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The Interacting Boson Model

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from slogging away at apparatus or data, which are often unrewarding sinks for energy and imagination.

During World War II Rabi was associate director of the MIT Radiation Laboratory, where the major US radar development effort was concentrated. He was also an adviser to Robert Oppenheimer at Los Alamos National Laboratory. After the war he resumed his research at Columbia, was a member of the General Advisory Committee of the Atomic Energy Commission and was influential in setting up a system enabling wise scientists to give advice to the government on scientific matters, a system now unfortunately no longer effective. As a man of experience, wisdom and principle, with a toughness acquired during a combative childhood in a religious family and an early career in the then shamefully anti-Semitic academic world, Rabi was able to see what was important and to cut through cant in ways that made him invaluable in many situations.

Rabi has said that he was much influenced by reading the biographies of such scientists as Heinrich Hertz and Hermann von Helmholtz. Physics has become a big business, but it is not any old business. The right kind of experiment—good physics—can bring you "nearer to God," Rabi says. If so, it is more important than ever to attend to the education of the heart. Our physics students would well profit from reading biography, this one in particular, possibly in an introductory course where one could also teach the relevant physics and politics. I have found by informal poll that Rabi is not well known among present-day students. Perhaps his methods and results, which at one time broke new ground, have now been superseded. His name stays with us in the "Rabi frequency" of the laser pumper, even though 40 years ago there was often not enough rf power to induce transitions rapidly up and down, nor did one want to do so in the search for minimum linewidth.

But read all about him in this excellent biography, the eighth book in a series by or about prominent and interesting scientists published with support from the Sloan Foundation. It was written over a five-year period of careful study of relevant documents, of extensive interviews with Rabi's associates and of much conversation with the Rabis themselves. Rigden describes admirably a complex and productive life with many pithy anecdotes—the book is a real *tour de force* and a pleasure to read.

A few complaints: Rigden presents Rabi as more bland and genial than he used to be. Joining "the two cultures," to use C. P. Snow's term, so that the educated humanist will understand, say, quantum mechanics, as Rabi would wish, will require an improbable overhaul of our educational system, with much more emphasis in the earliest years on manipulating, observing, remembering and reasoning. The book's technical descriptions will be clear to PHYSICS TODAY readers but not to many lay readers despite Rigden's valiant efforts. There are many typos and some unimportant confusions of fact. Most serious, if the Sloan Foundation is in the business of "encouraging the public understanding of science" they had better advertise these books. I have not seen any ads, nor is the book in stock at six Cambridge booksellers that I called. You may have to place a special order, but it is certainly well worth the effort.

The Interacting Boson Model

F. Iachello and A. Arima
Cambridge U. P., New York, 1987. 250 pp. $59.50 hc
ISBN 0-521-30282-X

The interacting boson model of nuclear energy levels has been controversial among nuclear physicists ever since Franco Iachello and his collaborators introduced it a decade ago. Fundamentalists argue that the proton and neutron degrees of freedom, which the boson model ignores, are basic to an understanding of nuclear structure. The nucleon-based shell model provides the framework for a comprehensive description of nuclear properties, and it has been enormously successful. However, on the other side of the controversy, the advocates of the boson model point to the impracticality of using the shell model for most of the periodic table. With its limited number of free parameters, the boson model provides an economical scheme for organizing the structural properties of just those nuclei that are most difficult to treat by the shell model. In any event, the introduction of the boson model has reinvigorated nuclear spectroscopy. Experimenters have discovered a new type of excitation as a result of the insight the model provides.

The Interacting Boson Model won't shed new light on the controversy or provide the reader with much data for evaluating the model as a phenomenological tool. Rather, it is a monograph on the model's simpler mathematical details and a reference source for more advanced topics.

The original model makes use of six bosonic degrees of freedom, loosely identified with s-wave and d-wave nucleon pairs. The algebra of the six boson operators forms an interesting group structure. The largest group is U(6), the set of all possible transformations among the six operators. The U(6) symmetries are broken by various terms in the Hamiltonian, reducing the group symmetry until one is only left with O(3), rotational symmetry. Three natural chains of broken symmetries connect U(6) to O(3); the authors describe these in detail, with particular attention to defining quantum numbers for states in the different chains. They derive algebraic formulas for the eigenvalues of group-symmetric Hamiltonians, using the Casimir operators of the various intermediate groups. Electromagnetic and other properties of the nuclear levels can be expressed analytically in the three group symmetry limits. The authors quote the formulas, but unfortunately readers wishing to see derivations of the formulas must refer to the original literature.

The authors explain the relationship of the boson model to the older geometric picture of nuclear excitations put forward by Aage Bohr and Ben Mottelsen. A boson state with definite geometric properties is constructed to connect the pictures. This state, which is similar to the one J. P. Elliott used for the SU(3) model of nuclear structure, displays interesting phase transitions between the group symmetries when the Hamiltonian is varied.

Remarkably, there are nuclei in nature whose low spectra are well described by the three group chains. However, more typical nuclei fall somewhere between the group theoretic limits. In these cases, one must diagonalize the Hamiltonians numerically. Here the book's exposition becomes vague, except for its treatment of the qualitative phase transition physics.

Many nuclei and aspects of nuclear structure cannot be understood with the U(6) model, and the authors describe in the latter half of the book various extensions of the model to deal with one feature or another. This material lacks the mathematical crispness present in the first chapters. Many of the extensions hardly seem justified by a greater scope of application.

For the model to be generally accepted, it must be related to the fundamental proton and neutron degrees of freedom. Iachello and Arima do not attempt to justify the model in this book, but the interested reader will find a discussion of the fundamentals in a recent article by Iachello and Igal Talmi, another original collaborator on the boson model (*Reviews of Modern Physics* **59**, 339, 1987).

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Mass Spectrometry: Applications in Science and Engineering

Frederick A. White and George M. Wood
Wiley, New York, 1986. 773 pp. $72.50 hc ISBN 0-471-09236-3

Recently, delivering a paper at the Fourth International Symposium on Accelerator Mass Spectrometry, Graham Cooks (Purdue) remarked: "Mass spectrometry is surely one of the most widely used analytical techniques. It has developed from physics, via chemistry, into the environmental, biological, materials and Earth sciences. Mass spectrometers are widely used in industrial as well as academic laboratories. It is estimated that 5000 scientists in the US alone use mass spectrometers as their primary research tool and some 1500 people attend the annual conference on mass spectrometry and allied topics organized by the American Society for Mass Spectrometry." These, and the many others whose research activities rely on mass spectrometry even peripherally, will welcome this book as a major contribution to the literature on this powerful and ubiquitous analytical tool.

The book in general is remarkably comprehensive and current. Almost one-third of it is devoted to instrumentation—including sections on ion sources, types of spectrometers, detection devices, data processing and the combination of gas–liquid chromatography and mass spectrometry to simplify the mass spectrum of a mixture of high-molecular-weight species. The remaining two-thirds of the book, however, is more fascinating, presenting the amazing variety of applications that mass spectrometry has in fields ranging from Earth and atmospheric sciences to pharmacology and forensic science. The authors have treated these applications in a fashion that is both highly intelligible and thorough, including comprehensive references for the reader who wishes to delve more deeply into a particular application. I found most stimulating the sections on geochemistry and