

conformational analysis. No previous book has covered these two areas of inorganic chemistry, and the present one provides a useful compilation of data and an elaboration of the associated concepts, even though at times the author ignores others' work in presenting his own views.

The first part of the book, dealing with conformational analysis of chelate rings, is expounded clearly and with excellent diagrams. The section on optical activity of coordination compounds is an attempt to present a professional approach to the problem of absolute configurations, a subject in which there are few specialists. Hawkins does an excellent job with the empirical methods, critically examining the evidence for assignments and dealing properly with correlations. The section on nonempirical methods of determining absolute configurations suffers because the uninitiated reader may not know what the argument is about. Here the author does not, as he does in the previous chapters, present the subject from the beginning. Such a presentation would have been helpful whatever the merits of the view he takes. The last part of the book is on nuclear magnetic resonance and is interesting.

On the whole this is a good book, but in order to proceed with equanimity the reader should realize that it has both heroes and villains; the bad guys are treated with Olympian disdain.

B. BOSNICH

Department of Chemistry,
University of Toronto,
Toronto, Ontario

Astrophysics

Cosmic Gamma Rays. Floyd William Stecker. Mono, Baltimore, 1971. x, 244 pp., illus. \$12.50.

Astronomy has made tremendous advances over the last two and a half decades as a result of the expansion of the observable range of frequencies from the narrow visible band at 10^{15} hertz. Now almost the entire span from the low end of the radio-frequency region at 10^8 hz through the x-ray region at 10^{19} hz is being utilized. Radio-frequency, infrared, and x-ray radiation from many astronomical objects has been found to have a much greater intensity than had been theoretically predicted. Thus the strong radio sources, quasars, "x-ray stars," and

pulsars have been added to the astronomer's lexicon.

Morrison pointed out in 1958 that, since electrons of at least 10^{12} electron volts were necessary to account for the synchrotron radiation observed from many of the strong radio sources, other high energy elementary particle reactions should also be taking place. These could be responsible for the production of the charged particle cosmic radiation and should also produce gamma rays,—that is, electromagnetic radiation above 10^{20} hz. Unfortunately for the experimentalist, in this portion of the spectrum the observed intensities have been much less than originally predicted. Although radiation has been observed up to 10^{23} hz, the experimental situation is still far from clear (Research Topics, *Science*, 24 Dec. 1971).

In this monograph, Stecker gives a very thorough treatment of the elementary particle reactions which produce high energy gamma rays and applies these to various astrophysical situations. Use is made of the recent data for p - p collisions available from high energy physics: cross sections, branching ratios, lifetimes, and so on. Above 30 Gev bombarding energy, where accelerator data are not yet available, the fireball models of meson production are used to extrapolate the gamma ray spectrum to higher energy. Inverse Compton collisions, bremsstrahlung, and matter-antimatter annihilation are the other processes most likely to produce cosmic gamma rays, and they are also adequately described. The lowest energy considered is the 0.51 Mev gamma ray from electron-positron annihilation. Not treated is the line gamma-ray radiation produced in nuclear reactions, although some of these rays are in excess of 1 Mev. Their detection would provide valuable information on stellar nuclear reactions and nucleosynthesis.

A less satisfactory part of the book is the discussion of the existing experimental data. Stecker chooses to consider only extended sources such as the interstellar gas in our galaxy bombarded by the high energy cosmic ray protons or the isotropic gamma rays from neutral pion decay at an early age of the universe, which we would observe red-shifted by $Z \sim 100$. Data in support of these processes came from experiments on the satellites OSO-3 and ERS-18, but later experiments have raised doubts about both results. The galactic radiation may be due primarily to point sources, as is the case with the galactic x-ray sources. No mention is

made either of the role played by the nonobservation of gamma rays from certain objects in rejecting proposed theoretical models. For instance, the energy source for the quasar 3C 273 cannot be nucleon-antinucleon annihilation because the resultant gamma ray flux would exceed the observed upper limit by a factor ≈ 100 .

In summary, this work will be of interest especially to the astrophysicist in providing a compendium of the relevant formulas for cosmic gamma ray production and to the general physicist by showing how the knowledge acquired in elementary particle physics in the last 20 years can enhance our understanding of the universe.

Donald Kniffen has contributed a useful appendix on the experimental techniques which have been used on balloons and satellites.

GLENN M. FRYE, JR.

Department of Physics,
Case Western Reserve University,
Cleveland, Ohio

Cosmological Physics

Relativity and Gravitation. Based on a seminar, Technion City, Israel, July 1969. CHARLES G. KUPER and ASHER PERES, Eds. Gordon and Breach, New York, 1971. xii, 324 pp., illus. \$24.50.

The dust cover of this book contains the statement "This book discusses the most recent developments in the theories of relativity and gravitation, and contains contributions from the leading experts in this field." While it is true that this book does contain contributions from many prominent workers in the field of general relativity, it is also safe to say that few of the contributions have anything significantly new to say. This is not to deny that there are indeed several interesting articles in this collection.

One of the most interesting, significant, and controversial experiments in recent times has been the work of Joseph Weber in detecting gravitational radiation. Weber gives an account of his results heretofore found only in several short articles in *Physical Review Letters*. He discusses the observed events—coincidences between detectors located 1000 miles apart—and by statistical analysis rules out these events' being due to chance. He also describes the reasons why it is unlikely that the events have been produced by non-gravitational phenomena: electromag-

netic radiation, cosmic rays, or seismic disturbances.

One of the most difficult, abstract, and enticing problems has been the attempt to formulate a quantum theory of gravitation. Peter Bergmann, in his article "Status of canonical quantization," presents a summary of three likely approaches to such a theory: the Schrödinger approach, the Hamilton-Jacobi or superspace approach, and the Feynman path (thin sandwich) approach. Why bother to quantize gravity at all? As Bergmann sums them up, the principal motivations are: the likelihood that if most physical fields are quantum fields gravitation will be no exception, and the expectation that a fully elaborated quantum theory of gravitation will be far more than a routine replica of other known quantum field theories.

In recent years there has been a great deal of experimental activity along astrophysical lines, due in no small part to a rapidly developing technological capability. In his article "The recent renaissance of observational cosmology," D. W. Sciama elaborates on two of the most exciting discoveries in the history of astronomy—both in the year 1965—the quasistellar sources of large red shift and the cosmic blackbody radiation.

Some other articles in the collection concentrate on details of a more mathematical nature. In "Twistors, symplectic structure and Lagrange's identity," Crampin and Pirani show that Penrose's twistors can be understood very simply in terms of the natural symplectic structure of the cotangent bundle of the manifold of space-time. "Applications of SU(2) technique in general relativity" by Moshe Carmeli is another article in which recent theoretical constructs (in this case, the Newman-Penrose constants) in relativity theory are elucidated in terms of standard mathematical constructs.

Peter Szekeres discusses a treatment of the gravitational field equations for the propagation of gravitational waves in a material medium analogous to the macroscopic treatment of Maxwell's equations. He derives "macroscopic" Bianchi identities for the Weyl tensor and a "dielectric constant of gravitation."

A general relativistic kinetic theory of gases provides a way of completing the Einstein equations for a material system without the need for an equation of state. In addition such a theory is of considerable astrophysical interest

—for example, analysis of the cosmic blackbody radiation. Jürgen Ehlers gives a brief survey of the present state of relativistic kinetic theory and a list of references suitable for further study in the subject.

There are a total of 36 contributed articles. Most of the articles are not suitable reading for the nonexpert in relativity and gravitation, one exception being Sciama's article on cosmology. For the expert, the book is useful (though not absolutely necessary).

FRANK J. ZERILLI

Department of Physics, University of North Carolina, Chapel Hill

Guide to Volcanology

Volcanic Landforms and Surface Features. A Photographic Atlas and Glossary. JACK GREEN and NICHOLAS M. SHORT, Eds. Springer-Verlag, New York, 1971. xxvi, 520 pp. \$32.

This handsome volume consists primarily of approximately 425 excellent photographs of terrestrial volcanic features and 8 of features on the moon, contributed by 90 different persons and institutions all over the world in addition to the editors. Each has an explanatory caption ranging from a few lines to half a page long. The photographs are arranged in categories, such as phenomenology of eruptions (views of active lava flows, fountains, lakes, glowing avalanches, and so on), calderas, volcanic cones (external form and internal structure), craters, domes, spines, necks, features of mud flows, lava flows, and pyroclastic deposits, erosional features in volcanic rocks, geysers and other hydrothermal phenomena, and lunar features.

The volume starts with a brief summary of volcanic processes, products, and structures by the late Arie Poldervaart. Particularly good features are a very short summary of the factors involved in eruptive behavior of gas-charged magma and an excellent bibliography. A few errors, such as the interchanging of figures 3 and 4 and symbols in figure 10, no doubt are due to the fact that proofs could not be checked by the author.

The endpapers of the book are a map showing the "principal" calderas and active subaerial and submarine volcanoes of the world.

Pages 457–513 are a glossary of volcanic and related terms, which the editors credit largely to the unpublished

third edition of the American Geological Institute's *Glossary of Geology and Related Sciences*. Comments have been added by Green. The glossary certainly will be useful to readers not already acquainted with volcanic terminology, and occasionally even to specialists.

The editors state that their primary purpose was to assemble for comparative and illustrative purposes, as an aid in teaching geology and geophysics (perhaps particularly geomorphology) and in interpreting photographs of objects on the surface of the moon and inner planets, a photographic record of nearly all types of terrestrial volcanic surface features that have thus far been described. This objective has been admirably achieved. It is questionable, however, whether the editors have achieved their further goal of keeping the book simple and general enough to be useful at the secondary school level or to the nonprofessional, except as a picture book. Probably unavoidably, too many technical terms have been used. Thus, for instance, few secondary school students or teachers, and for that matter not even all petrologists, will know what is meant by ijolite without looking it up, and it is not listed in the glossary. But to put the text wholly in terms familiar to the secondary school student would have greatly reduced its usefulness to geologists and college students of geology.

Some errors, mostly minor, are scattered through the text. For example, the structures shown in plate 149A are a consolidation effect known as "dendritic" lava, not lava cascades as is stated; Katmai Caldera (plate 101B) is now generally believed to have formed principally by collapse, not by explosion; Haleakala Crater (plate 27B) has been shown to be primarily erosional, not the result of "some explosion and much subsidence"; sharkskin pahoehoe (plate 145B) is formed by escaping gas bubbles, not by the pulling apart of plastic surfaces. A few names of persons are misspelled. Such errors will probably not be important to most readers, but persons using the material for research purposes should check the original literature.

This is a volume that most persons with a close interest in volcanoes will want to own and that all persons engaged in the interpretation of photographs of lunar and other planetary features should own and study.

GORDON A. MACDONALD
*Hawaii Institute of Geophysics,
University of Hawaii, Honolulu*