er, since Cohen leaves the history of that style largely unexamined, it is not clear precisely how much its development and adoption ought to be attributed to Newton. Cohen grants that that style was to some extent used by Archimedes, Ptolemy, Kepler, Galileo, and Huygens, among others, but he argues that Newton "transformed" it into his own style, which more completely represented reality and treated causes. Yet taking Newton's physics more into account might reveal his greater success with this style as being due primarily to his greater success with the physics itself, allowing him to apply it more deeply to more phenomena. Huygens, for example, whose *Traité de la lumière* was composed just a few years before the *Principia*, appears to me as adept at the Newtonian style as Newton. If he was unable to proceed further with optics, it was because of the limits of his physical conceptions and the relatively undeveloped state of optical science, and not because of his style.

Newton's own work in optics presents similar difficulties for Cohen's account. It appears to me that much of the Newtonian style is already evident in the *Optical Lectures*, Newton's first physical treatise, composed between 1670 and 1672. One reason this may not have been evident to Cohen is that he draws a more rigid distinction between Newton's mathematical and experimental sciences than Newton himself did. In addition, Cohen's concept of Newtonian style is too closely associated with Newton's later and more successful mechanics, whereas Newton's announced goal in his *Optical Lectures* was to present a mathematical science of color and not physical optics or mechanical models of light. Newton was only partly successful in fulfilling his goal, but, as with Huygens's optics, I would not attribute his failure to the lack of the style he supposedly developed only a decade later.

In the second part of his book Cohen presents his concept of the "transformation" of scientific ideas. By invoking a series of transformations he attempts to establish a relatively continuous account of scientific change in contrast to Thomas Kuhn's depiction of discontinuous scientific revolutions. However, I found Cohen's concept of transformations, like Kuhn's of paradigms, too broad and vague, encompassing "a fact of experiment or observation, a method, a theory, or a concept," and I do not think that this otherwise useful concept can alone bear the burden of accounting for scientific change. Cohen promises a separate book on scientific transformations, and a more detailed presentation may well resolve these problems.

Cohen artfully interweaves the two parts of his book by illustrating his concept of transformations with examples drawn from Newton's physics. His treatments of Newton's concepts of inertia and force and his third law of motion are particularly perceptive and enlightening. Although his concepts of style and transformation may require further elaboration and precision, Cohen presents them in a lucid, stimulating manner.

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Nuclear Physics

Exotic Atoms '79. Fundamental Interactions and Structure of Matter. Proceedings of a course, Erice, Sicily, Mar. 1979. KENNETH CROWE, JEAN DUCLOS, GIOVANNI FIORENTINI, and GABRIELE TORELLI, Eds. Plenum, New York, 1980. x, 404 pp., illus. $45. Ettore Majorana International Science Series, vol. 4.

Exotic atoms are atoms in which an exotic particle is bound to other, nonexotic constituents like electrons, protons, and nuclei through electromagnetic interaction. Which of these charged particles should be called exotic has not been unambiguously defined. However, if one adopts the view that the word "exotic" stands for rare, short-lived, and artificially created, then the class of exotic atoms may range from positronium to baryonium, the bound states of e^+e^- and $p\bar{p}$ respectively.

Light exotic atoms have played an important role in the development and tests of the concept of quantum electrodynamics. This is particularly evident for the positively charged leptons positron and muon, e^+ and μ^+. Compared with hydrogen, they offer the advantage of the absence of any strong interaction effects. More and more refined measurements, particularly in muonium, have stimulated a step-by-step improvement of quantum electrodynamic theory. As V. W. Hughes points out in the first two papers of the book reviewed here, even the tiny contribution of the weak interaction predicted by unified gauge theories may eventually be isolated in such experiments.

Exotic atoms are well suited for the study of fundamental interactions. Replacing an electron or a proton by a muon, pion, kaon, or antiproton results in drastic changes of atomic parameters like mass and radius, and as a consequence the higher orders of the basic interaction between the particles involved become more pronounced. Also, in exotic atoms the contributions of other fundamental interactions may be enhanced enough to be measurable. Several papers in the first section of the book deal with issues of this kind. Muon capture in hydrogen by weak interaction is sensitive to the pseudo-scalar coupling strength. Recent experiments are discussed by J. Duclos. Anomalous muon capture by processes in which the common laws of lepton number conservation are violated is treated by B. Hahn and T. Marti, with new upper bounds for such processes. P. G. H. Sandars reviews closely related experiments in nonexotic atomic physics that look for parity nonconservation in atoms and molecules. Results in this field are somewhat contradictory; improved experiments with better systems are under way. L. Grenacs, in a paper on polarization experiments in the Godfrey-cycle for the $A=12$ mass triplet, confirms that the weak magnetism found in the β^- decay of ^{12}B to ^{12}C also is found for the corresponding μ^- capture in ^{12}C. The experiments exclude the presence of second-class axial vector currents in β-decay.

The second section of the book deals with quark atoms, which are defined as heavy quark-antiquark systems like proton-antiproton ($p\bar{p}$). T. Appelquist reviews developments in theory and experiments, particularly those concerning the lifetime and decay modes of such systems, from the perspective of quantum chromodynamics. J. Rafelski and R. D. Viollier consider refined approaches to the potential of quark-antiquark pairs, and H.-M. Chan illuminates the question whether bound systems like $p\bar{p}$ should be considered as a nuclear atom consisting of two oppositely charged nucleons or as a color molecule consisting of two quark-antiquark pairs.

The remaining two sections of the book are devoted to muons in chemistry and solid-state physics. The liaison between the sections on fundamental interactions and those on applications to the structure of matter seems artificial at first; however, the particles and the accelerators, and quite often the scientists, are identical for these studies. There is also quite a large overlap in instruments and experimental know-how.

The third section contains papers devoted to questions of atomic capture and transfer processes of muons and fast muonic chemistry by M. Leon, H. Schneuwly, A. Bertini, A. Vitale, and J.

Rafelski. Nearly all of the material presented in these papers is based on measurements in atomic or molecular hydrogen and deuterium, the most interesting and basic systems in which the data can be interpreted with little ambiguity. The experiments provide unique information hardly accessible in other investigations and underline the important role of muons in these fields.

The last section of the book is equal in length to the other three. Its topic is muon spin rotation or resonance. In contrast to the preceding sections, most of the contributions (by A. M. Stoneham, D. Richter, H. Teichler, E. Karlsson, M. Leon, P. F. Meier, and E. Roduner) are not comprehensive for certain subfields but group reports from the world's leading meson factories in the United States, Canada, and Switzerland. The majority of studies seem to be devoted to positive muons in metals. This may be because μ^+ particles retain their polarization in a metallic environment quite well. Muons behave here like light protons.

In fact, scientific interest in the behavior of hydrogen in metals is still growing. The muon spin rotation technique could well fill an important gap regarding processes in the microsecond-to-nanosecond time scale and shed some light on the quantum nature of muon diffusion in metals. Altogether this section is a lively account of the ongoing activities in a rapidly developing field.

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Mineralogic Thermodynamics

Thermodynamics of Minerals and Melts. R. C. NEWTON, A. NAVROTSKY, and B. J. WOOD, Eds. Springer-Verlag, New York, 1981. xii, 304 pp., illus. $39.80. Advances in Physical Geochemistry, vol. 1.

The potential for the quantitative application of thermodynamic data and principles to the solution of petrologic and mineralogic problems is great and widely recognized among earth scientists. For example, given equations of state for silicate liquids and for the solid phases that crystallize from them, phase diagrams describing the melting phenomena of rocks could be calculated and the evolution of melts in planetary interiors or on planetary surfaces could be modeled without the need, as is now the case, for detailed experimentation on each composition that might be encountered. In metamorphic petrology, knowledge of the equations of state of the mineral phases found in a rock can permit precise determination of the values of such variables as the pressure and temperature at which the rock formed, essential information for deciphering the geological history of the region from which the rock came.

A number of developments in the last 30 years have stimulated a large amount of interest in such applications of thermodynamic principles. Some of the more important developments have been the introduction of apparatus and techniques for routine phase equilibrium experimentation at pressures above 1 atmosphere and in the presence of volatiles, the development and availability of the electron microprobe, the growth of the study of stable isotope geochemistry, the introduction of equations of state adequate to model the solution chemistry of naturally occurring minerals and silicate melts, and improvements and developments in high-temperature calorimetry applicable to silicates.

That this is a rapidly developing field is amply demonstrated by the bewildering number of workshops, symposiums, textbooks, handbooks, and monographs that have recently appeared on the subject. *Thermodynamics of Minerals and Melts* is the first of a promised series of books (Advances in Physical Geochemistry) that will provide a forum for the publication of original contributions and reviews on topics in mineral thermodynamics and kinetics and on their application to problems in earth and planetary sciences.

The book is divided into two major sections. The first deals with the thermodynamics of mineral systems. The papers in this section cover a wide range of topics, including the principles and application of stable isotope geothermometry, the development and application of the garnet-plagioclase-Al_2SiO_5-quartz geobarometer using the best available phase equilibrium and calorimetric data, and the inversion of phase equilibrium data obtained between 1 atmosphere and 40 kilobars to a self-consistent set of equations of state for pyroxenes in the system $Mg_2Si_2O_6$-$CaMgSi_2O_6$. The papers are generally informative and well written, but nonspecialists will have trouble with many of them. My only disappointment is that the authors have chosen, for the most part, to limit themselves to characterizations of the thermodynamics of mineral systems and have stopped short of applying their contributions to geological problems even when it is clear that such applications are possible.

The second section of the book, on the thermodynamics of melt systems, contains excellent papers on a wide range of topics; especially important are those papers on thermodynamic modeling of silicate melts and glasses. Here again there is little emphasis on the applications of the thermodynamic models to geological problems. In this case, however, it is clear that this reflects, at least in part, the state of the art in the application of thermodynamics to melt-bearing systems; the current emphasis is on reproducing simple experimentally determined phase diagrams and on developing appropriate solution models for molten silicates. It is a curious irony, however, that the one paper that takes an empirical approach to modeling crystallization of silicate melts and eschews a fundamental approach based on thermodynamics is successful not only in reproducing simple phase diagrams but also in predicting the crystallization behavior of complex natural silicate melts. The reader is left to wonder when the fundamental approach will reach this stage.

In summary, the appearance of this book and the series it begins are timely in view of the growth and interest in the theory and application of thermodynamics to petrology and mineralogy. This book is not for beginners or for those interested primarily in seeing how thermodynamics can be applied to geological problems, but for researchers and advanced students in mineralogy and petrology many of the papers will be required reading.

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Eocene and Earlier Deposits

Advances in San Juan Basin Paleontology. SPENCER G. LUCAS, J. KEITH RIGBY, JR., and BARRY S. KUES, Eds. University of New Mexico Press, Albuquerque, 1981. xii, 394 pp., illus. $27.50.

During the latest Cretaceous and the early Tertiary the San Juan Basin, in the northwestern corner of New Mexico, was the site of deposition of a thick sequence of terrestrial sediments. Although particularly well known for their concentrations of fossils of Paleocene age, documenting the evolution of mammal-dominated faunas immediately after the extinction of the dinosaurs, these strata have also yielded records of Cretaceous and Eocene biotas.