

timely, since 1997 was the centennial of Thomson's discovery of the electron. And although Dahl's account revolves around Thomson, the third Cavendish Professor of Experimental Physics at the University of Cambridge, the book also examines extensively Thomson's predecessors and contemporaries. And it extends its analysis to his followers, including Ernest Rutherford and Robert A. Millikan (it was Millikan who first measured the discrete charge of the electron).

On 30 April 1897, in his now famous Friday evening discourse at the Royal Institution, Thomson presented the result of his measurements of the "mass-to-charge" ratio ($m/e = 1.6 \times 10^{-7}$ g emu⁻¹) of cathode rays, and remarked: "This is very small compared with the value of 10^{-4} for the ratio of the mass of an atom of hydrogen to the charge carried by it. . . . These numbers seem to favor the hypothesis that the carriers of the charges are smaller than the atoms of hydrogen." Since then, this event has been regarded as the "discovery" of the electron. Yet, before Thomson, the same ratio of the cathode ray had been measured by other physicists, such as Emil Wiechert and Walter Kaufmann. Pieter Zeeman, with the help of Hendrik Antoon Lorentz, also calculated the same value for the rotating "ion" of an atom and obtained, before Thomson, almost the same small value. Further, Thomson was very reluctant to use the term "electron," which had been coined by the Irish physicist George Johnstone Stoney in 1891; instead, he stuck to the term "corpuscle," which he himself had chosen to designate the subatomic particles he discovered.

Therefore, the first question that Dahl raises—and answers—is, What constituted the "discovery" of the electron? And in what senses can Thomson be said to be the discoverer of the electron? For this, Dahl traces in some detail Thomson's research in 1896 and 1897 and compares it with that of Wiechert, Kaufmann and Zeeman. Unlike Wiechert and Kaufmann, who discarded the possibility of the corpuscularity of cathode rays because of the smallness of the value of m/e , and unlike Zeeman, who paid little attention to the ratio itself, Thomson was the first scientist truly to capture the radical meaning of the small value of m/e of the corpuscle: that the corpuscles are much smaller than hydrogen atoms and that ordinary atoms are built up from corpuscles.

Dahl, however, pays less attention to the Maxwellian context of electromagnetic research during the last quarter of the 19th century—the context in which Thomson's training in electromagnetic theory took place.

James Clerk Maxwell and Maxwellians like George FitzGerald and Oliver Lodge had developed a unique conception that viewed electric charge and current as epiphenomena of the electromagnetic field and the energy stored in it. When Thomson suggested the atomic, or materialistic, conception of electric charge in 1897, it immediately came into serious conflict with the Maxwellian conceptions.

Quoting Thomson's recollection, Dahl writes (on page 166) that FitzGerald thought that he, Thomson, "had made out a good case." But, in fact, it was FitzGerald who first published a critique of Thomson's corpuscle hypothesis. To save the Maxwellian dictum, FitzGerald identified Thomson's corpuscle with Joseph Larmor's free electron, which had been proposed as an end point of the ether strain. In FitzGerald's conception, the materiality of Thomson's corpuscle disappeared. This, in my view, is the true reason why Thomson was reluctant to adopt the term electron and its physical implications.

Dahl's book is certainly a welcome contribution to the historiography of the electron. It is, however, more synthetic than analytic. The full history of the electron has yet to be written.

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Planet Quest: The Epic Discovery of Alien Solar Systems

▶ Ken Croswell
Free Press, New York, 1997.
324 pp. \$25.00 hc
ISBN 0-684-83252-6

Worlds Unnumbered: The Search for Extrasolar Planets

▶ Donald Goldsmith
University Science Books, Sausalito, Calif., 1997. 225 pp.
\$28.50 hc ISBN 0-935702-97-0

The Quest for Alien Planets: Exploring Worlds Outside the Solar System

▶ Paul Halpern
Plenum, New York, 1997. 293 pp.
\$27.95 hc ISBN 0-306-45623-0

History will record the 1990s as the decade that saw the successful culmination of one of 20th-century astron-

omy's most vigorous quests: the search for extrasolar planets. As of this writing, some 10 giant planets have been discovered around nine Sun-like stars, and (perhaps most surprising) at least four terrestrial-sized planets have been observed around two pulsars, those extremely small, dense and distinctly non-Sun-like stars that mark one of the dead ends of stellar evolution.

Moreover, 1995 also saw the first confirmation of brown dwarfs: objects 13-to-80 times the mass of Jupiter that teeter on the brink of stardom but lack the mass to ignite normal fusion reactions. Brown dwarfs are very much a part of this story, because of the questions they raise about the nature of some of the new objects. There is no doubt of the brown-dwarf nature of Gliese 229 B, an object of 40-to-55 Jupiter masses, discovered by Shrinivas Kulkarni and his colleagues. And there is little doubt that the seven Jupiter-mass objects in nearly circular orbits around their respective suns, forever linked with the names Michel Mayor, Didier Queloz, Geoffrey Marcy and Paul Butler, are planets, even though some circle extremely close to their parent stars.

But it is just possible that the companion of HD 114762, discovered in 1988 by David Latham and his colleagues, with a minimum mass 12 times that of Jupiter, was the first extrasolar planet to be discovered. And it is possible that Marcy and Butler's "planet" 70 Virginis B is a brown dwarf rather than a planet. Clearly, much remains to be learned about the relationships of these objects, not to mention the mechanism of their formation. Such is to be expected at the beginning of a new field.

The discovery of these objects and the controversy over their nature make a dramatic story, and one well told in all three of these books: *Planet Quest* by Ken Croswell, *Worlds Unnumbered* by Donald Goldsmith and *The Quest for Alien Planets* by Paul Halpern. The Croswell and Goldsmith books, each written by a well-known Berkeley astronomer—author with a Harvard background, are intended for the intelligent and dedicated non-professional, while Halpern, an associate professor of physics at the Philadelphia College of Pharmacy and Science, has written one that is slightly less comprehensive; for example, it includes none of the tables summarizing the new planets and their properties that I found so useful in the Croswell and Goldsmith books, nor, in general, is it as detailed as the other two books.

All three cover much the same ground, but in quite different ways. Croswell's approach is chronological,

proceeding from the discovery of planets in our own solar system (which makes up the first quarter of the book) to the discovery in 1983 of shells around the stars Beta Pictoris and Vega, the totally unexpected discovery of planets around a pulsar in 1992 and, finally, the "harvest of planets" that began in 1995. Goldsmith, by contrast, proceeds thematically, beginning with the discovery of the new planets then proceeding to the question of life, the formation of planetary systems and the techniques for their discovery, before going further afield than Crowell to discuss the Drake equation and other aspects of life in the universe. (Curiously, Crowell's publisher is the Free Press, whose trademark is fp , which in the Drake equation represents the fraction of stars that form planets!) Halpern is broadest of all, devoting, for example, a whole chapter to Mars and sacrificing some depth in the process.

The hallmark of Crowell's book is his use of interviews with many of the participants in the discoveries, a technique that makes us feel as if we were present at those discoveries and lays bare the controversies over the differences between brown dwarfs and stars, brown dwarfs and planets, the formation of planets extremely close to their parent star and the very existence of pulsar planets. The books by Goldsmith and Halpern do a good job of describing the techniques for future searches in addition to describing the techniques now in use. (We can have only the greatest admiration for those who have toiled to measure 3 m/s radial velocities, milliarcsecond positions and extremely small magnitude changes in the search for planets and who are now toiling with interferometers, micro-lensing, adaptive optics and spaceborne instrumentation to find ever more planets of ever smaller mass.) All three books are worthwhile for the view they give of scientists tackling a subject of great import while struggling through the inevitable problems of functioning at the limits of their science.

There are some missed opportunities in all three books: Despite the attention given to our own solar system as a benchmark against which to measure others, none of the three discusses how the giant outer planets were discovered to be gaseous, an interesting and relevant story, given that most of the current extrasolar planets are probably gas giants.

Nor do any of the three make much of the earlier history of the search for extrasolar planets prior to Peter van de Kamp's announcement in the early 1960s of a planet (now believed to be spurious) around Barnard's star. This early history includes, for example, the

published suggestions of Lick astronomers William W. Campbell and Heber D. Curtis in 1905 (in connection with their observation of spectroscopic binaries) that radial-velocity might be used for planet detection, Otto Struve's proposal in 1952 for a high-precision radial velocity search for extrasolar planets, and the excitement in the 1940s over the announcement that such planets had been detected. And none of the books goes beyond the bare essentials of the amazing and accelerating discoveries of circumstellar disks, which as planetary systems forming or formed bear just as strongly on the question of what fraction of stars have planetary systems as do the actual extrasolar planets announced.

All three books are well produced and affordable, and they will go a long way toward satisfying the public's seemingly inexhaustible interest in other planets and the likelihood of life elsewhere in the universe. With an ever-expanding array of techniques, and the impetus provided by NASA's Origins program in supporting both ground-based and space-based activities as set forth in its Exploration of Neighboring Planetary Systems Plan, planetary-systems science and the search for extraterrestrial life are sure to constitute major themes in 21st-century astronomy.

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Gravity Currents in the Environment and the Laboratory

John E. Simpson
Cambridge U. P., New York, 1997
[1987]. 244 pp. \$74.95 hc
ISBN 0-521-56109-4

Gravity currents, flows caused by an intrinsic density difference between two fluids, are common in nature. Anyone not already convinced of their ubiquity need only spend some time with this beautifully illustrated book by John Simpson in order to appreciate the importance and prevalence of gravity currents in the everyday world.

In *Gravity Currents in the Environment and the Laboratory*, Simpson covers gravity currents involved in synthetic and natural phenomena with industrial, geological, oceanographic and atmospheric implications. Special topics include the flow of suspensions and the effects of rotation and stratification. Well chosen examples provide the impetus for understanding the dynamics quantitatively and are gener-

ally placed in a suitable context: Lahars and spills of dense gases are presented from a hazards point of view; analyses of air flow in buildings and termite mounds are presented as engineering problems. Certain topics and examples are notably absent, however: There is mention of neither currents in porous materials (applications to contaminant plumes) nor solidifying currents (applications to lava flows), and only a passing mention is made of currents in which interfacial tension is important.

The most engaging aspect of the book is that it is long on beautiful pictures, illustrations and physical explanations and short on mathematical analysis. Examples of gravity currents are typically illustrated with photographs of laboratory experiments, many of which come from Simpson's own studies; when appropriate, there are pictures of natural phenomena or figures showing measurements. To complement the photographs, there are clear sketches and schematic illustrations of important ideas. In many ways this book can be read by looking at the pictures alone.

Gravity currents are among the most approachable topics in fluid mechanics because they are commonly observed and can be understood physically in a straightforward manner. The mathematical analysis of gravity-current dynamics lends itself to scaling analysis and elegant similarity solutions for certain types of problems, and it is this particular aspect of the topic that is least developed by Simpson. For example, the time^{1/8} spreading of a liquid on a flat surface at low Reynolds numbers (a result that is simply cited on page 215) can be obtained by balancing viscous and buoyancy stresses and assuming conservation of mass. Despite the simplicity of elementary gravity-current analysis, only a few such results are derived, such as the speed obtained by equating potential energy loss and kinetic energy gain and the energy loss at a bore. This is unfortunate, as force balances, scaling and even similarity solutions are not beyond the understanding of undergraduates and could be included without compromising the accessibility of the material.

The concluding chapter on numerical solutions is unnecessary and out of date (it was not revised since the first edition in 1987). Despite Simpson's statement that "the time of writing is one of rapid development of numerical models," only works published in 1968, 1977, 1980 and 1985 are considered in this chapter. Much more insightful would have been an analytical and mathematical treatment of currents.