casting. Nordenson extends the discussion to a comparison of several conceptual models, covering the problems both of building and of comparing models. These papers plus several others give insight into the trends in conceptual modeling in hydrology in the West.

The proceedings do give a view of the state of the art in models for forecasting, although the supporting tools and techniques are neither fully covered nor well represented. The imbalance of papers reflects the imbalance of knowledge in forecasting. As with most symposia, the papers are uneven. For a general view of who is doing what, both for the teacher and for the practitioner, the volume is useful.

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The Source Method

Particles, Sources, and Fields. JULIAN SCHWINGER. Addison-Wesley, Reading, Mass., 1970. vi, 426 pp. $14.95. Addison-Wesley Series in Physics.

In his preface the author writes:

This book is a research document, and it is a textbook. It is the record of a highly personal reaction to the crisis in high energy particle physics. The ingredients were: frustration with the mathematical ambiguities and physical remoteness of operator field theory, dissatisfaction with the overly mathematical attitude and speculative philosophy of the supposedly more physical *S*-matrix theory, outrage at the pretension of current algebra to be a fundamental description rather than a low energy phenomenology. . . .

As a textbook, this volume is intended for use by any student, familiar with nonrelativistic quantum mechanics, who wishes to learn relativistic quantum mechanics. I think it of the utmost importance that such acquaintance with the liberating ideas of source theory occur before exposure to one of the current orthodoxies has warped him past the elastic limit. In the Preface to a volume on *S*-matrix theory, one author speaks of the desirability that the student have a certain innocence concerning (operator) field theory. I echo that wistful call, but widen the domain of innocence to include *S*-matrix theory.

. . . While a general critique of existing attitudes is essential in motivating this new viewpoint, it would have been too distracting if constant reference to techniques for which obsolescence is intended had accompanied the development of the new approach. The expert comes ready made with opinions about what has already been done. To the student all that matters is what is new to him and I hope that he will find much in these pages.

In the reviewer's opinion, much that is in these pages is likely to baffle or hornswoggle the student unless he is already an adept, experienced in cracking the Schwingerian code. What is the innocent to make of this statement (p. 29)?

In the example of the electromagnetic field, with $T_{kk} = T^{00}$ it is impossible to satisfy $4/3\,\langle T^{00}\rangle = 0$ since $T^{00} = \frac{1}{2}(\mathbf{E}^2 + \mathbf{H}^2)$ is a positive definite operator; the uncoupled electromagnetic field is not a physical system.

Is he supposed to know about zero point energy? and Wick ordering? Take another example (p. 33):

If the two correlation functions we have mentioned are known throughout the multiple space-time domain, they are known for the regions where x' and x'' are in a space-like relation. But there they are equal, or differ by a minus sign, depending upon the statistics of the particles *b* and *c*. Accordingly, the two functions are space-time extrapolations or continuations of each other. The implied connections among different reaction amplitudes are usually referred to as crossing relations.

The innocent is supposed to know that it is analytic continuation that is meant? Both these examples are taken from the introductory first chapter of the book, entitled "Particles" and containing subsections on unitary transformations, Galilean relativity, and Einsteinian relativity and a critique of particle theories. The reviewer cannot recommend to the uninitiated a discussion studded with such obscurities.

The interesting part of the book lies in its remaining two, much longer, chapters. (Chapter 1 comprises 36 pages; chapter 2, "Sources," 108 pages; chapter 3, "Fields," 251 pages.) Here the author is engaged in formulating a phenomenological theory of fields, a corpus of theory that he clearly feels deserves at least equal status with conventional operator field theory. What the innocent and not-so-innocent reader will want to know is: Is there anything really new here? The answer is: If there is anything new, it is sourcery. For example, in the conventional language of operator field theory, chapter 2 is a lengthy account of the formula

$$(\psi_0, (\exp i\psi(f))_+\psi_0 = \exp[-\tfrac{1}{2}\int dx\,dy\, f(x)\,(\psi_0, (\psi(x)\psi(y))_+\psi_0)f(y)]$$

where ψ is a free field, f is a test function, and $(\ )_+$ stands for time-ordered product. (The cases of spin 0, ½, 1, 2 massive and massless, as well as various formalisms for arbitrary spin, are discussed at some length.) In 1951, the author showed how the time-ordered exponential for coupled as well as free fields serves as the generating functional of Green's functions. Here, the objective is to get the right-hand side [with $(\Psi_0, (\psi(x)\psi(y))_+\Psi_0)$ expressed as the two-point Green's function] by inductive arguments, without mentioning the left-hand side or indeed anything else containing an operator-valued field. The rules evolved in this process are then to be applied to construct theories of interaction. In chapter 3 only the very beginnings of such applications are made in a treatment of such processes as pair production and bremsstrahlung in a Coulomb field, and the emission of soft photons by sources.

In the reviewer's opinion, the evidence offered for computational power of the source method is not very convincing. (The author could already outcalculate most of the members of the profession *before* he invented the new method.) The author seems to feel this to some extent also because he says in an exchange with his alter ego, Harold, which occurs on the last page of the book:

H. How can it be the end of the book? You have hardly begun. There are any number of additional topics I should like to see developed from the viewpoint of source theory. And think of the field day you will give the reviewers, who usually prefer to list all the subjects not included in a volume rather than discuss what it does contain.

S. Quite true. But we have now reached the point of transition to the next dynamical level. And, since this volume is already of a reasonable size, and many of the ideas of source theory are in it, if hardly fully developed and applied, it seems better to put it before the public as the first volume of a series. Hopefully, the next volume will be prepared in time to meet the growing demand for more Source Theory.

(Exchanges with Harold are a feature of chapter 3; for a complete listing consult the index under Harold.) It would have been particularly enlightening to see a calculation of nontrivial radiative corrections.

Although chapter 3 may not make a convincing case for the computational power of source theory, it is very interesting in its own right, treating as it does the dion theory of strong interactions (Schwinger's electromagnetic alternative to quark theory), the quantization of charge, and a variety of

theories of gravitation. As for the conceptual simplicity of source theory in the form offered here, the reviewer was not impressed; the theory is too plastic.

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Physics and Ontology

Atomic Order. An Introduction to the Philosophy of Microphysics. ENRICO CANTORE. M.I.T. Press, Cambridge, Mass., 1969. xiv, 338 pp., illus. $12.50.

The development of the modern theories of microphysics (kinetic theory, atomic and molecular physics) is viewed by the author of this book as a continuous fulfillment of the program of imposing an order upon observations. The subject is approached by the so-called inductive-genetic method: inductive because it starts from the detailed study of individual theories, genetic in the sense that it follows the development of individual theories as they "gradually unfold and develop in time."

This methodology does not imply, however, according to the author, any strict adhesion to the historical development of science—a subject of research which is considered as encompassing also priorities, mutual influences between discoverers, and controversies—because, "when occasion arises, the scholar goes beyond history in his investigation of orgins," having recourse for instance "to psychogenetic studies of the kind that have made famous Piaget's school at Geneva."

In the laying out of the development of theories, however, extensive use is made of secondary historical sources; since these sources, as is well known today, are not always reliable, this description is sometimes flattened, "linearized," if not distorted. This is the case, for instance, with the reported reconstruction of the discovery of Pauli's principle, which can be confronted with the more complex, if not essentially different, pattern described by Pauli himself in his "Exclusion Principle and Quantum Mechanics."

The role of philosophy relative to science consists, according to Cantore, in making the philosophically relevant aspects of science come to the surface, because "science has an immanent philosophical structure." The ontological implications of atomic physics are, among others, that "the recognition of universal intelligibility in the specificity and intrinsic order of matter is now a peaceful acquisition." The almost complete lack of reference to professional philosophers of science is justified by the consideration that discussion of their ideas would have made the book "insufferably long," owing to the "painstaking examinations and comparisons" that such a discussion would require.

The more physically oriented sections of the book, the description of the outlines of the atomic structure and periodicity of the elements, molecular structures, and macroscopic aggregates, reveal a remarkable effort toward clearness and conciseness. No use is made of mathematical formulas, but many graphs, diagrams, tables, and pictures illustrate the description. The principal conceptual features of modern theories are illuminated with penetration and acuteness. In this respect the book might be useful to those students of physics or scholars in general science whose aim is to grasp the main features of physical theories, which sometimes are hidden, in more specialized texts, under the burden of mathematical developments.

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Biophysics from Japan

Advances in Biophysics. Vol. 1, 1970. MASAO KOTANI, Ed. University of Tokyo Press, Tokyo, and University Park Press, Baltimore, Md. 1970. xii, 184 pp., illus. $11.50.

This volume is the first in a yearly series to be published under the auspices of the Biophysical Society of Japan. The editor considers biophysics to be the study on the basis of the physical sciences of the various biological processes essential to life. This definition is probably as good as any other and allows a free choice of topics. The purpose of the series is not to present comprehensive reviews but to give "complete accounts of the authors' works on specified subjects that will be understandable to interested readers without the necessity of their referring to other papers."

In the first volume the subjects discussed are the lateral line organ of sharks, the structure and function of ribonuclease T_1, polymerization of flagellin, and spin changes in hemoproteins. In general an effort has been made to make the papers understandable to an interested reader. As an example, the article on the lateral line organ is introduced by a section on the structure and distribution of the various types of specialized receptors which is very helpful in understanding the physiology to follow. In all cases the papers are amply illustrated and clearly presented, although there are a few instances in which the text might have benefited from scrutiny by an English-speaking editor.

Since each article is primarily a review of its author's work, rather than of the whole field, the result may seem somewhat unbalanced, but it has the advantage of being reasonably short. As many of the authors chosen for this and forthcoming volumes are important contributors to their respective fields, the series promises to be an interesting addition to the biophysics literature.

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