Computer Code Abstracts

CORGAM

1. Name of Code: CORGAM.
2. Computer for Which Code is Designed: IBM 360/50. Programming Language: FORTRAN IV Level G. Disk storage required.
3. Nature of Physical Problem Solved: A correlation algorithm[1] is coded to allow the unfolding of complex gamma-ray spectra typically collected in a neutron activation analysis procedure. The code 1) will compensate for electronic shifts in the data, 2) will correct for background, 3) will normalize the data to a fixed neutron flux level, 4) allows a choice of weighting factors, and 5) allows a choice of methods for calculation of standard deviations. The code requires a matrix of reference gamma-ray spectra. These spectra can be in a raw-data form. All of the modifications available to the complex gamma-ray spectra are available to the reference gamma-ray spectra. In addition, a decay correction is available for the reference gamma-ray spectra. Only the reference gamma-ray spectra that have intensity coefficients which are significant at a prescribed level of significance are retained in the final solution. The intermediate solutions, i.e., those solutions that contain reference gamma-ray spectra which have nonsignificant intensity coefficients at the prescribed level, are printed out. Therefore, several solutions are imbedded in the final solution.
4. Method of Solution: A backward elimination least-squares method[2] is employed. The elimination criterion is one in which the Student's t value of each intensity coefficient is compared to a t value at a prescribed level of significance. The calculation of the standard deviation for each intensity coefficient accounts for randomness in both the complex and reference gamma-ray spectra.
5. Restrictions of the Complexity of the Problem: Number of reference gamma-ray spectra: variable. Number of channels of data: variable. Currently the program is restricted to a problem of 400 channels and 15 reference spectra. There would be no difficulty in expanding this to as many as 4096 channels; however, the number of reference spectra is limited by the accuracy desired in the inversion procedure. The inversion program currently being used would suffer (from the accuracy standpoint) if the number of reference spectra were $> \sim 25$.
6. Typical Running Time: Running time depends entirely on which and how many of the program options are selected. A typical analysis, involving 256 channels and 14 reference spectra and using reference spectra which were suitably aligned, will require < 1 min of execution time.
7. Unusual Features of the Program: CORGAM is a novel method of unfolding complex gamma-ray spectra because the variance calculations include contributions from both the complex and reference spectra. Also, only reference spectra that have intensity coefficients which are significant at a preselected level are retained in the final solution. The intermediate results can be printed out, and the level of significance of each of the intensity coefficients can be observed.
8. Related Programs: Programs by Young,[3] Trombka,[4] Parr and Lucas,[5] and others[6] are described in the literature. Similar analysis methods are employed in these programs and CORGAM.
9. Status: The theory is being prepared for publication and a computer manual for the program will soon be finished. The code is being used routinely.
10. *References:*

[1]N. D. ECKHOFF, "Optimal Neutron Activation Analysis," PhD Dissertation, Kansas State University (June 1968).

[2]N. R. DRAPER and H. SMITH, *Applied Regression Analysis*, John Wiley and Sons, Inc. (1966).

[3]M. H. YOUNG and N. S. SINGHAL, *Nucl. Instr. and Methods*, **45**, 287 (1966).

[4]J. I. TROMBKA, *Trans. Am. Nucl. Soc.*, **10**, 33 (1967).

[5]R. M. PARR and H. F. LUCAS, Jr., *IEEE Trans. Nucl. Sci.*, **NS-11** (3), 349 (1964).

[6]G. D. O'KELLEY, Ed., "Applications of Computers to Nuclear and Radiochemistry," *Proc. Symp., Gatlinburg, Tenn.* (1962).

N. D. Eckhoff

Department of Nuclear Engineering
Kansas State University
Manhattan, Kansas 66502

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GAMBLE-5

1. Name of Program: GAMBLE-5, A Program for the Solution of the Multigroup Neutron Diffusion Equations in Two Dimensions with Arbitrary Group Scattering.
2. Computer for Which Program is Designed: UNIVAC 1108.
   Programming Languages Used: FORTRAN IV, but for scratch data handling use is made of UNIVAC 1108 assembly language.

3. Nature of Physical Problem Solved: The homogeneous two-dimensional multigroup diffusion theory equations with arbitrary group-to-group scattering and arbitrary fission transfer are solved for heterogeneous assemblies in x-y and r-z geometry. Homogeneous logarithmic boundary conditions are used at the outer surface of the assembly and at the surface of nondiffusion regions. The results include the group- and point-dependent neutron fluxes, the power distribution, the neutron multiplication factor (k effective), and a detailed neutron balance.

4. Method of Solution: The multigroup diffusion theory equations are approximated by five-point difference equations for an arbitrary nonuniform mesh grid. The system of difference equations is solved by an extension of the power method to find the eigenvector (neutron flux) and the eigenvalue (k effective). Successive line overrelaxation is applied in a special form[1] (exponential overrelaxation) that guarantees the nonnegativity of the neutron flux. Coarse mesh rebalancing[2] is used to improve the preasymptotic convergence behavior. A variation of Aitkens' method[1] is used to improve the asymptotic convergence behavior, assuming only one error mode.

5. Restrictions on the Complexity of the Problem:

Maximum number of energy groups	10
Maximum number of space meshpoints	20 000
Maximum number of different material regions	255

6. Typical Running Time: A seven-group problem (three fast groups and four thermal groups) in (r,z) geometry with 2842 space mesh points took 82 iterations assuming a tight convergence criteria (maximum relative flux change < 0.00007). The total running time (including extensive output) on the UNIVAC 1108 was 12 min.

7. Unusual Features of the Program:

a) the coarse mesh rebalancing scheme makes possible the successful solution of difficult problems for which certain group-mesh points are both strongly and weakly coupled to some of their neighbors (e.g., highly nonuniform mesh spacings or material properties, air gaps, cell problems with weak group coupling, etc.).

b) good convergence behavior for large power reactor problems is accomplished by a combination of coarse mesh rebalancing and an asymptotic flux extrapolation procedure that assumes a single error mode.

c) simultaneous performance of computation and data transfer with virtually no delay caused by the use of drum storage.

d) ability to do efficient restarts for longer running problems and the ability to accept a flux guess on tape from a similar problem.

8. Related and Auxiliary Programs: GAMBLE-5 is a major revision of the GAMBLE-4 code.[3] Some of the essentials of the iterative technique used have been adopted from EXTERMINATOR.[4]

9. Status: The program has been in production use since August 1967 and may be obtained by domestic users from the Argonne Code Center.

10. Machine Requirements: 65 536 words of core storage, 3 tape units on 1 data channel, 1 572 864 words of FH-880 drum storage from 1 data channel, and a peripheral printer.

11. Operating System or Monitor Under Which Program is Executed: EXEC-II, GAX 23.

12. *References:*

[1]J. P. DORSEY and R. FROEHLICH, "GAMBLE-5, A Program for the Solution of the Multigroup Neutron Diffusion Equations in Two Dimensions with Arbitrary Group Scattering for the UNIVAC 1108 Computer," GA-8188, Gulf General Atomic Inc. (1967).

[2]R. FROEHLICH, "A Theoretical Foundation for Coarse Mesh Variational Techniques," *Proc. Intern. Conf. Res. Reactor Utilization and Reactor Math. Mexico, D. F.*, **1**, 219 (1967).

[3]J. P. DORSEY, "GAMBLE-4, A Program for the Solution of the Multigroup Neutron Diffusion Equations in Two Dimensions with Arbitrary Group Scattering for the IBM 7044 FORTRAN-IV System," GA-6540, Gulf General Atomic Inc. (1965).

[4]T. B. FOWLER, M. TOBIAS, and D. VONDY, "EXTERMINATOR, A Multigroup Code for Solving Neutron Diffusion Equations in One and Two Dimensions," ORNL-TM-842, Oak Ridge National Laboratory (1965).

J. P. Dorsey
R. Froehlich

Gulf General Atomic Incorporated
P.O. Box 608
San Diego, California 92112

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