Lodestone discoveries

EXPERIMENTAL METHODS IN MAGNETISM, PART 1: GENERATION AND COMPUTATION OF MAGNETIC FIELDS; PART 2: MEASUREMENT OF MAGNETIC QUANTITIES. By H. Zijlstra. 532 pp. North-Holland, Amsterdam (Interscience, New York) 1967. $26.50 per set

by RICHARD J. HIGGINS

Magnetic fields and magnetic properties of matter have been the cornerstone (or perhaps lodestone) for many of our discoveries about the physical world. Recent examples are development of magnetic resonance with nuclear and electron spins as probes beginning in the 1940's and discovery of high-field phenomena in metals during the 1950's, enabling the mapping of numerous Fermi seas. Other developments are the type-II superconductors in the early 1960's with applications in the generation of high fields at low cost and discoveries in the mid 1960's of flux conservation and quantum interference in superconductors. Their fundamental importance and many applications include a digital magnetometer with a potential precision of one quantum of flux.

Since many of these discoveries were not discussed in the most recent (1961) edition of Bates's *Modern Magnetism*, the appearance of Zijlstra's *Experimental Methods in Magnetism* is of interest. But viewed as a state-of-the-art monograph, Zijlstra's book does not make the grade. The book has complete reference citations only through 1963. Superconducting solenoids get only nine pages of elementary treatment. Conspicuously absent is any mention of superconducting-flux conservation or quantum-interference phenomena. These are errors of omission, which leave a large gap in an otherwise useful book. It is, however, an excellent compendium of classical methods.

Volume 1 begins with two chapters on the magnetic potential and the use of spherical harmonics in solving potential distribution problems. The treatment is at the level of a good undergraduate course in electromagnetic theory. Chapter three is a thorough discussion of air-core solenoids, with emphasis on optimized Bitter solenoids and related high-field designs. A concise section on pulsed fields includes a discussion of energy conversion efficiency and a brief account of flux concentrators, which have been used to generate pulsed fields approaching a megagauss. The chapter closes with a section on cryogenic coils, emphasizing the reduction in energy dissipation by cooling a normal metal to the residual-resistance region. This section concludes with a discussion of superconducting solenoids, including methods of energizing (for example, flux pumping) and some of the special problems peculiar to superconducting systems. A good indication of the gaps left unfilled by this book is the shortness (nine pages) of this last section on superconducting solenoids, whose future importance will likely rival more classical methods of field generation. Though the general methods of the first two chapters are useful in optimizing superconducting solenoids, there is only passing mention of the mechanism that makes high-field superconductivity possible; yet this mechanism is a source of important differences in the behavior of superconducting solenoids (flux trapping, quenching, ac losses, field-dependent flux distribution and hysteresis). Volume 1 concludes with a chapter on iron-core magnets; the discussion of magnetic circuits is rather less clear than many textbooks, but it contains valuable information on optimized core and pole geometry not easily accessible elsewhere.

Volume 2 begins with a thorough chapter on magnetic field measurement, including fluxmetric, resonance and galvanomagnetic methods. Several designs for flux coils circumvent the problem of measuring a spatially varying field with a finite-volume coil. For time-varying fields these methods are evaluated, and low inductance current shunts are described. Chapter 2, "The Magnetized State," is a rare source for methods to calculate demagnetization effects in something other than an ellipsoid. Here, as elsewhere in the book, the author's careful mathematics is accompanied by a less than satisfactory physical description; a beginner should look elsewhere to find what is meant by the "demagnetizing field." The chapter concludes with an excellent account of eddy-current phenomena, including a complete discussion of the variation of field and phase within a cylindrical sample in an alternating magnetic field. Chapter 3 is an account of classical methods of measuring magnetization (fluxes and forces), which adds an adequate discussion of null methods and of the vibrating-sample magnetometer to Bates's earlier treatment. Chapter 4 on magnetostriction is inadequate, emphasizing strain-gauge methods with no mention of more sensitive capacitance and interferometric techniques. Chapter 5 is an account of magnetic anisotropy and the measurement of torques exerted by anisotropic substances in a magnetic field. Chapter 6 is an adequate introduction to magnetic resonance. The book concludes with a chapter on hyperfine interaction, emphasizing the probing of local magnetic fields in solids with the Mössbauer effect.

* * *

Richard Higgins is a professor at the University of Oregon, Eugene. His research is directed at applying the techniques of Fermi-surface measurements in high magnetic fields to study alloying and electron scattering in metals.

Ponderomotive force

ELECTRIC AND MAGNETIC FORCES. By R. R. Birss. 165 pp. American Elsevier, New York, 1968. $6.00

by JAMES B. KELLEY

At the outset of his book R. R. Birss, of the School of Mathematical and Physical Sciences, University of Sussex, defines a term that is new to American vocabulary but that fits quite nicely into what he is about, "ponderomotive force." A ponderomotive force would be, according to Birss, the force that moves an unrestrained piece of iron that has been placed in a magnetic field.

From this point the author follows classical electromagnetic theory, except that now problems are posed that include material bodies in electric and magnetic fields, which, incidentally, are treated separately.

The first chapter is largely a review of the well known principles of electromagnetism and the presentation of definitions to be used in succeeding chapters. The second chapter begins the study of the ponderomotive force, and here the discussion is in terms of the forces exerted on charges. The development is not unusual although it is in somewhat greater detail than one would find in the usual book dealing with electromagnetic problems. Both force and torque are treated in the same depth, and a particularly

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Edited by GIANCARLO BERTOLINI, *EURATOM, Joint Nuclear Research Center, Ispra, Italy; and* ANDRE COCHE, *Faculte des Sciences de Strasbourg and Centre de Recherches Nucleaires de Strasbourg-Cronenbourg. Articles by*

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long section is devoted to the electromagnetic conditions within matter.

The third chapter is a very good and concise summary of the elasticity of solid bodies, including the stress and strain tensors, the stress–strain relationship and stresses in dielectric and magnetic bodies. The discussion in this section is interesting and shows quite well the effects of magnetization on Young's modulus.

The fourth chapter discusses microscopic and macroscopic electromagnetic theories of physics, and there is a short section on solid-state physics. The discussions throughout this chapter are very useful, even though the reader is once again given the magnetic rather than the electrical case. The author explains that this approach is the simpler and much more readily provable case. The last two chapters deal with the prediction of the uniform and nonuniform strain tensor. For the latter, the development is, as one might expect, mathematically rather complicated. At various points in the book there is discussion of the magnetostriction phenomenon.

Altogether the presentation is a good one, the notation is standard, and the approach is straightforward. There are a few problems at the end of each of the six chapters, as Birss intends the book to be used in the classroom. It would appear, however, that the book's greatest use might be for a senior honors seminar or an intermediate graduate seminar. For such purposes the book could provide further depth to the initial upper-level electricity and magnetism course.

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James B. Kelley, professor of physics at Marquette University, specializes in electromagnetism and electrodynamics.

Hydrodynamic stability

STABILITY OF PARALLEL FLOWS. By Robert Betchov and William O. Criminale Jr. 330 pp. Academic Press, New York, 1967. $16.00

by JOSEPH GILLIS

It is perhaps natural that most people who have ever thought seriously about fluid flow have sooner or later come to recognize the central significance of stability. Leonardo da Vinci, who was deeply interested in flight problems, filled a notebook with drawings of turbulence. That great kite-flier, Benjamin Franklin, made some acutely perceptive remarks on stability. In the following century George G. Stokes, William T. Kelvin and John W. S. Rayleigh gave the subject a genuine theoretical basis, using the methods of their time, that is, separation of variables.

The development was continued in the present century by James H. Jeans, Rayleigh, Arnold J. W. Sommerfeld, Subrahmanyan Chandrasekhar and others. Chandrasekhar's book, published in 1961, is a monumental account of the then state of the art of linear-stability theory, and his volume seemed to be the last word on the subject. However, science moves on, and during the present decade the question of hydrodynamic stability has assumed a new and wider interest. This is mainly because of the development of nonlinear theory, initiated by Stuart and others during the late 1950's and made possible by the advent of high-speed computers. The new insights gained from the work of Stuart and others have in turn made possible substantial advances in the linear theory itself.

The new monograph by Robert Betchov and William O. Criminale attempts to sum up the present situation in parallel flows. The book begins with a careful formulation of the linear problem for two-dimensional flows, beginning with the general equations and developing a few special inviscid cases. These are used particularly to illustrate the basic physical mechanisms. The remainder of part one deals with standard two-dimensional problems of viscous parallel flow, boundary layers, channel flows, jets and wakes. I particularly welcome the concluding chapter of this part wherein computer methods are described in some detail.

The second part of the book presents a complete picture of the general problem. The basic theory and standard methods of analysis are carefully explained and related to experimental facts. Nonlinear problems are included, and there is also a long chapter on magnetohydrodynamic effects. An interesting final chapter is devoted to miscellaneous modern topics, including the complication of flexible boundaries, relevant both to problems of aerodynamic flutter and blood flow, and a short note on dusty gases.

Apart from the broad and clear presentation of the main problems, the book is also rich in incidental and illuminating information. The mathematical argument is careful and clear throughout and includes all the recent developments in the subject. There is a beautiful appendix explaining an analytic approach to the Orr–Sommerfeld equation through the method of inner and outer expansions. In this case the problem of matching the expansions is shown to be equivalent to that of finding a suitable path for a complex integration.

* * *

Joseph Gillis is a professor of applied mathematics at the Weizmann Institute of Science, Rehovoth, Israel.

Closer to field theory

PARTICLES AND FIELDS. By David Lurié. 506 pp. Wiley, New York, 1968. $15.00

by JEREMY BERNSTEIN

As a guide to prospective consumers I would like to propose that all books containing the words "particle" or "field" or both in their titles be given a content rating defined by the expression $a \times$ "particle" $+ b \times$ "field" where a and b are presumably positive numbers whose sum adds up to unity. This rating has no pejorative intent but should serve to warn the reader that the book he is about to buy, or order for his class, is either a book about phenomenological particle physics or formal field theory or a mixture. (The table below indicates my rating of a few of the books in this field.)

David Lurié's new book is called *Particles and Fields*. Despite this title I would put a for this book close to zero, according to my rating system, and b close to one, because the reader is presumed to know the phenomenology of elementary-particle physics. Although the nucleon–electromagnetic form factors are defined in terms of the one-particle matrix elements of the electromagnetic current, we are not told how they look experimentally or indeed how to go about computing them in various models. (I was a little puzzled in this discussion because in counting up the number of independent Lorentz vectors that can be made out of the Dirac matrices and two four-momenta, Lurié finds only five and I believe there are twelve.) Dispersion relations are not discussed at