The most perfect macroscopic objects in the Universe

The Mathematical Theory of Black Holes

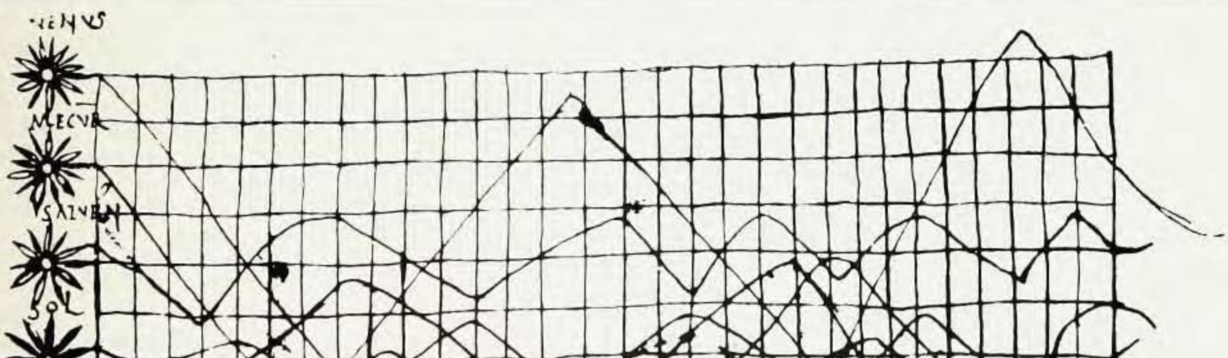
S. Chandrasekhar
646 pp. Oxford U.P., New York, 1983. $110.00

Reviewed by Allen I. Janis

"The black holes of nature are the most perfect macroscopic objects there are in the universe: the only elements in their construction are our concepts of space and time." With these words, Subrahmanyan Chandrasekhar introduces his mathematical study of black holes, objects presaged by his study of white dwarfs undertaken long ago in his student days. But this book is more than a study of black holes. It is a love song, celebrating the beauty of mathematical physics and the joy derived from its pursuit. Although Chandrasekhar's love affair with mathematical physics has lasted more than half a century, his youthful ardor still shines brightly in these pages.

By "the black holes of nature" Chandrasekhar means the Kerr family of solutions of the vacuum field equations of general relativity, solutions whose only parameters represent mass and angular momentum. Although arguing that "one does not expect any macroscopic body to possess a net charge," he devotes some attention to charged solutions both for the additional light that such study sheds on the nature of space–time and for its help in understanding the mathematical framework of the uncharged solutions. The bulk of this treatise, though, is devoted to the Kerr family; the emphasis is on geodesic motion and perturbation analysis, with applications to the transmission and scattering of incident waves. Much of this work was originally done by Chandrasekhar; even where it wasn't original with him, he has independently worked it out again from scratch.

The book's treatment of these topics is largely self-contained. It begins with a review of differential geometry and the Newman–Penrose formalism; throughout, it lays out the lines of argument carefully, with many of the



One of the oldest known graphs is this time-series plot of the movement of the Sun, Moon and planets. Apparently it was part of a tenth- or eleventh-century text for monastery schools. The graph appears in *The Visual Display of Quantitative Information* by Edward R. Tufte (Graphics Press, Cheshire, Conn., 1983. $34.00).

This beautifully designed book treats a large variety of graphs and graphical designs used in various fields and media, ranging from scientific monographs to mass media, and contains 250 illustrations, of which 75 are examples of the finest graphical work from 1700 to 1982.

The book is intended for anyone using visual methods to transmit information, including scientists, engineers, art editors and book designers, but the lively and interesting text makes it also enjoyable to those who fully appreciate graphic design as an important artistic form. Edward Tufte is professor of political science and statistics at Yale University, where he also teaches in the Department of Graphic Design.

mathematical details included. Naturally, not everything is explicit. In a note to the hundred-page ninth chapter, Chandrasekhar cautions that the reductions necessary to go from one step to the next in some cases require as many as fifty pages of calculations. He has deposited his derivations in the University of Chicago's library for the benefit of readers seeking further details.

The value of this book lies not only in what it teaches us about black holes and space–time. It is an object lesson in dealing with mathematically complex physical problems and in the pleasure gained in doing so. Time and again we see how appropriate groupings, definitions and transformations lead to results that had seemed impossible to extract. Chandrasekhar marvels at this along with us, using such words as "astonishing" and "remarkable" to describe properties of his equations. But he is not content merely to marvel when he finds "a remarkable coincidence shrouded in mysterious cancellations." Rather, he proceeds "to locate the origin of the mystery." This search for understanding at a deeper level is a valuable example even for those lacking Chandrasekhar's celebrated ability and tenacity in analyzing complicated systems of equations.

Black holes may be nearly perfect, but the book, alas, is blemished by a great many misprints. For me, at least, the annoyance at this was heightened by the book's exorbitant price; I am naive enough to expect high cost to reflect great care in preparation. For the most part, though, the misprints will be caught by careful readers, and it is a well-known axiom of research that someone else's equations should not be assumed to be free of errors. Mistakes that seem not to be just misprints are relatively rare.

On the positive side again, the table of contents is unusually detailed and informative and the bibliographic notes, while making no claim to be comprehensive, contain many interesting references. Chandrasekhar includes a brief summary of his account, published in a relatively obscure source, of the remarkable circumstances under which Karl Schwarzschild derived his famous metric.

The book makes no pretense of treating all aspects of the mathematical theory of black holes. Readers interested in topics such as black-hole thermodynamics, Hawking radiation, accretion disks and singularity theorems will have to look elsewhere. The treatment of the covered topics, though, is thorough and rewarding to neophyte and expert alike. It requires some hard work, though, to reap these rewards. The spirit of the book is perhaps best expressed by Chandrasekhar's words at the close of the ninth chapter:

> The treatment of the perturbations of the Kerr space–time in this chapter has been prolixious in its complexity. Perhaps, at a later time, the complexity will be unravelled by deeper insights. But mean time, the analysis has led us into a realm of the rococo: splendorous, joyful, and immensely ornate.

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book notes

Biophysics

Walter Hoppe, Wolfgang Lohmann, Hubert Markl, Hubert Ziegler, eds.
941 pp. Springer-Verlag, New York, 1983. $59.00

This massive text-*cum*-compendium contains some seventeen chapters on subjects ranging from the chemical structures of macromolecules, through biomechanics and neurobiophysics, to evolution and cybernetics; each chapter is written by specialists in the field. The book is a translation of the second German edition, published in 1982. In most cases the authors themselves did the translating; Brenda Winnewisser translated the remainder and smoothed the English in some of the chapters.

The authors—nearly seventy—are mostly German, of course, but there are also contributors from the US, Australia, Norway and Austria. Some will be familiar to readers of PHYSICS TODAY; Gerhard Neuweiler, for example, contributed a chapter on echolocation (see his article, August 1980, page 34). The editors have not limited the authors to narrow outlines but encouraged them to present the many parts of biophysics in as much depth as possible. This book should be useful not only to advanced students seeking an introductory overview but also to professional workers looking for a review of recent work in fields outside their own specialty. The book is beautifully produced, with a crisp type and compact two-column layout. Much information is accessibly packaged into its pages. —TVF

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Atomic, Molecular and Chemical Physics

Magnetic Atoms and Molecules. W. Weltner Jr. 422 pp. Van Nostrand Reinhold, New York, 1984. $42.50. *graduate text*