3.11 Monte Carlo calculations

Before leaving the problem of determining the neutron flux in a reactor (and by extension the generation of heat within the core) it is appropriate to describe briefly an entirely different calculational procedure that is used increasingly and that, at least superficially, appears to bypass all the integro-differential equations of the preceding sections. These are known as Monte Carlo methods and the simplest description of these is that one chooses to follow an individual neutron as it proceeds through a whole sequence of interactions within the core. Each interaction is governed by a selected probability distribution and the outcome of the interaction is determined by a known or estimated probability distribution combined with a random number generator. Fission interactions determine the next generation of neutrons, their number as well as their speed, direction and origin. The calculation proceeds until a steady state is reached, one that is independent of the location, speed and direction of the starting neutron or neutrons. Throughout the calculation the average neutron transport properties are assessed at every location within the reactor and when these properties asymptote to a constant value (in a calculation that seeks a steady state) then, provided the result is independent of the initial neutron distribution and properties selected, a potential solution to the neutron flux distribution has been found.

As with many other multiphase flow calculations it may still not be possible to simulate the kind of neutron or particle populations that are present in real reactors; in such cases methods known as *multiscale* or *reduced order* models have been developed in which a much smaller population is used to simulate a much greater population. The key with these reduced order models is the determination of the interaction coefficients in the reduced order model that are appropriate to modeling the interactions in the full scale application.

There are, of course, many details within the numerical method that require much more attention but the rapid expansion in computing power and the ability to adapt these relatively simple calculations to parallel computers has meant that these methods have become increasingly used and useful. For further detail the reader is referred to texts such as Carter and Cashwell (1975).