Book Reviews

Dynamics of Nuclear Reactors. By David L. Hetrick. The University of Chicago Press (May 1971). 542 pp. $18.50.

Over the past 20 years a great deal of work has been done in analyzing the dynamic behavior of nuclear reactors. The primary justification for this activity has been the great importance of predicting and understanding the transient behavior of reactors. However, many of those who have worked in this area have also been motivated by the fact that the problems encountered are often amenable to attack by a variety of sophisticated experimental and mathematical techniques. As a consequence, the literature abounds in papers which present a staggering amount to be assimilated by someone just entering the field. For such a person, Professor Hetrick's book should be extremely valuable. It provides a very thorough and orderly review of a significant portion of the field of reactor dynamics.

The material of the book is organized around the point kinetics equations. These equations are first derived and discussed in an approximate manner. Then the solutions for constant and time-dependent sources and reactivities are described—first analytically and then numerically. A chapter on reactivity feedback and reactor excursions is then presented, followed by chapters on linear and nonlinear system stability. Finally, there is a chapter on space-dependent neutron dynamics.

The literature on all the subjects covered is reviewed in detail. (There are 38 pages of references.) Yet the book is far more than a mere summary of pertinent papers. It is a unified whole, and the various parts fit together well. In many instances the same problem is attacked by several different methods to illustrate their interrelationships. The level of mathematical difficulty has been kept uniform (in some instances by quoting theorems without proof) so that the material should be readily comprehensible to someone having had the standard courses in mathematics required of most undergraduate engineers and physicists. Although there is one chapter on numerical solution of the point kinetics equations, most of the emphasis is on analytical methods. As a result, the feedback models are often highly simplified. Professor Hetrick, however, is careful to point out the limitations of approximate methods along with their virtues.

There are certain areas which, by the author's choice, *Dynamics of Nuclear Reactors* does not cover. Most notably, there is no material on neutron fluctuations. Also, the discussion of numerical methods and of space-dependent effects is limited. Finally, there is no presentation of the detailed mathematical models which are frequently applied during the design stage of a power reactor. The emphasis is more on how to analyze the dynamic behavior of a reactor in terms of certain general feedback parameters after it has been built rather than on how to predict its dynamic behavior beforehand.

I don't mean to imply criticism in pointing out these omissions, but merely to note them. (Professor Hetrick points out that he made them quite consciously.) The topics on which the book is concentrated are treated thoroughly and well, and I recommend it to anyone working in those areas. I also believe it would serve as a very good textbook for a course dealing with those topics. However, for this latter application, I believe the teacher should supplement somewhat the motivation and evaluation for certain approaches and possibly omit some of the material. For example, I think it is worthwhile in a reference book to include the analytical treatment of the ramp reactivity insertion problem. I would, however, be inclined to omit it from a one-term course in reactor dynamics.

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About the Reviewer: Al Henry has been professor of nuclear engineering at the Massachusetts Institute of Technology during the past few years following an extended association with the Bettis Atomic Power Laboratory. While at Bettis he was responsible for the nuclear design of submarine propulsion reactors. Dr. Henry, who completed his graduate studies at Yale in 1950, has helped guide Nuclear Science and Engineering *as a member of its Editorial Advisory Committee.*

Monte Carlo Principles and Neutron Transport Problems. By Jerome Spanier and Ely M. Gelbard. Addison-Wesley Publishing Company, New York (1969). 234 pp. $14.95.

Each of the authors should understand that each criticism below relates solely to the contributions of his colleague.

It should be mentioned that I have already reviewed the book (*Computing Reviews*, March 1970) for a different audience and that I have, on the closer examination appropriate for the present audience, changed my mind on some points.

The dual purpose of the book is already well indicated in the title. The first half (three chapters) is to serve as a general introduction to the Monte Carlo method. The second half (also three chapters) is to serve as an exposition of its application to neutron transport.

The authors have, however, charted a course which severely limits the value of the book as an introduction to Monte Carlo. They have selected a quite restricted class of neutron transport problems for discussion, explicitly omitting all problems of shielding and of reactor criticality. The two problems discussed in detail are the calculation of thermal fluxes and of resonance escape probabilities. Since these are the problems with which they and their associates have been most closely concerned, this course allows authoritative statement at the expense of completeness. There is, however, a subtle secondary effect. In general, the statistical problems in the field they cover are less severe than they are, for example, in shielding calculations. Thus, some of their observations, valid within their field, are not safely applicable to more general situations. We have in mind, in particular, their emphasis on the importance of normality of sampling distributions, an emphasis that would be distinctly out of place in deep penetration problems.

There are some striking omissions in addition to those planned and noted above. Neither time dependence nor the management of complex geometries is mentioned or discussed. Also, and, especially in the field of problems discussed in depth, one would like some guidance in the choice between the Monte Carlo method and more conventional methods for specific problems or classes of problems; none is forthcoming.

One of the chief attractions of the Monte Carlo method is its capacity to handle transport problems without extensive approximations. Here, however, we are led to believe that the multigroup approximation, for example, is the only method for handling energy dependence. The use of Monte Carlo as a design tool might not be practical without this and the authors' further approximations, but the reader is entitled to know that he can do better if he is willing to pay the price.

We come now to a tender subject: the quite startling frequency of error, by no means all typographical, in the book. The following list is, in all probability, far from exhaustive.

Page xiii, first paragraph. One can, by the use, for example, of a next flight estimator in an analog process, estimate the flux at a single point (see pp. 110-111, text).

Page 4. The equation displayed in point (5), middle of page, is meaningless; Δ, on the right, should be replaced with Δ^{-1} on the left (Δ is bound, by $\lim_{\Delta \to 0}$, to the left side).

Page 21, last paragraph. In addition to the evident flaw in the discussion, there is a further technical flaw, which leads to a possibly interesting problem. The condition (1.5.4) does not say, as the authors probably intended, that *each* subcube of the unit n cube carries the proper mass; this is only asserted, by (1.5.4), for those subcubes whose main diagonal lies on the main diagonal of the unit n cube. This does not imply the desired stronger result.

Page 28 (middle). As it stands, the discussion is wrong; one must take into account in the test the maximum of $h(x)$.

Page 34. The footnote here is, with any reasonable interpretation, at least very misleading, and should be deleted or ignored.

Page 37. The reviewer finds no reason for viewing the multiplicative congruential method as a variant of the midsquare method. Also (bottom of page), the mixed congruential method increases the period of the least significant digits only by a small factor; at most, 4. This is true also of the period of the generator as a whole, if the multiplicative generator is properly selected.

Page 44. The footnote here is quite optimistic.

Page 56. The basic equations (2.4.1) and (2.4.3) and the discussion of (2.4.5) are all completely wrong; these quantities are not probabilities. For example, $p(x)$ is not the probability of extinction at x (which is, presumably, zero for each x); instead, $p(x)\,dx$ is the probability of extinction somewhere in a small volume dx near x. Probabilities are functions of sets, not of points!

Page 69. The use of pseudocollisions, for an entirely different purpose, was introduced independently and at the same time by the British designers of the GEM code. They noticed that one can greatly simplify neutron tracking by making total cross sections equal from region to region with the help of pseudocollisions. See *Proc. Conf. Application of Computing Machines to Reactor Problems, May 17-19, 1965,* ANL-7050, Argonne National Laboratory.

Page 88. The definition of subcriticality given here is not quite equivalent to the second definition given on page 94. If there is no particle multiplication, they are equivalent. But a system allowing particle multiplication which is just balanced by absorption and leakage, and hence just critical by the later definition, is subcritical by this one. For, in such a system, each particle, and indeed each family of particles, is still obliterated with probability 1. However, the expected number of collisions appearing in such a family history is infinite, while this expectation is finite in cases which are really subcritical. Thus, each statement later made about subcriticality should be checked for validity. If a definition of this type is needed, we might define a subcritical system as one in which each random variable with bounded, collision-dependent contributions has finite expectation (maybe).

Page 155, Table 4.1. The entries for $e = 1.4$ and 3.8 are clearly erroneous; only a little less clear is the error for $e = 2.4$.

It is indeed unfortunate that the many flaws in this book have left no room for adequate discussion of its many merits.

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About the Reviewer: Bob Coveyou has been at the Oak Ridge National Laboratory since 1943 where his interests have been primarily in the physics of nuclear reactors and in the development and application of Monte Carlo calculations in that field. Mr. Coveyou received his academic training at the Universities of Chicago and Tennessee. He recently completed a two-year assignment to the International Atomic Energy Agency in Vienna.

Nuclear Theory, Volume 1: Nuclear Models. By Judah M. Eisenberg and Walter Greiner. North-Holland Publishing Company, New York (1970). 476 pp. $23.00.

The present volume, number 1 in a three-volume series, concentrates on the theory of the phenomenological models for the collective degrees-of-freedom of the nucleus. One of its distinctive features lies in its unified treatment of the collective motion associated with the deformation variables of the nucleus (vibrations and rotations) on the one hand and the neutron-proton density fluctuations (giant resonances) on the other. Research workers in the field will find much of interest in this volume, although its main aim is to serve as a text for an intermediate graduate level course in nuclear theory. In