3.6.6 Multigroup diffusion theories and calculations

A second and more important set of assumptions was the very limited discretization of the energy spectrum. Perhaps the most glaring deficiency of the one-speed diffusion theory is the assumption that all the neutrons have the same speed or energy. Consequently the most obvious improvement would be to allow a variety of neutron energies and to incorporate a model for the transfer of neutrons from one energy level to another. Such models are termed *multigroup diffusion models* and the simplest among these is the *two-speed diffusion model* in which the neutron population consists of one population of fast neutrons and another of thermal neutrons. This is particularly useful in a LWR in which the moderator helps maintain a balance between the two groups. More sophisticated models with many more energy levels are needed in order to accommodate the complexities of the neutron energy spectra described in 2.3.2. As illustrated in figure 1, the variations in the cross-sections (and source terms)

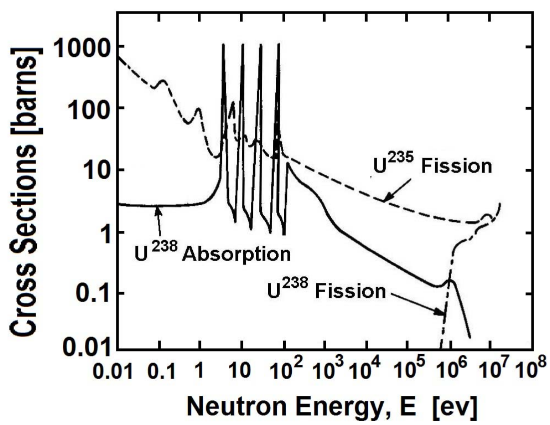

Figure 1: Qualitative representations of how the fission cross-sections for ^{235}U and ^{238}U as well as the absorption cross-section for ^{238}U vary with the neutron energy.

over the neutron energy range can be very complicated. It is therefore impractical to devise a neutron transport treatment that accurately incorporates all of these variations. In detailed, practical calculations a compromise is necessary and the energy spectrum is often divided into 20 or 30 energy levels (or *groups*), in other words it is divided much more finely than in the one- or two-speed models. However, because 20 or 30 groups still cannot adequately cover the variations of the cross-sections with energy level, it is necessary to devise averaging methods within each range or group in order to obtain *effective* cross-sections and source terms that adequately represent the neutron behavior within that group. It is evident that these methods and calculations are only as good as the accuracy of the source terms and cross-sections assumed. Therefore careful analysis and modeling of the scattering process is critical as is accurate representation and averaging of the cross-sections within each energy level. Diffusion equations have been developed for each of these energy groups, the approach being called *multigroup diffusion models*. Sophisticated numerical schemes have been developed for the solution of all these coupled differential equations (see, for example, Glasstone and Sesonske 1981, Duderstadt and Hamilton 1976) and modern reactor designs rely on these detailed calculations that are beyond the scope of this monograph.