MASTER

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From: D. W. Drawbaugh

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Subject: Informal outline of
Reactor Physics Program.

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ASTRONUCLEAR LABORATORY

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The following is a brief informal outline of the Reactor Physics & Math program.

I. TRANSPORT THEORY

A. Steady State Criticality Calculations

A goal we have in mind is a capability to do steady state diffusion or transport calculations with many thermal groups and many fast groups in one, two and three dimensions. We have in our work program, formulation and programming of a computer program for synthesizing two dimensional and one dimensional solutions to obtain three dimensional solutions.

This flux synthesis program will be based on Galerkins method as used by S. Kaplan at Bettis with considerable success. We are also getting the Bettis SYNG flux synthesis program. The latter will require modification to run on the 7094. We may find it easier to write our own program.

We now have available from Los Alamos the one dimensional DTK code which is an improved DSN code. Los Alamos has a two dimensional version of DTK in r, θ ; r, z ; x, y geometry but it is not yet debugged and has not been released. If a two dimensional r, θ , DSN program is not forthcoming from LASL in the near future, we shall start upon such a program here.

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The four-group conditional Monte Carlo program including control rods is now debugged. This code will use as zero iterate output from the Cure code or the two dimensional DTK code. A program is being written to prepare the input for the Conditional Monte Carlo code. The zero iterate problem can be run with more than four groups and the resulting fluxes collapsed to four group fluxes. Likewise the multi-group cross sections can be locally averaged over the multi-group spectrum to give effective four group cross sections to be used in the Monte Carlo code.

An iteration technique using the Monte Carlo program to calculate a Green's function to be stored on magnetic tape will be completed after the Monte Carlo milestone date.

The Monte Carlo program now does a calculation in three dimensions but requires homogeneity in the axial direction of a cylinder. The program was planned to allow removal of this restriction without complete reprogramming. The removal of this restriction remains to be done.

B. Shielding and Heating Programs

We want to investigate the possibility of writing the Bettis P3MG program extended to include anisotropic scattering for use on our 7094 computer. We also want to get the Niobe code and use it for comparison calculations. For very deep penetration problems, e.g., payload, irradiation, an extension of the Conditional Monte Carlo program may be useful.

II. DEVELOPMENT OF METHODS FOR GETTING EFFECTIVE CROSS SECTIONS

A. Fast Cross Sections

The object here is to get in operation as quickly as possible a systematic way of getting effective fast multi-group cross sections for an arbitrary number (more than three) of fast groups. The most expeditious way of doing this seems to be use of the GAM code. GAM is a slowing down code similar to MUFT. The GAM code has several features lacking in the MUFT code, namely:

1. The few group output is variable instead of being just three groups as with MUFT.
2. GAM allows accounting for non-isotropic scattering in the center of mass system.
3. GAM has P_1 as well as isotropic coupling between groups.
4. GAM has a proper treatment of $n, 2n$ reactions.

5. GAM has provision for inputting an arbitrary source spectrum or flux spectrum.
6. The GAM code we have has provision for computing both homogeneous and heterogeneous resonance integrals including doppler broadening for U^{238} .

We want to revise the GAM code to allow inputting resonance parameters or resonance integrals for an arbitrary isotope and including doppler broadening. This is especially necessary for U^{235} . A computer program for calculating the input required by GAM is nearly complete. We have a large amount of newer data including inelastic scattering differential cross sections and angular differential cross sections in the center of mass which we will be able to make use of when we get the GAM code in operation with the program for computing input.

When we get the GAM code operating properly we want to make comparisons between cross sections and spectra computed by GAM and by MUFT using the same input cross sections. We then want to investigate the effect of varying the number of fast groups using GAM and DSN. We also want to investigate the effect of the buckling used in GAM as a function of the number of fast groups. We will also be in a position to make comparative calculations using our cross sections and various LASL cross sections for the same number of energy groups.

We are in the process of making more accurate calculations of resonance integrals for U^{235} and 238 . In these new calculations we want to include the following things:

1. The effect of beaded fuel and the effect of unfueled elements clustered with fueled elements.
2. An analysis of doppler broadening in U^{235} by the multi-level formalism.
3. The effect of classifying the 235 resonances into $J = 3$ or 4 angular momentum as suggested in UCRL-6926.
4. The L factors to be used in MUFT or GAM should be computed resonance by resonance.

The GAM code will give multi-group cross sections suitable for use in diffusion codes such as CURE, all of the SN codes and also the Monte Carlo Code 18-0.

We are in the process of preparing tables of level excitation probabilities for inelastic scattering in the 18-0 code. We also want to prepare tapes of gamma production probabilities for 18-0. Also tables of Legendre polynomial expansion coefficients for anisotropic scattering for 18-0. The n,t reactions in Li will be

treated as an n, α reaction but using the proper n, t cross sections from LA-2643.

B. Thermal Range Cross Sections

Our system for calculating effective up and down scattering cross sections in the thermal range is now in fairly good shape. Charles Stevens is now in the process of calculating crystalline scattering kernels at various temperatures. The chief difficulty here is the lack of a good and accurate formulation of the transport approximation in multigroup theory, especially for hydrogen. This problem remains to be resolved.

Various point kernel and Monte Carlo neutron and gamma transport codes are being used in different groups at the Astronuclear Laboratory. Examples are the C-17 Convair code, the 14-0 ANP code, and the ANP 18-0 code. Each group is developing their own cross section library for these codes. These ad hoc cross section libraries are frequently crude and do not have a proper treatment of cross sections with resonances much less such things as doppler broadening, proper spectrum averaging etc. The GAM code should eliminate some of this duplication. However, we do not intend to use the cross section library that came with the GAM code but to develop our own cross section library based primarily on the original Bettis 54 group library, but brought up to date wherever we have newer data available.

III. BASIC MICROSCOPIC CROSS SECTIONS

There are numerous gaps in the available neutron cross section data. Two problems in this area are application of the multi-level formalism including doppler broadening to U^{235} and theoretical analysis of inelastic reactions.

IV. REACTOR KINETICS AND DYNAMICS

Our primary effort in reactor kinetics is to develop a program for solution of the non separable problem by the variational method. As a back up to this approach we are considering an extension of the perturbation analysis of A. Henrys. A memorandum by Jerome Riese describing the work to date on the variational method will be out soon. Riese will also attempt to study stability of the system in the variational formalism.

Particular problems here are:

- a) Calculation of temperature and density dependent parameters for each energy group.
- b) How to combine the non-separable kinetics most effectively with the detailed heat transfer and fluid flow program.

While applying the variational method to the non-separable kinetics problem Dr. Riese has discovered a new way of applying the variational method to find steady state solutions to the diffusion equation. His method can be applied to the many energy group and one, two or three dimensional problem. He will report on this new work elsewhere in detail. His technique could lead to large savings of computer time in calculation of the steady state fluxes required by the kinetics program. He will continue the investigation of the new technique.

V. HEAT TRANSFER

An attempt has been made to formulate the transient heat conduction-problem with channel flow in a way similar to "small source theory" in neutron diffusion theory. Programming such a formalism for the computer looks formidable.

We must ultimately formulate ways of solving heat conduction problems suitable for digital computation as a part of a long range thermal stress program.

VI. THERMAL STRESS ANALYSIS

We have made an effort to find out what work is being done on thermal stress analysis and what computer programs are available. Tom Mattson is spending a major part of his time studying the finite differences and iteration techniques used in solving these problems. As soon as Mattson has finished his first reading of the LASL stress analysis report of White's, he will probably go to Los Alamos to talk to White. We should then be in a position to outline a more detailed theoretical program.*

VII. VIBRATION ANALYSIS

Mattson now has the DYANA code working. One of the men on loan to us from IBM will be assigned to Mattson to learn how to program problems in the DYANA system. This will relieve Mattson from programming more or less routine problems with DYANA.

* We shall investigate the possible use of Galerkin's method and the variational method to problems in thermal stress analysis. It is possible that one of these methods could be very useful while requiring only a relatively simple computer program as compared with a full finite differencing of the differential equations and solution by iteration.

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