Book Reviews

Particulate Matter in Space

The Dusty Universe. Proceedings of a symposium, Cambridge, Mass., Oct. 1973. GEORGE B. FIELD and A. G. W. CAMERON, Eds. Published for the Smithsonian Astrophysical Observatory by Neale Watson Academic Publications, New York, 1975. x, 324 pp., illus. $15.

Interstellar dust grains constitute only about 1 percent (by mass) of the matter in space, but their light scattering and absorbing properties, their interaction with the ambient rarefied gas, and their role in the formation of stars and planetary systems combine to make them a subject of intense interest to astrophysicists. Interplanetary dust and debris represent the material from which the solar system formed; scientists studying the early history of the planets must therefore examine the nature of this material as well.

Traditionally astronomers have treated interplanetary and interstellar grains in quite different manners, and indeed very few researchers have attempted to study both. This division of effort arose for a combination of reasons, based largely on the separate historical development of and the differing techniques used in research on the solar system and on the interstellar medium. In a modern view of the universe it is clear that a neat dichotomy between interplanetary and interstellar dust is not realistic. Stars and planetary systems form out of condensations in the interstellar medium, and the supply of interstellar gas and dust is replenished by the ejection of matter from stars.

The Dusty Universe, which contains papers from a symposium honoring Fred Whipple, a pioneer in research on interplanetary material, is partly intended to bridge the gap between the two disciplines. Although it does succeed in collecting papers from both under one cover, the dichotomy persists except in the opening paper by A. G. W. Cameron and a discussion of grain condensation processes by Lawrence Grossman. The remaining 11 papers are devoted to research within one discipline or the other. It may be surmised that the greatest benefit of the symposium was the informal interaction among the astronomers present; perhaps research efforts begun in the hallways there will eventually fulfill the hopes of the conference organizers.

The book contains several outstanding papers, however, and may be recommended on that basis. A particularly good example is Grossman's paper, which describes thermodynamical model calculations of the condensation of solids during the cooling of the presolar nebula. Even though the quantitative details are omitted, the discussion of the results makes it clear that this is a promising line of research for understanding the composition of meteoritic material, and hence the condensation process itself. Furthermore, Grossman's models have special relevance to the purpose of this volume in light of the evidence, discussed in the chapter by George Field, that interstellar grains may have formed under similar conditions by similar processes. As Grossman points out, these similarities may indicate that his type of theoretical approach can be extended into the interstellar realm.

Among the remaining contributions, the papers by E. E. Salpeter on grain formation in stellar atmospheres and by Peter Millman summarizing the distribution and properties of interplanetary dust stand out, the former for its concise depiction of a very complex process, and the latter for its broad perspective and unifying overview. Finally, the short chapter by E. M. Purcell on interstellar grains as pinwheels, which describes a marvelously simple mechanism for inducing suprathermal rotation in grains as a result of collisions with gas atoms, not only makes good reading but in addition outlines a process that may be of far-reaching importance for understanding the alignment of grains in space, a long-standing problem.

Some of the remaining articles are too brief or are reiterations of material already summarized in many places. Despite such flaws and despite its general failure to stress sufficiently the relationship of interstellar and interplanetary grains, *The Dusty Universe* is a useful compendium for advanced students in astronomy or specialists in related fields.

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Celestial Mechanics

Interplanetary Encounters. Close-Range Gravitational Interactions. ERNST J. ÖPIK. Elsevier, New York, 1976. viii, 156 pp., illus. $26.95. Developments in Solar System- and Space Science, 2.

Understanding the dynamical history of the solar system requires discovery of the principles governing its behavior on a time scale of $\sim 10^{10}$ years, far beyond the 10^4 to 10^5 years accessible to direct numerical integration. On this long time scale the orbital evolution of "stray" bodies, such as comets, meteorites, planet-crossing asteroids, and primordial planetesimals, is essentially stochastic. This situation arises because the orbital perturbations associated with close planetary encounters are extremely sensitive to the minute details of previous encounters. Öpik's major contribution to this field has been to turn this difficulty into an asset by developing probabilistic methods for dealing with the orbital evolution of a swarm of small bodies with similar initial orbits. This development has played a major role in recent progress toward understanding the history and origin of these important interplanetary bodies.

Until the appearance of this book, most of this work by Öpik had been scattered through several journals and relatively obscure observatory reports, and although many have made use of his conclusions, few have worked through the theory that led to them. The theory is presented here in a systematic manner and may now receive the attention it deserves. The book is by no means a collection of reprints, but rather represents an original unification of the previous work, in some cases involving quite different derivations of the same results.

This is very much Öpik's book, in that little space is given to discussing the contributions of those who have extended the work during the past decade. To some extent this limitation seems to arise from Öpik's strong preference for analytical results over numerical simulation by means of computers. There is merit in this view, but the limitations of the analytical approach show forth in the difficulty of dealing in a straightforward way with some of the more complex problems of the real solar system, such as the common situation of a "stray" body simultaneously crossing the orbits of several planets. In contrast, this problem is readily amenable to the numerical Monte Carlo extension of Öpik's theory developed by Arnold. There is value in both the analytical and the numerical ap-

proach, and a more complete treatment of this subject will require filling in of the latter. Also lacking in the book is discussion of other phenomena that may affect long-term orbital evolution, such as the effect of the nonlinear interplay of the secular resonances discovered by Williams with close planetary encounters. In some cases, further work on such phenomena calls into question the validity of some of Öpik's conclusions.

These omissions need not be a problem, provided the reader regards the book as an introduction to the important field that Öpik pioneered. It may be hoped that its availability will result in more scientists' becoming his followers.

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Island Biota

Biogeography and Ecology in the Canary Islands. G. G. KUNKEL, Ed. Junk, The Hague, 1976. xvi, 512 pp., illus. + plates. Dfl. 160. Monographiae Biologicae, vol. 30.

Papers giving information about the natural history of the Canary Islands are countless and are scattered through periodicals that are often difficult to obtain. A summary of the subject has long been desired. Considering the difficulties of getting various specialists to write articles that together represent a substantial part of the disciplines included in "biogeography and ecology," the book Kunkel has produced is reasonably well balanced. Beyond the scope of the title, however, are contributions on place names and biochemistry. An analysis of the economic history of the islands from clearing time to tourism time would certainly have been more appreciated. The volume is attractively got up, with good illustrations. Extensive reference lists enhance its value.

The individual islands are introduced at the beginning. Together they form a chain that geographically can be considered a prolongation of the Atlas range. Hypotheses about the origin of the archipelago are numerous. According to one the islands were once part of Africa, later breaking away and drifting westward. According to another they arose as independent volcanoes from the sea bottom. Finds of fossil ostrich eggs and land turtles seem to imply that land bridges to the Continent once existed. Strictly geological facts, on the other hand, irrefutably favor a purely oceanic origin. Relevant data are still insufficient, and in this volume a comprehensive report, mainly stratigraphical and petrographical, on recent progress in the geology of the islands takes a cautious attitude.

Solution of the origin problem would offer the biogeographers a firm base for discussion of the controversial question of how the archipelago received its biota. The uncertainties notwithstanding, it is generally agreed that the islands became refuges for a once widely distributed Tertiary biota which was largely exterminated in the Tethyan area as a result of catastrophes such as the desiccation of the Sahara and the extension of polar ice caps. In a paper on endemic vascular plants paleobotanical and biogeographical arguments are given for this view. For example, certain genera and families common to the Canary Islands and America but now absent from the Mediterranean area are also represented in southeastern Asia. Furthermore, primitive floral features such as higher proportions of diploids and woody forms are typical of the archipelago as compared with the Continent, where survivors had to evolve in response to more drastic climatic changes. The island isolation led to a biota very rich in endemic species and also with many endemic genera.

Indigenous mammals are absent, but a fossil rodent is known. Probably the entire fauna was once richer than it is today. A paper on recent ground beetles of laurel forests, a faunal group extremely rich in endemics, indicates that volcanic activity may have been important for the development of the fauna. The westernmost islands, Hierro and La Palma, with surface rock from relatively recent geological times, are unexpectedly poor in species compared with their next neighbor island, Gomera, which was undisturbed for a long period. On Tenerife, the middlemost island, recent patterns of distribution indicate that the fauna of an intermediate zone was not too long ago exterminated by deposition of volcanic material. Through resulting isolation vicariants evolved in the remaining zones, contributing to an especially great wealth of forms.

Other papers in the volume deal with climate, the laurisilva flora of Hierro, lichen flora and vegetation, fungus flora, bird fauna (rich in species, poor in endemics), amphibian and reptile fauna (poor in species, rich in endemics), and limnetic Crustacea.

The rapidly accelerated influence of man on vegetation and soil is accentuated in an account of introduced floral elements and exemplified by a report on recent developments on Hierro. In these and several of the other papers mentioned it is stressed that certain species of plants and animals are on the point of being exterminated. Nature conservation is young in this part of the world, and the work before ICONA (Instituto Nacional para la Conservación de la Naturaleza) is enormous if the islands are to keep the character of a unique refuge. In the last page of text the pious hope is expressed that leaders of tourist groups could by increasing public interest contribute to the conservation of the biota. Perhaps it would be a good opening to put the present book in their hands.

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Nonlinear Optics

Quantum Electronics. A Treatise. Vol. 1, Nonlinear Optics. HERBERT RABIN and C. L. TANG, Eds. Academic Press, New York, 1975. In two parts. Part A. xii pp. + pp. 1–472, illus. + index. $35. Part B. x pp. + pp. 473–754, illus. $22.50.

The origins of nonlinear optics are linked to the advent of powerful laser light sources some 15 years ago. This very active and still vigorously growing field is concerned with the interaction of light with matter at high intensities where the material properties, notably the dielectric susceptibilities or optical refractive indices, are themselves functions of the light-field strength. Nonlinear optics has not only led to the discovery of interesting new effects and phenomena, it is providing powerful new spectroscopic tools to study the structure of matter, and it has become the basis for an increasing number of technical applications and practical devices.

Although some of the basic concepts of nonlinear optics have become standard material in textbooks, there remains a need for up-to-date and in-depth reviews of the many research results and important details scattered throughout the primary literature. Volume 1 of *Quantum Electronics*, a well-organized and well-edited collection of reviews of selected topics, meets this need admirably. The emphasis in most of the papers is on the nonlinear optical properties of crystalline solids. Other important developments of much current interest, such as nonlinear high-resolution laser spec-