cupation occurs on New Guinea in Melanesia. This large island was probably a stepping-stone in the migration to Australia, where radiocarbon dating indicates an occupation at least 20,000 years ago. Still, on New Guinea, archeological work has not succeeded in confirming the presence of man before 10,000 to 15,000 years ago. The domesticated pig appears by about 4500 B.C., cultivated plants by about 3000 B.C., and pottery by about 500 B.C. Man seems to have penetrated into Micronesia at a later date, but was making pottery there as early as the 16th century B.C. The occupation of Polynesia came still later, probably beginning about the 5th century B.C. in Samoa and Tonga.

As in other areas of the world, ceramic studies offer promise as aids in the unraveling of some of the more perplexing problems of migration and diffusion. Pottery is common in Melanesia and Micronesia, but in Polynesia it forms an important part of the material culture only on island groups immediately adjacent to Melanesia and Micronesia, especially Samoa and Tonga. Important new contributions to ceramic studies are embodied in papers by Poulsen, Dickinson, R. Shutler, and M. E. Shutler.

Throughout Oceania stone adzes and shell, or bone, fishhooks offer important criteria for the study of the distribution of culture traits in time and space. The characteristics of the stone architecture are equally important. Artifacts often occur in such small numbers in a particular site or level within a site that statistically valid studies must often be limited to broad island-to-island comparisons.

On the basis of pottery found in the earliest period, Sinoto sees the Marquesas Islands as the first in Eastern Polynesia to be settled from Samoa. He then postulates that the Marquesas formed the center for dispersal to Hawaii, Easter, the Society Islands, and New Zealand. He has already revised the recent interpretations for Marquesan archeology as set forth by Suggs on the basis of new excavations on Uahuka and Nukuhiva. Such revisions are a normal state of affairs in the early stages of archeological work in any area. Suggs's earliest occupation date is revised upward from about 124 B.C. to about A.D. 850. I think the true date may be found to lie somewhere between these two extremes when more work has been done in the area.

The symposium papers reveal that tremendous strides have been made in Oceanic archeology since the Tenth Pacific Science Congress in 1961, but because many of the reports are of a preliminary nature much remains to be done in the laboratory as well as in the field in the next decade before a really coherent picture of Oceanic prehistory emerges.

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Statistical Questions in Optics

Fundamentals of Quantum Optics. JOHN R. KLAUDER and E. C. G. SUDARSHAN. Benjamin, New York, 1968. xii + 279 pp., illus. $13.50. Mathematical Physics Monograph Series.

Since optics consists of the generation, propagation, and detection of light, one would expect *quantum* optics to be the study of the quantum mechanical aspects of optical sources or wave fields or detectors, or perhaps all three at once. But all three have been capable of quantum mechanical description for nearly 40 years. So what is new in quantum optics? And why have we had to wait until 1968 to find a book to teach us the Fundamentals?

The answer to the first question is simply statistics. The newest aspects of optics are those in which statistical fluctuations and correlations, both classical and quantum, play an important role. Those aspects have been systematically investigated only within the past decade—which answers the second question.

Statistical studies are farthest advanced in what might be called propagation optics, the part of optics that deals with the free wave field, and it is now well understood how the coherence properties of an optical field propagate in space and time. The rest of modern optics, having to do with coherence in detectors and sources, has been studied very little, although it has been nearly 15 years since Dicke first pointed out the possibility of highly correlated "super-radiant" atomic states. The study of cooperative optical processes such as photon echoes and self-induced transparency in the past three years indicates a growing interest in this area.

In their book Klauder and Sudarshan have then necessarily confined their attention to the statistical description of free electromagnetic fields. All of the very recent developments springing from Glauber's use of "coherent" quantum states of the field and the discovery by both Sudarshan and Glauber of the diagonal representation of density operators are given full exposure. The statistical questions arising in intensity interferometry and photoelectric detection are treated extensively, principally from the point of view of quantum electrodynamics. The approach taken to these questions is very much in the spirit of mathematical, rather than theoretical, physics.

The book begins with a sketchy introduction to classical statistical optics, stochastic processes, and photoelectric counting. With specific situations and physical examples thus disposed of, the authors then plunge into four chapters of very general discussion of the statistical states of the quantized electromagnetic field. Optics as such does not intrude into the discussion until more than a hundred pages later, when the photodetection problem is treated again. In the final two chapters the quantum electrodynamic coherent state formalism is applied to a number of different model radiation fields and to intensity interferometry. There is a good bibliography with emphasis on the last five years, with comments appended to nearly every reference.

The imbalance that might be inferred from the foregoing summary is actually the principal strength of the book. The degree of care with which mathematical questions are considered throughout the book is unusually high. Especially in the fifth and seventh chapters this is the case, and there one may find any number of interesting results derived or summarized. However, this strength is a serious flaw as well. So much attention is devoted to the almost purely mathematical aspects of the subject that the physics behind it is easy to lose sight of.

For this reason the title of the book is far from appropriate. It's even a bit unfair to the prospective purchaser who is approaching the subject for the first time. What is treated here isn't really the fundamentals of quantum optics at all, but rather mathematical questions suggested by problems in quantum optics.

Most of the usual faults with books written on the run about currently fashionable fields of study may be found here. The treatise itself might better be called a "benjamin" than a book, since it sits securely in the limbo between lecture notes and monograph. As far as style goes it is even lumpier than might be expected for a two-author project. One can frequently find common slips of the spoken language, such as *classi-*

cal for *classic* and *alternative* for *alternate*, that betray the book's lecture-note origin. These and many other slips, as well as the coinage of interesting new words such as *certaintude*, are a clear comment on the haste with which the book was planned and executed.

Finally, after everything is said the fact remains that the book is the first to be published in its field. Especially for that reason it is too bad that the title is so poorly representative of the contents. Some unwary instructor might even mistake it for a textbook. Nevertheless, it will have its considerable uses, particularly as a compact reference for the reader who is already acquainted with the fundamentals of the subject.

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Einstein's Theory

The Riddle of Gravitation. PETER G. BERGMANN. Scribner, New York, 1968. xvi + 270 pp., illus. $7.95.

The concept of force, though by no means necessary for the development of physical theories, has nevertheless been very helpful in the understanding of natural phenomena. Of all the forces invented by physicists to explain the macroscopic behavior of bodies, that of gravitation has long been the most mysterious. Numerous theories have been proposed to account for it. Newton's theory simply assumed the validity of his famous "law" of gravitation with its well-known statement that the force of attraction between any two mass particles in the universe varies inversely as the square of the distance between them. Though dissatisfied with this "action at a distance" idea, which was distasteful to many scientists of his time, Newton made no decisive attempt to probe more deeply into the significance of his postulate. Later theorists such as LeSage, Osborne Reynolds, and Bjerknes attempted to provide theoretical bases for the Newtonian principle, but without conspicuous success. The great 20th-century contribution to the problem has been Einstein's relativity theory of gravitation.

The purpose of the author of the book under review is to present an essentially nonmathematical elucidation of Einstein's theory for the nonexpert. This has involved a review of the special theory of relativity, which is admirably presented, particularly with reference to Minkowski's four-dimensional world. This review is followed by an account of the general theory of relativity, with particular emphasis on its relation to gravitation as a property of the space-time continuum. The significance of the principle of equivalence is stressed, as well as the closely associated fact that a freely falling reference system, by which a gravitational field can be canceled out, cannot be extended arbitrarily through space-time. The difference between flat and curved space-time manifolds is clearly explained, and much emphasis is laid on the Schwarzschild solution of Einstein's field equations as a means of drawing cosmological conclusions from the general theory.

The last third of the book is devoted to modern developments of the Einstein theory of gravitation, including such topics as gravitational collapse, the attempts to detect gravitational radiation, and the relation between gravitation and the quantum theory. Although the reader cognizant of recent developments will note the omission of several important advances such as Wheeler's geometrodynamics and gravitons, the book as a whole constitutes an admirable review for the general reader of a difficult but important segment of modern science.

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Coordination Compounds

Ligand Reactivity and Catalysis. MARK M. JONES. Academic Press, New York, 1968. viii + 272 pp., illus. $14.

More than a century and a half ago, Berzelius pointed out that when a nonmetallic group attaches itself to a metallic ion the reactivity of both is greatly changed. Other early investigators confirmed this observation through a great variety of experiments. Alfred Werner reported several ligand reactions, one of the most interesting being the "oxidation" of trans-$[Coen_2(NCS)_2]^+$ to trans-$[Coen_2(NH_3)_2]^{3+}$ by chlorine. However, neither Werner nor other early workers spent much time on the study of such reactions. They were, instead, engrossed in establishing the nature of the bond between the metal ion and the nonmetallic atom attached immediately to it. Extensive study of ligand behavior was not undertaken until many years after Werner's coordination theory was well established. This is surprising, for many important reactions depend upon the change in properties of a nonmetallic group when it coordinates to a metal ion. One might cite, for example, the Friedel-Crafts and several other important synthetic reactions and the functioning of biological systems in the presence of traces of metal ions.

Within recent years, however, ligand reactivity has become a very popular and fertile field for investigation. Many aspects of the subject have been discussed in research papers and in several symposia, but until the appearance of this book there has not been an extensive general review of the subject. This volume is therefore very timely.

Jones has done a real service in collecting and classifying the literature on ligand reactivity and catalysis. It is not possible, in a small book, to discuss each reaction in detail, but he has given a brief description of each type of reaction, and in many cases has outlined the reaction mechanisms. The extensive lists of references (about one thousand in all) will lead the reader to more detailed reviews and to the original research papers.

As Jones suggests in his preface, it is an author's prerogative to decide which topics shall be covered extensively and which shall be given only a little space. In this case, the author has relied too heavily on what interests him, and has slighted some topics that are of greater importance to coordination chemistry as a whole, for example, hydrogenation and reactions of biological significance. However, this criticism may reflect only the reviewer's prejudices.

In a reference book such as this, the index is of paramount importance. Can one quickly find any topic that is discussed in the book? The subject index in this book covers only eight pages, but it passes the test with a good grade. The author index (13 pages) is also well arranged, even including references to articles mentioned in the book for which the authors' names are not mentioned. Among books about coordination compounds, this one must be almost unique in that it mentions Alfred Werner only once, and then only briefly.

This is a very useful book, and it will be widely read.

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