Book Review

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Fundamentals of Nuclear Models; Foundational Models

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Nuclear structure study has developed remarkably in the past forty years. The research frontier has been greatly extended to high-spin states, highly-excited states and unstable nuclei near the neutron drip line. The publication of a modern textbook of nuclear structure physics has been long awaited. Fundamentals of Nuclear Models is a massive book written with passion for the purpose of conveying the fundamental concepts of modern nuclear structure theory to young researchers. The authors intentionally avoid giving all recent developments in the subfields reviewed. Rather they put emphasis on clarifying the experimental and mathematical foundations of the concepts from a modern viewpoint in which they identify the limitations and mutual relationship between four foundational models underlying the theory of nuclear structure ; Aage Bohr's collective model; the shell model; pair coupling models; and mean field model. The authors emphasize that nuclear structure properties are emergent phenomena and the importance of identifying phenomena for which the models fail.

Developments in microscopic theory make it possible to discuss the microscopic fundamentals of the basic models and their relationships. The present book is the first books of two related volumes. It is stated that, in the second volume, single-particle motion, collective motion, microscopic and macroscopic pictures of nuclei will be described in a unified manner by introducing a microscopic approach with more general applicability.

The first chapter of the present book outlines the way in which the physical interpretation and phenomenological models have been derived from various types of experimental data. It suggests a need to modify the traditional picture to better understand the widespread observations of many coexisting states of different deformation in nuclei. In the second chapter, an introduction is given to collective models of the nucleus in terms of Aage Bohr's original model for describing vibrational and rotational spectra in low-lying states. In the third chapter, Lie algebra and dynamical symmetry methods are introduced. The Bohr model is then reformulated as an algebraic model in the fourth chapter and it is shown how, with minor adjustment, it can be

embedded as a sub-model of the microscopic shell-model. The shell model is developed in the fifth chapter with inclusion of recent developments in effective interaction theory; for example, the Suzuki-Okamoto approach is explained in detail. The sixth chapter contains an analysis of the pair coupling models of nuclear structure, including BCS theory and its extension to neutron-proton pair coupling. Mean field theory and its time-dependent extension are described in the seventh and eighth chapters, respectively. Here the physical implication of the mean field approximation to nuclei as a quantum many-body system is discussed in depth from the viewpoint of the classical-quantum correspondence expressed in terms of generalized coherent state methods. The microscopic theory of large amplitude collective motion, as distinct from small amplitude fluctuations, is still in a developing stage. However the achievements summarized in the seventh chapter provides a foundation for future research.

There are several textbooks on nuclear physics in which various phenomena are described and each phenomenon is interpreted in term of different concepts. Unfortunately, they are not always careful to identify the mutual inconsistencies among the different concepts. In contrast, the present book avoids an enumeration of the many developments in nuclear structure theory and instead aims at a unification and a deeper understanding of the rich variety of nuclear phenomena. Publication of the second volume is awaited.

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