volcanism, crustal structure, trenches, and fracture zones without referring to the most far-reaching concept yet devised to explain these features. The East Pacific Rise is not only ignored as a spreading center; it is not even included in a list of the major structural features of the Pacific Ocean.

It is difficult, however, to dwell on the faults of a book as carefully prepared, lucidly written, and beautifully illustrated as this one is. It will certainly be well received by geologists and nongeologists alike.

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The Earth and Beyond

The Atlas of the Universe. PATRICK MOORE. Rand McNally, New York, 1970. 272 pp. $35.

This comprehensive, communicative, and beautifully produced compendium of pictorial astronomy contains much accurate information. A foreword by Bernard Lovell, an epilogue by Thomas Paine, and authorship by Patrick Moore, who is one of the best-known popular writers and broadcasters of astronomy, provide it with prestigious testimonials.

The large size of the pages, 10½ by 14½ inches, allows for a flexible layout. A combination of large and small, full-color and two-color photographs, diagrams, and drawings, with explanatory text in layman's language, is assembled on each double-page spread; this provides an easily assimilated survey of present-day astronomical and geological knowledge. Many maps are provided, and at the end there are a glossary, a beginner's guide to the heavens, and a good index. The sectional arrangement and choice of topics are sensible and helpful. The order is from the known to the unknown, outward from the earth, and before tackling any of the scientific results we have a look at the tools (many types of telescopes and accessories) and the behavior of light; concepts and methods are discussed, and a good deal of the history of astronomy is surveyed. The section that follows this introduction provides a short course on the earth as a planet and includes as illustration views from the moon and from artificial satellites, comparison of these with maps, explanations of weather phenomena, geological ideas, and life on earth. Next come several sections on the moon, the solar system, and the stars, the last named being too modestly titled as it actually includes everything outside the solar system.

The *Atlas* is as up-to-date as it could be, just missing the new International Astronomical Union list of named far-side lunar features but including descriptions of quasars, pulsars, and a number of strange galaxies.

The large-scale organization is good. In detail, I find it less so, perhaps because the quantization of the contents (one subject or sub-subject to a double page or a number of double pages) is too rigid. To me, an occasional treatment seems stretched to fit the layout while a few others inevitably seem compressed for the same reason. The subjects of meteorites, meteors, and tektites (one double page for all these dubiously related objects), and infrared and ultraviolet astronomy outside the solar system (practically nothing) appear to have been shortchanged, but there is truly a wealth of information elsewhere, the language is simple and well chosen, and the *Atlas* is a joy to look at.

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Predicting Floods

Hydrological Forecasting. Proceedings of a WMO/UNESCO symposium, Surfers' Paradise, Queensland, Australia, Nov.–Dec. 1967. World Meteorological Organization, Geneva, 1969 (U.S. distributor, UNIPUB, New York). xvi, 328 pp., illus. Paper, $21. WMO Technical Note No. 92.

The theme of this symposium was the "forecasting, especially for shorter time-intervals, of rainfall floods." The proceedings should present a state-of-the-art assessment of forecasting, and the papers should be judged both on their individual merit and on their integrated effect. Unfortunately, two major papers have been published in one-page summaries, and one of these is among the three introductory overview papers. One of the two published overview papers, by Philip, gives a good, brief summary of knowledge of the microprocesses of accretion to and depletions from soil moisture; the other, by Popov, covers surface routing of flows by both hydraulic (equations of flow) and hydrologic (unit hydrograph) methods.

The remainder of the volume is divided into sections on the forecasting of precipitation (4 papers), data (4 papers), forecasting techniques (16 papers), and operational aspects (4 papers). The precipitation papers are descriptive, and indicate the major problems of a lack of adequate models for predicting precipitation, even on a short time scale, for use in streamflow forecasting. Perhaps the best paper on precipitation is that by Alexander, "Mathematical models of area rainfall," contained in the data section, which outlines the problems in the use of rainfall in modeling runoff. The papers on forecasting techniques give an excellent coverage of present practices in various parts of the world. Anyone planning to develop or choose a forecasting model would profit from reading these papers and comparing and assessing models, but only one (that by Riggs and Hanson) discusses the probability aspects of forecasting.

Barakov presents an application of the method developed by Popov to handle the partial contributing area problem, which has been discussed extensively by the Tennessee Valley Authority group in the United States. Denisov presents an approach to modeling snowmelt runoff, with data requirements of temperature, humidity, and precipitation. Kutchment presents in outline form the Russian approach to unit hydrograph analysis through the theory of incorrect problems. This approach is being introduced extensively in Russian hydrologic literature. The problem is analogous to that attacked in the paper Kutchment cites by Eagleson, in that errors in data may produce unstable solutions to the convolution integral. Each event produces a different solution, so that the instantaneous unit hydrograph (IUH) is not unique. The theory of incorrect problems provides a tool for finding an optimal solution for the IUH. These papers, plus others included in the proceedings, give a good cross section of Russian developments in mathematical analysis of hydrologic problems.

Nash and Sutcliffe present a general approach to parametric model building along the lines presented more completely in a series by Nash and others in *Journal of Hydrology*. Crawford presents the use of the Stanford Watershed Model IV as a case study in the use of conceptual models for fore-

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