

tum physics between his "photoelectric effect" paper of 1905 and his paper on quantum radiation in 1916-1917, as Snow implies, but rather that he was continually preoccupied with the quantum nature of light in those years. Third, physicists as well as historians will be amused by Snow's remark that the "new mathematical tool" of group theory was first introduced into physics by Murray Gell-Mann. These and many other errors might have been corrected if Snow had lived to revise his draft; as it is, they weaken the book. What is special and valuable about Snow's *The Physicists*, however, is its portrait of scientists as human beings. Human passions and squabbles, foolishness and wisdom, acts of pettiness and of grandeur, are woven into accounts of discoveries and reflections on the problems of our scientific age. For this reason, *The Physicists* is an excellent book to hand, with suitable cautions, to undergraduate students of physics and history.

The publisher has enriched the book with a large number of striking and pertinent photographs, an introduction by Snow's friend William Cooper, and three appendices. The third appendix, Snow's 1960 speech, "The moral unneutrality of science," is welcome for what it tells the reader about Snow's background, literary style and attitudes towards scientists; it is particularly timely as an early call for physicists to work for disarmament.

* * *

Joan Bromberg is a historian of 19th- and 20th-century physics. Her most recent publication is *Fusion: Science, Politics and the Invention of a New Energy Source*.

Gauge Theory and Variational Principles

David Bleecker

179 pp. Addison-Wesley, Reading, Mass., 1981. \$17.50

Concepts and methods from differential geometry have been extensively used in the theory of general relativity for several decades. More recently, following the advent of gauge theories, this branch of modern mathematics has found important applications also in quantum field theory. This is just one instance of a general trend in contemporary mathematics, which has accumulated a very impressive record of applications to all areas of the physical sciences.

It is fortunate that several good textbooks are now available, providing an easy access to the basic geometric tools (for example, *Analysis, Manifolds and Physics* by Y. Choquet-Bruhat, C. De Witt-Morette and M. Dillard-Bleick and *Differential Forms in Mathematical Physics* by C. Von Westenholz).

However, the need remains for more purpose-oriented publications to bring readers in contact with the current frontiers of research in mathematical physics. The new series on global analysis, edited by Ralph Abraham, Jerrold E. Marsden and Philip J. Holmes, is intended to fulfill this need for reports from the research frontier.

The book *Gauge Theory and Variational Principles*, by David Bleecker, is the first volume of this series. It is unfortunate that this book falls short of reasonable expectations for a publication on geometric aspects of gauge theories: The treatment of the physics, which should motivate the deployment of the heavy mathematical artillery, is disappointingly shallow; the discussion often lacks in clarity and incisiveness; and overall the presentation is incomplete and out-of-date. In short, this book cannot be a valid substitute for the original papers and existing review articles in the field.

Chapters 0, 1 and 2 contain a discussion of the basic mathematical tools: differentiable manifolds, differential forms, connections on principal fiber bundles and curvature forms. The definitions are often too lengthy and sometimes clumsy; examples and intuitive considerations are scarce; and one feels the need for a clearer and more extensive presentation.

Chapters 3, 4 and 5 deal with particle fields, Lagrangians and field equations. Elaborate definitions are given without an appropriate motivation, to the point that it becomes difficult to recognize familiar concepts. For example, a rather involved definition of "current" is given without explaining how it relates to the corresponding notion in everyday physics. The gauge-covariant equation of continuity is written in differential and in integral form, but there is no discussion of the problem of defining a conserved invariant total charge in the non-Abelian theory.

Chapters 6 and 7 deal with spinor fields and their gauge interactions. Contact with the physicist's approach to Yang-Mills couplings is made only at the end of Chapter 7 and only for the group SU(2). Chapter 8 contains topics on tensor calculus on manifolds. The Cartan calculus and structure equations are not discussed, and torsion is only accidentally mentioned. (The name Levi-Civita is frequently misspelled.)

Chapter 9 and part of Chapter 10 deal with the Kaluza-Klein theory and its non-Abelian generalizations. The discussion is needlessly complicated and physical motivations are omitted. There is no mention of the 40-year-old criticism by Albert Einstein and Wolfgang Pauli, who pointed out the reasons why the Kaluza-Klein proposal failed to provide a genuine unification.

The difficulties due to the group-induced cosmological term, which occurs in the non-Abelian theory, are also omitted, as are the Jordan-Thyry generalizations of the theory. The book ends with some remarks on monopoles and instantons, but their possible role in the quantum theory is not appraised.

The choice of papers mentioned in the "selected bibliography" is not only too limited and out-of-date, but is also largely arbitrary; a list of recent review articles would have been more helpful and appropriate.

In conclusion, I hope that, in future volumes of the series on global analysis, authors will avoid the mistakes of neglecting the physics and of creating artificial formal complications; a good blending of rigorous mathematical notions and techniques with physical intuition and applications is needed in order to make such books useful to applied mathematicians and to theoretical physicists.

C. A. ORZALESI
University of Parma

Electronics and Instrumentation for Scientists

H. Malmstadt, C. Enke, S. Crouch

543 pp., Benjamin/Cummings, Reading, Mass., 1981. \$26.95

Experiments in Electronics, Instrumentation, and Microcomputers

F. Holler, J. Avery, S. Crouch, C. Enke

326 pp., Benjamin/Cummings, Reading, Mass., 1982. \$13.95

Throughout our present solid-state revolution, basic electronics has remained true to a traditional theoretical framework. The change from vacuum tubes to semiconductors, for example, has been in many ways conceptually superficial. Yet, electronic circuits do not spring from concepts alone. When components change, the thousands of little details that distinguish the working knowledge of a practicing designer from that of an electronic philosopher must all be incorporated in the educational process. Textbooks must change—and so we find the popular 1962 textbook *Electronics for Scientists* by Howard Malmstadt, Christie Enke, and E. Clifford Toren now replaced by the newly written *Electronics and Instrumentation for Scientists* by Malmstadt, Enke and Stanley Crouch.

Though similar in title and authors, the new text is not derived from the old. It has been designed to be more effective for course use, having 14 chapters of essentially equivalent length. Each chapter ends with about 20 problems that range from numerical applications to straightforward design. Chapter 1 initiates a discussion of physical mea-



Dark spokes in the rings of Saturn. The Voyager 2 spacecraft photographed the image on 22 August 1981 at a range of 4 million kilometers. Earlier detection of the spokes by Voyager 1 permitted improved resolution in images obtained by Voyager 2. (From *Voyages to Saturn*, D. Morrison, 227 pp. NASA, Washington, D.C., 1982. \$9.50.)

surements by introducing the various electrical formats in which information may be carried. The next two chapters cover the notions of frequency and frequency spectra, reactance, oscilloscopes, diodes, and power supplies. Chapters 4-8 resume the investigation of measurement techniques, primarily with analog circuitry (input transducers, operational amplifiers, bipolar devices and FETs). Chapters 9-13 cover digital devices, including combinational logic, microprocessors and their peripherals, and a number of larger-scale devices for data collection and manipulation. The last chapter treats several noise-reduction techniques—among them filtering, lock-in amplification, multichannel scaling and autocorrelation.

The change in the technology described has been accompanied by a change in format. The new format features wider pages whose wide margins contain notes of clarification, mathematical derivations and figures placed conveniently next to their reference in the text. The main text has key words highlighted at their introduction to facilitate reference and review. Very little calculus or complex notation is used—virtually all of it is found

in marginal notes—so that the overwhelming portion of the material appears to be accessible to advanced secondary-school students as well as to college-level readers. The book ends with a very fine bibliography (which ranges from sophisticated technical books to some of the popular hobbyists' books) and with four useful appendices on grounding and shielding, passive-component properties, manufacturers' addresses and logos, specification sheets and pin assignments for TTL logic.

A laboratory manual called "Experiments in Electronics, Instrumentation, and Microcomputers" is also available. Although entirely self-sufficient, this manual is linked chapter-for-chapter with the textbook and forms a convenient pair with it. The instructions in the beginning of the manual are quite detailed; those in later experiments draw more upon the developing experience of the students. The experiments are most easily performed at laboratory stations described in the appendices, with a pre-configured set of eleven patchboards. In addition, some experiments presume the availability of a few pieces of communal equipment, such as a curve tracer and an AIM-65

microcomputer. The instruction manual serves also as a laboratory notebook. It provides charts for recording results and has pages perforated to be removed and handed in. The projects culminate in three experiments dealing with the application of computers to noise reduction (multichannel analysis and scaling, signal averaging, smoothing and fast Fourier transformation). The authors introduce the computer language BASIC and assembly language and instruct on the use of computer input-output ports. They provide most of the necessary programs, and since there is no question of interfacing directly to the computer bus, the students address tasks that are quite manageable and progress very quickly to functioning devices. As a whole, this manual seems to be a very faithful realization of the topics in the book and to relieve many of the burdens of creating and running a laboratory course. The instructions, explicit and self contained, reduce substantially the amount of personal laboratory supervision required.

This textbook itself will make fascinating reading for beginners. The writing is exemplary. The book is well organized and consistent in level from cover to cover. While it is factually accurate, several small changes in wording could have corrected misimpressions. The discussion of modulation, for example, would have best avoided the suggestion that amplitude modulation is usually achieved by adding a carrier to a double-sideband-modulated signal, and that this modulation is usually undone by multiplication with a replicate carrier. These techniques are possible but not usual. Also, the section on noise reduction by phase-sensitive detection should have avoided the statement that a lock-in detector achieves noise reduction by a means completely different (using phase discrimination) from what bandwidth-narrowing devices use, when, in fact, the lock-in is fundamentally a bandwidth-reducing device whose phase sensitivity accounts only for an improvement of 3 dB in the signal-to-noise ratio.

One might wonder whether the book's heavily descriptive flavor may produce a "speaking" rather than a "working" knowledge of the subject. Graduates of a rigorous electronics course should be ready to exercise a degree of creativity and independence in developing circuitry for their own applications. To satisfy this goal there is a shortage of examples of practical circuits (most illustrations being presented in the form of block diagrams). Unlike a presently popular alternative, Paul Horowitz and Winfield Hill's *The Art of Electronics*, this book does not cover advanced topics such as tempera-

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Gravity, Black Holes and the Universe

I. Nicolson

264 pp. Halsted (Wiley), New York, 1981.
\$24.95

This book should be required reading for two audiences: undergraduates and specialists in general relativity. The remarkable feat of Iain Nicolson is to have provided at once both a very readable introductory account of gravitation and an up-to-date critical presentation of this esoteric field. I say this as a general relativist who despaired of finding a book for my "science for nonscientists" university courses. I have developed a fear of opening one more popular account of black holes, because of the inaccurate or superficial treatment that most books offer this complex subject.

I first expected Nicolson to fall into the "wormhole" syndrome. Most popular authors cannot resist telling the story of how space travelers will be able to rocket from one corner of the universe to the other, using the "maximal analytic extensions" (or Penrose-Carter diagrams) of black holes. That looked possible in 1968. However, a decade of work has shown such attempts at travel would destroy the unstable throat itself and crush the would-be explorers in a singularity. Nicolson points out this result: "It is sad in a way to lose so exciting a possibility as travel through black holes."

The other great failing of most books on relativity is their lack of up-to-date astrophysics, particularly observational. I believe many working relativists could benefit from the excellent overview of where we are looking for black holes today: binary x-ray sources, supernova remnants, the galactic center, and centers of radio galaxies and quasars. His diagrams and

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