have liked to have known before entering the competition." As a major contributor to the field, he remains cautiously optimistic about the future of amorphous ferromagnetic materials.

Rare-earth elements on their own have intriguing magnetic properties that have been systematically investigated in the last two decades. S. Legvold covers them and their alloys with one another. K. H. J. Buschow describes the properties of over 1000 intermetallic compounds that rare earths form with other metals. Many of these he and his colleagues at the Phillips Research Laboratories produced. In summarizing the ability of current theory to encompass the results on the compounds with nonmagnetic elements, Buschow says, "in a way all these results seem rather frustrating. Initially rare-earth intermetallics and their magnetic properties were believed to represent standard examples of the RKKY coupling scheme. From the discussion given above it would appear that the predictive value of the RKKY coupling scheme is actually rather limited and that for an *a priori* description of the magnetic properties in the rare-earth intermetallics a knowledge of details of their band structure would be required." Experimentalists are optimistic by nature, apparently.

When rare-earth elements are combined with Mn, Fe and Co, their Curie temperatures, in sharp contrast with those of all other compounds, are well above room temperature. Of all the compounds, perhaps the most likely to prove practical are the magnetostrictive rare-earth–Fe_2 compounds that A. E. Clark describes. Alloys that have been produced with magnetostrictions greater than 0.001, while maintaining high susceptibilities, yield the very high magneto-mechanical coupling coefficients suitable for transducer operation.

The mixed oxides of rare earths with transition metals, which crystallize in the garnet structure, find applications in microwave devices and thin films for magnetic bubbles. The late M. A. Gilleo presents the basic magnetic properties of the garnets. Their applications are given in chapters by J. Nicolas on microwave ferrites and by A. H. Eschenfelder on crystalline films for bubbles. P. J. Slick considers transition metal oxides of the spinel structure in a chapter on ferrites for nonmicrowave applications. Despite a lack of background in these applications of magnetic insulators, this reviewer found these articles interesting and easy to read. Eschenfelder has a second chapter devoted to amorphous films for bubbles. The typical example is a mixture of Gd, Co, and Mo.

As if there weren't enough magnetic materials already, nuclear technology has extended the actinide series, whose magnetic compounds W. Trzeviatowski covers. The magnetic properties are helpful in understanding the electronic structure of these materials.

The final chapter by S. W. Charles and J. Popplewell is on ferromagnetic liquids; these came out of the space program and have more recently been developed for use in rotating seals with impressive performance. The authors foresee many other applications for very fine ferromagnetic particles suspended in liquids. The secret is to prevent aggregation by coating the particles with a surfactant, typically a long organic molecule with a polar head. The authors neglect to point out that magnetic fluids make good toys, but everybody knows that about magnets in general.

Judging by the vast amount of information gathered from experiment and the small impact of theory on predicting magnetic behavior, one might conclude that magnetic materials are more fun to discover and experiment with than to try to understand quantitatively. Wherever the experimentalists are playing, they will find these volumes a must.

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Anthony S. Arrott is professor of physics at Simon Fraser University in British Columbia, where he studies the magnetic properties of iron and other transition metals, using neutrons, muons and magnetic induction. He serves as a member of the Commission on Magnetism of IUPAP.

Albert Einstein's Special Theory of Relativity: Emergence (1905) and Early Interpretation (1905–1911)

A. Miller
466 pp. Addison-Wesley, Reading, Mass., 1981. $39.50 cloth, $27.50 paper

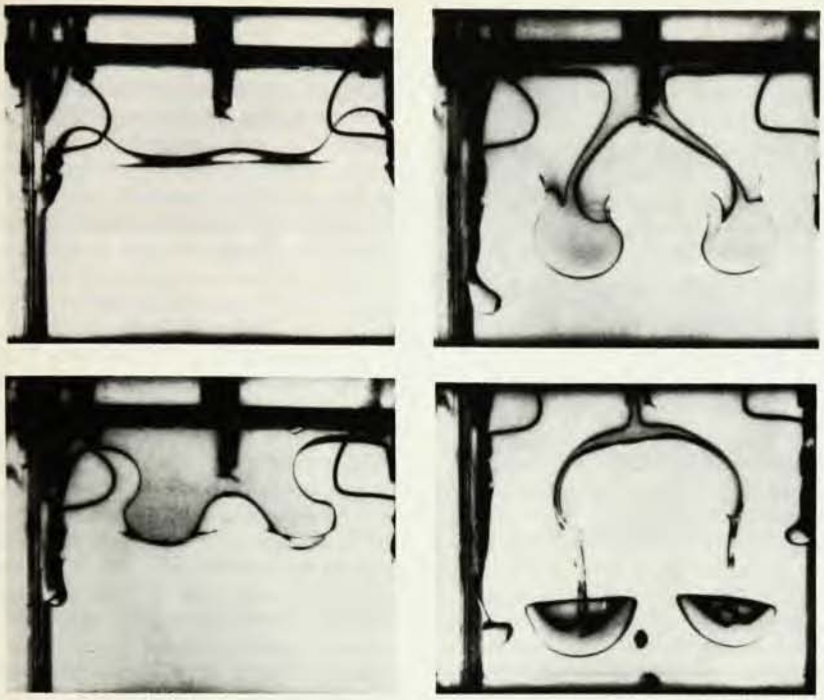
The development of the special theory of relativity—one of the most significant episodes in the history of science—is invariably made to serve as an empirical basis for the discussion of fundamental concepts in the history and philosophy of science. Any attempt to characterize the nature of theory change in science must deal with this episode in some manner. For example, in *The Structure of Scientific Revolutions*, Thomas S. Kuhn uses the transition from Newtonian to Einsteinian physics to argue for the incommensurability of scientific theories and against the possibility of choosing, fully rationally, among competing theories. Karl Popper, whose views are opposite to those of Kuhn, uses this case instead to demonstrate that although scientific theories can never be verified, they can be falsified, in principle by a single experiment.

Surprisingly, Arthur Miller's new book is the only work extant that attempts to describe the detailed technical context, both experimental and theoretical, out of which Einstein's special theory of relativity emerged and to chronicle the arguments that led to its eventual acceptance. The book is long and difficult, but the story it tells is fascinating because it little resembles the tendentious descriptions of this era found in physics texts or philosophy journals.

The major contribution of the book is that is brings to light a feature of the development of special relativity that is not widely appreciated by philosophers, historians or physicists and that goes a long way toward explaining why physicists were so slow in accepting the theory itself and Einstein's contribution to it. The importance of Einstein's work went unrecognized initially because he was attempting to construct a *macroscopic* theory that would lead to the covariance of Maxwell's equations, while, in contrast, his contemporaries were working with atomic theories.

Miller places the development of special relativity in the context of the research program of electromagnetic theorists in the two decades preceding Einstein's 1905 "relativity" paper. This research program, greatly influenced by the recent discovery of the electron by J. J. Thomson and others, had two ambitious goals: to derive the Lorentz contraction and related effects, which were known to imply the invariance of Maxwell's equations for all inertial observers, from a microscopic theory of the interactions of the charged atomic constituents of matter with the ether, and to derive the mass of the electron, that is, its resistance to acceleration, from the energy stored in its self-electromagnetic field, which could achieve, in principle, the quite revolutionary step of reducing mechanics to electromagnetic theory. By 1905 Konrad Lorentz and Henri Poincaré had developed a theory of the electron that essentially satisfied the first of these goals but not the second; another group led by the German theorist Abraham, had formulated a theory that satisfied the second goal but not the first. The two theories made different predictions about the expected velocity dependence of the electron's mass, which was being tested experimentally.

It was in this intellectual climate that Einstein published his 1905 paper. There he showed that the Lorentz transformations and Lorentz's prediction for the velocity dependence of the electron's mass could be derived from two general macroscopic postulates, that the form of the laws of physics was



Developing instability that occurs when the field holding a heavier liquid over a lighter liquid is shut off. These stills from the film *Complex Waves II*, produced by the National Committee for Electrical Engineering Films and distributed by Education Development Center, appear in *Continuum Electromechanics* by J. R. Melcher (MIT P., Cambridge, Mass., 1981. $37.50). The book, designed to be used as a graduate-level text and engineering reference work, presents an interdisciplinary account of the interaction of electromagnetic forces and ponderable media, the mechanical responses to electromagnetic fields, and the reciprocal effects of the material motions produced by those fields. It also treats such diverse applications of continuum electromechanics as design of rotating machines and synchronous generators, polymer processing, magnetic melting and pumping in metallurgical operations, and processing of plastics and glass.

the same in all inertial frames of reference (the principle of relativity), and that the speed of light was invariant. Miller shows that Einstein quite explicitly strove to develop special relativity on the basis of macroscopic postulates, because his contemporaneous investigations of the photoelectric effect had convinced him that Maxwell's equations were inadequate on the microscopic level and had made him suspicious of any attempts to *derive* the principle of relativity from atomic theory. Thus Miller brings out an essential feature of Einstein's theory, that Einstein brilliantly foresaw the difficulties involved in merging atomic and electromagnetic theory, which were only to be resolved many years later in quantum electrodynamics, and therefore presented special relativity in a formulation that was independent of any atomic hypotheses. Moreover, because Einstein's approach was basically an alternative formulation, which achieved Lorentz's mathematical results on a very different conceptual basis, one can understand the slowness of the physics community to accept it fully. The attention of most physicists was focused on the rival electronic theories. Which version of the "Lorentz-Einstein" theory was preferable seemed to be of secondary importance. And in *fact* the initial experimental evidence appeared to refute their theory. It was only over the next five years that the experimental findings began clearly to favor special relativity.

The strength of Miller's book is that it provides a subtle appreciation of the debates over the acceptability of special relativity—by no means a simple clash of Newtonian and Einsteinian ideas—and allows one to evaluate more critically the views of Kuhn, Popper and others. Its weakness is that the explanation of the physical ideas is hard to understand. The technical discussions are difficult to follow even for someone with advanced training in physics. For example, we are told that Einstein's version of special relativity actually did make some predictions different from Lorentz's concerning the relativistic Doppler effect, but it is not made clear exactly how this can be so, given the mathematical similarity of the two theories. In addition, Miller has included, for historical completeness, material that interrupts the essential conceptual development of the book. Unfortunately these problems make the book less readable for the general audience of physicists and philosophers, which it deserves since it is a valuable contribution to our historical understanding of the nature of theory change in science.

A. Douglas Stone
Massachusetts Institute of Technology

Optical Physics. Second Edition

S. G. Lipson, H. Lipson
463 pp. Cambridge U. P., New York, 1981. $55.00 cloth, $22.50 paper

The steady growth of optics in physics and engineering curricula has caused a gradual replacement of many of the traditional workhorses of the past twenty years with a new generation of textbooks in which the conventional development of classical optics has been blended with the advances of the laser era. Most successful new books—*Optics* by E. Hecht and A. Zajac, for example—owe some of their popularity to the authors' awareness of the thinning of the boundaries between optics and current technologies and to their abilities to convey the logical continuity between optics and the rest of modern science.

In the first edition of *Optical Physics* (1969) while S. G. Lipson and H. Lipson developed the traditional principles of optics, they emphasized the applications of these principles to other branches of physics. The second edition has undergone extensive revisions, additions and updating, while it has kept the original unifying concept: It stresses the existence of common traits between traditional optics and, say, electron microscopy, crystallography, astrophysics and radioastronomy. This insistence is a useful and valuable feature.

However, with this laudable concern, the authors might have covered several topics more extensively. Discussions of nonlinear optics, Fourier optics, thin films, lasers and synthetic apertures, for example, may not supply material required for adequate coverage in the classroom.

The chapters dealing with wave propagation, interference and diffraction are probably the best sections of the book. These subjects, properly based on Fourier analysis, are presented in informal and generally clear language. Other chapters are weakened by omissions. The treatment of polarization, for example, depends too much on formalism and not enough on more applied aspects; the development of optical instruments and image formation contains detailed coverage of the