NEA EACRP/"L" 116

MASTER

THE USE OF THE STACEY ALGORITHM TO IMPROVE THE ELASTIC MODERATION CROSS SECTION GENERATION

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1. Introduction

In the generation of multigroup cross sections for fast reactor calculations, the composition dependence of the elastic removal cross section due to intermediate element wide scattering resonances is one of the typical problems to be solved, since Stainless Steel-Na-Oxigen mixtures are involved in all the calculations.

Of the two most widely adopted methodologies for multigroup cross section generation, namely the ultrafine groups method /1/ and the self-shielding factors methos /2/, only the first is able to handle the composition dependence of the elastic removal process. Several attempts were made to overcome this difficulty of the original Bondarenko scheme, in order to keep acceptable accuracy in that scheme too, in view of its well known advantages of efficiency and economy, which can be exploited in the extensive core design parametric analysis. Among others, we recall the method of the 1DX code /3/ and the Stacey's method /4/.

The Stacey's method /4/, based on the results of the continuous slowing down theory, has proved to be highly effective in many cases of interest /5/. A method and algorithm comparison was performed, namely among the MC^2, Stacey, 1DX and original Bondarenko methods - MC^2-2 results /6/ were also obtained.

2. Numerical results

The comparison were performed for the cases of the iron resonance at ~ 28 KeV and the Na resonance at ~ 2.85 KeV. The reference system had a typical LMFBR composition (see Table I). The ENDF/B version 3 data were used (except for iron for which the ENDF/B version 1 data were used). The MC^2 code was run to obtain reference values for the light and intermediate element elastic removal cross sections.

The group elastic removal cross section calculation results are shown in Table II. The increasing degree of agreement with the reference MC^2 method, is evident in going from the original Baondarenko to the Stacey method. This last method gives results in better agreement with the MC^2 data for all the cases considered, and discrepancies for the light elements are never higher than ~1.5%. For the heavy elements, the results of the Stacey's method are to be preferred to the MC^2 data, since MC^2 computes the heavy elements σ_{er} only on a fine group basis, and thus comparable to the original Bondarenko cross section, i.e. with no influence of the light element scattering resonance.

The new version of the MC^2 code, the MC^2-2 code, takes properly into account this effect, as it is seen from the results of Table II.

The agreement is of particular interest in the energy region of the minimum of both Na and Fe resonances, which can cause large discrepancies when other methods are considered.

This was further investigated, when smaller lethargy widths were used. In Table III the results of the analysis relative to the interference minimum of the iron scattering resonance are shown for lethargy width $\Delta u = 0.5$, 0.25 and 0.1. The Stacey method is again in excellent agreement with the reference MC^2 calculation. Finally, the influence of the background on the resonant scatterer was investigated. In Table IV the iron elastic removal cross sections for the two reflector of Table I are shown.

The iron minimun effect, which results in flux build-up at the lower energy group boundary, is much more pronounced in the case of the predominant iron blanket, than in the U-238 blanket, where the iron resonance effect is smeared by the strong background effect. In both cases, the Stacey method was able to predict quite accurately the MC^2 values.

In view of the good results obtained, a new version of the 1DX code was developed, to account for the Stacey algorithm.

3. Conclusions

The use of improved algorithms for the elastic moderation calculation in presence of the typical iron and sodium scattering resonances was shown to be of relevance in cross section generation for fast reactors, when the Bondarenko cross section scheme is adopted. Large errors on the individual elastic removal cross section are avoided and also significant discrepancies on integral parameters, such as the sodium void reactivity effect /5/. Moreover, in several laboratories, an intermediate group number (~ 200) strategy in the generation of multigroup cross sections is currently being introduced, in order to couple the advantages of both the above mentioned methodologies. Still in this case, the increased number of energy groups cannot be sufficient to allow a satisfactory picture of the composition dependence when the intermediate mass resonant scatterers are predominant on the background and thus giving rise to collision densities far from constant.

These new intermediate group number methodologies will benefit of the Stacey algorithm, in particular when cross sections are to be generated for regions with a light or intermediate resonant scatterer predominant over the background.

References

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3. R.B. KIDMAN et al., Nucl. Sci. Eng. 48, 189 (1972).
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TABLE I

Composition	Isotope					External dimension of spherical model
	^{16}O	^{23}Na	^{56}Fe	^{238}U	^{239}Pu	
Core	0.015	0.010	0.018	0.006	0.001	80.0
^{238}U Reflector a)	--	--	0.001	0.035	--	124.0
^{56}Fe Reflector a)	--	--	0.080	0.004	--	124.0

Reactor Compositions (atoms/cm^3) x 10^{24} and dimensions (cm)

a) ^{238}U and ^{56}Fe reflectors were used in alternative

TABLE II Elastic Removal Calculation with Different Methods

Energy Interval ($\Delta u = 0.5$)	Method	Elastic Removal				
		^{16}O	^{23}Na	^{56}Fe	^{238}U	^{239}Pu
40.9 - 24.8 keV	Bondarenko	.90	.66	.67	.21	.17
	1DX	.90	.68	.42	.21	.17
	Stacey	1.01	.87	.11	.38	.32
	MC^2	1.12	1.00	.13	.18	.15
	MC^2-2	1.08	.99	.23*	.43	.36
3.35 - 2.04 keV	Bondarenko	.90	12.84	.40	.26	.22
	1DX	1.47	9.19	.90	.45	.41
	Stacey	1.77	7.32	1.01	.68	.57
	MC^2	1.73	7.94	1.11	.49	.31
	MC^2-2	1.72	7.86	1.33*	[illegible]	.58

*ENDF/B-III data, other Fe results based on ENDF/B-I data

TABLE III

Δu and ΔE	Method for σ_{er}		
	Bondarenko	Stacey	MC^2
$\Delta u = 0.5$ ΔE 40.9 - 24.8 KeV	0.672	0.105	0.130
$\Delta u = 0.25$ ΔE 31.8 - 24.8 KeV	2.010	0.239	0.272
$\Delta u = 0.1$ ΔE 27.4 - 24.8 KeV	1.205	0.355	0.385

Iron Interference Scattering Minimum Energy Region.

Comparison of Methods at Different Lethargy Structures.

TABLE IV

ΔU and ΔE	Method	σ_{er}	
		^{238}U Blanket	^{56}Fe Blanket
$\Delta U = 0.5$ ΔE 40.9 - 24.8 KeV	Bondaren-ko	0.9742	0.4088
	1DX	0.5747	0.2969
	Stacey	0.0746	0.2781
	MC^2	0.0704	0.2632

Iron Elastic Removal Cross Section Comparison for Different Background