Book Reviews

Annual Review of Nuclear Science, Volume 22. Edited by Emilio Segrè, Annual Reviews, Inc. (1972). 506 pp.

Soon after I was entrusted with the review of the *Annual Review of Nuclear Science, Volume 22,* a friend, himself a contributor to the book and deeply interested in reducing the specialization of his colleagues to some narrow area of nuclear physics, asked me whether I could conclude that this book will contribute to the broadening of the interest of nuclear physicists. I read the book, therefore, not only to learn some of its contents, but also to arrive at some answer to my friend's question.

I am glad to report that the answer arrived at is rather positive, although it is possible to criticize almost every one of the 12 articles. A few suggestions for making them more effective will follow. Nevertheless, there was no article about which I was tempted to tell myself "this was boring" or which did not leave some lasting impression on my mind. As to suggestions to increase the usefulness of the volume, I would mention three which particularly struck me. The first is that articles which deal with subjects further removed from the interests of most nuclear physicists should be dealt with on a more elementary level. I am afraid that perhaps only a fifth of all nuclear physicists will be able to follow Chiu's article on Regge poles. It assumes that "the readers are already familiar with, for example, Chapters 10 to 16 of Frautschi"; I am afraid this is an unjustified assumption. Incidentally, the article does not mention Omnes' excellent review in the 1966 volume of the *Annual Review*. My second suggestion is to define more, perhaps even all, of the symbols used. This is done only in two or three of the 12 contributions. It is perhaps correct to assume, with Noyes, that everyone knows that δ denotes the scattering phase shift; however, the meaning of Δ_{LS} or Δ_T will be familiar to only a few of the readers. Lastly, I would like to suggest, with some hesitation, a more general use of a few introductory paragraphs delineating the area discussed in the article in its relation to the total subject, mentioning also the areas which are not discussed.

After these somewhat critical remarks, I would like to add words of praise for practically all articles. The first article, by Pellegrini, deals with the problems and limitations of colliding beam accelerators; it is good for theorists to become better acquainted with these. Incidentally, this article appeared to this reviewer to be free of the implied criticisms voiced above. The subject of the second article, the validity of the isospin quantum number in nuclear wave functions, by Bertsch and Mekjian, is close to this reviewer's interests. Yet it provided him with a great deal of information and called his attention to many papers with which he was unfamiliar. The article describes a large variety of points of view and many suggestions and initiatives. It does concentrate, perhaps, too much on the work of the last five years, most likely assuming that the readers are familiar with earlier results. It would have been good, in this connection, to give a table of the numerical values of the Coulomb energies and to refer more explicitly to the two causes for the breaking of the isospin symmetry: (a) the Coulomb interaction, and (b) the differences between the magnitudes of proton-proton, proton-neutron, neutron-neutron interactions (cf. in this connection the volume's last article). In addition, the article possibly takes the validity of the independent particle model too much for granted. The reader will recognize, in these points, the personal views of the reviewer.

Jumping now to the article on thermal breeder reactors by Perry and Weinberg, one can be well pleased that this subject is taken up since it may become of crucial importance for overcoming our energy problem. With the recent broadening of the U.S. Atomic Energy Commission's point of view, interest in the subject can be expected to increase; it is good to have such a competent review of the subject. The article deals with three aspects of the subject: reactor physics, engineering, and economics. The claim for greater safety of thermal breeders, as compared with fast breeders, is not discussed and perhaps the problem of the chemical separation of the fissionable fuel from the fertile material, which will become fissionable in the breeder, deserves more attention. It is also evident that the use of molten salt as the moderator, i.e. thermalizer of the neutrons, is the authors' favorite; in this reviewer's opinion, heavy water is given too short a shrift. These points are mentioned to stimulate the interest of the reader, but they do not impair the excellence of the review.

The next article, by Box, on radiation damage is highly specialized. (The running title misreads, "Reaction Damage.") The article deals quite exclusively with the chemical reactions, and with these only as revealed through electron-spin spectroscopy. It contains no discussion of the radiation inducing the initial process (which is, in most cases, ionization) nor with the radiation-caused changes in the gross properties of the irradiated materials. It does consider a wide variety of substances, about 60 organic compounds, and discusses the chemical transformations following the removal of an electron or its addition to another compound. One cannot help marveling at the experimental techniques used, in many cases involving the use of isotopes, ^{13}C and ^{2}H, and accurate measurements of the magnetic moments of the resulting paramagnetic compounds in all cases. The writer is evidently deeply interested in his subject. Incidentally, he mentions not only "radio-protective" drugs, i.e., substances such as cysteine which reduce the effect of radiation if taken well ahead of the exposure to radiation, but also the existence of radiosensitizing materials having the opposite effect.

The last article, on the scattering lengths and effective ranges of the proton-proton, neutron-neutron, and proton-neutron interactions, by Noyes, is again in the more narrowly defined area of nuclear physics. The scattering length, usually denoted by a, gives the scattering cross section $4\pi a^2$ of the pair involved at very low energy, or would give it if only nuclear forces were involved. The range r determines the energy derivative of the cross section. If the three nuclear interactions, proton-proton, neutron-neutron, and proton-neutron, were equal—thus eliminating one of the reasons for the breaking of the isospin symmetry—both a and r would be identical for all three pairs. The article discusses the determinations of the three a's and three r's from the experimental point of view and the surprisingly many and intricate corrections that must be applied on the raw data. It also discusses the cross-section dependence at somewhat higher energies, several MeV, and the Cini-Fubini-Stanghellini formula which should account for these. It reaffirms the generally accepted conclusion that the ranges of the three interactions, close to $r = 2.8 \times 10^{-3}$ cm, are very nearly equal, but the scattering length of the proton-proton interaction, $a = 17.8 \times 10^{-3}$ cm, is considerably lower than that for proton-neutron interaction, $a = 23.7 \times 10^{-13}$ cm. The neutron-neutron interaction is very difficult to determine directly—the problem is discussed on a rather sophisticated level—and it may be best to assume that it is equal to the proton-proton interaction.

As was mentioned before, the book appears to be a useful contribution to the literature; the articles one can understand are rewarding reading.

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About the Reviewer: Professor E. P. Wigner, a revered member of the nuclear community, actively continues his contributions to nuclear physics following his retirement from the Thomas D. Jones Professorship of Mathematical Physics at Princeton. Dr. Wigner, a Nobel laureate in physics, was one of the principal strategists of the Manhattan Project. Interestingly, his early academic training was as a chemical engineer.

Fundamental Interactions and the Nucleus. By R. J. Blin-Stoyle. American Elsevier Publishing Company, Inc. (1973). 345 pp. $19.50

The phrase "fundamental interactions of the elementary particles" is usually associated with the experimental programs of the large accelerators and not with what we currently call nuclear physics. However, much of what is known about the strong and weak interactions has been learned from experiments with nuclei at relatively low energies. This is the subject of *Fundamental Interactions and the Nucleus* by R. J. Blin-Stoyle.

The subject matter is actually considerably less general than the title indicates. The emphasis is overwhelmingly on weak interactions. This focus reflects the interests of the author, who is well qualified to write such a book. He and his collaborators and students have made numerous contributions to the field, in addition to significant contributions to other areas of nuclear theory and several lucid review articles.

The theory of weak interactions is reviewed in Chap. I. This theory is very similar to the quantum electrodynamics in that the interaction of particles is taken to be proportional to the scalar product of their (four-dimensional) currents. The electromagnetic current of nucleons has a polar vector part plus a rank-2 tensor part arising from the anomalous magnetic moments. The weak interaction currents contain additional terms of axial-vector, scalar, and pseudo-scalar form. Associated with each is a coupling constant analogous to electric charge. The form of the interaction manifests itself through the properties of radiations emitted in various nuclear processes. These are reviewed exhaustively in Chaps. II through X. Five chapters are devoted to nuclear beta decay. Chapter VII treats muon capture; muon capture provides information on components of the interaction which manifest themselves strongly only in processes in which there is large energy-momentum transfer to the nucleus. Chapters VIII, IX, and X are concerned with the consequences of weak interactions on processes, such as alpha and gamma decays and nuclear reactions. The interacting current theory predicts a weak force which results in the violation of parity selection rules in gamma and alpha decay. Time reversal invariance may be violated in nuclear reactions. Chapter XI treats the meson-exchange corrections to electromagnetic moments and the charge dependence of strong nucleon-nucleon interactions. Chapter XII is a brief, almost perfunctory discussion of what we can learn about strong interactions from complex nuclei. Most of what is known about the strong interactions has resulted from studies of nucleon-nucleon scattering; this topic is not treated.

This book is written for readers with a serious interest in the subject matter. According to the Preface, "The book is pitched at a level which should enable a physicist who has been through, say, a first year postgraduate course in basic nuclear and elementary particles physics to understand virtually all sections." An absolute prerequisite, in my opinion, is a full-year course in quantum mechanics, including relativistic quantum mechanics, at the level of a text such as those of Schiff, Dirac, or Messiah. The book has five excellent appendixes on notation and conventions and quantum mechanics background material. I was delighted to find the notation and conventions for gamma matrices and the like to be quite conventional. Many readers may find, as I did, that the book is easier to read if these appendixes are studied first. For the somewhat limited audience for which it was intended, the book is highly recommended. A physicist who has never worked in this field would find it an excellent introduction. In addition to being very complete in coverage, the book gives approximately 1100 references to original papers.

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About the Reviewer: Tom Pinkston is currently professor of physics and chairman of the Department of Physics at Vanderbilt University, where he has been a member of the faculty since 1959. Following completion of his graduate studies at Catholic University of America in 1957, Dr. Pinkston was at the Naval Ordnance Laboratory and at Princeton University. His research has been in theoretical nuclear physics with interest in nuclear-shell model calculations and the effects of nuclear internal structure on cross sections for direct reactions. His present interests are in heavy-ion reactions.