22.05 Reactor Physics - Part Twenty-Four

Monte Carlo Analysis

1. Reference Material

See pp. 371-378 of A. F. Henry's Nuclear Reactor Analysis, copy attached.

2. Monte Carlo analysis is the last of the five methods that were listed in the first lecture of this course as techniques for the determination of reactor flux. The other four methods were: neutron life cycle analysis; one-velocity model; diffusion theory; and transport theory (not covered in this course).

Monte Carlo analysis involves two major steps. These are first to generate neutron case histories by computer simulation and second to sample those histories to obtain estimates of the neutron flux. Prerequisites for the Monte Carlo method are therefore the same as for the other methods of reactor physics analysis: accurate knowledge of the nuclear data (i.e., cross-sections), precise modeling of the reactor so that all regions are current in terms of both materials and geometry, and massive computational power. The latter is particularly important because accuracy increases with square root of the number of case histories.

Because of its reliance on computer-generated case histories and statistical sampling, Monte Carlo analysis is often viewed as distinct from the other methods of analysis that we have considered. But, in another sense, it is the limiting extension of multi-group theory where the widths of the energy groups have been made so small that exact cross-sections are used at every energy.

Monte Carlo methods are clearly in their ascendancy and work is on-going to extend these to transient analysis. Students who wish to do graduate work in reactor design and/or work as professionals in the industry should learn codes such as MCNP (Monte Carlo Neutron Photon).

Thought Question: The MCNP code was first developed for prediction of neutron and photon fluxes and only some years later extended to protons and electrons. Why? (See next page for answer.)

Answer to Thought Question

MCNP is computation intensive because many case histories are needed in order to obtain an accurate result. Neutrons and photons undergo only a few interactions before being absorbed. Protons and electrons, because they are charged particles (see lecture eight supplemental) may undergo thousands of collisions before slowing down. So, their case histories require orders of magnitude more computer power.