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.

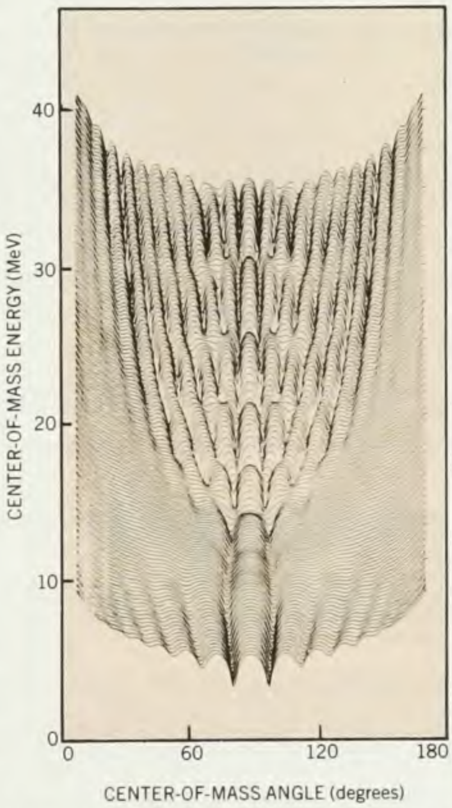
Nuclear Heavy-Ion Reactions

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



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.*

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.

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

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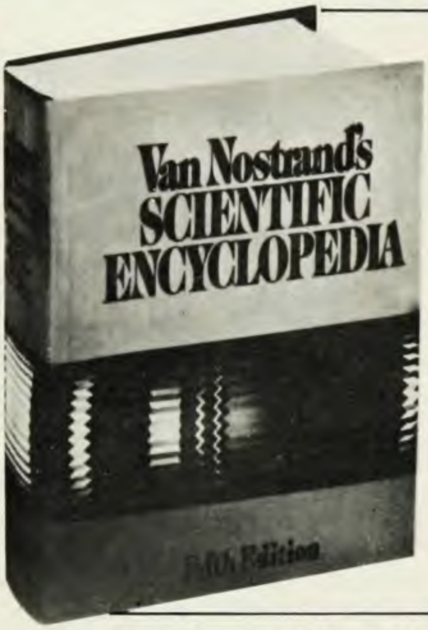

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was first developed for nucleon scattering. The application of this model to heavy-ion scattering, as Hodgson points out, has been more a matter of convenience than of firm physical justification. Various applications of optical-model analysis are reported, leading up to the development of microscopic potential models that is still underway.

One of the exciting phenomena encountered in heavy-ion reactions is the possibility of forming quasi-molecular nuclei—that is, nuclei that remain in contact after a grazing collision for a sufficiently long time to rotate as a dumbbell before either coalescing or separating. Formation of this unusual configuration of nuclear matter appears to be restricted to the relatively light nuclei for which level densities of the compound system are relatively small. Resonances are expected in such systems, and the early discoveries of such states are reported by Hodgson. His book prepares the reader to follow the ongoing debate concerning evidence for new quasi-molecular states.

Effects due to the structure of the interacting nuclei are most readily observed in grazing collisions. Such collisions are favorable to transfer reactions in which one or more nucleons move from one nucleus to the other. These reactions are powerful spectroscopic tools and also provide information about the interaction between the nuclei. Hodgson examines a number of cases in which the distorted-wave Born approximation has been successfully used and reviews the more accurate coupled-channels analysis, which is required for strong coupling cases. The aggregate research is so extensive that three chapters of the book are devoted to transfer reactions.

One phenomenon that distinguishes heavy-ion collisions from light-ion collisions is the high probability for formation of a compound system or fusion for an impact parameter somewhat less than that for a grazing collision. Semiclassical models have been applied to this phenomena, and Hodgson underscores the evidence for structure in the fusion-reaction excitation curve which is not explained by those models. The conditions under which fusion-reaction data can be interpreted as resonance phenomena continue to be a subject of intense research interest.

While fusion is typically the dominant reaction in an energy range that extends well above the barrier, for sufficiently heavy ions at sufficiently high energies, fusion is inhibited. This quenching of fusion frustrated early attempts in the quest for superheavy elements, a quest which to date has led to no positive results. Several models explain a large body of heavy-ion fusion data, and an acquaintance with their development provides an excellent background for more recent experimental results that are not readily explained by the earlier models.

A phenomenon that has attracted wide attention is a collision during which heavy ions come together with a kinetic energy well above the barrier but later separate with a kinetic energy approximately equal to the barrier potential energy. Rather large amounts of relative motion kinetic energy are converted into internal excitation energy. This so called "deep inelastic" scattering takes place at angles near that corresponding to a grazing collision. As Hodgson notes, the phenomena can be accounted for as an inability of the system either to form a rotator at the exceptionally high angular momentum or to dissipate the angular momentum in a mechanism that would lead to fusion; but in terms of a microscopic mechanism, the question remains: How does it do it?

Nuclear Heavy Ion Reactions is very readable, which is itself a significant accomplishment considering the diversity of topics and the voluminous literature. A book summarizing progress in a rapidly changing field is likely to become out-of-date in a few years. After that happens to Hodgson's book, it will remain a useful resource for many years to come.

ROBERT H. DAVIS
Physics Department
Florida State University
Tallahassee

Fields, Particles and Currents

A. H. Völkel
354 pp. Springer-Verlag, New York, 1977. $14.30

"Mathematical physics" is a nonce word denoting the *rigorous* study of quantum field theories, much to the dismay of physicists of other mathematical persuasion. Adolf Heinrich Völkel, a practitioner of the art, offers us his essentially unedited set of lecture notes addressed to "students intending to work in [mathematical physics], physicists with some intellectual interest in this field and mathematicians who just want to glance beyond [sic] the fence." *Fields, Particles and Currents* is concise, honest, completely conventional, and often clear and useful.

What is worth doing is worth doing well, or so it is said. This book (volume 66 in Springer-Verlag's "Lecture Notes in Physics" series) is a particularly careless and shoddy production. The publishers have reproduced the text directly from typescript with handwritten insertions of formulae, parentheses and symbols. There is no index. References appear alphabetically at the end, and are not retrievably keyed to the text. Worst of all, the atrocious syntax drives a pedant like me to distraction. Must I sacrifice my linguistic heritage to study physics?