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Progress Report No. 18

15 March 1972 -- 15 June 1972

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1) Cell Stitching Procedures

The first phase of the work described in earlier reports (Nos. 12,14,15,16, and 17) concerning a cell stitching procedure for determining detailed flux shapes throughout a reactor has been completed. Application in one-dimension for one and two energy groups has been encouragingly successful. This work was reported at the June meeting of the American Nuclear Society,⁽¹⁾ and a detailed project report will be issued shortly.⁽²⁾

We have now undertaken the extension of the scheme to two-dimensional x,y geometry. An essentially new problem comes up in such an extension in that the flux at most points between two cells of different composition will generally be discontinuous. We expect a major part of our efforts to extend the scheme will be concerned with accounting for this behavior.

2) Reduced Truncation Error in Kinetics Methods

We have continued work on the problem of frequency selection for kinetics methods. The basic ideas were reported in PR # 15 and 16. The simple explicit scheme is to define Ω such that

$$e^{\Omega h} \psi^j = (I + hA) \psi^j \quad (1)$$

The procedure works well in 1D but is unstable in 2D. We have tried various forms of splitting to approximate $(I + hA)$ in a stable manner and found the methods stable, but with little improvement in truncation error. We believe we understand the truncation error behavior and are making improvements in the frequency selection.

The difficulties come from the use of a single group frequency, and the use of the thermal group to calculate the frequency. To avoid excess work we actually calculate the frequencies for the thermal group only, in the form,

$$e^{\Omega h} \phi_g^j = (I + hA_g) \phi_g^j + h \underline{S}^j \quad (2)$$

where $\underline{S}^j$ is the slowing down source from all groups to the thermal group, say g . A_g is the matrix representation of the thermal group leakage plus removal. In the above form, in 2D, the method of frequency selection is unstable. We therefore try a splitting of A_g in the form

$$e^{\Omega h} \phi_g^j = [I - A_{g1}]^{-1} \{ (I + hA_{g2}) \phi_g^j + h \underline{S}^j \} \quad (3)$$

We find the procedure outlined in Eq. (3) stable, but inevitably the frequencies are underpredicted.

If we assume A_{g1} and A_{g2} are negative definite, which is true for all systems except a superprompt-critical, one-group reactor, then we can explain the consistent underprediction. Assume the system asymptotic so that

$$A_g \phi_g^j + \underline{S}^j = \Omega \phi_g^j$$

Then from (3) we have

$$e^{\Omega h} \phi_g^j = [I + (I - hA_{g1})^{-1} h \Omega] \phi_g^j$$

since A_{g1} is negative definite we then have

$$e^{\Omega h} \phi_g^j < (I + h \Omega) \phi_g^j$$

so we underpredict the appropriate behavior.

We believe we can improve the truncation error by at least two different schemes. The first is to use a splitting of the form

$$e^{h\phi_g^j} = (I - hA_{g1})^{-1}(I + hA_{g2})\phi_g^j + hS^j$$

The other is to use a scheme

$$e^{h\phi_g^j} = (I - hA_{g1})^{-1}[(I + hA_{g2})\phi_g^j + h e^{hS^1}]$$

Both methods are now under evaluation

The work on 3D kinetics completed some time ago was recently reported at Las Vegas in reference 3 below.

References

1. Trans. Amer. Nucl. Soc., Vol. 15, p. 283, A Consistent Coarse Mesh Homogenization Procedure, Patrick G. Bailey and A.F. Henry.
2. Variational Derivation of Modal-Nodal Finite Difference Equations in Spatial Reactor Physics, by Patrick G. Bailey and A.F. Henry. Report MITNE-138, COO-3052-S (July, 1972)
3. D.R. Ferguson & K.F. Hansen, "Solution of the Space-Dependent Kinetics Equations in Three Dimensions," Trans. Amer. Nuc. Soc., Vol. 15, No. 1, p. 290 (June, 1972).

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