Book Reviews

Mesophases

The Physics of Liquid Crystals. P. G. DE GENNES. Clarendon (Oxford University Press), New York, 1974. xii, 334 pp., illus. + plates. $32.50. International Series of Monographs on Physics.

It is commonly agreed that mesophases were first properly identified by Reinitzer in 1888. When Friedel classified the various phases as nematic, smectic, and cholesteric, in 1922, a considerable body of data on their simpler physical properties and the relationships between their molecular structure and their behavior had already been accumulated. There was, indeed, even the beginning of a theory.

This early progress was reported in a series of papers that appeared in one of the "Discussions" of the Faraday Society (1933). In those papers, the theory and the experiment were spelled out in a manner so convincing and so nearly exhaustive that interest in the field subsequently waned. In rereading those "Discussions" recently I was startled by the clarity, the brilliance even, of Oseen's now celebrated paper.

It was not until this past decade that the subject reemerged and progressed to a point well beyond the apex of 1933. Several reasons can be advanced to account for this rush of activity, not the least of which is the possibility, pointed out by Fergason in his persuasive essay in the *Scientific American* (Aug. 1964), that a considerable market exists for stable liquid crystal display devices. To an experimentalist, liquid crystals are attractive because they offer excellent systems on which to employ the rich assortment of experimental techniques that have grown to maturity in the past two decades—laser light scattering, nuclear magnetic resonance, electron spin resonance, and ultrasonic dispersion and attenuation, for example. The theorist interested in the physics of anisotropic fluids is attracted by the prospect of yet another variety of phase transitions on which to test the ideas that have begun to provide some deeper insight into the universal nature of critical phenomena. Then, too, lyotropic mesophases, which undoubtedly play a significant role in the structure of lipid bilayers and in solutions of biopolymers, are of increasing interest to biologists and biophysicists.

No wonder, then, that the Fifth International Liquid Crystal Conference held in Stockholm in June 1974 was attended by a wide cross section of the scientific community. A large number of the participants were from the "French school," which centers about de Gennes, whose work in recent years has had a strong influence on the subject. This book is more than a recital of the accomplishments of the Orsay group, but it is strongly influenced by them and tends to be somewhat deficient in areas they have not cultivated. Very little attention is paid, for example, to the statistical theory of mesophases. In particular, those developments that owe their origin to the classic paper of Onsager, go by the name of "hard-rod theories," and emphasize the role of the short-range repulsive force are treated too briefly to be appreciated by any general reader, and a few misstatements appear in the treatment.

Other deficiencies include an incomplete discussion of the subject of mixtures and inadequate consideration of the possibilities for tricritical points in mesophase systems. A better account of the relationships between molecular structure and phase stability would have been helpful, since these issues are by no means settled and are of interest to both experimentalists and theorists in both physics and physical chemistry.

This book almost certainly is intended for a limited audience, principally physicists, for whom the style, the appeal to analogs in ferromagnetism, and the use of modern ideas about critical phenomena will seem straightforward and natural. For other readers, including students, I suspect, the going will not be easy. What will be found here, nevertheless, is a rather broad account of liquid crystal physics that is well written, entertaining, frequently provocative, and at its best, for example in the chapter on dynamical properties of nematic mesophases, remarkably good. That chapter will no doubt be of particular interest for the discussion it provides of the hydrodynamic problems presented by the nematic mesophase. Used in conjunction with a volume emphasizing structure and giving a fuller account of the experimental situation, this book could serve as a valuable introduction to liquid crystal physics.

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Plasma Physics

Theory of Plasma Instabilities. A. B. MIKHAILOVSKII. Translated from the Russian edition (Moscow, 1971) by Julian B. Barbour. Consultants Bureau (Plenum), New York, 1974. Two volumes, illus. Vol. 1, Instabilities of a Homogeneous Plasma. xviii, 290 pp. $32.50. Vol. 2, Instabilities of an Inhomogeneous Plasma. xviii, 314 pp. $32.50. Studies in Soviet Science.

Much of the original work on the theory of plasma instabilities has been carried out in connection with the controlled thermonuclear fusion program. Although much of the theory has been widely used, particularly in astrophysics and space physics, it has been the perplexingly anomalous behavior of experimental plasmas in fusion machines that has provided the impetus for the theoretical analysis of plasma stability on the basis of increasingly sophisticated physical models. It is surely then of some significance that essentially no new types of instabilities have been discovered in the controlled fusion program over the last five years. Most of the current theoretical work in fusion is concerned with analyzing geometrical effects on known instabilities, investigating nonlinear saturation of instabilities, and exploring the possibilities for using waves and instabilities for the heating of laboratory plasmas. We must conclude that the theory of plasma instabilities, at least in their linear regime, is fairly mature. Accordingly, this translation is a welcome and timely contribution to the literature.

The anomalies of plasma behavior take the form both of enhanced non-classical velocity-space scattering of non-Maxwellian, but apparently collisionless, plasmas and of enhanced nonclassical transport of plasmas across magnetic field lines. The first volume deals with velocity-space instabilities of a non-Maxwellian, spatially uniform plasma, and could broadly be said to address itself to the former type of anomaly. The second volume deals with instabilities of a Maxwellian, but spatially nonuniform, plasma and is thus addressed to the latter type of anomaly. In both volumes, all the important original material up to 1970 is covered. Thus, for example, the second volume ends with a discussion of trapped-particle effects, which are currently a subject of active research in connection with the Tokamak program.

The most valuable feature of these volumes is their completeness. Essentially all significant known plasma modes are derived and discussed, with all destabilizing mechanisms exhaustively cataloged. Although the books contain no index, the material is sufficiently well organized and the notation sufficiently transparent that they are easy to use for reference purposes. Each chapter ends with an annotated bibliography of original papers. This reviewer has been told that the books are very popular in the Soviet Union, especially among experimental plasma physicists, who use them as source books of plasma theory. They should prove equally valuable in the United States.

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Planetary Atmospheres

Aeronomy. P. M. BANKS and G. KOCKARTS. Academic Press, New York, 1973. Two volumes, illus. Part A, xiv, 430 pp. $28. Part B, xvi, 356 pp. $24.

In the preface to this book, the authors define aeronomy as the study of the composition, movement, and thermal balance of planetary atmospheres. The book discusses the physics and chemistry of the earth's atmosphere in the height interval from about 50 to several thousand kilometers, with references to other regions in space when appropriate. It is neither a collection of empirical facts and observations nor a historical survey of the field, but rather an attempt to develop a mathematical description of the physical and chemical processes responsible for observed atmospheric behavior. More precisely, it provides adequate tools for simple as well as sophisticated modeling studies of the atmosphere. In fact, I think the underlying theme of this book is the evolution and current status of upper atmospheric modeling.

It is impractical to develop the subject of aeronomy in a logical, sequential fashion from first principles because this approach would require solution of the coupled equations for conservation of mass, momentum, and energy for all constituents of the atmosphere, both neutral and ionized. A substantial portion of the book is devoted to a detailed explanation and interpretation of models that provide a reasonable description of selected regions of the atmosphere, for example, the thermosphere or the exosphere, or of certain selected parameters that characterize the atmosphere, for example, the neutral temperature or the electron and ion temperatures. The assumptions adopted in each model are discussed, and the parameters included in the various terms are described in detail. The book achieves a satisfying blend of physical description, mathematical development, and numerical results of model computations, in which observations serve as starting points as well as tests for the models. The emphasis on the comparison of modeling results with observations is illustrated by the presentation of not just one set of altitude profiles of neutral constituents, but a series of results indicating the effects of a range of exospheric temperatures on these profiles. Through this approach, the reader gains some feeling for the sensitivity of the results to various input parameters in the model, leading to an insight into the mechanisms found in the real world.

The major topics covered include solar radiation, photon absorption by the atmosphere and photoionization, all relevant atomic, molecular, and ionic collision processes, chemical reactions of aeronomic importance, transport processes in the neutral and ionized atmospheres, and thermal processes. Discussion of the airglow, the optical radiations resulting from aeronomic processes, is woven into several chapters. Since the book does not treat effects of energetic particle bombardment on the atmosphere, there is only passing reference to the aurora.

At the end of each chapter is a good list of references. This is an important part of the book because it was impossible for the authors to provide the complete background for each concept and each equation introduced. The reference lists draw attention to the diversity of disciplines in aeronomy.

The last six chapters, 208 pages, are devoted to the ionized portion of the atmosphere, the formation of the ionosphere and the physical processes associated with it. These chapters were the most satisfying to read, in part because the discussion could draw on all the preceding material, thus achieving a level of authoritative completeness that the early chapters could not claim.

This book is the most ambitious and comprehensive work on aeronomy to date, and it will probably be unequaled for some years.

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Laser Advances

Dye Lasers. F. P. SCHÄFER, Ed. Springer-Verlag, New York, 1973. xii, 286 pp., illus. $25.10. Topics in Applied Physics, vol. 1.

Dye lasers provide the capability of generating continuously tunable coherent radiation across the 330- to 1000-nanometer spectral range. Their impact is yet to be fully appreciated, but it is fair to say that tunable dye lasers are leading to a revolution in spectroscopy and laser chemistry. The enormous power and spectral brightness of dye lasers compared to previously available incoherent sources have led to measurements on the time scale of picoseconds and to spectral resolution of better than 1 megahertz. Chemists have learned to establish nonequilibrium population levels by optical pumping, to selectively enhance chemical reaction rates, and recently to effect laser isotope enrichment with a photon utilization that approaches unity. The economic implications of these research advances are already apparent. The advances in linear and nonlinear spectroscopy are equally impressive. This book provides an overdue review of all these developments.

The book consists of five chapters, each written by one (or two) authors. An introductory chapter by Schäfer precedes the more specific chapters. The use of a common reference list and a subject index make this volume much easier to read and use than a mere collection of separate chapters.

Schäfer's introduction is a very clearly