century the "numerical method" was increasingly under fire. The Baconian promise of knowledge through inductive methods had not really panned out, and the very limited mathematical techniques underlying medical statistics further obstructed progress. Medical research moved into laboratory work, and the devotion to numbers for numbers' sake waned. Cassedy's book affords us a look at an era when our culture's romance with numbers began; his impressive amount of evidence will surely spark further explorations into the origins of statistical thinking.

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The Southern Sky

Surveys of the Southern Galaxy. W. B. BURTON and F. P. ISRAEL, Eds. Reidel, Boston, 1983 (distributor, Kluwer Boston, Hingham, Mass.). xiv, 309 pp., illus., + appendixes. $46. Astrophysics and Space Science Library, vol. 105. From a workshop, Leiden, Netherlands, Aug. 1982.

Dutch astronomers have a gift for convening small international meetings on developing topics that often lead to breakthrough contributions to our knowledge of galactic structure and stellar evolution. *Surveys of the Southern Galaxy* contains an exciting account of such a conference.

Since 1960 the long-standing neglect of the skies above southern latitudes has been counteracted quite splendidly by the installation of major astronomical observatories in Chile, Australia, Africa, and Argentina. Indeed, the former "hidden quadrant" of the Milky Way galaxy, which cannot be observed from northern obervatories, is increasingly well studied and mapped at these excellent new sites.

Molecular clouds are aggregates of gaseous matter with a little bit of dust added. Their diameters extend for some 90 light-years, and their masses are equal in some cases to about a million solar masses. In these clouds we observe the most abundant molecule, hydrogen, along with carbon monoxide, cyanogen, ammonia, and some 60 other molecules—enough to stock the shelves of any respectable cosmic chemist. Carbon monoxide appears to be the best tracer over wide areas; carbon sulfide is an excellent indicator of density in the clouds. Almost all of the lines and bandheads can serve as indicators.

Molecular clouds form the basis for most of the research discussed in *Surveys of the Southern Galaxy*, and surveys of carbon monoxide receive special attention and emphasis. A report by B. J. Robinson, W. H. McCutcheon, R. N. Manchester, and J. B. Whiteoak on a survey at CSIRO in Australia points to a four-armed spiral structure with a pitch angle of 12 degrees for our galaxy. Authors combine and compare their results with data on carbon monoxide from the Northern Hemisphere. A report by Th. de Graauw, F. P. Israel, and C. P. de Vries on a survey by a Dutch group at La Silla in Chile also contains results from both hemispheres. The late entry by astronomers from the United States into radio research on the southern skies is a reflection of the economic recession in the United States, a lack of discernment by groups responsible for planning and funding research, and an overreliance on future observations by both radio and optical telescopes in space. A paper by R. S. Cohen, the head of the Columbia University Southern Hemisphere millimeter-wave survey group, describes the duplication at the U.S. observatory at Cerro Tololo in Chile of Columbia University's successful millimeter telescope. Surveys on the telescope have been successfully inaugurated, and the results bid fair to equal or surpass in quality the results obtained at the Manhattan station of Columbia.

The book neglects the optical and infrared spectral regions though it contains excellent contributions by J. A. Graham, who discusses a dust globule embedded in the Gum Nebula, and A. I. Sargent, who suggests that southern OB associations are keys to a fuller understanding of the processes of star formation.

The book contains a brief and clear review of prominent satellite missions and of high-energy surveys by K. Bennett and a clear overview of the scientific expectations of the European Space Astrometry Mission, Hipparcos, by M. A. C. Perryman.

Though the book is concerned chiefly with the Milky Way galaxy and specifically with its southern portion, well-justified attention is devoted to problems and results from other galaxies, specifically the Magellanic Clouds (which rise only in the South) and the Andromeda galaxy. A paper by J. S. Young discusses her survey of molecular clouds in spiral galaxies, which may open up our investigation of star formation and evolution beyond the limits of our own system. This of course would help us understand these processes better in our own Milky Way.

One worthy feature of the publication is the absence of discussion notes. Another is the presence of a fine set of appendixes; these show the distribution over the whole (northern and southern) Milky Way of neutral hydrogen, carbon monoxide, the 408-MHz continuum flux, and the gamma-ray emission. The final appendix shows the distribution of neutral hydrogen in the Andromeda galaxy for comparison with the Milky Way. These charts will be consulted long after many of the conclusions presented in the text have been revised and perhaps forgotten.

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Cosmology

The Constants of Physics. W. H. MCCREA and M. J. REES, Eds. Royal Society, London, 1983. viii pp. + pp. 211–363, illus. £23.40. First published in *Philosophical Transactions of the Royal Society of London*, series A, vol. 310. From a meeting, London, May 1983.

The artwork on the dust jacket of this volume of proceedings displays a number of what used to be called "fundamental constants," and Planck's constant $\hbar$ is only one of them. However, quantum mechanics (plus special relativity) dominates everything about a modern discussion of the constants of nature and is the reason why so many seemingly different topics have to be discussed together. The many facets of the subject are reflected in the number of contributions (18) in the volume, a large fraction of them written by theorists (but with frequent references to experiments). Sixty years ago one could discuss each constant separately, and, if the unit of length referred back to the size of the king's foot, one could have referred to a flea's foot or an elephant's foot instead. This soon changed when the importance of dimensionless ratios was demonstrated with the Sommerfeld fine structure constant, $\alpha = e^2\hbar c \approx 1/137$ (where e is the charge of the electron and c is the speed of light). It not only "tied together electrostatics and light," but it was a "dimensionless coupling constant"—the electrostatic force in the hydrogen atom was now "weak" in an absolute and unique sense. Atomic physics, it was thought, would now provide natural units for length, momentum, energy, frequency, and the like—the foot of the flea or the elephant was to be expressed in terms of the Bohr radius ($a_o \sim 0.5 \times 10^{-8}$ cm) of the hydrogen atom. The practical side of the measurement of the fundamental constants (discussed in the book by K. F. Smith and by B. W. Petley) is today also geared to expressing everything in terms of atomic units.

The gravitational force obeys an inverse square law, just like electrostatics, and Gm_pm_e (where G is the gravitational constant and m_p and m_e are the proton and electron masses) is an analogue to e^2 for the hydrogen atom. The gravitational fine structure constant $\alpha_G = Gm_pm_e/\hbar c \sim 10^{-38}$ is very small, relevant if e were zero. The gravitational Bohr radius of the hydrogen atom not only is large ($a_{oG} \sim 10^{28}$ cm) but is close to the present-day value of R_U, the radius of the observable universe. R_U is changing with time because the universe is expanding, and Dirac (1937) raised the question whether the dimensionless constants of nature (especially α_G) might themselves be changing with time. So far all attempts at finding time variations of fundamental constants have turned out negative (as is discussed in a paper by R. D. Reasenberg and in one by B. E. J. Pagel), including an accurate demonstration of the constancy of the coupling for the nuclear force (from the bizarre occurrence of the Oklo natural reactor (J. M. Irvine). The importance of the large dimensionless numbers for many macroscopic phenomena is summarized in the book (M. J. Rees), and even biological evolution (B. Carter) and the human four-minute mile (W. H. Press and A. P. Lightman) are treated.

If the constants of nature are really constant are they also related? The hope for an affirmative answer provides the underpinning for much of fundamental particle theory of today (S. Weinberg, C. H. Llewellyn Smith, J. Ellis). The successes to date relate mainly to results of high energy experimental physics, which are very plentiful, so the theories still have quite a number of parameters in them. Grand unification including gravity is still the end of the rainbow, partly because the weakness of gravity translates into large masses: with the Planck mass M_{Pl} defined by $GM_{Pl}/\hbar c = 1$, $M_{Pl} \sim 10^{19}\ m_p$ is even larger than the grand unification mass ($\sim 10^{15}\ m_p$) where the various couplings (excluding gravity) approach each other. Thus it is not clear yet whether the empirical relation $ln(M_{Pl}/m_p) \sim (3\alpha)^{-1}$ can be derived from fundamental theory. I will dodge the question whether this book is entirely successful in explaining the state of the art in each subject to readers outside the field. So many specialized fields must be brought together that success in this may be impossible. However, even if one does not understand much of what one reads one is carried along by the sense of excitement, especially when it is understated (for example, the note added in proof on the discovery of the Z-particle, p. 46, which pretty well verifies what was predicted in the talk).

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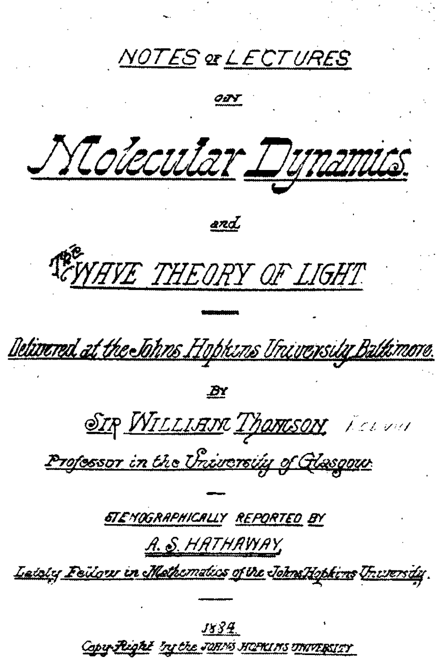
Mechanists and Deviationists

American Physics in Transition. A History of Conceptual Change in the Late Nineteenth Century. ALBERT E. MOYER. Tomash, Los Angeles, 1983. xx, 218 pp., illus. $30. The History of Modern Physics, 1800–1950, vol. 3.

In this book Albert Moyer examines the "prehistory" of the American reception of quantum theory and Einstein's theory of relativity. He demonstrates that in the decades preceding 1905 there existed in American physics a questioning of foundations and a search for alternatives to what was seen as a failing mechanistic world view, paralleling the ferment in European physics in the same period.


NOTES OF LECTURES
ON
Molecular Dynamics
and
THE WAVE THEORY OF LIGHT
Delivered at the Johns Hopkins University, Baltimore.
BY
SIR WILLIAM THOMSON,
Professor in the University of Glasgow.
STENOGRAPHICALLY REPORTED BY
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Lately Fellow in Mathematics of the Johns Hopkins University.
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Cover of William Thomson's "Baltimore Lectures." Thomson's use in these lectures of an analogy between the luminiferous ether and "Scottish shoemaker's wax" as a "commonplace, concrete 'illustration' to justify his assumption of an elastic ether points to the feature for which the . . . lectures are best known today: his insistence on mechanical models in explicating the molecular dynamics of light. . . . American misgivings about even Thomson's self-critical and circumspect mechanical outlook suggest that by the mid-1880s, physicists were not as uniformly and deeply committed to the atomo-mechanical viewpoint as Stallo contended." [From *American Physics in Transition*; Rare Book Department, University of Wisconsin Library]

Moyer begins with a careful analysis of J. B. Stallo's 1882 critique of the "metaphysical" commitment of contemporary physicists to an "atomo-mechanical" world view, that is, to the explanation of all physical phenomena in terms of particles or an ether obeying the laws of mechanics. Then, surveying the views of a dozen presumably representative American physical scientists active about 1880, and the transformations and realignments of these positions after 1895, Moyer finds a spectrum of opinion even among mechanists, both at the level of "content" (theories, hypotheses, and models) and at the level of "scientific ideologies" (philosophical stances, methodologies, and values). His "orthodox mechanists" Alfred M. Mayer and Amos Dolbear were born in the mid-1830's, "modest mechanist" John Trowbridge and "muted mechanist" Henry Rowland in the 1840's, and "practical" mechanists Albert Michelson and Edwin Hall in the 1850's. Moyer points out that the increasing complexity and subtlety of their positions reflected changing patterns of education and research in American physics. Yet four of his five "deviationists," spokesmen for nonmechanical outlooks that could have undermined the dominant "atomo-mechanical" position, were born in the same decade as his "orthodox mechanists," a coincidence of which he takes no notice. The potentially subversive views of these five included the operationalism of Simon Newcomb, the incipient pragmatism of Charles S. Peirce, the phenomenalistic "leanings" of Willard Gibbs, and the skepticism of Samuel Langley and Francis Nipher toward claims of scientific truth.

The section of the book delineating the philosophical and methodological positions of these physicists is its strongest part, providing essential support for Moyer's argument. A second strength of the book lies in the evidence it presents for the influence of European physicists in the United States. Moyer gives attention to the lecture tour of John Tyndall in 1873, the visits of Rayleigh, William Thomson, and others in 1884, the appearance of Helmholtz in Chicago in 1893, and the attendance at the 1904 St. Louis Congress of Arts and Sciences of a galaxy including Poincaré, Boltzmann, Ostwald, Langevin, and Rutherford.