

selves publishing in the *Journal of One-Dimensional Physics*. When that happens, it will be time for us to move on. Luckily, Lieb has already shown us the way. Since this book was finished, he has solved in rapid succession three outstanding problems of mathematical physics in two dimensions.

* * *

In 1965 the reviewer received the APS-AIP Heineman prize for contributions to quantum field theory and the theory of the S matrix. He is at the Institute for Advanced Study.

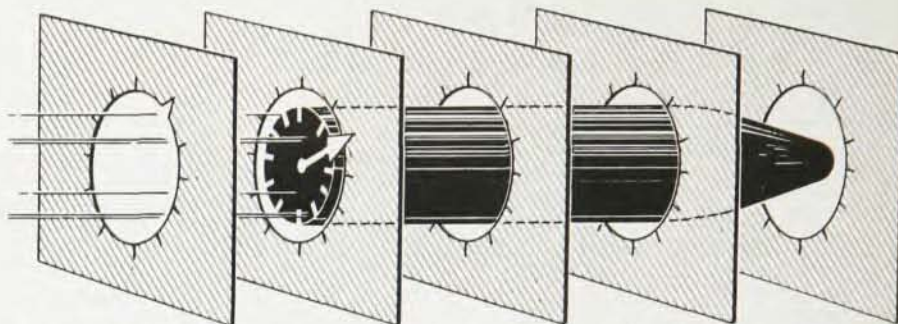
Stimulating creativity

SPACETIME PHYSICS. By Edwin F. Taylor, John A. Wheeler. 208 pp. W. H. Freeman, San Francisco, 1966. \$4.75

by Jules Aarons

The collaboration on this sprightly book teams a senior professor (John Archibald Wheeler of Princeton) who has a distinguished career in research and in education with a younger man, Edwin F. Taylor, professor at MIT, who has a deep interest in teaching methods. The result is a free-wheeling text, forcing the student to wander beyond the readily apparent. Space and time relationships always appeared to me to be an interplay between concrete experimentation and the imagination; *Spacetime Physics* exemplifies this interplay perfectly. The subject matter and the presentation are beautifully matched. The authors move through scientific worlds lightly and imaginatively in the text, the format and the illustrations.

The textbook, in its illustrations and its problems, moves from a full discussion of Robert H. Dicke's experiment to the "large-pole-in-a-small-barn" paradox. The book was designed for the beginning college student in an honors physics course. It has been used in intermediate courses as well. A good high-school course in physics would be the least preparation necessary even for the bright student since the examples given, although undemanding mathematically, presuppose a good physics background. The book contains a comprehensive index as well



LABORATORY CLOCKS compared with one rocket clock. (*Spacetime Physics*)

as end-paper tables of use to the students.

From the point of view of the research physicist such as the reviewer, the book is very well done. Its examples and problems range from space to nuclear physics. Its real advantage is that it directs the student into a creative mode in his study pattern leading into the creative aspects of science. Too often university

courses cause the student to expect that research-problem solving will be a pat succession of experiments and theoretical development. A course with this book will stimulate the student's awareness of creativity in science.

* * *

The reviewer is chief of the radioastronomy branch at the Air Force Cambridge Research Laboratories.

Black box not opened

THE ANALYTIC S MATRIX: A BASIS FOR NUCLEAR DEMOCRACY. By G. F. Chew. 103 pp. W. A. Benjamin, New York, 1966. \$7.50

THE ANALYTIC S MATRIX. By R. J. Eden, P. V. Landshoff, D. I. Olive, J. C. Polkinghorne, 287 pp. Cambridge U. Press, Cambridge, 1966. \$14.00

by Tullio Regge

The S matrix has played a key role in modern theoretical physics and many papers—time consuming computations with an occasional sprinkling of philosophy—have been dedicated to this vexing subject.

The physicist who in 1937 first conceived a rudimentary idea of the S matrix was John A. Wheeler, but Werner Heisenberg was the one who in 1943 realized its far-reaching possibilities in the description of elementary particles.

In the words of Eden and his coauthors, "The S matrix is an operator which connects the input and the output of a scattering experiment without seeking to give a localized description

of the intervening events." In this way a physical system is treated like a black box that should not be opened unless we want to face the severe difficulties encountered in field theory. The program heavily relies of course on the contention that we never need to look inside the box and that a consistent theory of elementary particles can be worked out by way of the S matrix only.

For Chew this is an obvious requirement of any future theory and indeed the reward to be reaped would be enormous. There would be a drastic reduction in the number of variables needed for the description of the system. One would achieve a unified description of the world in which there would be no distinction between elementary and composite particles. In this sense a deuteron, any nucleus, even an atom would not be a more complicated object than an electron and composition would be replaced by a much milder statement about anomalous thresholds. This philosophy, if carried to its extreme consequences, would tend to represent even macro-

scopic systems, forgetting thermodynamics, on the same footing as elementary particles. In this sense they would be represented as a rather fabulous set of cuts and superanomalous thresholds in some unfathomable chapter of the analytic S matrix.

The theory is, however, not yet here, and to obtain information on the S matrix we have to go back to old field theory. This information can be classified as follows:

Relativistic invariance. Easy to reach by a covariant formalism. In this way we also take into account energy and momentum conservation.

Unitarity. As it involves nonlinear relations among matrix elements. These relations impose quite powerful constraints on the scattering amplitude which have not been completely exploited.

Analyticity properties. Evident in particular models discussed so far, these properties have been shown to be intimately connected with causality, that is, the fact that particles do not travel faster than light.

A complete, systematic and reliable list of analytic properties of the S matrix does not exist although several of them are clearly connected with the physical system under investigation. In his book Chew boldly proposes a few analyticity principles from which the S matrix should be uniquely and completely constructed. As far as we can see these principles are inspired by and in agreement with computations carried out in conventional field theory. What Chew is stressing, however, is that in holding onto these principles one should forget original sin and that we should go ahead and compute everything including, in principle, the collision of viruses in vacuo.

Chew is neither so naive nor so inordinately bold to stake any claim on the viruses. Instead he applies his principles to the simplest physical systems in which his powerful physical insight has produced so much outstanding physics in the past.

The book is written in a highly personal but very clear style: "In absence of experimental evidence for strongly interacting aristocracies why should there be resistance to the notion of a complete nuclear democracy?" The author's view on the current status of the theory of the elementary particles

comes out quite transparently for those who are used to contemporary jargon in physics. I have the feeling, however, that the analytic S matrix has reached the stage at which qualitative ideas are simply not enough and that the methods and ideas of modern mathematics could be profitably used to achieve a simple and general treatment. Unfortunately from what I know of professional mathematicians they will find the book frustrating to read. In particular the analyticity principles are never stated explicitly but rather explained through specific examples. The reader is then invited to extract himself the generalization or is referred to other publications. Altogether the book makes for challenging and interesting reading. The examples are very well selected and clearly explained, and even those who do not agree with the general views will find lots of ideas to think about.

In 1959 Lev D. Landau published an extremely interesting paper in which he proposed a very simple method for the computation of the singularities of the scattering amplitude in perturbation theory. The Landau equations and later on a paper by Cutkosky injected new ideas in a field where they were, and still are, badly needed; the result has been a copious production of papers by many authors, notably

the British group at Cambridge of which Eden and his colleagues are well known exponents.

In this book the authors have tried hard to bring order in a subject that has been constantly growing in the years since Landau's paper; since they have contributed many interesting papers in the field, they are quite naturally biased in favor of their own methods but not at the expense of being disturbingly so. A rough estimate shows that about two fifths of the 160 odd papers quoted in the references come from authors connected with the Cambridge group. The book is divided into four chapters:

An introduction, where a sort of master plan is laid down for the whole book. Here one finds a survey of objectives and a preliminary explanation of the methods used in order to achieve the results.

Analytic properties of perturbation theory. This chapter contains a highly technical account of the Landau theory, probably the most extensive ever published.

Asymptotic behavior. This part of the book elucidates the link between the Feynman-Dyson expansion and the asymptotic behavior of scattering amplitudes by way of the complex-angular-momentum plane as conjectured by Chew and many others.

Chapter 4 contains many scattered

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topics concerning S-matrix theory including unitarity, Lorentz invariance, TCP, crossing, unstable particles.

Comparison with Chew's book having the same title is unavoidable and quite instructive. It is quite evident that Eden and his colleagues have tried to de-emphasize the philosophical content of the theory and to avoid high-brow discussions on the future of the theory of elementary particles. Their aim has been mainly technical and they have written a book for the young physicist who wants to reach a professional level through a detailed knowledge of the relevant methods and also for the not-so-young who wants a useful reference book. Despite the title the work of Eden et al does not overlap with that of Chew although in principle they speak on the same subject, using the same methods.

Although I think it is not the fault of the authors, I am personally unsatisfied by the status of the theory expressed in chapter 2. My feeling is that chapter 2 will have to be replaced in the future by more advanced techniques borrowed from algebraic homology. In spite of interesting attempts in this direction by Pham, Fotiadis, Lascoux, Froissart and others we are far from having achieved anything worth using as a replacement.

Until that day the best we have is a sort of heuristic theory that becomes rapidly inadequate for higher-order graphs. The book is in general written in a clear and satisfactory style. It contains however some clearly wrong or misprinted formulas (for example 1.5.34, page 36), and there is a definite tendency toward neglecting the "constant multiplicative factors" in

writing integrals (2.2.1, page 51); this tendency is quite excusable during a spoken lecture but I do not like it in a widely published book.

Apart from these minor flaws the book fills quite efficiently an existing gap in the literature. It is not, as should be clear by now, a general treatise on field theory; for it does not deal with topics like Wightman axioms, local algebras, function spaces, distributions, etc., but these are adequately covered in the existing literature. In its own field, however, it will be an extremely useful book for many years.

* * *

Tullio Regge, professor at Turin University and permanent professor at the Institute for Advanced Study, received the 1964 APS-AIP Heineman Prize for "introducing into particle theory the concept of analytic continuation in angular momentum."

The history of radioactivity and nuclear fission

OTTO HAHN: A SCIENTIFIC AUTOBIOGRAPHY. Translated and edited by Willy Ley. 296 pp. Scribner's, New York, 1966. \$7.95

by R. Bruce Lindsay

A well written autobiography of a celebrated scientist can not fail to be of interest to the scientific community since it is almost sure to provide some historical perspective on the field of activity of the scientist and may occasionally give insight into his research methods. When the field is that of nuclear chemistry and physics and the author is the distinguished co-discoverer of nuclear fission, the relevance of the work would appear to make it particularly attractive to scientists and laymen alike. This is indeed a readable book though it must be stressed at the outset that it leans very heavily on the rather detailed description of the author's scientific researches and tells less of his personal life than most readers expect to find in an autobiography.

Otto Hahn started his professional career as a more or less routine organic chemist with the expectation of a life in industrial research. It was indeed a lucky accident that led him to be sent to England in 1901 to work in Sir William Ramsay's laboratory in University College, London. His firm sent him

ostensibly "to learn English," but he learned far more than the language; for Ramsey set him to work on the chemistry of the newly discovered radioactive materials. This was the beginning of the scientific preoccupation which has marked the whole of Hahn's career.

This volume traces the story of the author's visit to Ernest Rutherford's laboratory at McGill University in Montreal in 1905-06 and his inter-

esting researches on thorium there. On his return to Germany he became a member of the Chemical Institute of the University of Berlin and for six years continued his work on nuclear chemistry but at the same time gradually got more involved in physical research through his scientific collaboration with the physicist Lise Meitner, a cooperative venture that had important scientific consequences. With the founding of the Kaiser Wilhelm



OTTO HAHN has been called "the father of radiochemistry and its more modern offspring, nuclear chemistry."