Book Reviews

Variational Methods in Nuclear Reactor Physics. By Weston M. Stacey, Jr. Academic Press, New York and London (1974). 181 pp. $18.50.

I am going to be complimentary about this book, so I should first declare my interest. I am one of those who over the years have been entranced by the elegance of the variational method; I have been associated with Academic Press in the annual review series, sister to the *Nuclear Science and Technology* book list; and I, like the author, had this interest nurtured in the bracing atmosphere of Manson Benedict's Department of Nuclear Engineering at MIT. Having made these professions, I can leave others to evaluate the fairness of this review.

The present monograph, No. 10 in the publisher's series, is a careful review of the formalism of the variational method as it has been developed over the years in reactor physics, with not a little of this due to the author himself. The general formalism has been extended now well beyond the conventional Rayleigh-Ritz methods and, with the perturbation theory that Stacey develops from it, gives a powerful technique for the calculation of such characteristic numbers as reactivity effects, reactivity coefficients subject to system changes (as in temperature changes), ratios of significance such as the breeding ratio or power fractions, reactor kinetics parameters, etc. The general theory also lends itself to one consistent approach to obtaining approximate equations or theories in a systematic way.

Such a general outline is admirable and should serve to signpost the route for teacher and student alike. It is based, of course, on the bilinear approach giving equal significance to the adjoint function as to the forward or flux-density function. Stacey shows, however, a brief connecting path to self-adjoint systems, what might be called quasi-symmetric systems (one-speed transport theory) and the quadratic or self-consistent variational methods utilizing one function only. There is a formal field theoretical chapter to 'imbed' the principles in the developments of Pontryagin and Bellman. I would have liked a little more discussion of the functional derivative. Pomraning's account of this (reference given) certainly illuminated things for me and should perhaps have found a place here.

Another good feature of Stacey's work is the attempt to illustrate the theory with practical examples, with the intention of convincing the reader of the utility of the method. These examples range from some standard work in slab transport calculations through the generalized perturbation theory for reactor kinetics parameters and sensitivity calculations. On the whole, these succeed admirably though I would like to have had at least one case show, in tabular form perhaps, the comparative computing costs of variational and direct methods for comparable accuracy. Certainly, a reasoned account of the accuracy available is given for several cases.

When we get to the illustrations of devising approximate theories or equations, and I am thinking specifically of synthesis with overlapping trial functions, I am not quite so convinced. For one thing, a discussion of the pathological behavior of adjoint weighting in cases where Galerkin weighting is successful is omitted (although the chapter references are provided to the source material). Perhaps it is not fair to put the blame for this on the author, when others of us should have contributed to what in my mind is an unresolved problem in the research literature. There is a detailed discussion of the consequences, in the way of over-determined boundary conditions, for discontinuous trial functions when both forward and adjoint functions are discontinuous at the same interface. This seems a theoretically insurmountable problem which can only be resolved, as Stacy himself suggests, of course, by certain approximations for the redundant conditions whose efficiency can only be determined case by case and lie outside the nature of the variational method. Has the last word been said on the subject? Is there something to be explored in the self-adjoint or symmetric variational principles for discontinuous trial functions if a maximum principle is available?

The reviewer has the classic advantage of attacking ground that the author has chosen to defend but must stand passively surveying. To establish superiority, it is essential to demonstrate an eagle eye for trivia and misprints. In this spirit, I offer a couple of ** for Eqs. (1.4.31 and 1.4.32) in Chap. 1, a pair of [ ] and a μ for Eq. (2.3.9a) and page 71 of Chap. 2, and boldface type for a number of the omegas in Chap. 3. In view of the heavy mathematical content, neither the author, as General Officer Commanding, nor Academic Press as his Chief of Staff, can feel mortally wounded by such inconsequences and rather are to be congratulated on producing a technical monograph to a price which is large, positive, but at least bounded by a *supremum*.

One of the author's expressed hopes is to make these techniques as developed in nuclear reactor physics available to other workers. Clearly, he has done his bit; I wonder whether the readers will make their contribution. In the short term, I rather doubt it. The introduction to reactor physics given here is really too brief to satisfy any but the converted. In the long term, however, I hope reactor physics will repay the immediate debt it owes to quantum mechanics and, tracing further back as far as Rayleigh himself, for the ideas and techniques it has lifted. I have a vision of graduate students in future departments of geothermal engineering (applied hydrogen or perhaps even the alcohol economy) looking for some inspiration, preferably not noticed by their supervisors, and this is one of the works I would recommend them to steal, or should I say take out on indefinite loan, from the 21st-Century Library.

Even before that day, however, I think we could allow some public acknowledgment of the credit that should go to the Nuclear Engineering Department of the Massachusetts Institute of Technology for developing what might be recognized as a school of variational theorists, including Martin

Becker, Gerry Pomraning, and Weston Stacey in their number, three still young but already distinguished contributors to a deep-welling mainstream of mathematical physics.

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About the Reviewer: Jeffery Lewins drank at MIT's well in the late 50's, after quite dissimilar employment with the British Army in Korea. He notes the claim of military *engineering (the second oldest profession?) to predate civil, nuclear, or any other form of engineering. The attempt of MIT to turn him into an experimentalist having been one of those better experiments that are valuable for having gone wrong, he returned to military life confident in finding plenty of paper for the theoretician if he could carry around his own supply of pencils in his knapsack. Fifteen years later, after excursions to Germany, the University of Washington, Scotland, and other foreign postings, he returned to London. Here he is again attempting the impossible feat of combining academic study with active service; this time the field of operations—not a battlefield he hastens, in an unquiet age, to add,—is a men and women's student residence for the University where he is Warden, and some peripatetic lecturing in engineering topics around the colleges of the University. The pencil is still there, though in putting down roots (or at least in becoming stationary) it has grown itself a digital and an analog computer; the abiding love of the variational method is there too whenever he can persuade an audience to listen to him.*

Topics in Radiation Dosimetry (Radiation Dosimetry, Supplement 1). Edited by F. H. Attix. Academic Press, New York (1974). 556 pp. $28.00.

This volume is the first in a projected series of supplements to the three-volume second edition of *Radiation Dosimetry.* Additional supplements are to be issued from time to time, as the need arises to update and augment the second edition. It is the desire of the editor and publisher that the second edition of *Radiation Dosimetry*, together with the supplements, provide the most comprehensive reference source available in radiation dosimetry.

Supplement 1, which is 556 pages in length, contains eight chapters, written by different authors. Four chapters cover special topics in dosimetry. M. J. Aitken and S. J. Fleming describe the interesting field of thermoluminescence dosimetry use in archeological dating. They treat the subject in 74 pages of text with 36 figures and four pages of references. The basic principles are explained, and measurement techniques are described. Glow-curve data from a number of samples, including forgeries, are shown and analyzed. J. R. Greening discusses the dosimetry of low-energy x rays—those generated at potential differences of <100 keV and particularly at <50 keV. Measurement of energy fluence, exposure, and absorbed dose are treated. D. Nachtigall and G. Burger cover the use of moderator methods in the determination of dose equivalent in neutron fields. They discuss REM counter techniques, monitor techniques, neutron spectrometry, and instrument calibration. E. Piesch contributes a chapter on radiophotoluminescence dosimetry. His article supplements the basic introductory contribution of J. F. Fowler and F. H. Attix in Volume II of the second edition of *Radiation Dosimetry* and updates the literature. Recent advances in understanding the physics of radiophotoluminescence, particularly as they affect personnel dosimetry, are emphasized.

Three chapters cover special measurement techniques and instrumentation. Klaus Becker presents a comprehensive review of dosimetric applications of track etching. He summarizes procedures for etching materials and counting tracks. Special sections of the chapter are devoted to the use of fission-fragment as well as alpha-particle and recoil-nuclei registration in neutron dosimetry. The article provides a good review of these new techniques and their application to neutron dosimetry. Ten pages of references, principally newer ones, are included. T. E. Burlin discusses vacuum chambers and their use in making radiation measurements. He treats the fundamental processes of electron energy loss, secondary electron energy-angle spectra, and electron slowing-down spectra and develops Greening's theory of the vacuum chamber. The chapter includes sections devoted to the use of vacuum chambers as dosimeters, electron-beam monitors, and energy spectrometers as well as their use for pulse measurements and for interface dosimetry. William A. Glass and William A. Gross contribute a chapter on wall-less detectors. Their use in microdosimetry is based on the need to avoid distortion in the registration of energy-loss events that occur in dual-density systems, such as a solid that contains a gas cavity. Although the design and use of wall-less counters is perhaps not of great practical consequence in the daily business of dosimetry, it is nevertheless related directly to our fundamental understanding of the physics of energy deposition by ionizing radiation.

The remaining chapter, by R. Katz, S. C. Sharma, and M. Homayoonfar, is entitled "The Structure of Particle Tracks." The title is somewhat misleading, since the article is not devoted to this subject *per se.* Except for a very brief description of the delta-ray theory of track structure, which forms the basis of the models developed by Katz and his coworkers, most of the article is devoted to the predicted responses of chemical and biological systems. The chapter provides a comprehensive review of the contributions to dosimetry and radiation biology made by Katz and his collaborators.

The above summary briefly describes the contents of *Topics in Radiation Dosimetry.* Consistent with the three volumes of the second edition of *Radiation Dosimetry* (and the first edition by Hine and Brownell!), the contributions in this first supplement are first class. They are interesting and authoritative, having been written by investigators who have significantly advanced the specialities about which they write. This reviewer recommends this volume to readers of *Nuclear Science and Engineering* who have more than a superficial interest in radiation dosimetry. Based on the quality of this first supplement, he eagerly awaits the second!

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About the Reviewer: James Turner is associate director of the Health Physics Division of Oak Ridge National Laboratory where he has been stationed for more than a decade. Since completion of his graduate studies at Vanderbilt, Turner has acquired much experience in personnel dosimetry. We welcome him again to these columns.