

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?

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Does no one at Springer-Verlag speak English?

Most of the material in this book may be found in a more professional volume *Introduction to Axiomatic Quantum Field Theory* by Nikolai N. Bogoliubov, Anatolii A. Logunov, and Ivan T. Todorov (W. A. Benjamin, Reading, Mass., 1975). Much of both books is devoted to the now standard litany: the notion of a quantized field, the axiomatic formulation of Arthur Wightman, and the notable contributions in the 1950's and 1960's of Rudolf Haag, David Ruelle, Pierre Lehmann, Wolfhart Zimmermann, Kurt Symanzik and others. Indeed, the two books are so comparable that one is forced to ask why the later (Völkel) book was published at all. Certainly, there is little enough in the way of original work in the book, and all of the analyses are by now quite standard. Here are three possible answers. Völkel's book is shorter and is more to the point; it is fit for browsing as well as for reading. It is also very much cheaper than the Bogoliubov book, and probably can serve the same purpose. Finally, Völkel includes a useful chapter dealing with current algebra and with the Goldstone theorem, subjects not represented in the older book.

Sometimes the ways of mathematical physicists seem inscrutable to us unmodified physicists. Towards the middle of the book, Völkel assembles a great arsenal to prove Theorem II-19, which "explains the experimental fact, that no half integer self conjugate isospin multiplets of fields or particles occur in nature." The weaponry is hardly necessary. The point is simply that the spin representations of  $SU(2)$  are not real. For example, an isospin doublet of mesons is represented by two *complex*, hence four Hermitian fields. Eli Cartan, more than Peter Carruthers, explained K mesons to us.

This brings to mind another objection to this book. Although it is published in 1977, the median date of its references is 1964. Völkel does not even mention most of what has happened in the 1970's. There are no words about global symmetry groups larger than  $SU(2)$ , despite the evident relevance of  $SU(3)$  to fundamental physics. There is no discussion of local symmetry groups, let alone spontaneously broken local symmetries. Constructive quantum field theory, a most important contemporary development of mathematical physics, "could not even be touched for the lack of space and also for the limited strength of the author." *Tant pis* for the student intending to enter the field.

Despite all I have said, this is basically a good book. All the standard arguments, correctly presented, are there to be found in logical sequence. A mathematical physicist would be happy to have this book at hand. (Unlike my colleague Chiara Nappi, I am not a mathematical

physicist. I rewarded her kind assistance in preparing this review by a free copy of the book, and it is to her joy that I refer.) I would even recommend it to the aforementioned student, should I fail to change his intentions.

SHELDON LEE GLASHOW  
Department of Physics  
Harvard University  
Cambridge, Mass.

## Geomagnetic Diagnosis of the Magnetosphere (Physics and Chemistry in Space, Volume 9)

A. Nishida  
256 pp. Springer-Verlag, New York, 1978.  
\$38.50

The interaction between a magnetized celestial body and a magnetized plasma flow is one of the basic phenomena in cosmic electrodynamics. This subject has evolved from a study of geomagnetic disturbances, namely a study of Earth's magnetic field and the solar wind, which is one of the important subjects in the field of solar-terrestrial physics. In fact, many of the modern concepts, such as the magnetosphere and magnetospheric substorms, have evolved on the basis of a study of geomagnetic disturbances.

There is no doubt that satellites and space-probe observations of our electromagnetic environment have drastically improved our understanding of physical processes involved in the interaction between Earth's magnetic field and the solar wind. However, for a quantitative understanding of this interaction, Earth is still the most important platform for the observations among all "satellites." This is partly because most magnetospheric phenomena manifest themselves in the polar region along magnetic field lines, and thus one can infer the magnetospheric phenomena by setting up networks of observatories.

Among various instruments used in this study, a ground-based magnetometer is one of the oldest and an extensive network of magnetic observatories has been operating for many years. Their geomagnetic observations are widely used in monitoring or *diagnosing* magnetospheric conditions. It is very appropriate that the "Physics and Chemistry in Space" series has a comprehensive review of this subject. Atsushi Nishida is certainly one of the most appropriate choices to take on this task, since he has considerable experience in the subject.

The author describes clearly and concisely how we use geomagnetic variations on Earth's surface and in space (satellite observations) as a diagnostic tool in understanding various processes in the magnetosphere. A diagnostic tool would, of course, not be reliable unless one fully understands how a specific magnetospheric phenomenon manifests itself as a specific type of geomagnetic variation in

the magnetosphere and on the ground. At the present time, some of the identifications of the manifestation are still controversial. In such cases, the author presents his own view and those of others.

For the readers of PHYSICS TODAY, the major point of this book would be to show how complicated the seemingly simple interaction between a magnetized celestial body and a magnetized plasma flow is—and how far magnetospheric physics has come in understanding this interaction.

S.-I. AKASOFU  
Geophysical Institute  
University of Alaska  
Fairbanks

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**Collective Ion Acceleration.** C. L. Olson, U. Schumacher. 238 pp. Springer-Verlag, New York, 1978. \$34.00

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**Experimental Methods in Heavy Ion Physics.** K. Bethge, ed. 251 pp. Springer-Verlag, New York, 1978. \$14.30.

**Excited States in Quantum Chemistry** (Proc. of the NATO Advanced Study Institute, Kos, Greece, June, 1978). C. A. Nicolaides, D. R. Beck, eds. 585 pp. Reidel, Dordrecht, The Netherlands, (US dist.: Kluwer Boston, Hingham, Mass.), 1978. \$59.00

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**Plasma Transport, Heating and MHD Theory** (Proc. of a workshop, Varenna, Italy, September 1977). T. Stringer, R. Pozzoli, E.

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