Mathematics and the model

Peter E. Hodgson

The Interacting Boson Model. By F. Iachello and A. Arima. *Cambridge University Press: 1987. Pp. 250. £32.50, $59.50.*

THE nuclear shell model has been spectacularly successful in providing a detailed account of the light nuclei and of heavier nuclei around doubly closed shells. Unfortunately it is quite impracticable to apply it to heavy nuclei away from closed shells because of the complexity of the configurations in shell model terms. Yet such nuclei do show simple structures, such as rotational and vibrational bands, that demand a simple explanation, and this has been provided by the collective models. It is, however, unsatisfactory to have different models for different nuclei; there are no sharp divisions between the types of nuclei. In the case of collective nuclei, what is needed is a way to truncate the full shell-model space so that it still contains most of the essential physics. The interacting boson model is one of the most successful attempts to do this.

The model originated in the work of Feshbach and Iachello, who in 1969 analysed light nuclei in terms of interacting bosons, and in that of Janssen, Jolos and Dönau, who in 1974 proposed that collective quadrupole states can be described in terms of the SU(6) group. The model was further developed by Arima and Iachello, who realized that the bosons can be interpreted as nucleon pairs, thus providing a microscopic model of nuclear excitations. Initially the formulation was in terms of s and d bosons, and it was found that for even nuclei the Hamiltonian containing all possible boson interactions can be diagonalized exactly, giving an analytical expression for the energies of the excited states. Subsequently the model was extended to include transition probabilities, and was found to agree well with a wide range of experimental data.

A further elaboration was the introduction of unpaired fermions, thus bringing odd–even nuclei within the model's scope. Other refinements include configurational mixing and giant resonances, and the model has been applied successfully to light as well as to heavy nuclei.

This is the first book devoted to the interacting boson model, and as it is written by the two physicists who have been most prominent in developing the theory, it is destined to be a standard work on the subject. The authors' purpose is to present the basic mathematical framework as it is applied to even nuclei, and to collect together all the formulae that have been used over the years to account for the collective properties of nuclei. A second volume is promised on even–odd nuclei, and then a third on the microscopic structure and justification of the model.

The first section of the book is devoted to the boson calculus, the mathematical technique fundamental to the theory involved. This has wide applications to other branches of physics such as molecular structure. The boson calculus is described in detail, and formulae are given for physical quantities such as electromagnetic transition rates, binding energies, radii and moments of inertia. The second section is concerned with the refinements that are necessary in order to include in the model the distinction between neutrons and protons, and the third section considers other refinements such as the inclusion of isospin.

The treatment throughout is highly mathematical, with heavy reliance on group theory, and little attempt is made to describe the physical ideas underlying the model in a way that will be intelligible to experimentalists. But for theorists the book provides a systematic account of the subject that will be invaluable for easy reference. □

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Relative reactions

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The Comparative Reception of Relativity. Edited by Thomas F. Glick. *Reidel: 1987. Pp. 412. Dfl. 198, £54.50, $79.*
Einstein in Spain. By Thomas F. Glick. *Princeton University Press: 1988. Pp. 391. $42, £23.50.*

SPECIAL relativity shares with quantum mechanics the property of being in conflict with common sense. So in both cases the question of their reception is a complex one, involving the reactions of the scientific and the lay communities (who, whatever they may think, do not act independently of each other).

In 1983, a double session at a colloquium in Boston looked at the reception of relativity on a national basis, and was enough of a success to suggest a combined volume by some of the participants and other contributors. What is most interesting is not the way in which different countries eventually came to the same view of relativity as part of scientific orthodoxy, but the national differences, whether produced by political or cultural contexts.

In the United States, as Goldberg shows, the early emphasis was still on ether drift experiments. After that, the dominant concept of usefulness — either in applications or in the sense that any theory that was true had to be comprehensible to everyone — required that the new theory should be fitted into an epistemological framework that was already familiar. The ether also played an important part in Britain, according to Sanchez-Ron's chapter, but in a more theoretical way, for the heritage of Larmor (to go back no farther) needed the new theory to be made compatible with some kind of ether. But, in Britain, there were other important currents; Cunningham was very clear about the role of the Lorentz transformations in Maxwell theory by 1907, Robb gave his new axiomatization in 1911 and, although Jeans was slow to admit relativistic ideas to his *Electricity and Magnetism*, his final revisions in 1920 showed a complete understanding of them.

The emphasis in Germany was almost as opposed to that in the United States as it is possible to imagine. Pyenson sees the touchstone to acceptance there as the revolutionary character of the theory. Politically suppressed intellectuals sought a freedom in the realm of ideas that was denied to them elsewhere; but also the need was felt for a new vision to synthesize the specialist knowledge into a unified view of the world. Pyenson works out a detailed analogy, character by character, with the French Revolution, but this chapter, perhaps the best in the book, contains much else besides.

In France itself, on the other hand, notwithstanding the contributions of Poincaré and Langevin, the theory made little progress for many years, and only in the 1950s did textbooks and university courses reflect its acceptance. The great tradition of mathematical physics acted as a barrier to progress in any field that needed to cross the divide between physics and mathematics. So much is clear from Paty's chapter, but the point is further emphasized by Biezunski's account of Einstein's visit to Paris in 1922. Here, a momentary change of attitude seemed to overcome the disadvantages in French eyes of the theory being revolutionary and of German (indeed Jewish) origin, but the potential generated by the visit was never realized.

In Italy, according to Reeves, not only was Einstein's use of the glories of Italian differential geometry appreciated, but Mussolini himself gave public approval to the theory as early as 1921. No matter that this was a vulgar confusion between relativity and relativism; the practical help was there. Spain, according to Glick, followed Italy, but he deals with this in greater detail in the other book under review, which I mention below.

Vizgin and Gorelik give a detailed account of the reception of the special and general theories in Russia and the USSR;