

Book Reviews

Mathematical Theory of Elementary Particles. Eds., R. Goodman and I. Segal. The MIT Press, Cambridge, Mass. (1966). 188 pp. \$6.00.

This compact volume contains the proceedings of a conference bearing the title of the book, held at Endicott House, Dedham, Mass., September 12-15, 1965. The conference was aimed at bringing about an exchange of ideas between pure mathematicians and physicists, mainly axiomatic field theorists.

The title is a misnomer, for there are neither "theories" nor "elementary particles" in this book. It is perhaps justified by the fact that if everyone at the conference solved all the problems they wanted to solve, then maybe one can catch a glimpse of some "mathematical theory of elementary particles." This is not meant to be disparaging, but to set the proper perspective, for when mathematicians try to understand what physicists are doing (and probably vice versa) the hardest thing to come by is the proper perspective. The content of this book actually shows that this conference was both worthwhile and interesting.

Twelve of the thirteen contributions are by physicists. The sole mathematical contribution is an article on "Quantization and Dispersion for Nonlinear Relativistic Equations" by I. Segal. To a physicist, the article is a rigorous treatment of classical scattering in a relativistic ϕ^4 theory, with emphasis on the asymptotic condition.

An excellent summary of the present status of axiomatic field theory is given by A. S. Wightman, who reviewed recent work on inequivalent representations of commutation relations and solvable models. The former includes a discussion of current commutators, which has "the exhilarating feature that it seems to have something directly to do with the real world." Wightman ends on the optimistic note that it may be within one's reach to prove the existence of a field theory with dynamical content.

S. Coleman presented a discussion on the impossibility of constructing certain relativistic extensions of symmetry groups that have been relatively successful in classifying states of elementary particles at rest. This is the only paper that mentions elementary particles.

M. Froissart gave a brief but clear summary of the application of algebraic topology to the study of singularities of Feynman diagrams. This technique has not been found helpful so far, but Froissart's summary is an excellent introduction for those who wish to look into the subject.

All the remaining contributions deal with formal field theory. They include O. W. Greenberg, on statistics other than Bose or Fermi; A. Jaffe, on existence of cutoff ϕ^4 theory; G. Kallen, on holomorphy envelopes; E. Nelson, on two-dimensional ϕ^4 theory; D. Ruelle, on axiomatics; R. F. Streater, on Goldstone's theorem; K. Symanzik, on Euclidean quantum field theory; J. Tarski, on Green's functions; and A. Visconti, on renormalized propagators.

This is an excellent book for those interested in field theory who wish to have a bird's-eye view of the main activities in this field in the past year.

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About the Reviewer: Kerson Huang is Professor of Physics at the Massachusetts Institute of Technology. He has worked on the many-body problem and is the author of a graduate textbook on Statistical Mechanics. His current research interest lies in high energy physics, especially the interactions of strongly interacting particles.

Unified Theory of Nuclear Models and Forces. By G. E. Brown. John Wiley and Sons, Publisher (1967). 252 pp.

Nuclear structure theory attempts to explain the properties of atomic nuclei by describing them as collections of protons and neutrons (nucleons). We know this to be an oversimplification. The nucleons interact with each other by exchanging other elementary particles, whose degrees of freedom should be included in a complete dynamical theory. It is hopefully assumed that nuclear properties at low energies, below the pion rest mass of 135 MeV, can be understood in terms of the degrees of freedom of the nucleons alone. The effect of the neglected particles is simulated by allowing the nucleons to interact through a potential that correctly describes the properties of the two-nucleon system. This potential is very complicated, and so, even though we have retained only the nucleon degrees of freedom, we are still left with a very intractable many-body problem. In spite of the complexity of this mathematical problem, the nuclei themselves exhibit many simple regularities. Thus, it has been tempting for the nuclear theorist to invent simple models that exhibit these simple regularities. This approach has been very successful. The models have correlated a great amount of experimental data, and have often guided new and fruitful experimental programs. However, nuclei in different regions of the periodic table exhibit different sorts of regularities. Thus, nuclear structure theorists work with the independent particle model near closed-shell nuclei, with the rotational model far from closed shells, and with the vibrational model in between. All the while, they have recognized the unsatisfactory nature of this situation, and have sought to derive these models from a more fundamental theory, preferably from the original Schrödinger equation with realistic two-body forces.

G. E. Brown has been an active nuclear theorist for almost 20 years. He has stressed the need repeatedly to

relate nuclear models to each other and to first principles. In 1964 he published a book with the title *Unified Theory of Nuclear Models*. Here his unifying element was the notion of the self-consistent field. When this field was spherical, it provided the usual shell-model potential. In other instances, the self-consistent field was nonspherical, and then the nucleus possessed rotational excitations. In either case, certain linear combinations of particle-hole excitations in the self-consistent field had the character of vibrational states. Thus, a single framework was available for treating the different nuclear models.

Actual calculations require matrix elements of the true nucleon-nucleon interaction between particles moving in the states of the self-consistent field. Since 1964, Brown and his collaborators have carried out an ambitious program of calculating these matrix elements, using techniques of modern many-body theory to handle the hard core of the internucleon potential. Thus Brown believes that he has brought nuclear forces within his unified scheme, and has amplified his book to include these new developments. Chapters on the theory of nuclear matter and on Brueckner theory have been added also. Both the original volume and this one contain a chapter on the optical model of elastic scattering.

The first time nine chapters of this book, also included in the 1964 edition, could serve as a text for a graduate-level course in nuclear structure theory. Brown's arguments are always very physical. He is not afraid of formalism, but the formalism is always presented in a way that makes its physical content transparent. However, the pace is swift, and the reader must be prepared to fill in many of the intermediate steps himself. It seems to me that the chapters added in this second edition are more difficult. They provide a summary of progress to date in this rapidly developing field, one that will be useful to the specialist but not to the student coming to this material for the first time.

This book is thoroughly modern in its outlook. It gives an excellent picture of nuclear structure theory in the 1960's, a field to which Brown himself has made many contributions. Finally, its bibliography is a valuable list of important recent papers.

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About the Reviewer: The reviewer, now an Associate Professor in the Physics Department of the University of Minnesota, did his undergraduate studies, in chemical engineering, at Cooper Union and his graduate studies at the University of Edinburgh. He has worked in the Bohr Institute at Copenhagen and has served on the faculty at Princeton. Dr. Bayman's present professional interests concern nuclear structure and nuclear reactions, particularly nucleon-nucleon correlations derivable from reactions that transfer two nucleons to or from a target.

Lie Groups for Pedestrians. By H. J. Lipkin. 2nd Edition. John Wiley & Sons, Publishers, New York, N. Y. (August 4, 1966). 180 pp. \$6.50.

In this little book of less than 200 pages, the author shows in a painless way how Lie Groups are applied in physical problems. Here many of the standard proofs,

properties, and problems of group theory are neglected in favor of understanding the few properties needed in physics.

The book is based on two series of talks—at Argonne National Laboratory in 1961 dealing with the atomic nucleus, and at Illinois University concerned with elementary particles. The merger actually concentrates more on the applications to elementary particles. The main text contains mostly general principles with Appendixes A, B, and C dealing with the specific example of the group SU_3 in the field of elementary particles. Appendix D merely reminds us what a headache phases can be.

The author has approached his subject in an unconventional way by a direct study of the finite number of infinitesimal or generating operators of the continuous Lie Groups of infinite dimensions. In fact, only a fleeting glimpse is given of the connection between the generating operators and their associated group. Since, however, most physical properties are deduced from the algebra of the generating operators, this neglect is in keeping with the general theme of this book. Because of the unconventional approach, references in the text are avoided. In the Bibliography only a few (less than 25) general references are given. This drastic step could be annoying to the reader intending a further study when he comes across, as he will on many occasions, such phrases as "... it can be shown ..." and "... it is well known that ..." There is also the risk of misleading a student who may not be aware of theorems and properties well established using the conventional approaches. (This reviewer never found, for example, the definition of a group!)

The book opens with a discussion of the algebra of angular momentum operators, the connection with the rotation group in three dimensions being covered by an "... it is well known ..." phrase. We are then shown the simple generalization of the angular momentum concept to other Lie Groups and how their properties are shared by bilinear combinations of creation and destruction operators. With operators like the fermion creation and destruction operators for neutrons and protons, it is shown in Chapter 2 how to construct the isospin group and we are thus led to a simple demonstration of the power of the group concept in physical problems (consequences of charge independence, etc.). Chapter 3 extends the logic with the addition of a third fermion particle, the Λ -hyperon, and develops the algebra and predictions of the Sakata model of elementary particles with the symmetry of the group SU_3 . The abstract properties of the group SU_3 are emphasized in Chapter 4 where the three types of operators of the previous chapter are replaced by three types of boson operators in the three-dimensional Harmonic Oscillator. The connection is then established with the Elliott classification of states in the nuclear many-body problem. The algebra of pairs of fermion operators is extended in Chapter 5 with the introduction of the pairs that change the number of particles. Here the questions of "pairing quasispins" and symplectic symmetry are considered. The chapter ends with a brief but interesting look at pairs of boson operators that do not preserve the number of quanta and the non-compact groups. Chapter 6 skips lightly over the general ideas of permutations, bookkeeping, and Young diagrams in seven pages with the specific example of SU_3 relegated to Appendix A.

In the second edition of the book, a Chapter 7 has been added which extends the ideas of the previous chapters to groups of higher rank: These have been in nuclear theory for some time and have been used in recent years in the discussions on elementary particles.