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Monte Carlo
Research Series

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thermal flux
program for a
slab system

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ABSTRACT

The program described in this paper was designed to compute a quantity, Q , proportional to the neutron scalar flux, in an infinite heterogeneous slab system. The system is generated by a two-region unit cell. Q is the average track length per unit length, in a given interval, arising from the neutron traffic established by a spatially distributed monenergetic source. The program is coded for the IBM 704 computer.

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1.0 Statement of the Problem

The program described in this paper was designed to compute a quantity, Q , proportional to the scalar neutron flux, in an infinite heterogeneous slab system. The system is generated by a two-region unit cell. Q is the average neutron track length per unit length, length being measured in the direction normal to the slab faces, in a given interval also oriented in the normal direction. A spatially arbitrary, monoenergetic, stationary source is present in one region of the unit cell. Q arises from the neutron traffic established by this source. Scattering occurs without a change in neutron energy. The program is written for the IBM 704 computer.

The geometry of the system is illustrated in Figure 1.

2.0 Physical Model

Neutron histories are traced out using a standard analogue Monte Carlo method. At each neutron-nucleus collision a decision is made either to scatter or absorb the neutron. Scattered neutrons are tested for forward scattering. The average cosine in the local laboratory coordinate system, pertinent to the scattering mode which occurs (forward or backward), is assigned and a transformation is then made to the fixed laboratory coordinate system. The average cosines for forward and backward scattering from each type of nucleus present in the system are pre-computed on the assumption of isotropic center of mass scattering. Up through five distinct nuclear types are allowed in each region. The track length traced out in each of 26 histogram regions is tallied. The average neutron flux in each histogram region is proportional to the track length tally for that region divided by the region width.

3.0 Input

The input for this program is composed of:

- 1) The width of each histogram region

Figure 1a: The infinite heterogeneous system is generated by a two region cell, G , defined here. $R1$ and $R2$ are the two contiguous homogeneous regions which make up G . The distributed source is located in $R1$.

Figure 1b: Each region in the generating cell is divided into 13 histogram regions for the purposes of making the flux tally. The three solid lines denote interfaces between different materials. The equi-width histogram region partitioning shown here is not mandatory, arbitrary widths can be used if desired.

- 2) The right end point of each histogram region
- 3) The macroscopic scattering cross section for each nuclear type
- 4) The macroscopic scattering and total cross section for each material region
- 5) The point values for the source position cumulative distribution function
- 6) The probability of forward neutron scattering from each nuclear type.

4.0 Output

The program output gives the raw and weighted track length tally in each histogram region. The weighted tally, for a given histogram region, is obtained by dividing the raw tally for that region by the region width. The weighted tally is proportional to the scalar flux. Thirteen histogram regions are assigned to each material region.

Two output histograms are included here as examples of what one may expect from the program. The results of a flux computation for a Be- U^{235} system at three different temperatures are plotted in Figure 2. This flux distribution arose from a uniformly distributed source in the Be region. A flux kernel for the same system for one temperature is plotted in Figure 3. This kernel results from a plane source at the center of the Be region. One observes that the kernel is represented by flux averages in 42 histogram regions. We have mentioned previously that exactly 26 histogram regions must be used in every case. The 42-region histogram in Figure 3 was accomplished by making three separate runs, each run gave detail in a different part of the generating cell, and was initiated by the same random number generator. The detailed histograms for the three runs were joined to give the composite featured in Figure 3. Figure 4 is a smooth curve fit to the histogram in Figure 3.

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Figure 4: Smooth Representation of Histogram in Figure 3

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5.0 Operating Characteristics

This program has been used as a production program at GE-ANPD since January 1, 1958.

The computing time for 1000 case histories is approximately given by

$$t = 3 + (T - 20) / 133 \text{ minutes}$$

where T is the system temperature in degrees centigrade.

6.0 Flow Diagram

The flow diagram for this program follows in sequel.