

22.05 Reactor Physics - Part Twenty-Three

Few-Group and Multi-Group Approaches¹

1. Objective:

The object here is to define the terms “few-group” and “multi-group.” The distinction is important because one finds the two terms used widely both in the literature on reactor physics and in the numerical codes that are used in reactor design.

2. Meaning of “Few Group” and “Multi-Group”

“The essential assumption of one-group theory is that there is a rigid spectrum function $\Psi^k(E)$ ($0 \leq E < \infty$) present throughout each material composition k . Similarly the essential assumption of two-group theory is that there are two rigid spectrum functions, $\Psi^k(E)$ for the range $E \geq E_c$ and $\Psi_2^k(E)$ for the range $E < E_c$, present throughout each composition k . Clearly, by dividing the asymptotic spectrum into more segments and associating a different spatial shape with each segment, we can derive energy-group models that are better able to match the true energy of the flux at interfaces between material regions, where the energy dependence of $\Phi(\mathbf{r}, E)$ is not close to any asymptotic spectrum. This representation of the energy dependence, since it is made up of rigid pieces of the asymptotic spectrum, will be discontinuous at the energy cut points between groups. Nevertheless, the overall representation of $\Phi(\mathbf{r}, E)$ at such points will be better.

It has been found that a model using three or four groups provides a very good representation of a thermal reactor. This is because most of the important neutron interactions take place at energies below 1 eV. For fast reactors, however, twenty or thirty groups are often necessary.

As the number of groups in the energy-group model increases, the individual segments into which the energy range 0-15 MeV is partitioned become increasingly small, and the behavior of the portions of $\Psi^k(E)$ within a group becomes increasingly uniform. In fact, in the limit where the number of energy groups for the spatial problem equals the number used to solve the spectrum equation, there is no longer any reason to perform separate spectrum calculations. Instead, we may assume that the energy shape of $\Phi(\mathbf{r}, E)$ within each of a very large number of groups is flat or (in view of the discussion of approximate flux shapes in Section 17 of these notes) is proportional to the fission spectrum $\chi(E)$ in the high-energy range, to $1/E$ in the slowing-down range, and to a Maxwellian

¹ Material in this section is verbatim from Henry (pp. 188-195) with all quantitative discussion omitted.

distribution in the thermal range. We shall call the group diffusion equation containing group parameters obtained by averaging over portions of spectra having an arbitrarily assumed shape, *multi-group* diffusion equations. In contrast, group equations for which the parameters are found by averaging over spectra $\Psi^k(E)$ determined for each material composition by a separate, infinite-medium, multi-group calculation will be called *few-group* diffusion equations.

To summarize, the essential distinction between a multi-group and a few-group approximation lies in the manner in which the spectrum functions $\Psi_g^k(E)$ are determined. For a few-group computation, a separate spectrum must be calculated (for example, by a multi-group solution of the position-independent equation) for each composition k . For a multi-group model, the spectra $\Psi^k(E)$ are assumed known beforehand and are taken to be the same for all material compositions.

In particular, a scheme is termed “multi-group” if

- For a given energy group g the same $\Psi^k(E)$ is used throughout the entire reactor (i.e., superscript k is dropped).
- The “energy shape” of each $\Psi^k(E)$ (i.e., a plot of $\Psi_g(E)$ versus E in the range of ΔE_g) is taken to be the same for all reactors.”
(Henry, pp. 188-193)