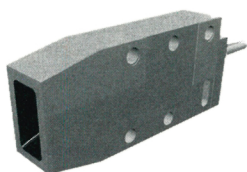
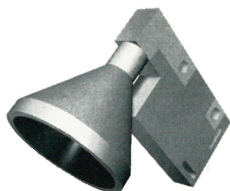


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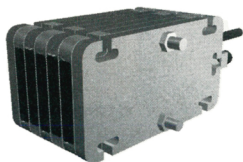
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comets. Jacqueline Mitton has authored and coauthored several popular books and accounts on astronomy. The appearance of the book is well-timed. We have learned a great deal about the Pluto-Charon system over the past three decades, and scientists are in the process of defining a Pluto-express mission concept—the next milestone towards Pluto's exploration.

Although Pluto was known merely as the ninth planet—a moving speck of light on the sky—from 1930 until the mid-1970s, it is now known as a cold and icy world, and a double planet. The Pluto-Charon system orbits the Sun every 248 years, at a heliocentric distance varying from 30 to 50 AU. Ices such as nitrogen, methane and carbon monoxide sublime on their surfaces in the summer and condense in winter.

Stern's research involvement ensures an accurate and up-to-date account. Undoubtedly, further mysteries will be uncovered in the coming years, as adaptive-optics techniques and optical interferometry on large-aperture telescopes become available. The research results described in this book may well remain the standard reference for the next decade. Future ground-based and Hubble Space Telescope discoveries may merely refine the theories and ideas presented.

One of the more interesting facts about Pluto and its appearance in our Solar System became known in the 1990s with the discovery of the first comets in the Kuiper belt, a hypothetical torus of short-period comets, beyond Neptune's orbit, theorized around 1950. With the discovery in 1992 of the first Kuiper belt comets by David Jewitt and Jane Luu, some researchers suggested that Pluto may not be an oddball among the planets, but rather a planet-sized end member of the icy bodies in the Kuiper belt. Charon, which is about half the size of Pluto, may have come to be in a giant collision between Pluto and another Kuiper belt member, in a process analogous to our current concept of the origin of the Moon. In addition, the Kuiper belt may also be the birthplace of Triton, Neptune's largest moon and, considering its appearance and composition, an apparent cousin to Pluto. The authors describe the discovery of these first-discovered Kuiper-belt objects and the consequences of putting Pluto in its proper context in our Solar System.

In discussing the exploration of the Pluto-Charon system, the authors describe in simple language the methods researchers use to explore the universe and the way ever-improving instrumentation helps their knowledge advance. Stern and Mitton's account concludes that the next major improvement

in understanding the twin system will come from a spacecraft mission.

The authors summarize the chronology of Pluto explorations at the end of the book, while quantities such as orbital parameters, size and albedo are mostly scattered throughout. For a quick professional review, it would have been useful to have a table summarizing all known parameters, with detailed references to the original literature.

This book is at a level and readability comparable to *Naked Earth* by Shawna Vogel (Dutton, Penguin, 1995) and *T. Rex and the Crater of Doom* by Walter Alvarez (Princeton U. P., 1997), both of which are popularized geophysics-oriented books on topics of ongoing research.

IMKE DE PATER

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The Babylonian Theory of the Planets

▶ Noel M. Swerdlow
Princeton U. P., Princeton, N.J.,
1998. 246 pp. \$39.50 hc ISBN
0-691-01196-6

This important book grew out of the need to determine how the Babylonians arrived at the numerical parameters of their planetary models in the middle of the first millennium BC. Those models have, in the course of the 20th century, been well established as based on step functions and linear zigzag functions (broadly designated as systems A and B) and combinations of the two. How the models were arrived at, however, and for what purpose remain something of a mystery. Since their ancestral role in the history of the exact sciences is of very great importance, any light that can be shed on their beginnings is to be welcomed.

Noel Swerdlow, in *The Babylonian Theory of the Planets*, does not disappoint us: The observational basis of the Babylonian achievement is known to be contained in the Babylonians' so-called Astronomical Diaries, in which were recorded observations of the planets dated to the day of the calendar month, but with only approximate indication of place (and this by zodiacal sign). Swerdlow shows how, from the dates of the phenomena in the Diaries, synodic times could have been found. ("Synodic" here refers to a separation from the mean Sun.)

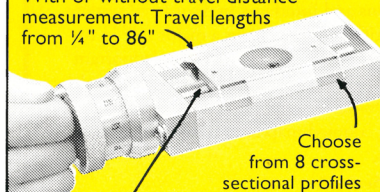
It is known that Babylonian ephemerides make use of a rule according to which synodic arc and synodic time differ by a constant specific to the appropriate planet. From synodic times, therefore, synodic arcs could in principle have been found and, from them,

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the required parameters of the ephemerides.

Here, in a nutshell, is the main message of the book. The elegance of the proposed procedure should be clear: It requires no precise measurement of position in the heavens—no elaborate coordinate system, for example. The greatest virtue of Swerdlow's hypothesis is that it shows how, historically, an extraordinarily complex astronomical system could have been generated from very plausible beginnings in celestial divination.

Swerdlow opens with a summary of the vast collection of Babylonian celestial omens that survive from as early as the second millennium BC—chiefly signs from the gods as to the likely fortunes of kingdoms and their kings, who were held responsible for military success and failure, even pestilence and famine. Personal astrology of the sort that still stagnates in dark corners of our world had not yet arrived on the scene. As an example of the extent of this material: The richest extant collection, the Enūma Anu Enlil omen series—a compendium from the second millennium BC—contains about 7000 omens, many of them solar, lunar, meteorological, planetary and stellar. So seriously did the priesthood take their divinatory schemes that they made nightly observations of the Moon and planets, relating their positions loosely to the stars.

It seems intuitively obvious that the theory of omens was intimately connected with the sophisticated mathematical astronomy that followed it, but finding a plausible link is easier said than done. Roughly speaking, one can say that the priesthood responsible (Swerdlow plays safe with terminology and simply calls them "scribes") discovered the existence of rule-based periodicities, such as those in the heliacal risings and settings of planets, which were found to transcend the vagaries of the weather that inevitably obscured some of them.

It is in the details of that system of cyclical relationships and its genesis, however, that Swerdlow's hypothesis has to be put to the test, and those details he presents in a very plausible way—not without difficulties or disagreement with other scholars in the field, but nevertheless, with great coherence. Periodicities, of course, need to be supplemented with starting points, specific positions at some specifiable epoch, and Swerdlow is able to explain even the establishment of these without demanding precise measurement of position. He argues that they were found from conventional values of the elongations of phenomena from the mean Sun.

Swerdlow's book presents the reader with far more than a new historical hypothesis. It is an almost self-contained history of Babylonian planetary astronomy, and it is eminently readable at the graduate or advanced undergraduate level. The book naturally rests heavily on such works as Otto Neugebauer's *Astronomical Cuneiform Texts* (Institute for Advanced Study, 1955), and *A History of Ancient Mathematical Astronomy* (Springer, 1975), and the equally monumental *Astronomical Diaries and Related Texts from Babylonia* (Austrian Academy of Sciences, 1988–96), begun by the late Abe Sachs and continued by Hermann Hunger. Neugebauer was always somewhat impatient with divinatory themes—not that he denied others the right to study them, but he did not think them central to his own researches.

One of the most welcome aspects of Swerdlow's new study is the way in which it knits together astronomy (along the lines laid down by Franz X. Kugler, Neugebauer and others) with materials of the type published by Hunger in his *Astrological Reports to Assyrian Kings* and Simon Parpola in *Letters of Assyrian and Babylonian Scholars* (published in Helsinki in 1992 and 1993 respectively). In short, Swerdlow's book will speak to a wider audience than much of the rather austere analytical literature on which it rests. No matter how the finer details of the new work will be judged over the next few decades, it cannot have anything but a salutary effect on future historical approaches to what, by any reckoning, is an extremely important episode in human history.

JOHN D. NORTH
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The Netherlands

Particle Astrophysics

▶ Hans V. Klapdor-Kleingrothaus
and Kai Zuber
Translated from German by
S. M. Foster and B. Foster
IOP, Philadelphia, 1997. 507 pp.
\$200.00 hc ISBN 0-7503-0403-0

Hans Klapdor-Kleingrothaus and Kai Zuber must be commended for discussing in a single book an impressive number of topics relevant to the emerging discipline of particle astrophysics. This new field of inquiry, at the boundary lines between particle physics, nuclear physics, astrophysics, gravitational physics and cosmology, is gathering momentum both theoretically and experimentally, and such a work is very timely.

In their *Particle Astrophysics*, the authors address four major themes.