2.8.2 Neutron history in a thermal reactor

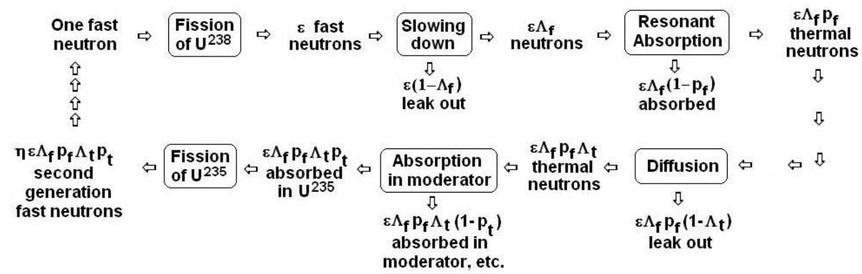

Figure 1: Simplified history of neutrons in a thermal reactor.

Figure 1 delineates the typical neutron history in a thermal reactor. Using a single fast neutron as an arbitrary starting point (upper left), this fast neutron fissions a ^{238}U atom and produces ϵ fast neutrons. Some fraction, $(1-\Lambda_F)$, of these fast neutrons leak out through the boundaries of the reactor and another fraction, $(1-P_F)$ are absorbed in ^{238}U leaving $\epsilon\Lambda_F P_F$ that have been slowed down to thermal speed either in the moderator or otherwise. Some fraction, $(1-\Lambda_T)$, of these thermal neutrons also leak out through the boundaries and another fraction, $(1-P_T)$, are absorbed in the ^{238}U or the moderator or other material. This finally leaves $\epsilon\Lambda_F P_F \Lambda_T P_T$ thermal neutrons to cause fission of ^{235}U and thus produce $\eta\epsilon\Lambda_F P_F \Lambda_T P_T$ second generation fast neutrons. In this history, η is the *thermal fission factor of* ^{235}U, ϵ is the *fast fission factor*, Λ_F is the *fast neutron non-leakage probability*, Λ_T is the *thermal neutron non-leakage probability*, P_F is the *resonance escape probability*, and P_T is the *thermal utilization factor for* ^{235}U.

It follows that the multiplication factors, k and k_∞, are given by

$$k = \eta\epsilon\Lambda_F P_F \Lambda_T P_T \qquad ; \qquad k_\infty = \eta\epsilon P_F P_T \tag{1}$$

known respectively as the *six-factor formula* and the *four-factor formula*. It also follows that a reactor operating at steady state will have $k = \eta\epsilon\Lambda_F P_F \Lambda_T P_T = 1$ and the control system needed to maintain such steady state operation must be capable of adjusting one or more of the factors P_F and P_T.

The thermal energy resulting from this process comes mostly from the fission process and therefore both the neutron population and the neutron flux (see section 3.2) are roughly proportional to the rate of generation of heat within a reactor core. Thus an evaluation of the neutron flux by the methods of chapter 3 can be used to estimate the generation of heat within the components of the core as described in chapter 5.