Book Reviews

Nuclear Structure. Vol. I, Single-Particle Motion. By Aage Bohr and Ben R. Mottelson. Benjamin, New York, 1969. 474 pp. $25.00.

In 1953, Bohr's and Mottelson's famous paper on "Collective and Individual-Particle Aspects of Nuclear Structure" was published, itself the fruit of two years collaboration. Since then, Copenhagen has been the Mecca for nuclear theorists. The most important subsequent advances have originated there such as the description of nuclei with spheroidal shape, and the recognition and systematic treatment of pairing effects in analogy to the electronic correlations in superconductors. At most nuclear physics conferences and summer schools either Bohr or Mottelson, or some of their pupils, stood up and reported on some new and beautiful interpretations of particular nuclear phenomena. Yet it was very difficult for anyone not personally traveling to Copenhagen to follow these developments. At the summing up of the Nuclear Structure Conference in Tokyo in 1967, the state of the art was described by the simile of the blind men and the elephant. Each one feels one part, the trunk, the tusks, the flank, legs and tail, but none has a picture of the animal as a whole.

Bohr and Mottelson, themselves, have felt this lack of coherence very keenly and they have labored for ten years to write and rewrite a modern text. Now the first volume of three planned ones has appeared. It is completely novel and unlike any other book on nuclear physics.

The aim of the authors was not so much to deduce everything from first principles. Instead they say "In the study of a many-body system such as the nucleus with its rich variety of structural facts, the central problem appears to be the identification of the appropriate concepts and degrees of freedom that are suitable for describing the phenomena encountered. Progress in this direction has been achieved by a combination of approaches based partly on clues provided by experimental data, partly on the theoretical study of model systems, and partly on the general exploration of general relations following from considerations of symmetry."

The multidimensionality of nuclear physics presents a difficulty for any writer on this subject. The authors try to overcome this hurdle by a three-tier division of the material presented into text, illustrative examples, and appendices. The divisions are clearly marked. The text attempts a systematic development of the subject proceeding in a reasonable linear order. It emphasizes the physics considerations underlying each concept. The results from detailed calculations are generally given and explained but not derived. Most of the discussion of the empirical data is given in the illustrative examples. Here results from any part of the book, inclusive of the not yet published ones, have been used freely, so that the full panoply of available tools and information can be brought to bear on a particular subject. Each such section represents thus a kind of essay in depth. The Appendices treat the more mathematical aspects such as angular momentum algebra, β-decay and nuclear reaction theory. The treatment is concise and elegant with emphasis on defining the matrix elements occurring in various processes. While most of these developments are too brief for a first introduction, they give an excellent compilation of needed formulas and references for more detailed study.

In the main, this structure of presentation is very successful in overcoming the difficulties of multidimensionality. On the other hand, it necessitates a continuous back and forth leafing. Thus, this is not a book to be read from cover to cover in one session. It is there to browse, to look things up, to be encouraged to think. The serious reader will be delighted by the many sudden insights it provides and by many contacts with particle-, astro-, and atomic physics.

The presently available Vol. I deals with single-particle motion. It starts in Chap. 1 with the consideration of symmetries and conservation laws which serves as a leitmotiv for the whole book. Chapter 2 on independent particle motion covers such topics as bulk properties of nuclei, evidence for nuclear shell structure, nuclear species and abundance, average nuclear potential, and nucleonic interactions. Chapter 3 takes up single-particle configurations with the subheadings quantum numbers and wave functions inclusive particle-hole symmetry, energy spectra, matrix elements of electromagnetic moments, beta-decay matrix elements, and reaction processes.

The future Vol. II will be devoted to the phenomenological analysis of nuclear deformation with chapters on rotational and vibrational spectra and on one-particle motion in nonspherical nuclei. Finally, Vol. III will deal with the microscopic theory of collective phenomena with chapters on few-particle configurations, pair correlations and quasi-particle spectra, and microscopic theory of nuclear deformation effects.

As mentioned earlier, it is not the intention of the book to derive nuclear properties from first principles. Thus, the work in this direction by Brueckner, Bethe, Brown, and others is only mentioned shortly. It may, however, be considered as an omission that the "healing" properties of the nuclear wave functions are not considered at all. This property, first discussed by Moszkowski and Weiskopf, has the effect that the wave functions remain relatively simple in spite of the complexities of the nucleon two-body forces (which are discussed) and thus lead to an easier understanding why relatively simple models can give such good and far-reaching results. But, maybe, this topic will be discussed in a later chapter.

In the history of nuclear physics there have been two theoretical works which summarized the knowledge of their times and exerted such a profound influence that they are still profitable to read today. They are Bethe and Bacher's

articles in *Review of Modern Physics* in 1936-37 and Blatt and Weisskopf's *Theoretical Nuclear Physics* in 1952. Now after another 17 years we have in "Bohr and Mottelson" a worthy follower of these predecessors. A comparison will show how much nuclear physics has progressed in the intervening years and how powerful are the new methods now available. This is not a book for the novice or the nuclear engineer who want a quick survey of the field. However, it will be indispensable for every serious student of nuclear physics, theorists and experimenters alike.

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About the Reviewer: Lothar Nordheim, a frequent and generous contributor to these columns, was educated in Europe and has held professorships at Purdue and Duke and has been prominently associated with the laboratories at Oak Ridge, Los Alamos, and, most recently, at General Atomic. Presently a consultant for Gulf General Atomic, Dr. Nordheim has been an observer of and participant in the nuclear scene for about forty years. He is a Fellow of the American Nuclear and Physical Societies and a member of the Editorial Advisory Committee of Nuclear Science and Engineering.

Fundamentals of Radiation Protection. By Hugh F. Henry. Published by Wiley-Interscience, New York (1969). 473 pp. $17.50.

The author sets himself an unusual task which he describes in the preface as follows: "If this book in any way helps to place the overall subject of radiation, its hazards and control, into an appropriate perspective for the casual reader while at the same time helping to clarify its basic concepts for those with a more serious interest in the subject, my purpose in preparing it will have been at least partly fulfilled."

The book, in fact, seems to be aimed primarily at the general interest student level. It is rather difficult for the reviewer to assess fairly what its penetration might be either for the casual reader or as a clarifier of basic concepts for those who expect to advance in the subject. On the whole, we would find it rather difficult to discover appropriate merits for this last class.

Dr. Henry writes in an easy style and manages to compress a good number of facts into a short exposition, a feature which seems to be increasingly rare in writing about radiation protection. Thus, the first three chapters on the basic physics of atomic structure and nuclear transformations are highly readable and appropriate. Chapters 4 through 9, which take the reader into the areas of biological effects and establishment of physical and biological dose relationships, are adequate. Whatever selection is made from this vast body of material can easily be criticized by the next potential author. With a few exceptions, Dr. Henry's choice seems to be appropriate if one is willing to overlook a number of minor faults. Some are not readily excusable, as when he says on page 3 that the erythema dose is now estimated to be about 1800 rads, whereas by page 116 the sensitivity of the skin has increased to the point that 700 rads (or reportedly as low as 300 rads) has resulted in erythema while at 1500 rads blisters appear. It is equally surprising to find that "the tragic and well publicized cases of the radium dial painters" involved only *several* girls.

Those who have spent their careers in association with radiation therapy will be dismayed to discover that "certain diseases and disabilities have *apparently* been relieved by such exposures." The underlined word could surely have been omitted.

The middle section of the book, which is concerned with permissible exposure limits, internal exposure evaluations, radiation detection and measurement, and the basic principles of monitoring, generally seems to meet the standards that the author set for himself. We are less happy with the final section beginning with Chap. 16, which offers "Guides to Practical Protection Measures." We would have found this much more helpful if the reader had been given a clue as to the principal hazards likely to apply in normal operation of typical facilities. For example, if one is concerned with radiation protection for a reactor installation, are the principal issues the emission of high-intensity neutron beams, the radiation from activated fuel or fuel casing pieces removed from the reactor, or radioactive gases that leak into the atmosphere, or some other cause? The text, as it were, tends to offer solutions to these problems without first indicating what the problems are and how they may arise. Of all the people who take any part in a radiation protection program, it is doubtful if as many as 1% ever have any contact with a radiation accident. Yet the text on accidents and emergencies seems to be more vigorous than that on mundane affairs of day to day operation. This section, and especially the chapter on administration, bears too heavily on the circumstances in the typical major U.S. Atomic Energy Commission programs. There is only about one sentence that refers to other circumstances, and this sentence is totally unsatisfactory. One simply cannot accept that a radiologist is a normal and appropriate health physicist for a hospital. Either a more balanced presentation between the needs of U.S. Atomic Energy Commission programs, current commercial operations, university and other laboratories, and medical programs should have been given, or this section omitted. Similarly, we feel that space could have been occupied better than with a discussion of nuclear weapons and the fallout problem. Finally, we find the most inappropriate assignment of space to be Appendix II, Part 2, which consists of 71 pages of the standard tables on maximum permissible concentrations that the specialist would have on his desk from normal NCRP and ICRP sources, and which others will find completely useless.

In summary, applying the standard subjective appraisal methods currently so popular in radiation protection we must say that the benefits of exposure to this text clearly outweigh the risks. In fact, if Dr. Henry had not tried quite so hard to make a little irradiation sound tolerable, if not actually desirable, we might have recommended that one of the philanthropic foundations could have found many less satisfactory ways of using its funds than in some way giving a free copy of this text to everyone who purchases a copy of any one of the current "Perils of Pauline"-type accounts of radiation hazards.

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