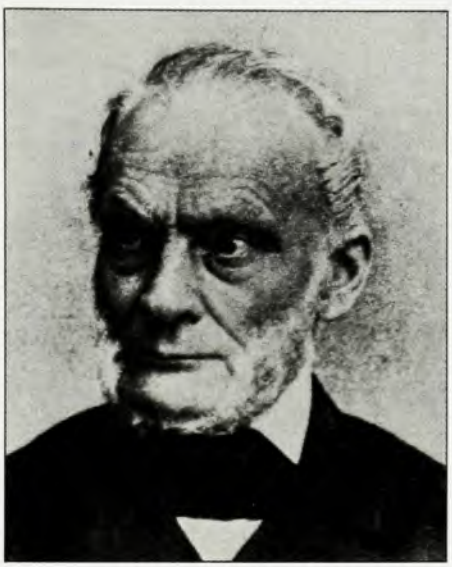
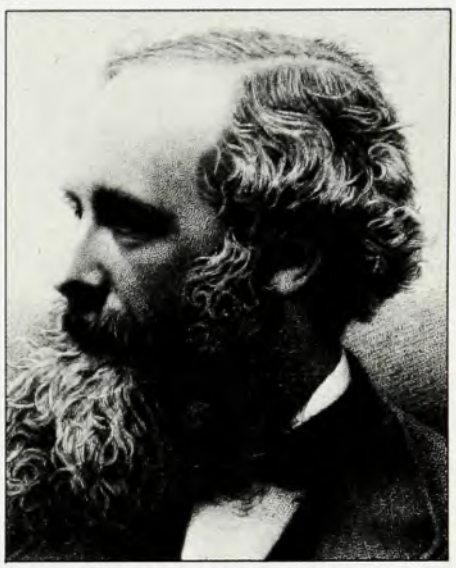
Boltzmann, Clausius, Maxwell and friends

LUDWIG BOLTZMANN, 1844–1906



RUDOLF CLAUSIUS, 1822–88



JAMES CLERK MAXWELL, 1831–79

The Kind of Motion We Call Heat: A History of the Kinetic Theory of Gases in the 19th Century

Book 1: Physics and the Atomists
Book 2: Statistical Physics and Irreversible Processes

S. G. Brush
300 and 496 pp. North-Holland: Amsterdam, 1976. $24.75 and $59.75 ($75.00 for the 2-volume set)

Reviewed by Martin J. Klein

The development of the kinetic theory of gases in the nineteenth century is full of the variety, confusion, and complexity that characterize the history of most human endeavors. These traits help make it a rich subject for the historian of science, as Stephen G. Brush amply demonstrates in this substantial two-volume work. Brush has the proper qualifications for his task, having worked in statistical mechanics for a number of years before he became Professor of the History of Science at the University of Maryland almost a decade ago. His interest in the history of the kinetic theory goes back to his undergraduate days, and he has already edited a three-volume selection of historic papers in this field and translated Ludwig Boltzmann's *Lectures on the Theory of Gases*. Brush has also been writing papers on various aspects of this history for some twenty years, and his book consists in large part of a collection of these papers, somewhat revised and reworked, accompanied by a hundred-page "Introductory Survey," and an extensive bibliography (over five hundred items) of virtually everything original written on the subject in the nineteenth century.

Brush's book is an impressive achievement. I know of no other work treating the subject with anything like its scope and depth. (The documentation provided in some two thousand footnotes shows the extremely wide range of Brush's studies and provides a rich source of material for anyone interested in nineteenth-century science.) This first volume contains a series of studies of physicists who worked on the kinetic theory. In addition to his relatively brief discussions of the three major figures—Rudolf Clausius, James Clerk Maxwell, and Boltzmann—Brush treats some less obvious subjects. Among these are two who had the misfortune to be premature kinetic theorists, and as a consequence are very little known—John Herapath and John James Waterston. (Waterston's paper containing, among other matters, the first statement of an equipartition theorem, was rejected by the Royal Society of London in 1846 when the referee reported it was "nothing but nonsense, unfit even for reading before the Society.") Brush also discusses that staunch and unyielding skeptic, Ernst Mach, who died in 1916 without abandoning his view that atoms were, at best, a convenient fiction.

In his second volume Brush has gathered seven longer essays that treat in considerable detail the history of some major problems involving the kinetic theory of gases. These are, on the whole, more rewarding reading, not only for the greater depth of their discussions but also because they allow Brush to deal with a historiographical problem that cannot be avoided in writing the history of a special subject like the kinetic theory. The historian cannot treat his subject as an isolated one, restricting his attention to only those matters that are now considered as belonging to the kinetic theory, as though they were neatly separated from the rest of science. Brush is very much aware of the dangers of such an approach, points them out explicitly, and takes pains to avoid them. As a result his work is full of the kind of surprises that make the history of science fascinating: the questions that led to the discovery of now-familiar results are often completely different

from what a modern scientific reader expects from his knowledge of the answers. A striking example appears in the chapter on the Stefan–Boltzmann Law where Brush traces Josef Stefan's work to its "historical origin .... in a research tradition, going back to Newton, that was primarily concerned with the problem of heat transfer," a tradition quite distinct from Boltzmann's concern with the thermodynamics of radiation pressure.

There are some flaws that come from the book's not having been planned and written as a single unified work. The level and style of exposition are quite different in different chapters; some major papers (like Maxwell's last article) receive less attention than they deserve and the broad outline of the development may not always be clear to a reader with no historical background.

Neither these nor other critical comments that might be made reduce the magnitude of Brush's achievement. This is a book that has much to offer any student, teacher, or researcher in statistical physics, and beyond that anyone who cares about what Maxwell called "the most interesting of all subjects, the history of the development of scientific ideas."

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Pulsars

R. N. Manchester, J. H. Taylor
281 pp. Freeman, San Francisco, 1977.
$19.95

It is over a decade since the extraordinarily exciting discovery of the first pulsar by Jocelyn Bell and Antony Hewish. Now hundreds of active pulsars have been identified in our region of the galaxy, and extinct pulsars, or spinning magnetized neutron stars, probably constitute close to one thousandth of all stars. Almost a hundred active pulsars have been observed in some detail. An enormous amount is known about them but much less is understood. Or, at least, investigators have not attained a compelling consensus supporting a single one of the very many models for the origin of the fantastically intense coherent radio beams which identify active pulsars; they have not agreed on the mechanism for the production of gamma-ray, x-ray and optical pulses by the pulsars within the young Crab and Vela supernova remnants, and they have not concurred on how currents move through the pulsar magnetosphere or how the rotational energy of a young rapidly spinning neutron star is converted into that of extreme relativistic electrons or positrons in a surrounding supernova remnant. Although the surface of the rotating star is not disputed as the very precise pulsar clock, certainly no accord has been reached on the causes of its sudden small speed-ups ("glitches").

Richard Manchester and Joseph Taylor, one-time colleagues at the University of Massachusetts, are radio astronomers who have been among the most important contributors to the wealth of pulsar data. Despite the lack of a consensus on theoretical understanding to match the rich detail of observations, they have probably chosen a propitious time for this excellent volume, which summarizes present knowledge about pulsars. After a decade of regular and exhaustive observations and a hundred analyzed pulsars, it is not very likely that, as pulsar searches and exploration are extended in the future, new surprises will be discovered to point the way to definitive pulsar models. The significant clues are probably already in the data summarized by Manchester and Taylor. Theoretical developments come slowly in fields without experiment to test, modify and suggest. Theories once proposed never die; they just fade away, if that. Given then the dichotomy of much beautiful and detailed data but no accepted theoretical framework in which to interpret it, Manchester and Taylor offer an exceptionally complete selection of probably all present observations that are likely to prove relevant to interpreting pulsar phenomena: the shapes of radio pulses from many pulsars, various individual polarization patterns, fluctuations, pulse envelopes, the often ordered drifting of position of subpulses within pulse envelopes, stability, radiopower, microstructure, detailed timing measurements of pulsar clocks, the statistics of pulsar locations and velocities and more.

About a third of the book is devoted to a discussion of the interaction of pulsars and their radiation with externally generated plasma. The propagation of the radio pulses through the intervening plasma of the interstellar medium affects the polarization and arrival time of pulses. The measured frequency dispersion of these effects are a unique probe of interstellar magnetic fields and electron densities. A major focus of much present theory and observation is the consequence of accretion of plasma onto a spinning neutron star from a close binary companion. For special ranges of mass accretion rates a rotating x-ray beam is formed. The phenomenological description of these accretion-powered x-ray pulsars is simpler and already better understood than that of the isolated radiopulsars.

Theoretical discussions of the latter constitute the last quarter of the book. They are marked by a special effort to summarize the points of view of most who