books

How to understand and use crystal symmetry operations

Space Groups for Solid State Scientists

G. Burns, A. M. Glazer
278 pp. Academic, New York, 1978.
$14.50

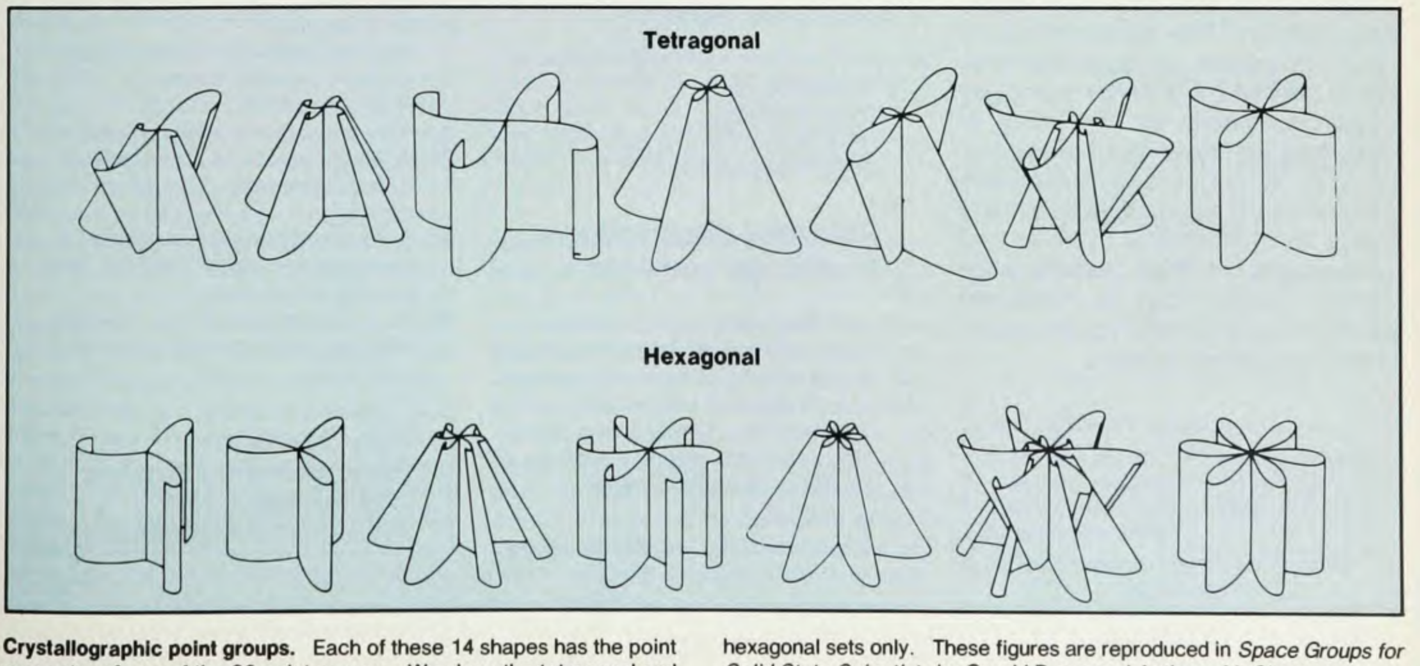
Reviewed by Alexei A. Maradudin

We live in an age of "How-To" books. Nearly every kind of human activity, including home and automobile repair, divorce and probate, various self-help activities and other forms of social interaction and intercourse, has its own manual to aid the inexperienced or inept to do it better, or to do it at all. With the appearance of this book the study of crystal symmetry joins the list.

Unlike many books of this genre that are exploitative, superficial, or deal with essentially trivial subject matter, *Space Groups for Solid State Scientists* fills a definite need and fills it well. A great deal of research activity in solid-state science today, both theoretical and experimental, is concerned with physical properties of crystals (for example, electronic band structure, lattice vibrations, optical properties) in materials that possess many atoms in a primitive unit cell, low symmetry, or both. Examples include A-15 compounds, layer and quasi-one-dimensional compounds, ternary superconductors, fast ionic conductors and oxidic perovskites. The use of group theory can often simplify the solutions of the problems being studied, for underlying the group-theoretic methods are the symmetry properties of the crystals. These properties are known and have been tabulated. The average solid-state scientist who needs this information, and whose knowledge of the structure and symmetry of crystals is limited to highly symmetric crystals with only one or two atoms in a unit cell, often does not know where to find it or, having found it, how to use it. It is to such people that this book is addressed.

The authors state in the preface of their book that it is their intention to show the interested solid-state scientist both how to obtain all the symmetry and related information from the compilation of the 230 space groups in three dimensions in the *International Tables of X-Ray Crystallography: Vol. 1,* and how to "understand, generate, and use the symmetry operations of a crystal." The authors are admirably qualified to carry out this program. Gerald Burns is a well-known Raman spectroscopist and the author of a recent book on group theory, while Michael Glazer is an expert on x-ray crystallography, and the EXAFS technique. They proceed systematically in their presentation. Starting with a classification of the symmetry operations that can act at a point in a crystal, they show how these operations give rise to the seven crystal systems, and how, in turn, these crystal systems combined with the requirements of translational periodicity lead to the fourteen Bravais lattices. Finally, they show how the 230 space groups are obtained on combining the Bravais lattices with the symmetry operations at a point.

There are no derivations as such in this book. The approach used is to provide a description of how, say, the fourteen Bravais lattices can be obtained, and then to present them with a discussion of their properties. This book also is not a book on group theory. Although the authors summarize the basic elements of group theory, there is a presumption that the reader is already acquainted with the subject or can refer to standard articles and books for the background needed to understand the applications of space



Crystallographic point groups. Each of these 14 shapes has the point symmetry of one of the 32 point groups. We show the tetragonal and hexagonal sets only. These figures are reproduced in *Space Groups for Solid State Scientists* by Gerald Burns and Anthony M. Glazer.

North-Holland ANNOUNCES:

Mesons in Nuclei

edited by **MANNQUE RHO,** *Centre d'Etudes Nucléaires de Saclay, France, and* **DENYS WILKINSON,** *University of Sussex, England.*

The nucleus is commonly thought of as consisting of neutrons and protons, and yet physicists are aware of a large range of other constituents. On the one hand are mesons of integral intrinsic spin that can be created and absorbed in arbitrarily large numbers; on the other are the excited states of the neutron and proton into which these particles can be raised by the absorption and emission of the mesons. Any full account of what is going on inside the nucleus must therefore take into account both the mesons and the excited states.

This book is the first effort in physics literature to systematically study this problem. The editors move toward an answer to the question of to what degree the nucleus cannot be regarded simply as consisting of neutrons and protons.
The book contains a preliminary discussion of the nucleus as a many body field theoretical system, and also examines other, usually neglected, effects, such as relativistic corrections that also affect observable nuclear properties.

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1979; 464 pages,
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groups presented (chiefly for an analysis of lattice vibrations). The book is clearly written, in a very readable style. It is lavishly illustrated and well printed. It contains many examples to illustrate the points being made, and these, together with the problems for solution at the end of each chapter, make it suitable for use as a textbook at the graduate level. In addition to its role as a guide to the *International Tables* the book is valuable for the research scientist because of the many tables it presents. Chiefly in nine appendices, it collects useful information concerning the symmetry of crystals as the 3 × 3 real, orthogonal matrix representations of symmetry operations, the thirty-two crystallographic point groups, seven crystal systems, fourteen Bravais crystals, the 230 space groups and their symmetry operations, and character tables for the crystallographic point groups. Finally, it should be noted that this useful and attractive book sells for what today is a very reasonable price.

* * *

Alexei A. Maradudin is a solid-state theorist at the University of California at Irvine. He is interested in crystal physics and has published several papers on the use of symmetry and group theory for the analysis of lattice vibrations in perfect crystals and in crystals containing defects.

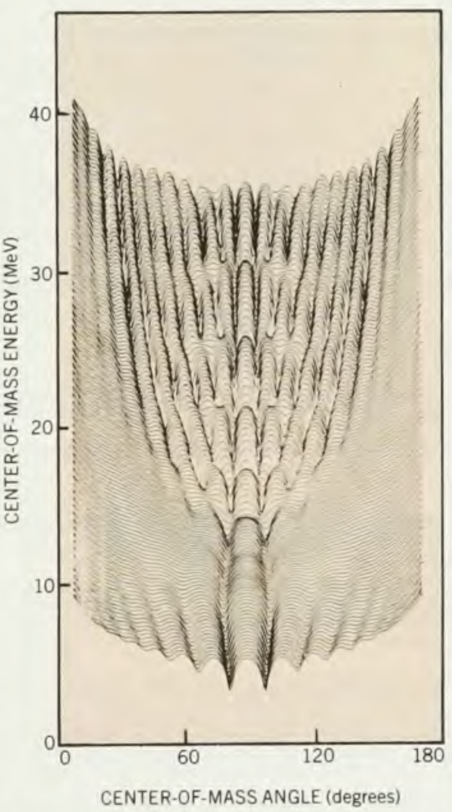
Nuclear Heavy-Ion Reactions

P. E. Hodgson
588 pp. Clarendon (Oxford U.P.), New York, 1978. $45.00

The succession of discoveries of new phenomena in nuclear heavy-ion reactions since the early 1960's and the companion increase in the number of heavy-ion accelerator laboratories has produced a wealth of experimental results and a variety of models for the interpretation of the data. Peter E. Hodgson, professor of physics at Oxford University, has succeeded in the difficult task of reviewing the progress in heavy-ion physics in his book *Nuclear Heavy Ion Reactions.* Without losing the reader in a plethora of detail, Hodgson moves the exposition briskly through the sometimes diverse experimental results and model interpretations with an emphasis on their consistent aspects. Hodgson's criticism comes by way of subject-matter selection rather than by explicit comment. *Nuclear Heavy Ion Reactions* is an excellent introductory book for graduate students in nuclear physics and contains an extensive bibliography of the literature up through 1976.

Hodgson is the author of two previous books, *The Optical Model of Elastic Scattering* (1963) and *Nuclear Reactions and Nuclear Structure* (1971). The present book differs from the earlier books in that topics are covered in less detail, a consequence of both the diversity and, in some cases, the embryonic state of the subject matter. Where comprehensive discussions of topics are available in the literature, key references are given. At several points throughout the book, progress is summarized by a more extensive report of definitive research results or a model development that appears promising.

The semiclassical aspects of heavy-ion reactions are discussed first in order to present the general features of heavy-ion reactions. Heavy-ion reactions differ from those for light ion reactions in three respects: large Coulomb forces, a high probability for reaction, and, in general, large orbital angular momenta that can reach, in some instances, values in the hundreds. Rather remarkable progress has been made with semiclassical ideas. The fact that the incident projectile flux is absorbed inside a rather sharply defined impact parameter simulates the classical optical properties of an absorbing disc. A diffraction model based on this simple idea accounts for many experimental results and provides an insight into results obtained with more complicated models.



Calculated energy dependence of differential cross section for $O^{16} + O^{16}$ elastic scattering. Graph by A. Gobbi, R. Wieland, L. Chua, D. Shapira and D. A. Bromley; reproduced in P. E. Hodgson's *Nuclear Heavy-Ion Reactions.*

Perhaps the most frequently used model in the analysis of elastic-scattering data is the nuclear optical model, which