The Interacting Boson Model

Interacting Bose-Fermi Systems in Nuclei. Proceedings of a seminar, Erice, Italy, June 1980. F. IACHELLO, Ed. Plenum, New York, 1981. x, 406 pp., illus. $49.50. Ettore Majorana International Science Series, vol. 10.

There are two major models utilized in the study of nuclear structure, the shell model and the collective model. The concepts of the former, considered the more fundamental, were borrowed largely from atomic physics. Though there have been impressive gains in power of implementation, no fundamental changes in concept have occurred since the adaptation was carried through.

By contrast, the collective model, in the version elucidated in the early '50's by A. Bohr and B. Mottelson (BMM), has, since 1975, faced an increasingly formidable challenge from the interacting boson model (IBM). Within the context of nuclear physics the boson is a construct that describes correlated pairs of protons and neutrons, introduced to simplify the mathematical description of a wide range of phenomena occurring in all but the very lightest nuclei. Since the BMM also utilizes bosons, one must seek elsewhere to understand the impressive surge of the new ideas.

The explanation for this revolution in the making lies first in the intrinsic merit of its concepts, second in the unfailing energy and intelligence with which one set of authors of the model, A. Arima and F. Iachello, with the aid of a growing army of collaborators, have elaborated and promoted their ideas, and last in the stimulus it offers to nuclear spectroscopy to produce new and more accurate data against which to test the model.

Much of this development can be gleaned from the volume under review, which results from a workshop that was the second of what may well be a continuing series. This volume thus serves as a companion to *Interacting Bosons in Nuclear Physics*, which commemorates the first workshop, held in 1978. Since bosons alone can at best describe systems with even numbers of neutrons and protons, in order to include (the usually more complex) odd nuclei, one must mix boson ideas with some residuum of the description in terms of individual neutrons and protons (fermions). This recent development has provided the title for the new volume, even though only the last third of the book is devoted to it. (Of course, the BMM model also has its versions for odd nuclei.)

To assess where the subject stands requires that we address at least three questions: Does the IBM model work? How new is it, and, in particular, what is its relationship to the BMM, which has reigned for more than a quarter of a century? To what extent has success crowned efforts to derive the model or models from the next deeper level of theory—the shell model?

To give a sensible answer to the first question one must distinguish between model as a toolbox of ideas (boson and fermion constructs) and model as narrowly defined by the particular tools that have been utilized so far. Even with the narrow definition, the overall agreement of model and experiment is hugely impressive at low excitation energies. On the other hand, clear discrepancies have emerged at higher excitation energies, for which remedies exist, such as the addition of "g" bosons to the s and d bosons currently utilized. Such conclusions emerge quite clearly from a reading of this volume.

Important contributions both to the first volume and to the present volume address the problem of establishing the relationship between the boson variables of the IBM and the bosons that occur in the BMM. The reviewer has also written on this subject, more recently, in agreement largely with views found in the earlier volume, but not developed further in the current one. The major conclusion is that there is only one concept in the new toolbox that is absent from the old: In the IBM the total number of bosons, N, is fixed for each nucleus, since it is related to the number of neutrons and protons in the nucleus. On the other hand, for the (physically different) bosons of the original BMM the number is both variable and unbounded. However, by changing unbounded to bounded by N, there emerges a mathematical theorem of equivalence of the IBM framework to the BMM framework thus altered. This is to say that for every analysis of experiment by means of the IBM there is a corresponding analysis within the framework of the altered BMM that yields exactly the same concordance with experiment.

No such alternative analyses were presented at the workshop. That is because any experimental group requesting it has been furnished with an IBM program for analyzing its data, but no such gifts have even been forthcoming from the proponents of the BMM.

There is more to the IBM, however, than its impressive achievements in spreading the faith. Of paramount importance, the IBM lends itself in a natural way, precluded for the BMM, to group theoretical or symmetry arguments for the classification of spectra and other properties, which have resulted in important new discoveries, most recently for odd nuclei.

Another important distinction is that because of the different physical meaning of the variables in the two frameworks there is an implication that there have to be technical differences, perhaps major ones, in deriving each from the shell model. The task of deriving the BMM from the shell model, a topic outside the proper framework of the workshop, has been a serious but restricted occupation for over 15 years. Increasing success has been reported. The task of deriving the IBM from the shell model, moderately clear in its outlines, is a young subject, discussed in both volumes. It is a reasonable but not yet ineluctable conclusion that the IBM is more closely related to the shell model than the BMM and is therefore the more natural way to go.

We are currently on the exponential rise of the curve measuring work done on or stimulated by the IBM. We may have even greater need in the near future for such workshops and their reports.

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Stellar Physics

Physical Processes in Red Giants. Proceedings of a workshop, Erice, Italy, Sept. 1980. ICKO IBEN, JR., and ALVIO RENZINI, Eds. Reidel, Boston, 1981 (distributor, Kluwer Boston, Hingham, Mass.). xvi, 492 pp., illus. $66. Astrophysics and Space Science Library, vol. 88.

After spending most of their lifetimes as dwarfs, stars exhaust the hydrogen supply in their cores and become red giants for a relatively short period of time. But it is during this brief evolutionary phase that stars exhibit the most dramatic density contrast between their cores and their enormous convective envelope, dredge up to their surfaces material previously processed by nuclear reactions in their interiors, with which they enrich the interstellar medium through mass loss, and generally reach such high luminosities that, despite their relative scarcity, their light dominates the optical spectra of distant galaxies.

In recent years, high-resolution spectroscopy, aided by advances in the theory of stellar atmospheres, has revealed the great complexity of the physical conditions and the chemical abundances of red giant surfaces, while computer modeling of their interiors has provided a link with the theory of stellar evolution.

This active and multifaceted field is the topic of this symposium proceedings. The book contains 50 contributions divided into sections on the evolution and composition peculiarities of red giants: red giant variability and envelope dynamics; winds, chromospheres, grains, and mass loss; red giant masses; and red giant remnants.

The book begins with a review by I. Iben of the physical properties of red giant interiors, with particular emphasis on problems of nucleosynthesis and mixing. The highlight of the paper and of the first section of the book is the discussion of the origin of the carbon stars observed by Blanco and McCarthy, Richer, and Frogel and his co-workers in the Magellanic clouds. The difficulties in reconciling current theoretical models with the observations point to a promising field for future research.

B. Gustafsson then discusses atmospheric theory, emphasizing the need to clarify the little-known consequences of density inhomogeneities, non-LTE (local thermodynamic equilibrium) effects, and molecular absorption on the structure of the photosphere of red giants. The section also includes two detailed reviews of the problem of chemical abundances, one by D. Lambert on the observed effects of the first dredge-up phase, the other by J. Scalo on the more general topic of abundance peculiarities. Scalo's attempt to classify these peculiarities and to identify them with specific mixing mechanisms is a welcome addition to the literature on the subject.

In the second section, six papers treat the observations and dynamics of the reddest among red giants, whose envelopes are known to pulsate and in the process to eject a substantial amount of mass into interstellar space. This discussion introduces the third section, which is concerned with quiescent mass loss. Here considerable progress in both the variety and the quality of observations of mass loss is described. The situation is much less satisfactory on the theoretical side. Several mechanisms are described that may play a role in different physical contexts and may even interact with each in complex and still poorly understood ways.

The contributions on stellar masses stand apart from the others. The physical situations discussed are fascinating in themselves, but it is still difficult to assess at this point what impact if any this research will have on the broader astrophysical picture.

The book ends with six contributions on the evolutionary status of planetary nebulas, viewed here as red giants that have recently lost most of their envelopes.

One of the unavoidable drawbacks of such proceedings is the uneven treatment given to various topics. Little is said in this book, for instance, about old disk and halo population stars, about chemical inhomogeneities among globular cluster red giants, or about the physics of the helium core flash, all very active areas of research at this time. But within these limits *Physical Processes in Red Giants* is an excellent survey of current research in the field, highly recommended as reading in any graduate course in stellar physics.

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Biota of Hawaii

Island Ecosystems. Biological Organization in Selected Hawaiian Communities. DIETER MUELLER-DOMBOIS, KENT W. BRIDGES, and HAMPTON L. CARSON, Eds. Hutchinson Ross, Stroudsburg, Pa., 1981 (distributor, Academic Press, New York). xx, 584 pp., illus. $34. US/IBP Synthesis Series, 15.

By far the most provocative parts of this book are the final two chapters by Mueller-Dombois. In these some old ideas are aired in a modern context. The discussion is sometimes unconvincing but will be of benefit as a thought-starter to both academic nesologists and government personnel entrusted to conserve and manage island ecosystems.

Mueller-Dombois suggests that the stability of island ecosystems (meaning resistance to invasion by exotic pest species) is probably unrelated to species diversity because pest species have narrow requirements and most communities offer a low diversity of potential host species. Other questions discussed are: Is it possible to restore some of the original vegetative cover if stresses introduced by humans are removed? Can relict stands survive under protection? Is the extinction of island biota inevitable? Is there a way to predict which exotic organisms, once introduced to islands, have the potential to become disruptive invaders? What makes some island ecosystems more stable than others?

Early naturalists like Darwin and Wallace argued that indigenous species on islands are inferior competitors to species evolved on continents. Mueller-Dombois rejects this thesis and points out that other kinds of ecological interactions, especially with herbivores, can tip the balance on the side of exotic competitors. The leitmotiv of this book is succinctly put (p. 500): "If humans had not entered the island environment as a new dispersal agent, island ecosystems could be considered biologically very stable." With this I concur.

Hawaii in 1778 (the year of its discovery by James Cook) had Polynesian humans living on it but no other mammals (except for one bat species), an avifauna rivaling that of the Galápagos in peculiarity, and a lush tropical green mantle. The key to the survival of many native species on Hawaii appears to be the Koa and ʻŌhiʻa forests, which have suffered a dramatic decline through farming, urbanization, and browsing by introduced mammalian herbivores.

The bulk of the book consists of extensive ecological details on the present-day biota, covering an impressively wide variety of organisms—vascular plants, birds, rodents, ectoparasites of rodents, canopy-associated arthropods, arthropod predators of seeds, wood-boring beetles, various flies including *Drosophila*, soil arthropods, terrestrial algae, and soil and leaf fungi. As one would expect, some are studied inadequately. There are four themes: distribution and abundance along an elevational transect; the allocation of niches in the forest; phenology; and genetic variation. The coverage of this last subject is not broadly based, as nearly all the papers deal with the very diverse *Drosophila* fauna. I would have hoped for comparable studies on the ecological genetics of the surviving indigenous bird and snail faunas.

This book will make students of island ecology cast an envious eye upon the Hawaiian archipelago, for here is a large quantity of base-line data that will aid biological conservation in the islands and also permit meaningful comparative studies with other islands in the archipelago and elsewhere in Polynesia.

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