Astrophysical Phenomena

Atoms and Molecules in Astrophysics. Proceedings of the Scottish Universities Summer School (a NATO Advanced Study Institute), Stirling, Aug. 1971. T. R. CARSON and M. J. ROBERTS, Eds. Academic Press, New York, 1972. xiv, 368 pp., illus. $23.50.

Most of the material of astrophysics is provided by spectroscopic observations. Given thermodynamic equilibrium, the construction of quantitative models that reproduce the observed radiation involves only data on spectral line positions and radiative transition probabilities. To astrophysicists atomic physics once was in effect atomic spectroscopy. The discovery of numerous stellar and more particularly interstellar molecules extended the required background in atomic and molecular physics to include the spectroscopy of diatomic and polyatomic molecules, but more significant has been the recognition that few objects in the universe exist in conditions of thermal equilibrium, and that a detailed understanding of atomic and molecular processes of excitation and deactivation, of formation and destruction, is consequently needed if the correct physical content is to be extracted from the observations.

The range of physical processes is very broad, and the breadth creates a demand for abbreviated presentations of the basic material that can rarely be satisfied without loss of precision and clarity in the exposition of the underlying concepts. *Atoms and Molecules in Astrophysics* is a brave attempt to provide a brief account of some of the more immediately relevant areas. The lectures include a survey of atomic scattering theory by P. G. Burke, an introduction to molecular spectroscopy by H. Foley, a summary of collision theories for highly excited atoms by I. C. Percival, and a very brief description of theoretical studies of line broadening by H. Van Regemorter. The article by Foley is particularly lucid, but they are all well organized and economical in presentation. Greater reference to experimental aspects would have provided a more satisfactory description of the discipline, but for those who need a rapid reminder of the content of the subjects treated in the lectures the book has value. Clearly much of the physics of atoms and molecules involved in astrophysics today is omitted, and the book is in no sense comprehensive.

The book also contains two lectures on astrophysical phenomena whose interpretation demands a particular knowledge of atomic and molecular processes. M. J. Seaton presents a clear and instructive discussion of the present theory of gaseous nebulae which includes the question of the widths of the radio recombination lines from H-I regions. The lecture by M. Litvak deals with interstellar molecules with particular reference to the physical conditions and processes leading to interstellar masers. It is more complex than Seaton's elegant account, but so perhaps is the subject.

The book concludes with several summaries on related topics, all of which have already been more adequately discussed by the authors in the journal literature.

Finally, then, the book has some good parts but the whole is no more than a sum of its parts. It is in fact a typical summer school.

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Marine Studies

The Biology of the Indian Ocean. Proceedings of a symposium, Kiel, Germany, Mar. 1971. BERNT ZEITZSCHEL, Ed. Springer-Verlag, New York, 1973. xiv, 550 pp., illus. $55.40. Ecological Studies, vol. 3.

The International Indian Ocean Expedition (1959–65), unlike the early expeditions, was not a voyage by one ship with a defined purpose but resulted from a decision of the oceanographic community to concentrate activity for a number of years in the relatively unexplored waters of the Indian Ocean. This volume contains the proceedings of a symposium devoted to the biological investigations. The majority of the 44 papers describe the distribution of plankton, fish, and benthos in the area. These will be essential for anyone working in the region and valuable to those concerned with general oceanic distributions of plankton. Many of these papers are based on the collections at the Indian Ocean Biological Centre.

The geographical distribution of effort and the types of investigation depended on the interests of the participants. A unique feature of the Indian Ocean is the reversal of the surface circulation in the tropical belt produced by the change from northeasterly to southwesterly monsoons. In turn this plays an important role in the upwelling along the Arabian coast. In consequence, much of the effort was concentrated in the Arabian Sea and results are much sparser for the southern parts of the ocean. The general features of the physical environment, including nutrient distribution, are described in papers by Dietrich, Wyrtki, and Currie, Fisher, and Hargreaves. These provide a necessary background for the understanding of the distribution of organisms. At the basic level of primary production, there is good agreement between measured areas of high productivity and those expected on the basis of physical and nutrient distributions. At the highest trophic level discussed here, tuna, it is apparent that there is no simple correspondence between abundance of tuna and physical factors or basic productivity. Thus, as well as displaying relations between different features of the area, these papers also indicate unresolved problems.

The strengths and weaknesses of this international, interdisciplinary study of a large area are revealed in the paper by Cushing, which attempts to estimate the energy flow at the lower levels of the food chain. Presumably Cushing uses the same basic data to derive primary production (grams of carbon per square meter per day) as Krey (in another paper in the book) uses, yet there are considerable quantitative differences between the presentations which are not explained. For secondary production there is the advantage that all collections for zooplankton biomass were taken with the same type of net hauled in the same way (vertically 200 meters to surface), but these data expressed as displacement volume (milliliters per square meter) have to be converted first to grams of carbon per square meter. Then a "growth" rate is obtained by calculating the duration of each generation as a function of temperature from data on *Calanus* from the west of Scotland. (The calculations are given too briefly and appear to contain errors in presentation.) No account is taken of the effects of predation in determining the production-biomass ratio. These estimates, combined with primary production data, allow Cushing to calculate transfer efficiency from phytoplankton

to zooplankton. He obtains a range of values which show a trend from 5 to 20 percent with the higher values at low levels of primary production. The question remains whether this is "real" or the result of the necessary simplifications in the calculations. Cushing's synthesis is valuable in displaying the potential of these data even if the interpretations of this and other general relations are best regarded as hypotheses for further, more experimentally oriented studies.

The last paper, by Tranter, is really in a separate category, since it gives the results of detailed studies along a meridional section off the west of Australia and describes, statistically, the evidence of relations between different trophic levels. Yet, as Tranter points out, many of the data require explanation in terms of horizontal water movements across the section, so that interpretation depends on a knowledge of results elsewhere. This points to the general usefulness of this "expedition" in providing a broad basis of knowledge and many interesting problems for further work in particular parts of the Indian Ocean.

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Solid State Physics

Magnetic Interactions in Solids. H. J. ZEIGER and G. W. PRATT. Clarendon (Oxford University Press), New York, 1973. xvi, 660 pp., illus. $62.50. International Series of Monographs on Physics.

The effects of magnetic fields on solids provide many classic examples of quantum mechanics applied to observable phenomena. A detailed analysis of such phenomena requires an understanding of the unperturbed system as well as the effect of the field, and the study of "magnetic interactions in solids" must therefore involve many aspects of solid state physics as a whole. Any book, even such a large one as this, is therefore forced to take a rather selective point of view, and it is particularly important for the prospective reader to know what he may expect.

The formal structure of the theory in this field is very highly developed, and there is a great body of knowledge that may be described as "pure theory based on first principles." Such theory forms the starting point of all quantitative descriptions, but in practice one often encounters technical difficulties arising from the complexities of the problems one attempts to treat. To minimize the difficulties one can restrict oneself to consideration of specially simple cases, one can make judicious approximations, or one can adopt a semi-empirical point of view in which the essential elements of the theory are supplemented with quantitative estimates of parameters derived from experiments. The proper relation of such pragmatic approaches to the pure theory is vital if one aims to handle all cases that may be found in nature, but it is not important if one's goal is to illustrate the basic ideas behind the theory.

In the present volume the authors have clearly chosen the latter approach. They have assembled an impressive number of theoretical concepts that are important in understanding the magnetic behavior of solids, but no attempt has been made to present a comprehensive or unbiased survey of the field. The book will thus be found useful mainly in conjunction with other texts and with the many references that are cited at the end of each chapter. The volume is divided into two roughly equal parts. The first deals with systems with localized electrons, and the second discusses itinerant electron systems.

The first three chapters give a survey of basic quantum mechanics as applied to the theory of many-electron atoms, the treatment being the kind one may also find in various other books. The discussion here is clear and useful as a general introduction, though one might wish for more discussion of modern applications of Racah algebra and tensor operators. The next chapter is a long one attempting to cover under the heading "Magnetic properties of ions in crystal fields" many of the observed magnetic phenomena in insulating crystals. This is a tall order, even if one supplements the reading with the 141 references given at the end of the chapter. Perhaps the most useful aspect of this chapter is that it provides a starting point for further study in a number of important areas, as indicated by such key words as crystal fields in $3d$ and $4f$ compounds, spin Hamiltonians, group theoretical methods, covalent effects, interaction of light with ions in crystals, the Jahn-Teller effect, and exchange interactions in insulating crystals. One's only regrets in this respect must be that the references are not more complete and that some of the topics are not developed further. It is a pity that there is no cross reference in this chapter to another volume in the same series (Abragam and Bleaney's *Electron Paramagnetic Resonance of Transition Ions*), which covers some of the same material in much greater depth.

The second half of the book takes a rather different point of view. Rather than discussing magnetic phenomena per se, it concentrates on information that can be obtained by using applied magnetic fields as a probe in the study of itinerant electron systems. There is an extensive discussion of band electrons and the effective mass approximation, and these sections will be of interest more to workers in "solid state physics" than those in "magnetism." Key words in these chapters include cyclotron resonance, de Haas–van Alphen effect, conduction electron resonance, effective mass equations for various types of bands, interband transitions, shallow donors, and excitons. Maybe the best way to characterize this section is to point out that the examples that are discussed relate to such materials as copper, magnesium, silicon, germanium, and bismuth, all systems that are not usually studied for their specifically *magnetic* interest.

The final chapter in the book is a brief discussion of indirect interactions in metals, a topic that is of considerable current interest. It is somewhat disturbing to find that only two of the 73 references in this chapter are later than 1967 and that these two are review articles written more than four years ago.

Indeed, the omission of current references, here as elsewhere in the book, must make one question the value of any selective monograph of this kind. A point of view is useful only when it sheds light on a developing field, and for that it must be really up to date. When a book is written to consolidate a field it must be comprehensive, both in its scope and in its bibliography. The present volume contains much useful information, but mainly for the reader who knows what he is looking for and who can fill in for himself what is missing.

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