omitted. Nonetheless, there is no volume that provides a better collection of ideas on mate choice. If you are interested in mate choice you must read this book.

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The Plasma State

Physics of Ion-Ion and Electron-Ion Collisions. F. BROUILLARD and J. W. MCGOWAN, Eds. Plenum, New York, 1983. xii, 538 pp., illus. $69.50. NATO Advanced Study Institutes Series B, vol. 83. From an institute, Baddeck, Nova Scotia, Canada, Sept. 1981.

The study of matter in the ionized and plasma state encompasses a wealth of interesting problems associated with the various subfields of physics. It exhibits its closest connection with atomic and molecular physics, and the present book establishes that connection quite firmly by illustrating how atomic and molecular physics provides the key to understanding the structure and underlying collisional energy pathways of the plasma state.

The book serves as another excellent reminder of the significant advances that have been made in the past 25 years in the field of atomic and molecular physics and of the contribution the field has made to the study of astrophysics, controlled thermonuclear fusion, and lasers. It provides a clear review of the ionized state in astrophysics and in thermonuclear fusion, together with detailed discussions of the appropriate theoretical quantum mechanics and laboratory experiments for the rates and cross sections of certain specific collisional mechanisms.

Not only does the formation of a plasma in the laboratory represent a complex sequence of atomic and molecular energy-change processes, the plasma state, which may last anywhere from a few microseconds in some high-energy plasmas to a few hours (as in a low-density glow discharge), is controlled by a dynamic balance of various recombination-dissociation processes.

The recombination of electrons and of ions to form neutralized species, or other ion-pair systems, determines the ionization structure of plasmas. The analysis of the recombination spectrum associated with the removal of the excess energy of recombination by the emission of radiation is a powerful diagnostic probe of the physical environment in which the emitting species resides. The formation of ion pairs H^+ and H^- by dissociative recombination between electrons and hydrogen molecular ions has attracted considerable attention from the thermonuclear fusion community, which is interested in producing high-current H^- ion sources for neutral beam injectors.

Dalgarno sets the astrophysical scene in a particularly interesting, lucid, and engaging chapter on the roles of electron-ion and ion-ion collisions in astrophysics. The physical conditions here range from the cold, weakly ionized molecular clouds associated with gaseous nebulas (for which the sources of ionization are energetic cosmic rays) to the hot, highly ionized solar and stellar corona (for which the sources of ionization are thermal electrons heated by shocks driven by supernova explosions in the disk of the galaxy, supplemented by absorption of x-ray and ultraviolet photons associated with the recombination spectrum) and comets and planetary atmospheres (which are ionized by solar ultraviolet radiation). The chemical energy-change pathways appropriate to the various physical conditions are concisely described by Dalgarno.

Post then provides a comprehensive account of the role of atomic collisions in magnetic and inertial controlled fusion research. He discusses the hot central plasma, where fusion reactions occur; the plasma edge, where the plasma interacts with the external environment; methods for the production of the hot plasma; and techniques for the diagnosis of the physical properties of the plasma. Both Dalgarno and Post furnish fairly exhaustive lists of references.

The subsequent ten chapters deal with the theoretical and experimental methods required to yield detailed cross-section information on specific collisional mechanisms, such as electron impact excitation and ionization of atoms and ions, electron-ion and ion-ion recombination, and ion-atom charge transfer collisions.

Although quantum mechanical scattering theory is in principle a well-documented subject, extensive theoretical development is still required for implementation of the various working models associated with the various collisional mechanisms. Also, the recent advent of intersecting beam ion traps and laser excitation techniques has provided much more sensitive and wide-ranging approaches to recombination experiments than were previously available.

The present vigor of the field is well characterized by the theoretical developments and new experimental techniques discussed in this book. Although the list of processes discussed is fairly complete, a few chapters, particularly those dealing with high-energy collisions, are quite routine and could have been replaced by chapters dealing with current research on the theory, say, of ion-molecule state-to-state collisions and reactions at thermal energies and of ion-ion recombination in dense plasmas. The inclusion of such work would have been more appropriate to the chemistry of the interstellar medium and would have provided greater balance to the book.

My enjoyment in reading the book was somewhat marred by the well-above-average number of typographical errors. All in all, however, the book is thoughtful and stimulating. It would prove invaluable not only to active researchers in the appropriate fields but also to those interested in reviewing the great contribution that atomic and molecular physics has made to astrophysics and to fusion programs.

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The Planet Venus

Venus. D. M. HUNTEN, L. COLIN, T. M. DONAHUE, and V. I. MOROZ, Eds. University of Arizona Press, Tucson, 1983. viii, 1143 pp., illus. $49.95. Space Science Series.

Venus is closer to the sun than Earth is, yet it absorbs less sunlight than Earth. In spite of this, its surface temperature is maintained at a baking 730 K because of effective blanketing by a thick atmosphere that blocks the loss of thermal radiation to space. The atmosphere contains an opaque cloud deck whose major constituent is sulfuric acid. Photochemical production of the acid at high levels is balanced by destruction in the lower atmosphere, or perhaps even by a cycle that involves the planetary surface and geological processes. The solid body of the planet rotates very slowly (period 243 days) in a retrograde direction, but the atmosphere at the level of the cloud deck rotates at the robust rate of about once every four days. Although very similar to Earth in mass and size, Venus possesses only a trace of the volatile compound most abundant on Earth, water. It shows no evidence yet discernible of the kind of tectonic activity that dominates terrestrial surface geophysics.

Altogether, Venus is an interesting planet and provides a humbling example of the diverse consequences of the laws

of nature even for quite similar systems such as nearest-neighbor planets. The Soviet Union has systematically pursued exploration of Venus since 1967 with its Venera series of probes. The most recent of these carried imaging experiments that returned the only existing pictures of the planetary surface. The United States program included most recently the highly successful Pioneer orbiter-probe mission in 1978, whose orbiter is still in operation. This book grew out of a post-Pioneer international conference. The timing for a summary book is good, since there has been time for the community to digest the Pioneer results and there will probably not be a new infusion of data of comparable magnitude until the NASA radar mapping orbiter mission of 1988.

The ambitious purpose of this book is to present the whole subject of the planet Venus, and it succeeds. Chapters by Seiff, by Tomasko, and by Taylor, Hunten, and Ksanfomality present the atmospheric thermal structure and treat the question of its maintenance. There is no longer any question about the validity of the greenhouse explanation for the high surface temperature. Measurements of the temperature profile and of the solar flux reaching the planetary surface are firmly in hand. Infrared flux measurements are still uncertain, however, and so is the explanation for the precise value of the subadiabaticity of the lower atmosphere, a crucial quantity controlling atmospheric dynamics. Composition, photochemistry, and clouds and hazes are treated in chapters by von Zahn, Kumar, Niemann, and Prinn, by Krasnopol'sky and Parshev, and by Esposito, Knollenberg, Marov, Toon, and Turco. In spite of a wealth of new information there are still questions about chemical cycles and atmospheric history that will require for their answers more precise composition information and probably also cloud particle composition determinations in situ. Donahue and Pollack review the atmospheric evolution question. Geophysical fluid dynamicists will find from Schubert's chapter that the puzzle of Venus's atmospheric super-rotation is still a puzzle. Truly diagnostic information on momentum transfers has not yet been obtained. Topographic results from the Pioneer radar experiment are discussed by McGill, Warner, Malin, Arvidson, Eliason, Nozette, and Reasenberg. Venus has a unimodal elevation spectrum strikingly different from that of Earth, but horizontal resolution of only 100 to 200 kilometers renders detailed interpretation difficult. The upcoming radar mission will improve the situation. Other chapters discuss geophysics, aeronomy, and interaction with the solar wind. About half the chapters treat specific experimental results, rather than provide summary reviews; most of these chapters are by U.S.S.R. Venera experimenters.

In my opinion this book accurately reflects the state of the subject. It is long and there is overlap among chapters, but opinion is divided on many subjects and different points of view are useful. This book will remain the standard reference on Venus for many years. It is written for an audience of scientists, such as readers of this magazine, and will be particularly rewarding for those involved in terrestrial atmospheric science or geophysics.

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Precambrian Geology

Geological Evolution of the Earth During the Precambrian. LAZARUS J. SALOP. Springer-Verlag, New York, 1983. xii, 460 pp., illus. $65.80. Translated from the Russian edition (Lenigrad, 1982) by V. P. Grudina.

This new book by Lazarus J. Salop, of the All-Union Geological Research Institute in Leningrad, presents a succinct statement on Earth's evolution during the Precambrian. The book consists of an introductory chapter on the methods and principles of Precambrian division; a chapter for each of Salop's six main chronostratigraphic divisions; and a concluding synthesis. The main contribution of the book lies in the description and interpretation of 75 key lithostratigraphic sections as a basis for the recognition of natural stages in the evolution of Precambrian continental crust.

In Salop's unique time classification the five larger Precambrian units (megacycles—comparable to eras), are separated by first-order global orogenies, named, from oldest to youngest with respective terminal orogeny and age in parentheses, as follows: Archean (Saamian, 3.7 to 3.5 billion years), Paleoprotozoic (Kenoran, 2.8 to 2.6 billion years), Mesoprotozoic (Karelian, 2.0 to 1.9 billion years), Neoprotozoic (Grenville, 1.0 billion years), and Epiprotozoic (Katangan, 0.7 to 0.6 billion years). These units correspond almost exactly to the more conventional fivefold division of the Precambrian. Salop's rejection of the conventional classification is based upon his perception of the Saamian orogeny as the most important turning point in geologic history, separating the Precambrian into its two largest time divisions (megachrones), each with conspicuously distinctive thermal-tectonic regimes. This division, combined with the equally distinctive organic record of the last 570 million years, leads Salop to divide all geologic history into Archean, "dawn of life" (more than 3.5 billion years ago), Protozoic, "primitive life" (3.5 to 0.57 billion years ago), and Phanerozoic, "true (or evident) life" (0.57 billion years ago to the present)—apparently a logical global tectonobiostratigraphic synthesis. However, the synthesis turns on the validity of considering the Saamian orogeny as the key turning point in geologic history. And this will be the parting of the ways for many. According to Salop, Archean rocks, which form basement to all remaining geologic formations, are uniquely characterized by high-grade metamorphism (especially granulites), ubiquitous though irregular granitization and migmatization, and dominance of plastic deformation. In other words, all Earth's high-grade metamorphic terrains are considered by Salop to be older than 3.5 billion years. Many will be surprised to see, for example, that as a result of this unusual interpretation most of the Grenville and much of the Churchill province of the Canadian Shield are classified as more than 3.5 billion years old. The more conventional viewpoint is that high-grade metamorphic rocks have been developed periodically throughout geologic history and thereby lack any first-order temporal significance. According to this view the Saamian orogeny is just one in a series of global orogenies, no more important in the geologic scheme of things than, say, the Kenoran orogeny. In sum, the basis for Salop's classification and terminology appears to be dubious.

The bulk of the book is devoted to the stratigraphic columns. The substance of the columns is neatly summarized in two introductory tables of lithostratigraphic units arranged by era and including individual name, age, and characteristics. The stratigraphic columns and accompanying descriptions provide a useful global compilation of Precambrian lithostratigraphy, the columns illustrating the less-well-known Siberian and European (Russian) platforms in particular. However, some proposed global stratigraphic correlations are highly suspect. Further, Salop proposes global thermal trends that are based on uncritical acceptance of stable isotope interpretations. His system of Precambrian subdivision is based