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a tachyon detector becomes a tachyon emitter in some frames of reference and therefore one must discuss measurements with some care. Also, he might have modified his remark that statistical mechanics cannot explain an entropy increase if he had considered coarse-graining. What I found most surprising is that Horwich envisages repeatedly that "time itself" is temporally asymmetric without ever explaining what this might mean.

However, this is indeed as wide-ranging a book on the purely philosophical problems of time as one is likely to find. I am happy to agree with physicist Arthur Fine (quoted on the book's jacket) that the chapter on Gödelian universes is good fun. The discussion is also "unified" by the repeated use of certain flow charts—but real unification of such diverse discussions is not really possible.

Sachs is the author of the well-known *Nuclear Theory* (Addison-Wesley, Reading, Mass., 1953), and in his new book he gives a workmanlike introduction to all important aspects of the time-reversal transformation, T . After short chapters on time reversal in classical mechanics and in quantum mechanics he takes us through the physics of decay processes to T invariance in classical and quantum field theories. This thorough and pedagogical treatment arrives at the CPT theorem in the second half of the book, where the connection with experiment (K mesons, for example) and unified field theories is carefully explored.

Here C stands for the operation of charge conjugation, whereby the field operator associated with a particle is replaced by the analogous one for the antiparticle; P stands for parity, or roughly the operation of spatial inversion $\mathbf{r} \rightarrow -\mathbf{r}$; and T stands for the operation of time reversal $t \rightarrow -t$. Separate C and P invariance of the fundamental physical interactions was replaced by the idea of their invariance under the joint action of C and P in view of studies on neutral K mesons. This led to the idea of the CP mirror, which (in common with normal mirrors) converts a right-handed coordinate system to a left-handed one, and which in addition converts every particle to its antiparticle. The discovery that the weak interactions violate even CP invariance then led via the assumed CPT invariance also to violation of T invariance. Sachs exposes the subtleties of this well-known story, which lead one to ask for even more searching experimental tests of CPT invariance and for deeper analyses of the foundations of the proofs of the CPT theorem. A tabular

summary of key features of the theory and history of these problems would have helped.

This is a book for theoretical physicists, and it is unique in the depth of its treatment of the quantum mechanical aspects of time reversal. I highly recommend it.

Science, Computers and People (From the Tree of Mathematics)

Stanislaw Ulam

Birkhäuser, Boston, 1986.

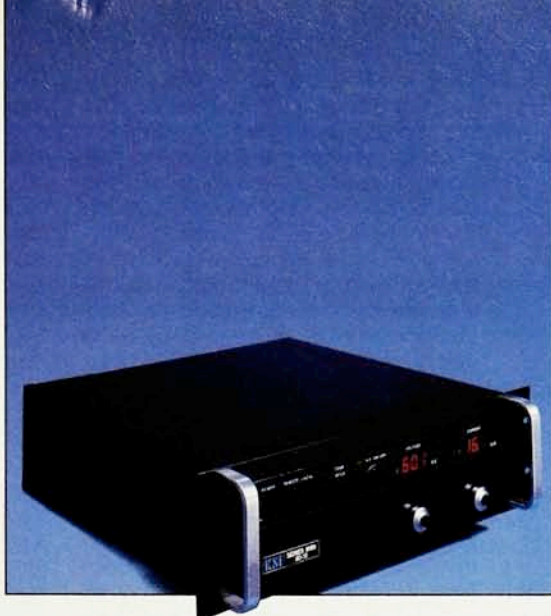
264 pp. \$39.00 hc

ISBN 0-8176-3276-X

Although trained formally as a pure mathematician, Stanislaw Ulam truly flowered intellectually when he arrived at Los Alamos in 1944. There he entered a period of remarkable developments in applied mathematics and particularly the application of mathematics in novel ways to somewhat unconventional fields. And with tutelage from such greats as J. Robert Oppenheimer, Enrico Fermi, John von Neumann and others, he built up a penetrating physical insight. This he applied in many areas, including hydrodynamics, nonlinear mechanics and statistical mechanics. Perhaps most remarkable of all is that he is credited, along with Edward Teller, with inventing a method for igniting thermonuclear reactions, which made possible the construction of thermonuclear bombs (certainly far afield for a mathematician!). For another 40 years Ulam remained a catalyst for an amazing variety of brilliant intellectual advances at Los Alamos.

The present book is a posthumous collection of about two dozen short essays by Ulam on the topics specified by the title: science, computers and people. Those on people are easiest to characterize. We are presented with seven descriptions, some serving as obituaries, of people like von Neumann, George Gamow and Stefan Banach. They are delightful. Each contains factual material and personal observations and inferences blended in an informative and entertaining way. The editors have done us a great service by gathering this material from diverse and sometimes obscure sources into one convenient volume.

The essays on science and computing are less straightforward. First, it is hard to say for whom some of the articles are written. They would be extremely elementary for the average physicist, yet for the lay reader they often use too many technical terms



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and assume too varied a background, particularly an awareness of what is going on in other, related fields. Second, all of the articles are old—about half of them more than 20 years old. Most are badly obsolete. The reader who took them at face value would come away with very incomplete, outdated and sometimes distorted views.

But happily, help is at hand. The new special issue of *Los Alamos Science* (number 15, 1987) is a 300-page volume devoted entirely to Ulam. The reader can now read Ulam's own words and wisdom in *Science, Computers and People* and follow them up in *Los Alamos Science* to see how they developed. For example, from the modest beginnings described by Ulam one can trace the development of the "cellular automaton" into a major new tool of computational nonlinear mechanics. And readers can get some sense of the incredible steps being made toward massive parallelism in machines like the Connection Machine or the University of Illinois CEDAR project. Or how Ulam's fruitful ideas in the celebrated Monte Carlo technique make possible huge computations of awesome complexity, which would otherwise be intractable. And finally one can discern how computational physics has continuously moved its focus away from "solving equations," first to "modeling" and most recently to "simulation"—a choice of words meant to imply a progressive increase in realism and a progressive diminution of numerical or technical issues in favor of physical insight.

While I would not put this book on my list for personal purchase, I recommend it to those who have a particular interest either in Ulam himself or in those fields he touched with his genius.

DIMITRI MIHALAS
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Principles and Models of Biological Transport

Morton H. Friedman
Springer-Verlag, New York,
1986. 260 pp.
\$39.00 hc ISBN 0-387-16370-0

Out of the notes for the course he teaches at Johns Hopkins, Morton Friedman has fashioned an excellent introductory text on biological mass transport. The material is presented at a level amenable to advanced undergraduates or beginning graduate students in biophysics and is more physical and mathematical

than what one finds in a standard physiological text. The book presents the biological processes first, then the physical principles and mathematical tools needed to describe and analyze them. By this organization the author hopes to give the reader a physical perspective on the methodologies needed to deal with real biological transport processes, which are often poorly defined or understood systems and so call for more phenomenological and simpler physical models.

The first part of the book is devoted to principles. The first chapter presents basic ideas of equilibrium thermodynamics. The next three chapters describe in general terms the primary solute transport mechanisms seen in biological systems—free diffusion, facilitated diffusion and active transport. Solvent flow and flux coupling are treated in the following chapter on nonequilibrium thermodynamics. The chapter after that describes cell membranes and several models of transport across them. The final three chapters illustrate the earlier concepts by applying them to single cells—erythrocytes and excitable cells (nerve and muscle)—then to epithelia and lastly to oxygen transport.

While not a comprehensive reference, the book does discuss the more important aspects of the field, with emphasis on mechanisms, models and the underlying assumptions. I can think of no better text for a student beginning a study of biological transport or for the practicing scientist who wishes to learn about this exciting field of so much current interest.

STANLEY A. BERGER
University of California, Berkeley

Principles of Charged Particle Acceleration

Stanley Humphries
Wiley, New York, 1986. 573 pp.
\$65.95 hc ISBN 0-471-87878-2

The education of designers and builders of particle accelerators has not kept up with the blooming of the field. More and more engineers are finding themselves in a technical area for which schools did not give them the necessary background. Acutely aware of this need, a few institutions are trying to fill the gap. The summer accelerator schools that are organized to encourage more scientists and students to work in the accelerator field are helpful. Progress at universities is slow because trained instructors, proximity to accelerator research facilities and textbooks geared at the appropriate level are all lacking. Us-

ing nearby accelerator research facilities, Stanley Humphries is addressing this need at the University of New Mexico in a two-term course on the physics of charged-particle acceleration for physics and engineering students with no previous background in accelerator theory. *Principles of Charged Particle Acceleration* evolved from the first term of this course.

Charged-particle acceleration is a vast and rich field covering a broad range of applications and using a diverse set of technologies. It is difficult to cover in a single book at the introductory level. Humphries assumes minimal preparation in related fields. He provides an extensive review of the basic principles, devoting seven chapters to the basic concepts of motion of charged particles under the influence of an electromagnetic force. He simplifies derivations introducing approximations as early as possible rather than at the end. Lenses and orbits are treated in the single-particle limit, an approach that precludes discussion of collective particle effects and beam instabilities. The concept of beam emittance is not introduced. Apparently these important concepts are dealt with in the second term of the accelerator curriculum.

The author's background in pulsed-power devices is readily apparent since these types of devices receive more extensive treatment than cyclic accelerators. For example, 129 pages are devoted to electrostatic accelerators, pulsed high-voltage devices and induction accelerators, compared with 55 pages for cyclotrons and synchrotrons. The modest, three-chapter treatment of resonant cavities, waveguides and rf linear accelerators reflects strongly the University of New Mexico's proximity to Los Alamos National Laboratory, where linac development has prospered for almost three decades.

Accelerator specialists may be disappointed at not finding adequate treatments of their favorite topics. For example, the principle of strong focusing, one of the great advances in the art, is only briefly mentioned—in the last five pages of the book. The book is also aimed more at engineers than at physicists. But one should not lose sight of the goal of the book: "to present the theory of accelerators on a level that facilitates the design of accelerator components and the operation of accelerators for applications." In the introduction Humphries readily admits the unevenness and deficiencies in coverage, and they are partly compensated by a tabulation of more detailed books and papers in the bibliography. This book could be a