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-