Book Reviews

Interstellar Matter

Cosmic Dust. Its Impact on Astronomy. PETER G. MARTIN. Clarendon (Oxford University Press), New York, 1979. xiv, 266 pp., illus. $23.50. Oxford Studies in Physics.

The existence of interstellar dust was not recognized by astronomers until long after they knew about stars, planets, clusters, and nebulae. William Herschel and J. C. Kapteyn, among others, reached the conclusion that we are near the center of our star system from the fact that the apparent star density decreases outward from the sun in all directions, an effect we now know to be due to the extinction (absorption plus scattering) of starlight by small interstellar particles. Wide-field photographs of regions in the Milky Way taken by E. E. Barnard at the end of the last century showed unmistakably that there are dense, opaque or nearly opaque "clouds" that must contain dust particles that block the light of stars beyond them. Finally in 1930 R. J. Trumpler proved convincingly that dust is generally distributed in and near the galactic plane. His observational data showed that the apparent brightness of stars in clusters falls off more rapidly on the average than the inverse-square law would predict on the basis of relative distances derived from the apparent angular sizes of the clusters. This result, as well as the statistical increase in the color index (redness) of cluster stars with distance, which Trumpler also found, shows that there must be dust in almost every direction we look near the galactic plane.

At first regarded chiefly as a nuisance that renders difficult the accurate determination of the distances to stars, and hence complicates the study of galactic structure, interstellar dust is now itself the object of much theoretical and observational research. Sensitive photoelectric detectors, efficient spectral scanners, and accurate polarization analyzers applied to extinction studies have added much to our knowledge of the properties and distribution of the interstellar particles. Satellite observations in the ultraviolet have provided further information, and the advent of sensitive infrared detectors has made it possible to measure the heat radiation from cool interstellar clouds of dust particles and thus to learn much more about them.

Peter Martin's *Cosmic Dust* is a very good summary of what is known about interstellar dust and of the methods that are being used to learn more about it. The first chapters give a good summary of the necessary theoretical tools for studying the interaction of radiation with solid particles; the chapters shift almost imperceptibly to a discussion of the recent observational data and their implications. The interactions between the dust particles and the atoms, ions, electrons, and molecules in interstellar space are discussed, and the condensation, growth, and destruction of the particles in various environments are described and analyzed in physical terms.

Although most of the matter in stars and interstellar space consists of hydrogen and helium, two elements that do not form solids under interstellar conditions, the heavy elements, oxygen, nitrogen, carbon, iron, silicon, and the like, can and do exist in particles in forms such as H_2O, NH_3, CH_4, graphite, carbonates, and silicates. A significant fraction of the heavy elements may be locked up in solid particles; this must be kept in mind in determining abundances from interstellar absorption-line measurements. Reactions between interstellar atoms and ions, beginning with $H + H \rightarrow H_2$, can occur at the surfaces of interstellar dust particles; the particles thus catalyze the formation of molecules. The particles are usually electrically charged as a consequence of the photoelectric effect and of collisions with ions and electrons. Collisions usually prevent dust particles from separating themselves from the gas clouds in which they are immersed, and condensations in the "dust" clouds become the nuclei from which new stars form.

The book is well written. Many references are given, nearly all to recent work, and the specialist will have to trace back through them to find earlier papers. Overall the book is highly recommended for astronomers and astrophysicists seriously interested in research on interstellar dust.

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The Liquid State

The Molten State of Matter. Melting and Crystal Structure. A. R. UBBELOHDE. Wiley-Interscience, New York, 1979. xvi, 454 pp., illus. $58.95.

The liquid state is a theorist's nightmare and an experimentalist's delight. Both of these aspects are apparent in *The Molten State of Matter,* a monograph that amply documents the rich variety of atomic, molecular, ionic, metallic, and polymeric liquids too often ignored by theorists in their search for unifying simplifications. In both topic and treatment, this volume calls for comparison with J. Frenkel's classic, *Kinetic Theory of Liquids*, first published in 1943 and still a standard in the field. In his introduction, Ubbelohde remarks that "few authors yet take the vital step of referring any liquid under discussion to the parent crystal as the starting point." Yet Frenkel begins his preface, "The recent development of the theory of the liquid state . . . is characterized by the reapproximation of the liquid state . . . to the solid (crystalline) state."

What then are the differences between the books? A major one has to do with the inclusion of experimental data. *The Molten State of Matter* has a table or graph on almost every other page, whereas Frenkel's book has essentially none. Much food for thought is contained in this collection of data, which ranges over such diverse phenomena as the changes in thermopower on melting, the correlation between melting point and coefficient of thermal expansion, and the melting points of rigid quasi-cylindrical organic molecules.

The strength of Frenkel's book lies in the systematic application of statistical thermodynamics and lattice dynamics to high-temperature crystals and their melts. Ubbelohde tends to be much less systematic and less critical in his treatment of model calculations. For example, in chapter 11, "Statistical theories of melting and crystal structure," he discusses in detail the icelike-cluster model of liquid water and even lists cluster sizes to three digits but omits mention of the molecular dynamics calculations of Stillinger and Rahman, which cast serious doubt on the fundamental premise of the cluster model for water.

Likewise, the book does not clearly separate assertions from conclusions, and the basis for assertions is not normally supplied. A typical example occurs on p. 20: "Low values of S_f (entropy of fusion) imply a simple mechanism of melting." This reviewer is un-

aware of any connection between the thermodynamic properties of initial and final states and the mechanisms involved in the change from one to the other.

A very valuable feature of this monograph is its extensive tabulation of premelting and prefreezing phenomena near the solid-liquid transition. However meager, these slim clues may offer our best hope of eventually understanding the phenomena of melting and freezing.

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Bacterial Photosynthesis

The Photosynthetic Bacteria. RODERICK K. CLAYTON and WILLIAM R. SISTROM, Eds. Plenum, New York, 1978. xxii, 946 pp., illus. $85.

Two ideas have profoundly influenced modern thinking about photosynthesis. One of them goes back 50 years to C. B. van Niel, who, working with anoxygenic photosynthetic bacteria, suggested that the primary reaction in photosynthesis results in the production of a reducing component and an oxidizing component. Today this is known as a charge separation.

The other idea is more general and originated outside of this field. It is the chemosmotic coupling hypothesis of P. Mitchell. According to this hypothesis, the transfer of electrons down a redox gradient in a unit membrane occurs in such a manner as to produce a proton gradient over the membrane. This latter gradient serves to drive phosphorylation of adenosine diphosphate and other energy-demanding processes in the membrane.

These ideas are central to the subject of photosynthesis, and, accordingly, they form the basis for the largest section in this book, entitled Photometabolism. The section is built up around the reaction center, the isolation of which, by Clayton and co-workers, is one of the more recent landmarks in photosynthesis research. The sequence of events beginning with the transfer of excitation energy from antenna pigments to reaction center, and the conversion of this energy into a proton gradient, are described and discussed in 15 chapters.

The redundancy that the editors mention in their preface is most apparent in this section. Whether or not this is a disadvantage is a question for the individual reader to decide. I found it slightly irritating.

Organisms that carry out the processes described above are structurally very specialized. Therefore, the section on structure is an important one. Most of the chapters in the section are concerned with membranes or membrane components. The membranes of purple bacteria are much better understood than those of the other groups, and hence the long, well-written chapter on them by Niederman and Gibson dominates the section.

The structure of the photosynthetic apparatus of the green bacteria is unique. One of the light-harvesting components of these bacteria is a water-soluble bacteriochlorophyll a–protein complex that has been purified. Its structure and properties are described in a pithy paper by Olson.

Over the years a large number of data on many of the chemical constituents of photosynthetic bacteria have accumulated. Much of this information has been collected, ordered, and evaluated in the section on chemical composition. Carotenoids, cytochromes, and complex lipids are treated here. Methods of isolation and identification are also included, and these chapters will serve as invaluable sources of reference for years to come.

Apart from these sections and the balanced introductory chapter by Pfennig, the book presents a disconnected picture. Everybody would agree that the ability to convert light energy to chemical energy only under anaerobic conditions must have profound physiological (and ecological) consequences for the organism concerned. It follows that the ways in which the cell's physiological and biosynthetic machinery interacts with this special type of energy metabolism are very important. An awareness of this is cardinal in any attempt to properly describe the photosynthetic bacteria. But the sections on phosphorylation, peripheral oxidations and reductions, biosynthesis, and physiology seem to have been compiled without this in mind. As the chapters in these sections show, there are plenty of data and ideas. What is needed is coordination and a more imaginative disposition of the subject matter so as to integrate the various aspects, as is accomplished in the section on photometabolism.

Nevertheless many of the individual papers in these sections are very good. One of the most exciting is that by Kaplan on the control and kinetics of photosynthetic membrane development. Although it is established that at least some of the intracellular photosynthetic membrane is continuous with the peripheral, cytoplasmic membrane, it is still uncertain whether the intracellular membrane originates by invagination of the peripheral membrane. Kaplan's group has attempted to answer this type of question by the use of the technique of density shift, in which "heavy" membranes produced during growth in heavy water may be separated from those produced after a period of growth in ordinary water.

A sense of up-to-dateness is given here, as it is in many of the other chapters, by the inclusion of a note added in proof. Kaplan's addition describes an extraordinary finding with synchronous cultures of *Rhodopseudomonas spheroides*. In these cultures the rate of synthesis and incorporation of membrane proteins and photosynthetic pigments was shown to be constant throughout the cell cycle. However, synthesis and incorporation of the phospholipids was limited to a short period just prior to cell division. These results raise questions of great significance with respect to membrane synthesis, not only in photosynthetic bacteria, but in every kind of cell.

In summing up, I would say that the book's strength lies in its up-to-date treatment of the photochemical and closely associated metabolic and structural aspects of the anoxygenic photosynthetic bacteria (the blue-green photosynthetic bacteria are scarcely mentioned in the book), and it should be available to every research worker in the field of photosynthesis, oxygenic and anoxygenic alike. Those looking for a coherent picture of the biochemistry and biology of the photosynthetic bacteria will not find it here.

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Commonalities

On Aesthetics in Science. JUDITH WECHSLER, Ed. MIT Press, Cambridge, Mass., 1978. xii, 180 pp., illus. $12.50.

In his essay on "Darwin's tree of nature" in this volume, Howard E. Gruber comments on the existence of different esthetic moods in science. The prevailing mood in the present volume is one of reaction against the cold formality of the idealized model and admission of the subjectivity of science.

This subjectivity was imposed on physics early in the present century