2.10 Criticality

The discussion of the criticality of a nuclear reactor will now be resumed. It is self-evident that a finite reactor will manifest an accelerating chain reaction when $k > 1$ (or $\rho > 0$); such a reactor is termed *supercritical*. Moreover a reactor for which $k = 1$ ($\rho = 0$) is termed *critical* and one for which $k < 1$ ($\rho < 0$) is *subcritical*. Note that since the neutron escape from a finite reactor of typical linear dimension, l, is proportional to the surface area, l^2, while the neutron population and production rate will be proportional to the volume or l^3 it follows that k will increase linearly with the size, l, of the reactor and hence there is some *critical size* at which the reactor will become critical. It is clear that a power plant needs to maintain $k = 1$ to produce a relatively stable output of energy while gradually consuming its nuclear fuel.

Consequently there are two sets of data that determine the criticality of a reactor. First there is the basic neutronic data (the fission, scattering and absorption cross-sections, and other details that are described previously in this chapter); these data are functions of the state of the fuel and other constituents of the reactor core but are independent of the core size. These so-called *material properties* of a reactor allow evaluation of k_∞. The second set of data is the geometry of the reactor that determines the fractional leakage of neutrons out of the reactor. This is referred to as the *geometric property* of a reactor and this helps define the difference between k and k_∞. These two sets of data are embodied in two parameters called the *material buckling*, B_m^2, and the *geometric buckling*, B_g^2, that are used in evaluating the criticality of a reactor. These will be explicitly introduced and discussed in chapter 3.