BOOK REVIEWS

Progress in the Infrared

Infrared Astronomy with ISO. TH. ENCRENAZ and M. F. KESSLER, Eds. Nova, Commack, NY, 1992. xxviii, 547 pp., illus. $132. Les Houches Series. From a workshop, Les Houches, France, June 1991.

Ten years ago the Infrared Astronomical Satellite (IRAS), a joint project of the United States, the United Kingdom, and the Netherlands, opened our eyes to the infrared sky for the first time by making an all-sky survey at four wavelengths between 12 and 100 micrometers. The helium-cooled 60-centimeter telescope, operating in the cold, black night of space, was able to make observations with a thousand times more sensitivity than ground-based or airborne telescopes. IRAS revealed a great variety of new phenomena that continue to make news today—from protostars and protoplanets to protogalaxies, from the large-scale structure of the solar system and the Milky Way to the large-scale structure of the universe.

The exciting prospects of following up these discoveries with another sensitive space telescope, the European Space Agency's Infrared Space Observatory (ISO), are ably described in this volume of proceedings. The ISO satellite will be launched in 1995 and will operate for 18 months as a general-purpose observatory enabling astronomers from around the world to obtain images and spectra of thousands of individual sources.

The present proceedings will be of interest to specialists in infrared instrumentation, who will find papers on each of the four ISO instruments, and to anyone interested in a snapshot of infrared astronomy on what the editors thought would be the eve of ISO's launch. (The launch, originally scheduled for late 1993, has been delayed until 1995 owing to technical problems.) The first part of the book, describing the ISO mission, the observing procedures, and the instruments, is essential reading for any astronomer interested in submitting a proposal for use of some of the more than 60 percent of the time that will be open to guest observers.

This volume contains useful reviews of some of the many scientific disciplines that ISO will impact. In one of these Crovisier describes what infrared spectroscopy can reveal about the chemical composition of comets and how this primitive material might relate to the interstellar matter out of which our solar system formed. In others, van Dishoeck, Falgarone, and Puget discuss the chemistry, energy balance, and structure of the interstellar medium in considerable physical detail. ISO spectroscopy of molecular hydrogen (17 and 28 micrometers) and ionized carbon (158 micrometers) will be particularly important in advancing our understanding of the thermal balance of the interstellar gas.

Léger and his collaborators describe the remarkable angstrom-sized planar molecules called polycyclic aromatic hydrocarbons (PAHs) that IRAS revealed to be responsible for 10 to 30 percent of the entire infrared emission of our own and other galaxies. PAHs, containing only 50 to 100 atoms, can be heated by the absorption of single ultraviolet photons to radiate short-wavelength (1- to 30-micrometer) radiation far in excess of that expected from their equilibrium temperature of 20 to 30 K. Infrared spectroscopy by ISO will help define the molecular constituents of PAHs, including species such as coronene and ovalene, and determine the physical conditions responsible for their creation and destruction.

Moorwood and Lequeux summarize our present understanding of infrared emission from normal and active galaxies. ISO observations will be of particular importance in understanding whether ultra-luminous infrared galaxies are the precursors of quasars and whether objects like the IRAS source F10214+4724 really are galaxies in formation.

Harwit gives an informative discussion of the evolution of the early universe and the question of galaxy formation. Whether ISO results will bear on these problems remains to be seen, but Harwit and other ISO scientists are planning very deep surveys with ISO cameras to search for the most distant, youngest objects in the universe.

Under the terms of collaborations currently being negotiated with the European Space Agency, the United States and Japan will play minor roles in the ISO project in return for a small amount of guaranteed observing time; U.S. astronomers will also compete for guest-observer time. But what U.S. astronomy really needs in order to advance into this last unexplored spectral region is approval by NASA and Congress of the Space Infrared Telescope Facility (SIRTF). As SIRTF project scientist Michael Werner recounts in these proceedings, SIRTF will combine the twin revolutions of a cryogenic telescope and large arrays of infrared detectors to make an observatory thousands of times more powerful than ISO or any ground-based facility. SIRTF, the highest-priority recommendation of the National Research Council's Decennial Survey ("The Bahcall Report"), will follow up on numerous ISO discoveries and break new ground with its own deep surveys of the infrared sky. This volume describes an important component in the continuing progress of infrared astronomy where each step is thousands of times more capable than its predecessor: IRAS in the 1980s, ISO for the 1990s, and, ultimately, SIRTF in the first years of the next century.

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Future-Oriented Physics

Dynamics of the Standard Model. JOHN F. DONOGHUE, EUGENE GOLOWICH, and BARRY R. HOLSTEIN. Cambridge University Press, New York, 1992. xviii, 540 pp., illus. $100. Cambridge Monographs on Particle Physics, Nuclear Physics and Cosmology, 2.

There has been a revolution in particle physics in the last 20 years, and the rallying cry of the revolution has been the standard model. Created in 1964 principally by Glashow, Weinberg, and Salam and building on contributions from many others, the standard model is an elegant theory that has demonstrated great power in predicting experimental results in high-energy physics. A major part of most high-energy physics experiments now and for the past 15 years has been dedicated to verifying the model, measuring its parameters, or trying, unsuccessfully, to find a chink in its armor.

The standard model provides a simple and coherent framework within which most current experimental results in high-energy physics can be understood. All matter is composed of six quarks and six leptons (plus antiparticles). The weak, electromagnetic, and strong interactions between these fundamental constituents are described by the exchange of gauge bosons: the photon that mediates the electromagnetic interaction, the heavy $W^{\pm}$ and Z^0 that mediate the weak interaction, and the gluon that mediates the strong interaction. The first step in the construction of the standard model was to show that the weak and the electromagnetic interactions are not two distinct phenomena. At first sight, this was a shocking observation, since at the low energies typically available to experiment before 1980 the two interactions are strikingly different. The unity of the two interactions as two manifestations of a single electroweak interaction has now been verified to high precision.

The next step in the construction of the standard model was to apply the principles that worked so successfully in unifying the weak and electromagnetic interactions with the strong interaction. The strong interaction presents a much greater technical challenge to the theorists, but where comparisons with experiment can be made the model is remarkably successful. Virtually all of modern high-energy physics is contained in a single equation of motion that is the standard model Lagrangian.

Given the remarkable successes of the standard model, it is appropriate that books in the field no longer dwell on the development of our current understanding of high-energy physics but rather present the world as we now know it. *Dynamics of the Standard Model* by Donoghue, Golowich, and Holstein takes just this approach. Instead of showing the confusion of the '60s and '70s, the authors present the enlightenment of the '80s. They start by describing the basic features and structure of the standard model and then concentrate on the techniques whereby the model can be applied to the physical world, connecting the theory to the experimental results that are the source of its success. Because they do not dwell on ancient (pre-1980) history, the authors of this book are able to go into much more depth in describing how the model can be tied to experiment, and much of the information presented has been accessible previously only in journal articles in a highly technical form.

The approach that Donoghue, Golowich, and Holstein take in presenting their material is an unusual one. A highbrow formal theoretical approach often does not deign to teach the reader how to calculate anything of use or bother to make connections to experiment. A straightforward experimental approach tends to concentrate only on the lowest-order predictions of the model and not explore calculational subtleties of the theory. Though all of the authors are card-carrying theorists (this reviewer is an experimentalist, it must be confessed), they go out of their way to stress applications and phenomenology and to show the reader how real-life calculations of use to experimentalists are done and can be applied to physical situations: what assumptions are made in doing them and how well they work. This is of great value both to the experimentalist seeking a deeper understanding of how the standard model can be connected to data and to the theorist wanting to see how detailed the phenomenological predictions of the standard model are and how well the model works. Furthermore, the authors constantly go beyond the lowest-order predictions of the standard model to discuss the corrections to it, as well as higher-order processes, some of which are now experimentally accessible and others of which will take well into the decade to uncover. The calculations they present are sophisticated and well referenced for the reader who wishes to pursue all the details.

Another unusual feature of this book, a direct consequence of the authors' emphasis on phenomenology, is that the strong interactions are treated on equal footing with the weak and electromagnetic interactions. There are very few experimental tests of the standard model that can escape strong-interaction effects, since the real world is made of mesons and baryons, not quarks. This book includes many of the approximate methods that are used to cope with the strong interactions, and these sections constitute a valuable resource in themselves.

The theoretical development and experimental verification of the standard model have dominated high-energy physics for almost 20 years. The history is thrilling and illustrates wonderfully the deep interdependence of experiment and theory and how each supports and advances the other in this field. However, that story has been told in many excellent books, and it is exciting now to move away from the historical approach and start to confront the detailed predictions of the model. It is in a deep and detailed understanding of the phenomenology of the standard model that we can hope to find the first glimmer of the new physics that awaits us beyond its horizons.

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Life of an Evolutionist

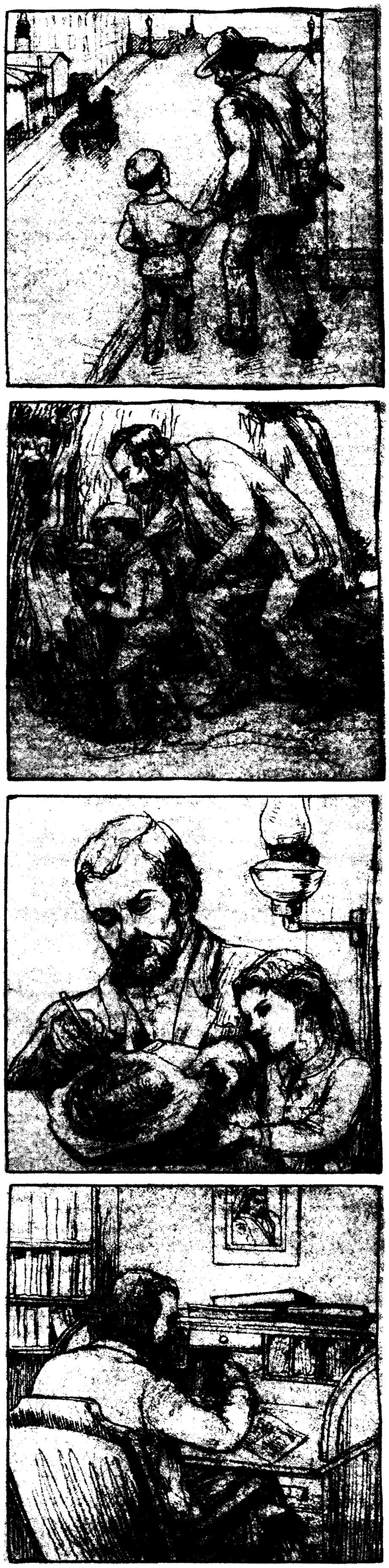
William Diller Matthew, Paleontologist. The Splendid Drama Observed. EDWIN H. COLBERT. Columbia University Press, New York, 1992. xvi, 275 pp. + plates. $45.

William Diller Matthew (1871–1930) represents the transition between two eras in American vertebrate paleontology: that of the pre-modern evolutionary synthesis, typified by Henry Fairfield Osborn (1857–1935), who was Matthew's teacher at Columbia University and subsequently his superior at the American Museum of Natural History, and that of the modern evolutionary synthesis, exemplified by George Gaylord Simpson (1902–1984), who was strongly influenced by Matthew early in his career and later succeeded him at the American Museum. This, the first full biographical study of Matthew, is written by his son-in-law, Edwin Colbert (b. 1905), himself a distinguished vertebrate paleontologist and former American Museum colleague of both Osborn's and Simpson's.

Born and raised in St. John, New Brunswick, Matthew obtained his Ph.D. at the Columbia School of Mines with the intention of becoming a "hard-rock" geologist. While at Columbia, however, he took several courses from Osborn, and each impressed the other; upon completing his Ph.D. Matthew was appointed to a full-time staff position at the American Museum. Before long he was juggling the demands of long field seasons away from wife and family, of excavating, describing, and interpreting an ever-increasing supply of mammalian teeth and jaws, skulls, and other bones, and of organizing materials for exhibition halls—all under the direction of the overbearing Osborn. As Matthew gained professional experience and self-confidence, he found himself more and more at odds with Osborn's evolutionary theorizing as well as with contemporary interpretations of the sedimentary environments in which many of the fossils of the American West were deposited. In a series of classic monographs Matthew expounded on the principles of stratigraphic correlation, the nature of ancient environments, evolutionary histories and trends, and concepts of biogeography.

After 30 long years of service, often approaching servitude, at the American Museum, Matthew accepted the chairmanship of the department of paleontology at Berkeley, where he now was completely his own man, intellectually and administratively. Unfortunately, his tenure at the University of California was short-lived, for within a few years, several months short of his 60th birthday, he died of kidney disease.

With access to the archives of the American Museum and more especially to family records, letters, and anecdotes, Colbert provides an engaging and informative account of Matthew's professional and personal life. Besides giving us an intimate family portrait, he brings to life the various personalities of early 20th-century vertebrate paleontology, including not only Osborn but also Matthew's other American Museum colleagues such as William King Gregory, Roy Chapman Andrews, Barnum Brown, Walter Granger, and the all-important preparators and field hands like Albert ("Bill") Thomson.



"A reconstruction of the discovery of the giant trilobite, *Paradoxides regina*." Top to bottom: "George Frederic Matthew sets out with his son Will for some fossil hunting in the outskirts of Saint John; Will discovers the fossil, much to the delight of the two fossil hunters; The rock containing the fossil has been excavated, and is brought home and admired by father and son; George Frederic Matthew writes a description of the fossil, published some years later in the *Transactions of the Royal Society of Canada*. He proudly named the fossil *regina*, in honor of Queen Victoria." [From *William Diller Matthew, Paleontologist*, drawings by Margaret Matthew Colbert]