An Eventful 100 Years in Astronomy

A History of Astronomy: From 1890 to the Present

David Leverington
Springer-Verlag, New York, 1995.
387 pp. $32.00 pb
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Reviewed by Kevin Krisciunas

"The twentieth century, for so long synonymous with progress and modern thinking, has but a short way to go before it becomes the last century." This obvious point, but an insight nevertheless, begins David Leverington's summary of the past hundred years of progress in astronomy, an exciting hundred years to be sure.

Why begin the narrative ten years prior to the turn of the last century? The early 1890s mark the start of much important work: the plan for an international collaboration to map the whole sky photographically (the *Carte du Ciel*), the establishment of the first permanent mountaintop observatories, systematic photographic searches for asteroids, the start of the Harvard spectroscopic surveys and the establishment of the *Astrophysical Journal*. By the first decade of this century, physicists had discovered x rays and the electron and laid the groundwork for quantum mechanics and relativity. Larger reflecting telescopes began to supplant long-focus refractors as the instruments of choice, and astrophysics began to supplant positional astronomy as the activity of choice amongst astronomers.

Leverington, who has worked as a high-level manager for the European Space Agency and for British Aerospace Communications, does a commendable job in *A History of Astronomy* of summarizing much of the instrumental developments and many of the specific discoveries of the past century.

A famous astronomer once told me, "All science becomes anonymous. Nobody calls it the Rutherford model of the atom any more." Leverington adopts the perspective, rightly advocated by the protagonists of the big bang theory, Ralph Alpher and Robert Herman, that proper credit does matter. So in this book we find various discoveries associated with the famous and the not so famous. For example, it was Charles Boyer, a French amateur astronomer living in the Congo, who discovered in 1957, through ultraviolet photography, that the clouds of Venus rotate around the planet with a period of four days. (This was finally confirmed by the US probe, Mariner 10, in 1974.) The first to see the active volcanoes on Jupiter's moon Io was Linda Morabito of the Jet Propulsion Laboratory, who was studying Voyager 1 images. Ian Shelton, Oscar Duhalde and Albert Jones independently discovered supernova 1987A.

I would certainly recommend this book to any reader with an interest in astronomical history and modern research. The coverage is sufficiently up to date to touch on the repair mission to the Hubble space telescope and the identification of the gamma-ray source Geminga as a pulsar with a period of 237 ms. It taught me that my knowledge of what is known about the Solar System was in need of some serious updating. For such updating, the book suffices. However, it does not contain exhaustive references to source material.

My biggest criticism is directed at the publisher, and at publishers in general. Imagine an author's dismay, after having corrected the proofs, to find that the publisher removed the section numbers to which refererence was made throughout the book. An erratum slip is enclosed, but this makes only partial amends. And surely there could have been a bit more proofreading, to keep the two dozen typesetting errors (by my count) out of the finished product. This seems to be the going rate for astronomy books, and I fear that things are getting worse.

An editor from a different publishing house wrote to me recently and asked which were the "most important five or six corrections" to be made among the two dozen mistakes in the equations in my article for their encyclopedia! It is important for everyone to pay attention to the details. Otherwise we open ourselves up to the criticisms by creationists and the like that we do not know what we are doing.

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Interplanetary Magnetohydrodynamics

Leonard F. Burlaga
Oxford U. P., New York, 1995.
256 pp. $70.00 hc
ISBN 0-19-508472-1

Several decades of interplanetary exploration, and especially such tremendously successful missions as Pioneer, Helios, Voyager and Ulysses, have made enormous contributions to the understanding of space plasma physics. Although not a traditional field of physics, this discipline has proved to be of fundamental importance in magnetospheric, solar, stellar and cosmic applications, and its underlying basic physical processes are certain to be key elements in unraveling problems ranging from space weather to cosmology. Unlike its cousin, laboratory plasma physics, space physics has always been dominated by *in situ* observations, and all too frequently the taxonomy of "events" has stood in place of real physical theory.

In *Interplanetary Magnetohydrodynamics*, Leonard Burlaga focuses on a well-explored subset of space plasmas, the interplanetary medium or solar wind. Throughout the book, he describes phenomena in terms of a magnetofluid approximation, which enables him to develop a number of concepts and physical principles skillfully, and at a reasonable level of detail, while maintaining close contact with crucial space-data sets. It is laudable that Burlaga did not attempt to cover the field completely; this is not an extended review article. Instead, the book follows closely the conceptual path Burlaga has taken in his three-decade involvement with space exploration, space-physics theory and, especially, the Voyager magnetic-field and plasma instrumentation. In *Interplanetary Magnetohydrodynamics*, Burlaga blends his detailed understanding of the observations with both standard plasma theory and modern concepts from nonlinear dynamics, turbulence theory and other fields. The mix is almost always satisfactory, and sometimes it is much more. The benefit of this approach more than justifies (and perhaps, requires) a scientific perspective that is clearly personal and of admittedly limited scope.

Burlaga's accounts of the basic physics of the interplanetary medium provide the reader with accessible discussions of the theoretical principles that organize the data. The tangible satisfaction of coming to an understanding of the observational results is frequently balanced by an appreciation of the still-outstanding questions. The reader learns, for example, that pressure-balance structures are frequently observed in the solar wind plasma, and even that a "principle of pressure balance" is sometimes useful. But Burlaga also makes it clear that questions still exist as to why magnetohydrodynamics (or perhaps kinetic physics) tends to produce this balance in the solar wind plasma. The description of magnetic clouds is equally lucid and important, but perhaps somewhat more satisfying because Burlaga supplements the evidence for their detection and structure with an account of the coronal ejection processes that produce them.

Some of the ideas summarized in the book, such as the corotation, interaction and merger of streams, are critical to an understanding of the physics of the outer heliosphere and observed effects on cosmic rays. On the other hand, a few sections of the book, such as the one dealing with the application of catastrophe theory to shocks, seem to lack motivation and are not well explained. Topics such as the application of fractal and multifractal analysis to solar wind observations are more speculative. The book would be better balanced if these more advanced concepts from turbulence theory were introduced by a discussion of magnetohydrodynamic turbulence in a more basic form. However, the multifractal presentation is clear and may be useful to nonlinear-dynamics theorists in developing more detailed models.

On balance, this book will be a valuable and stimulating guide for advanced graduate students and researchers who want to enter space physics or who want a concise discussion of the highly relevant topics that the book covers. Space plasma physics is not yet a mature enough branch of physics to produce greatly refined pedagogical accounts, but Burlaga's blend of concept and experimental reality is a needed step along the way.

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The Collected Works of P. A. M. Dirac, 1924–1948

Edited by Richard H. Dalitz
Cambridge U. P., New York, 1995.
1310 pp. $250.00 hc
ISBN 0-521-36231-8

General Theory of Relativity

P. A. M. Dirac
Princeton U. P., Princeton, N.J., 1996 [Wiley, New York, 1975].
71 pp. $10.95 pb
ISBN 0-691-01146-X

Paul Dirac is widely revered as one of the pioneers of quantum mechanics and one of the great theoretical physicists of this century. Beginning with his days as a graduate student, he spent most of his career at Cambridge University, where he served for 37 years as Lucasian Professor of Mathematics, in the prestigious chair once held by Isaac Newton. After his retirement from Cambridge in 1969, Dirac moved to Florida, where he accepted a post as research professor at Florida State University and remained active in physics until shortly before his death in 1984, at the age of 82.

The Collected Works of P. A. M. Dirac, 1924–1948, edited by Richard Dalitz, is introduced as "the first of two volumes which bring together for the first time all of Dirac's scientific publications, with the exception of his books." Of Dirac's nearly 200 research and expository papers, 84 are reprinted in this first volume.

Almost all of Dirac's major contributions to physics originated during a short period of youthful creativity between 1925 and 1933, his "golden years," at the end of which, at age 31, he was awarded the Nobel Prize in Physics for his innovations in quantum mechanics. *The Collected Works* contains all of the seminal papers for which he will be remembered, including:

▷ "On the Theory of Quantum Mechanics" (1926), in which he elucidated Schrödinger's wave mechanics and Fermi–Dirac quantum statistics;

▷ "The Physical Interpretation of the Quantum Dynamics" (1927), in which he presented his "transformation theory," unifying the different quantum mechanical schemes of matrix mechanics, wave mechanics and q-number algebra, and in which he introduced the famous "delta function" that became associated with his name;

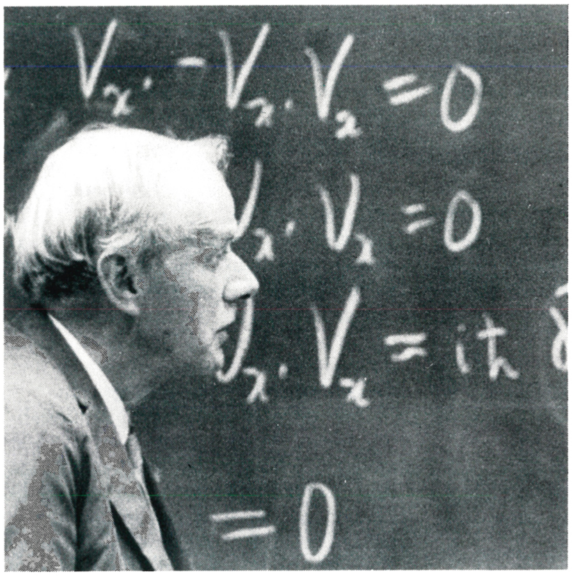
▷ "The Quantum Theory of the Emission and Absorption of Radiation" (1927), in which he developed a primitive but important version of quantum electrodynamics;

▷ "The Quantum Theory of the Electron" (1928), in which he derived his fully relativistic wave equation of the electron;

▷ "A Theory of Electrons and Protons" (1930), in which he presented his theory of "holes" (in the distribution of negative-energy electrons), at first identifying the "hole" incorrectly with the proton;

▷ "Quantised Singularities in the Electromagnetic Field" (1931), in which he introduced into theoretical physics the antielectron (or positron)—the correct hole candidate—and the antiproton, as well as the magnetic monopole; and

▷ "A New Notation for Quantum Mechanics" (1939), in which he introduced his "bra–ket" formalism for quantum



P. A. M. Dirac at Clemson University in 1971. (Photo Courtesy of AIP Emilio Segrè Visual Archives.)