependent hydrogen-equivalent parameters are obtained by replacing a part of the hydrogen with a target nuclide. Resonance integral tables can be obtained with a change of the geometry and a composition by the MERIT code. Subgroup data can be directly calculated from resonance integral table.

2.4 Burnup data

Burnup data are composed of decay constants and fission product yields. Since LIBERTE adopts an exponential matrix method for the burnup calculation, the burnup chain shown in Figure 2 should be established suitable to this method. A main control deck includes a designation for each nuclide whether this will be involved in the burnup calculation or not. The GENEDIT program edits the decay constants and fission product yields according to the burnup chain from the ENDF/B decay and the fission product libraries. ENDF/B fission product library includes direct and cumulative fission product yields with 1 to 3 incident neutron energies. Effective fission product yields are obtained through a fission rate weighting on the log-log interpolated or extrapolated yields by the GENEDIT program. Fission reaction rates can be obtained from the typical PWR fuel pin calculation.

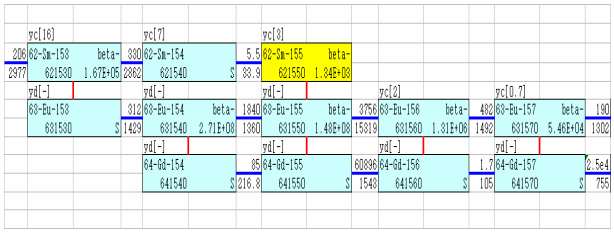

Figure 2. Part of burnup chain for the fission product nuclides

2.5 Master library

We used ENDF/B-VI Release 8.0 mainly and ENDF/B-VII β1.0 partly. The number of energy groups in the master library is 190 and the number of resonance groups is 69. Resonance energy groups range from 1.855 eV to 9118 eV. New library includes 327 nuclides of which 145 are for activation nuclides, 40 for heavy nuclides, and 142 for the fission product nuclides. Burnup chain is composed of 61 activation nuclides, 40 heavy nuclides and 142 fission product nuclides. Resonance integral tables were prepared for 43 nuclides which were calculated with 9 different background cross sections including an infinite dilution. Potential cross sections and hydrogen-equivalent parameters were obtained for 172 nuclides. Delayed neutron data were obtained for 19 nuclides. (n,2n) and (n,3n) cross sections were obtained for 101 and 68 nuclides, respectively. 19 nuclides include P1/P2/P3 scattering data. The number of fissionable nuclides is 31. This 190 group master library can be used to generate fewer group libraries with the specified neutron spectra.

3. Conclusion

We have developed a new procedure to generate a library and a new master library with 190 energy groups. We will have to perform lots of benchmark calculations to verify and validate this master library as a future work. This library will be a final stage for the possession of the domestic reactor physics analysis technology. This will be a corner stone for a worldwide technical superiority in the reactor physics analysis in the future.

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