Book Review

Advances in Nuclear Science and Technology, Vol. 8. By E. J. Henley and J. Lewins, Eds. Academic Press, New York and London (1975). 349 pp. $35.00.

This series is the European analog to *Annual Review of Nuclear Science*. Every year it brings articles on selected topics. The emphasis is on the discussion of the results obtained from an extensive list of references. It appears that this volume covers the state of the art at the end of 1972 with some updates to 1973 but none later.

"Quasi-Exponential Decay of Neutron Fields" by Noel Corngold. In neutron transport problems in subcritical or nonmultiplying assemblies, it is generally assumed that the solutions can be developed as a superposition of eigenfunctions in time and space. The smallest, discrete eigenvalue will then prevail at large times or distances. This asymptotic, generally exponential, behavior has been used in countless experiments to extract information about the properties of the media. However, the discrete eigenvalues disappear when the dimensions of the system become too small. This happens, for instance, when a mean-free-path becomes larger than a typical dimension. An example is that of cold neutrons whose energy is below the Bragg limit for coherent scattering. Nevertheless, there is generally no sharp break in experimental behavior when such a limit is reached. The answer to this puzzle, as developed by Corngold, is that in such situations there is a complicated energy dependence of mean-free-path and/or reaction rates. Thus there may be a "quasi-exponential behavior" if only a small fraction of the neutrons is involved. It is all a problem of trapping and leaking of certain neutron groups. Corngold illustrates such behavior in some simple models which, however, still require quite advanced analytical methods. He discusses many experimental results and the efforts to analyze them, and concludes that there is much good physics left to resolve the discrepancies that still abound. This reviewer, however, feels that there is a law of diminishing returns in analyzing in ever greater detail very complex problems, whose basic ideology has been clarified, but whose intricacies are of little concern to designers of actual reactors.

"Evaluation of Integral Physics Experiments in Fast Zero Power Facilities" by Edgar Kiefhaber. This article represents a thorough and well-written review through 1973. It has admittedly a European bias. However, the extensive report on work in Germany and in the USSR may be of special interest also to U.S. readers. It gives a detailed discussion of the accuracy of nuclear data now and as hoped for in the future and their implications for reactor design. There are tables with estimates of the contribution of cross sections and other data to uncertainties in k_{eff}, breeding ratios, and other reactor characteristics. It is concluded that integral experiments will remain indispensible for quite a few years. In a last section the present status of such topics as heterogeneities, material worth, and Doppler effect are discussed.

"Evaluated Nuclear Data Files" by S. Pearlstein. It is the task of an evaluator of nuclear parameters to assign their most credible values after consideration of all pertinent and often conflicting information. The author gives some guidance on procedure and the organization, checking, and use of data files. There is a compilation of available sources of information and short descriptions of the many data files available in the various countries and laboratories.

"Management of Fission Products and Alpha Wastes" by J. P. Oliver. This rather short article gives a concise and readable survey of its vast subject. It defines the magnitude of the problem both with respect to the amounts to be disposed and to the times involved. It is quite optimistic in outlook. It considers the methodologies for short-term storage as liquids and interim storage in solid form as essentially solved. The author sees no inherent difficulty for the ultimate disposal in stable geological formations such as salt beds, but considers that more research is needed on the very long term aspects. He estimates that the cost of high-level waste management represents only 0.5 to 1% of the total cost of nuclear-generated electricity.

"Finite Element Methods in Reactor Analysis" by K. F. Hansen and C. M. Kang. In the finite element method a large system is divided into finite subregions or blocks, each of which can be considered as homogeneous. The functions to be determined, such as the neutron flux in reactors, are represented in each subregion by a polynomial, but differently in each block. This is called the *piecewise polynomial approximation*. The coefficients are determined by variational procedures. This method has been introduced and very successfully applied in structural stress analyses. Its application to reactor problems is due to the authors. Their research paper[1] with the same title covers essentially the same ground.

The method has some obvious advantages:

1. It can be used for problems with complex geometries.
2. The number of parameters to describe a problem is much less than that required by the usual finite difference schemes that demand a fine mesh for accuracy.
3. It provides local approximation and is thus well suited to describe quantities with strong local variations.
4. It is possible in many cases to obtain rigorous bounds on errors.

[1] K. F. HANSEN and C. M. KANG, *Nucl. Sci. Eng.*, **51**, 456 (1973).

The article provides a detailed mathematical exposition of the method. It gives examples for its application to one- and two-dimensional diffusion problems and also to point- and space-dependent kinetics. It appears to be quite likely that the method will find growing usage in reactor analysis.

"Coated Nuclear Fuel Particles" by N. Piccinini. The possibility of high-temperature graphite-moderated reactors became a reality with the development of coated particles. These contain kernels of fissile and/or fertile materials in the form of oxides or carbides and several layers of coatings for containment of the fission products and mechanical stability. These layers include generally a buffer of low-density graphite to take up the impact of fission products and to provide space for gaseous fission products, one or more dense pyrolytic carbide layers for retention of most of the products and mechanical strength, and a layer of SiC which prevents the escape of rapidly diffusing species such as cesium and strontium. Minor changes in the production process may result in large changes in the properties of the particles that must retain their integrity under the harsh reactor conditions of high temperatures, strong temperature gradients, and large neutron fluences. A huge amount of research on this subject has been carried out mostly in the U.S., England, and Germany. Piccinini's article presents the first comprehensive review of this field. Perhaps more emphasis could have been placed on the mechanism of fuel failure during irradiation. However, on the whole the article is very informative and well written.

All in all, this volume presents six articles of commendable quality on topics of high current interest.

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About the Reviewer: Lothar W. Nordheim is a senior citizen with extensive experience and accomplishments in many fields of theoretical physics. He received his education in Europe where he was associated with such personalities as A. Sommerfeld, M. Born, David Hilbert, and Niels Bohr. In the U.S. he held professorships at Purdue and Duke Universities. He received his initiation to the nuclear energy business at the ground floor at the Manhattan Project in Chicago and Oak Ridge, 1943-1947. He served as a resident consultant at Los Alamos, 1950-1952. In 1956 he joined General Atomic as one of the first staff members and where he still continues in semiretirement as consultant. He has been a member of the Editorial Advisory Committee of Nuclear Science and Engineering *for many years, where he is usually asked for advice on delicate points of fact and personalities. He is still actively involved in nuclear and reactor physics.*