PHYSICS OF NUCLEAR KINETICS

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7-1). In the numerical solution of Eq. (9-7), neutron density is given explicitly as a function of time, no iteration being required as is the case with many numerical methods for solution of the reactor kinetics equations. For many kinetics problems this simplification represents a considerable saving in computing time and in general operational efficiency.

The explicit numerical solution of Eq. (9-7) for neutron density, n_m, in the mth time interval may be written

$$n_m \simeq \frac{n(0) + \sum_{j=0}^{6} A_j e^{S_j m h} \sum_{l'=0}^{m-1} e^{-S_j l' h}\, \delta k_{l'} n_{l'} h + \Omega_{0_m}}{1 - \sum_{j=0}^{6} A_j\, \delta k_m h}, \tag{9-8}$$

where h, the integration time interval, is restricted to values less than

$$\left[\sum_{j=0}^{6} A_j\, \delta k_m\right]^{-1} \simeq \frac{l}{\delta k_m}$$

in order to obtain finite n_m. Recursion relations have been developed which greatly reduce the number of numerical operations formally indicated by Eq. (9-8). The general numerical solution for $n(t)$ in Eq. (9-7) has been coded in FORTRAN II for IBM 704 and IBM 7090, and is designated the RTS (Reactor Transient Solution) code.* The inverse problem—given $n(t)$, find $\delta k(t)$—is also included as part of the RTS program.† Details of the RTS code, including development of the recursion relations, flexibility features, etc., are given in Appendix A of Ref. 4.

For some problems a single integration interval h can be used over the entire time range of interest. In general, however, it is desirable to vary h automatically as dictated by functional behavior of the problem. Thus ideally the time scale is expanded or contracted to provide near-optimum time intervals for local $\delta k(t)$ and $n(t)$ variation. In the RTS code the fractional change in n per integration interval is taken as an indicator to dictate changes in h. Thus when $|\delta n/n|$ is within a specified range, h is held constant, and when $|\delta n/n|$ is outside this range, h is appropriately increased or decreased by a specified factor. The testing sequence actually used in the code is given in Appendix A of Ref. 4.

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* The RTS code and RTR code have recently been extended to include up to 9 photoneutron groups in addition to the six regular delayed-neutron groups. The corresponding roots and coefficients, S_jB_j and R_j, have been computed for up to 15 groups (6 delayed neutrons plus 9 photoneutron groups) for both D_2O and Be systems. (In practice it is seldom necessary, or even desirable, to include the full 15 groups in reactor kinetics calculations.)

† Starting with Eq. (9-7), Evans [3] has recently developed an independent method of explicit numerical solution of the inverse problem giving $\delta k(t)$ in terms of specified $n(t)$. This code (written in FORTRAN II) also utilizes the characteristic roots and coefficients tabulated in Appendix B.