Ernst Mach subjected the entire program of mechanical explanation to searching historical and philosophical criticism; Wilhelm Ostwald and the energeticists sought to found physical science on energy relations alone; and a wide variety of theorists considered replacing the mechanical universe with an electromagnetic one.

Many elements of this story are well known, but no one previously has attempted to collect the entire range of issues in one small book. We have seen numerous popular treatments, for example, of the problem of objects moving in the luminiferous ether that emphasize its relevance to Einstein's special theory of relativity, but Harman's book demonstrates the fertility of the ether for theory and experiment in optics, electromagnetism, thermodynamics, and matter theory as well. Teachers and students surveying the history of physics, as well as readers interested more generally in the history of scientific ideas, will welcome the overview, and as an attempt to set the concepts straight the book deserves high praise.

So brief an overview has limitations, however. This is not so much a history of physics as a descriptive catalogue of ideas arranged chronologically, and there are some unfortunate lacunae. At the most general level, we never learn what the relation is between analytical dynamics, energy physics, and field theory. A simple answer exists, even for a non-mathematical reader, in the replacement of Newtonian forces acting between atoms by extremum principles governing entire systems. Thomson and Maxwell began that shift by applying extremum conditions on the energy of fields to describe the moving forces on bodies located in and contributing to the fields. Hamilton's principle and Maupertuis's principle of least action provided similar foundations for analytical mechanics quite generally, although Thomson and Tait in their influential *Treatise on Natural Philosophy* (1867) continued to regard these principles as derivative from conservation of energy. Such determinants on whole systems were essential to many of the shifts in explanatory goals that Harman does describe: from atomistic mechanics to continuum mechanics, from action at a distance to contiguous action, from force physics to energy physics, and even from deterministic mechanics to statistical mechanics.

There exist also more specific conceptual difficulties. Helmholtz's "tensional force" (potential energy) between two bodies is presented in modernized form (p. 43) as a product of force and distance (presumably a sum of forces times infinitesimal changes in distance), whereas Helmholtz himself described it as a sum of the forces themselves "consumed" at each point along a path. The difference is subtle but critical to understanding how Helmholtz's concept of energy emerged from that of force. Similar problems appear with respect to Boltzmann's understanding of the relation between statistical mechanics and the second law of thermodynamics (pp. 142–143) and to Thomson's usage of "imaginary magnetic matter" for describing magnetism (p. 82). Harman has this matter spread over all space as a continuous magnetic ether, whereas for Thomson it appeared only at inhomogeneities in magnetic substances.

Harman includes in the book an extensive guide to secondary sources on 19th-century physics, providing a bibliographic essay of a sort that is much needed. It would be even more valuable, however, if he had indicated from which sources he has drawn his major theses. This is a matter not only of giving credit but of providing the reader with a basis for evaluation. Several of the difficulties with Harman's treatment seem to have arisen simply from the secondary articles drawn on.

I would like to call attention, finally, to the exemplary use Harman has made of diagrams from primary sources. They are remarkably clear and amplify in intriguing ways the textual material.

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Grand Unification

Third Workshop on Grand Unification. Chapel Hill, N.C., April 1982. PAUL H. FRAMPTON, SHELDON L. GLASHOW, and HENDRIK VAN DAM, Eds. Birkhäuser, Boston, 1982. x, 374 pp., illus. $22.50. Progress in Physics, no. 6.

Two of the great triumphs of physics in the past dozen years have been the unification of the electromagnetic and the weak interactions and the development of the understanding of the strong force. Beyond these, models of the unification of these three forces have been proposed. The general idea of such unification is known as grand unification. Grand unification, just one step away from the ultimate unification of all forces (including gravity) in nature, is clearly one of the most exciting ideas in physics in recent years. It predicts, among other things, that matter must eventually decay (that is, protons are unstable) and that superheavy magnetic monopoles (with mass around 10^{-8} gram) must exist.

This book is a collection of 27 papers presented at a symposium on the subject. About half of the papers deal with theoretical aspects of grand unification, the other half with experimental aspects. Many of the papers are reviews, so readers can get a good picture of the latest developments in grand unification, up to 1982.

One of the most exciting happenings in physics in the past year is the report by Blas Cabrera of Stanford University of an event suggestive of a magnetic monopole. This was reported in many newspapers and magazines and the result was published in *Physical Review Letters*. However, because the length of such a letter is limited, many important details were missing. In this book, Cabrera explains at length his experimental set-up, the result, and his future plans. His detailed report should be of great value to readers who want to know more about his results.

Traditionally, particle physics tests are mostly the domain of high-energy experimental physicists. However, the development of grand unification has rapidly changed that. Of the 14 experimental papers only one discusses experiments done at high-energy particle accelerators. Many papers discuss crucial experimental tests of the grand unification idea that were being carried out by low-temperature physicists (monopole search) and atomic and nuclear physicists (neutrino mass, neutron-antineutron oscillation). Any experimental physicist who has access to deep underground facilities and does not have claustrophobia can always start a new proton decay experiment or join an existing one. For non–high-energy experimental physicists who are interested in performing tests of the grand unification idea, this book should prove invaluable.

The theoretical papers cover many aspects of grand unification, with heavy emphasis on the application of supersymmetry. Supersymmetry relates bosons and fermions and is one of the most profound symmetries known in physics. Many theorists believe it must have something to do with nature and probably with grand unification. The question is how. Steven Weinberg puts it appropriately in his paper: "Supersymmetry is a wonderful toy, with which many theorists have enjoyed playing for the last six or seven years. It is a toy of whose purpose we are so far unsure, and the question what supersymmetry is good for is clouded over by the fact that, whatever this toy is good for, it is certainly broken. We would very much like to know where it is broken and what broke it." Most of the papers on supersymmetry are attempts to answer these two questions.

Some readers may be disappointed at the lack of discussion of the recent developments in cosmology and of the idea of composite quarks and leptons.

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