augmented at a frightening rate, while some of the very fundamental concepts in this area continue to be found only in the rather sketchy original accounts of the research journals. It appeared to us that the time was ripe to attempt a consolidation of this material."

In general, the book is not difficult to follow, provided the reader has a background in quantum mechanics and introductory nuclear physics.

The first part, Radiation Theory and Nuclear Photoexcitation, is mainly a review. Though a good part of this material is available in other books, part 1 still is a very useful starting point and reference.

The next part, Electroexcitation of Nuclei, is quite comprehensive, covering electron scattering, both elastic and inelastic, Coulomb excitation, muonic atoms. Much of this is not available in book form. Part 3 deals with weak interactions in nuclei, in particular nuclear beta decay and muon capture. This part is less comprehensive than the first two, but it might still be useful as a reference.

The appendices should be of considerable help to readers who want to study the book in detail. This is especially true for appendix A—"The quantum theory of angular momentum." Even though this material is available elsewhere, its inclusion makes the book more self-contained.

Altogether this book should be useful to both graduate students as a textbook and to nuclear physicists as a reference. In this reviewer's opinion, Eisenberg and Greiner have succeeded very well in their stated goal.

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Electronic Phenomenon

Electron Paramagnetic Resonance of Transition Ions. A. ABRAGAM and B. BLEANEY. Clarendon (Oxford University Press), New York, 1970. xvi, 912 pp., illus. $41.50. International Series of Monographs on Physics.

About 25 years ago Zavoisky discovered electron paramagnetic resonance in solids. Today paramagnetic resonance is not only a subject of study in itself but also a tool used in many fields of investigation. It is one of the important tools in the investigation of the electronic properties of the ground state of magnetic centers, and its applications are found in physics, chemistry, biology, metallurgy, and geology.

The authors of *Electron Paramagnetic Resonance of Transition Ions* are among the first pioneers in this field. Abragam, together with Pryce, while working in Oxford, provided the main theoretical framework for the understanding of the properties of transition ions in single crystals. The initial important experimental work was done by Bleaney in the early '50's and was extended by his students and co-workers. The Oxford school consisted of scientists such as Stevens, Elliott, Judd, Ingram, Baker, Hayes, Griffiths, and Owen, each of whom has significantly enlarged the scope and importance of this field.

This monumental book is the outcome of the research of this group and bears the imprint of their knowledge and philosophy. It is a very large book, even within the restriction of dealing only with transition ions. Among the best chapters are the beautiful preliminary survey, a discussion of the implication of the spin Hamiltonian, and (in chapters 5 through 8) a detailed discussion of the ground state of the energy levels of transition ions. The theoretical survey (chapters 11 through 16) deals lucidly with aspects of crystal field theory and group theory. There are many standard textbooks dealing with these subjects, however, and these chapters, which, though clearly written, are not directly related to the main body of the book, are somewhat superfluous. In addition, the transition from the group theoretical calculations to the spin Hamiltonian is not clearly indicated. On the other hand, the theoretical discussion contains probably the finest descriptions available of time reversal and Kramers degeneracy, and of the Jahn-Teller effect in paramagnetic substances.

The book before us is the most authoritative book in this field. It will be used both as a reference book by the expert and as a book of study by the graduate student beginning to work in the field.

The reviewer does not do himself justice without a few words of criticism. There is no discussion of the paramagnetic resonance spectra of transition elements in organic biological materials or in metals; the authors deal nearly exclusively with transition ions in inorganic salts and should have indicated this in the title of the book. (On the other hand, in the discussion of the electron nuclear double resonance, or ENDOR, the authors illustrate the ENDOR effect mainly through spectra of donors in silicon where the paramagnetic center is not a transition ion and the host not an inorganic salt.) Reference should also have been made to paramagnetic resonance of transition elements of optically excited states. This field is probably going to become more important in the future and may provide some additional tests of various fine points of the theory of spin resonance in solids.

This volume is a worthy companion to Abragam's classic *Principles of Nuclear Magnetism.*

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Volcanic Chain

Volcanism and the Upper Mantle. Investigations in the Kurile Island Arc. GEORGII S. GORSHKOV. Translated from the Russian edition (Moscow, 1967) by Charles P. Thornton. Plenum, New York, 1970. xvi, 385 pp., illus. $35. Monographs in Geoscience.

Gorshkov's original Russian text was entitled "Volcanism: Kurile Island Arc." The change of title to emphasize the nature of the upper mantle as understood from studies of the products and roots of Kurile volcanoes was not done entirely to generate wider interest in this important book. This emphasis is the message, and it comes through loud and clear.

Deep seismic soundings by refracted explosion waves clearly show that the relatively simple Kurile island arc is underlain by three distinct types of crust: in the north by a continental crust of 30 kilometers' thickness; in the center by an oceanic crust 10 to 15 kilometers thick; and in the south by a 30-kilometer-thick "suboceanic" crust composed of a "basaltic" lower sequence overlain by up to 7 kilometers of volcanic rocks. In effect, the arc has roots at the northern and southern ends, but with different seismic velocity layers; these are separated by a 200-to-300-kilometer-long central gap with little or no crustal root.

The surprising thing is that the chemistry of the volcanic rocks along the arc shows almost no relationship to this major difference in basement rocks. The north and central Kurile Islands have identical calc-alkaline lavas, and the southern Kurile lavas are similar

but slightly less alkaline. In contrast, the well-known variation of volcanic petrochemistry across the arc is clearly present. Volcanoes on the Asiatic (western) side of the arc produce rock types that are alkalic compared to the main trend of the volcanic arc even though underlain by the same crust. Gorshkov comments, "These facts, based on indisputable geophysical and geochemical data, force us to question whether contamination and the assimilation of crustal rocks play any significant role in the volcanic processes and to look for a source of volcanism below the crust, in the upper part of the mantle." Oceanic basalts are clearly marked by most petrologists as mantle-derived, but the dominance of mantle material in andesitic volcanoes is a more tentative but ascending hypothesis.

Besides giving both the geophysical data on the roots of volcanoes and the geochemical data on the evolution of the volcanic products, this book is the first comprehensive source in English on the geology and volcanology of the Kurile Islands. The structure of the Kurile arc, the history of investigations, the stratigraphy (Cretaceous to Recent), and the Quaternary geology are summarized and documented by a comprehensive bibliography of both Russian and Japanese sources.

The largest chapter (180 pages) covers the description and eruptive history of 160 Quaternary volcanoes in the Kuriles, of which 104 have been active in postglacial time. Diagrammatic sketch maps prepared from aerial photographs are presented for many of the more prominent volcanoes. Most of these maps have no scale, probably a censorship rather than an oversight in the Russian edition. However, Gorshkov provides enough numerical data in the text on diameters of islands or calderas so that scales can easily be constructed. Their omission is my only criticism of the excellent translation by Charles Thornton.

The last two chapters deal with the petrochemistry of other island arcs and oceanic volcanoes and give Gorshkov's interpretations of the origin of volcanism in the upper mantle. These are a major bonus in an already classic work.

At the beginning of the chapter on the volcanoes of the Kurile Islands, Gorshkov comments that it is perhaps not modest but that "looking back at the road travelled, I cannot help but feel some satisfaction." His important synthesis and interpretation of many years of rugged field work have certainly earned him this reward.

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Stars and Spectra

Stellar Atmospheres. DIMITRI MIHALAS. Freeman, San Francisco, 1970. xiv, 464 pp., illus. $16. A Series of Books in Astronomy and Astrophysics.

The subject of stellar atmospheres may be logically divided into study of the continuous spectrum and study of the line or Fraunhofer spectrum, and in this book Dimitri Mihalas has devoted about equal space to each topic.

The author is well known for his calculations of model atmospheres of early-type stars, and the chapters dealing with such models are authoritative and complete. There is a good discussion of the comparison of the results of such calculations with observations. In particular, we note the section at the end of chapter 7 where the importance of deviations from local thermodynamic equilibrium (LTE) in stars with low surface gravities is demonstrated. This is probably the best discussion of model atmospheres of early stars in the literature today, and is essential reading for anyone who wishes to work in this area.

The portions of the book that cover the spectral lines are far more theoretically oriented, and for this reason of less use to the practicing astronomer. In any case, it would have been well to have a reproduction of at least one stellar spectrogram, just to let the theoretician know what he is supposed to be working on. In fact, one must look rather closely to find *any* observational data on spectral lines.

Much of the discussion is devoted to subtle effects which are often dwarfed by other phenomena in real stars. Bulk motion or turbulence, perhaps the most insidious of these mechanisms, has been given only a brief and callow discussion. Zeeman effect, hyperfine structure, and stellar rotation are not discussed, although they are well known to influence line shapes in stars.

There is a comprehensive discussion of the important work now going on in the nonequilibrium theory of spectral line formation. Mihalas discusses the application of these techniques to the hydrogen lines in early stars, where the theory has had some success in predicting the cores of the line profiles. The cores of some strong solar lines are also discussed, but here the comparison of theory and observations is much less favorable because of severe inhomogeneities in the emitting gas which are traditionally ignored in the theoretical treatments.

For the majority of lines in the majority of stars, the practical worker falls back on "classical" methods which assume local thermodynamic equilibrium. These methods are also discussed by Mihalas, but only briefly, and it is unfortunate that he has chosen to stress the uncertainties of the method while largely ignoring its tremendous success in the measurement of stellar abundances. Indeed, the comparison of stellar abundances with predictions of theories of stellar evolution, galactic structure, and the origin of the chemical elements has been one of the most exciting and rewarding areas of research in stellar atmospheres over the past several decades.

In summary, *Stellar Atmospheres* is an essential contribution to the literature on model stellar atmospheres and the continuous spectrum of early-type stars. The later portions of the book, which deal with the line spectrum, will be of interest chiefly to those who are interested in the onerous nonequilibrium theory of spectral line formation per se.

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