

grant group more able and more adaptable than those who remained behind, or were they no different from the rest? Mrs Fermi asserts that immigrants were more suited to the rigors of migration and Charles Weiner shows, in his examination of the physics community, how criteria of scholarship and personal capacity were applied in decisions on which scholars were to receive aid. Weiner notes with no little irony that, for younger scholars, not to have published was to perish.

Third, would the immigrants' achievements have been of the same quality had they remained in Europe, even if the war had not occurred? Although it is impossible to answer questions of this sort, they do lead one to identify the conditions in the US that facilitated work for the émigrés and the ones that stood in their way. And last, what sorts of adjustments, personal and intellectual, were required for the émigrés and to what degree did these vary according to their fields and scholarly dispositions?

These volumes might best be examined in tandem for their differences make them complementary. Where Mrs Fermi explicitly asks, for example, how much immigrant physicists contributed to the winning of the war (a great deal, she reports; but they were by no means responsible for radar, the war's most important technological development), Szilard's memoir, full of his characteristic wit and robustness, covers similar territory from the perspective of a participant. The difference between the two is a difference in angle of vision and knowledge. Even in physics, Mrs Fermi is an outsider, and this defect becomes especially pronounced in her treatment of psychoanalysis. She has, it appears, little or no familiarity with the development of psychoanalytic thinking in the US, which leads her to overemphasize the establishment of analytic institutes at the expense of intellectual substance. Major figures in American psychoanalytic theory, Heinz Hartmann or Ernst Kris, for example, receive little attention in her lengthy chapter on the analysts.

At the same time, she does rather well in other fields. At the expense of being parochial, I can testify that the section on my colleague, Paul Lazarsfeld, is both succinct and correct. One misses the intimacy of his own memoir in the Fleming-Bailyn collection and his account of the es-

tablishment of large-scale social research in America, but Mrs Fermi's treatment is competent enough for her purposes.

Each volume then succeeds in its own way. Mrs Fermi's is the more comprehensive and superficial, the less subtle and luminous. She has, however, made an effort to bring together materials that exist nowhere else and to juxtapose them so as to reveal patterns that would otherwise be invisible. For this, we should be grateful. Where Mrs Fermi's work is earnest and responsible, several essays in the Fleming-Bailyn volume are dazzling, both in their scholarship and their literary grace. Collections of this sort are inevitably uneven in quality, but Fleming's own piece on the role of physical thinking in the development of molecular biology more than compensates for some of the more routine companion papers. Even physicists who have followed the emergence of molecular biology should learn some-

thing new on the contributions by Bohr and Schrodinger via the onetime physicist Max Delbrück, now Nobel laureate and patron saint of the "Phage Group."

Appended to Weiner's paper on the physicists are reproductions of several documents of considerable historical interest: the most striking is from *The Manchester Guardian* (May, 1933) listing, day by day, the names of German professors dismissed from their posts. It is a chilling reminder of those days.

The Fleming-Bailyn book has already been celebrated by several prizes, and Mrs Fermi's book has received good notices as well. Physicist readers should find both deserving of their attention.

* * *

Harriet Zuckerman is a member of the department of sociology at Columbia University. Her work in the sociology of science has focused on scientific elites, especially Nobel laureates.

Topics in Atomic Collision Theory

By Sydney Geltman

247 pp. Academic, New York, 1969.
\$13.00

Atomic physics, that staple of sophomore physics courses, remains incompletely understood despite more than a half century of study. True, we do possess the laws of interaction between the electrons and nuclei composing atoms, laws that we lack in more recently accessible energy domains. But the practical difficulties that impede our understanding of any many-body system are present in atomic physics as in other areas.

We are forced to rely on approximation schemes in computing cross sections for collisions between even the simplest atoms. Continued refinements of experiments and computational techniques permit us to probe ever finer details of collisions, and it is a continuing task for theorists to provide adequate formalism for atomic-physics calculations.

Motives for refining the theory of atomic collisions are not hard to find. Atomic physics *per se* continues to interest many people. Astrophysicists seek more accurate rate coefficients to use in constructing more realistic models of astronomical gases. Still others are concerned with excitation and ionization phenomena in the earth's at-

mosphere (a euphemism for study of ballistic-missile reentry).

The present book examines selected aspects of the quantum mechanics of binary encounters between nonrelativistic particles. Specifically, it discusses scattering of a spinless particle from a real potential (part 1), scattering of electrons by hydrogen and other atoms (part 2) and atom-atom collisions, including rearrangements (part 3). As the book title suggests, this is a collection of topics taken from the very large and rapidly growing domain of atomic physics; it is not intended to provide either a complete discussion of atomic collisions (as was earlier done by N. F. Mott and H. S. W. Massey, *Theory of Atomic Collisions*, Cambridge U. P., 1965) or a compendium of results (as has been recently published by B. L. Moisewitsch and S. J. Smith, US Government Printing Office, NSRDS-NBS 25).

The selection includes major standard topics, such as the analytic behavior of potential scattering amplitudes, the continuum Hartree-Fock equations for electron-atom scattering and the Landau-Zener curve-crossing model for atom-atom collisions. Both the choice of topics and the presentation reflect the origin of the book as a course of graduate lec-

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BOOKS & JOURNALS

A SPECIAL REPORT

tures (at the University of Colorado and University College London).

The author, a professor of physics at the University of Colorado, has published numerous articles on collision theory. Perhaps his most often referenced work concerned application of variational techniques to calculations of electron scattering by atoms.

I would recommend this book as a text for a graduate "topics" course or to students seeking an introduction to atomic-collision theory. Although the author is patient with his exposition, most readers will wish he had provided more extensive references to the literature. The meager bibliographies at the end of sections are too modest even to give proper credit to the author's own contributions. Serious students of atomic collisions will wish to follow this with the very thorough four-volume treatise by H. S. W. Massey and his coworkers, *Electronic and Ionic Impact Phenomena* (Oxford U. P., 1969).

BRUCE W. SHORE
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Kansas State University

The Technology Of Computer Music

By M. V. Mathews

188 pp. MIT Press, Cambridge, Mass., 1969. \$12.00

Electrical and electronic musical instruments have been with us for over 75 years, but have yet to achieve a place in the musical world comparable to that of conventional instruments. However, the current generation of electronic musical instruments has gone beyond conventional real-time performable instruments such as the electric organ. We now have a new kind of musical instrument, the programmable instrument, which does not normally work in real time, but contains storage and superposition features that allow complex musical structures to be generated one layer at a time, stored and superposed. The contemporary analog synthesizers, of which the Moog is the best known, are of this type. They now boast a very wide range of musical possibilities and

are still undergoing rapid evolution.

Outside this development, in a parallel route, lies the alternative possibility of dispensing entirely with musical hardware, and creating music by generating mathematically-produced waveforms that are later converted to sound. A music-generating computer program does exactly this and, in addition, allows the most precise and detailed control of the sound. In computer-generated sound, every vestige of the technical difficulty of performance on ordinary instruments disappears, and everyone becomes a potential virtuoso, limited only by his imagination and his control over his willing and obedient orchestra.

In this book we have for the first time a complete although brief description of the pioneering effort of Max Mathews and his colleagues, which gave the world its first serious and artistically valid music-generating computer program. Mathews here describes the current version, MUSIC V.

The book is divided into three sections. The first is a short exposition of the basic principles of computer generation, in digital form, of a sampled representation of the desired waveform. This part demands the greatest technical sophistication, which is needed for the explanations of the sampling process and its errors. Even here there is nothing more complicated than Fourier integrals. With suitable simplification, the nonscience undergraduate is capable of absorbing this material.

The second part is devoted to a sequence of tutorial examples, and includes a musician's guide to the use of the "orchestra" compiler that MUSIC V still retains (but now, finally, in FORTRAN). That is, the user must define (with suitable unit generators

that simulate oscillators, adders, function generators and filters) the software equivalent of the kind of instrument he might patch together with cables on an idealized Moog synthesizer. MUSIC V differs in this respect from ORPHEUS, an earlier all FORTRAN descendant of MUSIC IV, in which there is just one all purpose instrument, defined once and for all.

The third part of the book, called the "MUSIC V Manual," is devoted to an exposition of the program itself and explains its operation in considerable detail. Given a copy of this manual, a printout of the program and a means of providing the digital-to-analog conversion for the computer output tape (any small computer with a magnetic tape input, a clock and a D-to-A converter will suffice), anyone with enough computer time can start his own orchestra.

The potentialities of computer produced music, shown by the existing output, easily exceed those of the much more popular analog synthesizers, such as the Moog. Even so, the world has paid little attention to this new technology; in particular, musicians, for lack of understanding and technical grasp, have tended either to ignore it in the hope that it would go away or to denigrate it as mechanical, or worse as "electronic." The new craft still languishes for want of active practitioners, although not for aspirants. What is lacking is not enthusiasm or ability, but computer time. Here lies the greatest fault of the new technology: The amount of computer time required is still too great to make extended performance on the computer anything but a plaything of the industrious rich—that minuscule plutocracy that commands big blocks of available time on a large computer.

