

Trip to a beautiful world

MATHEMATICAL PHYSICS IN ONE DIMENSION: EXACTLY SOLUBLE MODELS OF INTERACTING PARTICLES. (Reprint collection) Elliot H. Lieb, Daniel C. Mattis, eds. 565 pp. Academic Press, New York, 1966. \$11.50

by Freeman J. Dyson

A favorite sport, among theoretical physicists frustrated by the difficulties of the real world, is to solve analogous problems in an imaginary one-dimensional world. Various excuses can be offered for this retreat from reality. First, one may concoct real substances, for example copper tetraamine sulphate monohydrate, in which the magnetic ions form linear chains so that a one-dimensional theory is reasonably accurate. Second, one can use one-dimensional problems as a testing-ground for approximations: when no exact solution to a three-dimensional problem can be found but several approximate solutions are available, one chooses a one-dimensional problem that can be solved exactly and sees which approximate method comes closest to giving the right answer. Third, one can study one-dimensional problems in the hope of developing new physical concepts or mathematical tricks that will remain useful in a wider context. I consider that all three reasons are valid justifications for doing one-dimensional physics. However, my personal reason for

working on one-dimensional problems is merely that they are fun. A man grows stale if he works all the time on insoluble problems, and a trip to the beautiful world of one dimension will refresh his imagination better than a dose of LSD. If Hans Bethe in his youth had not wasted his time solving the one-dimensional Heisenberg model of an antiferromagnet, I doubt whether he would have created the theory of energy production in stars any sooner.

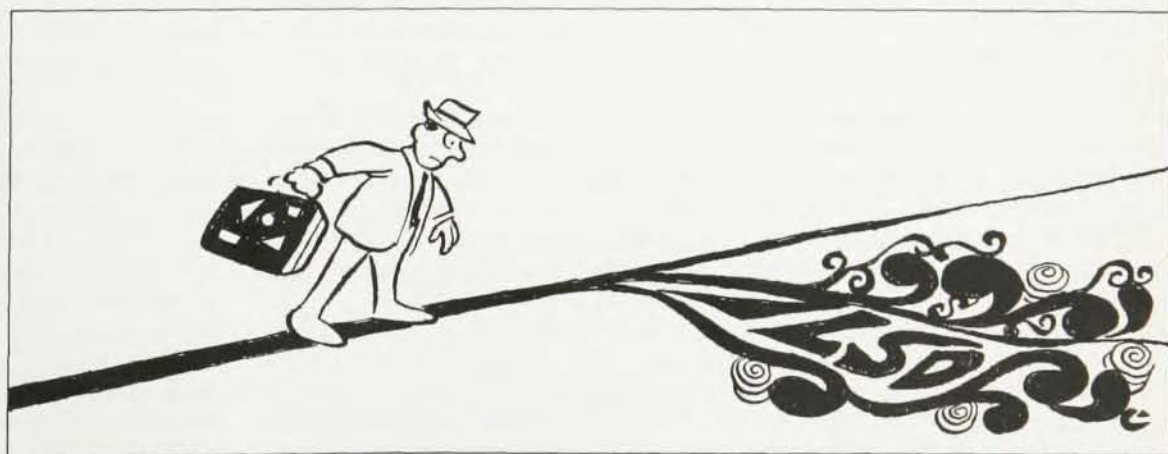
Lieb and Mattis have brought together in this book papers on one-dimensional physics in all its aspects. There are seven chapters, each containing up to ten papers. The chapter headings are: "Classical Statistical Mechanics," "The Disordered Chain of Harmonic Oscillators," "Electron Energy Bands in Ordered and Disordered Crystals," "The Many-Fermion Problem," "The Bose Gas," "Magnetism," and "Time-Dependent Phenomena." Each chapter begins with a historical survey of the field by the editors, including a bibliography of all relevant papers whether reprinted here or not. These introductory reviews are uniformly excellent, and the bibliographies alone are worth the price of the book to anybody who is seriously interested in the subject.

I have only two complaints to make, one serious and one frivolous. My first complaint is that in several cases

the editors omitted the early, historic and less accessible papers in favor of recent items that are on the shelves of every library and are perhaps of more ephemeral value. Sometimes they did not, however, make this mistake; for example, the splendid paper of Sin-itiro Tomonaga (1950) on the many-fermion problem is happily included. But it was bad to omit Walter Thirring (1958) on the Thirring model, and it was worse to omit the work of Bethe (1931) and Lamek Hulthén (1938) on the Heisenberg antiferromagnet. Worst of all is the omission of the Los Alamos report by Enrico Fermi, J. Pasta and Stanley Ulam (1955) on the nonlinear vibrating string. This Fermi-Pasta-Ulam report is extremely hard to find, [It does appear, though, in *The Collected Works of Enrico Fermi*, Vol. 2, University of Chicago Press (1965).] and it describes a most remarkable phenomenon that is not adequately explained in the two papers of Joseph Ford and John Waters that are here reprinted. In short, a golden opportunity for making the Fermi-Pasta-Ulam work accessible to a wider public has been missed.

My second complaint about this book is that it will have the effect of making one-dimensional physics too popular. If we are not careful, we shall soon have competing volumes of reprints, next will come *Annual Reviews*, and finally we shall find our-

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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.

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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.

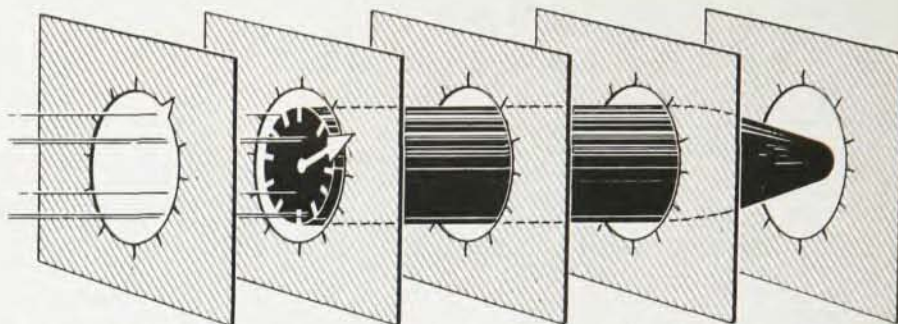
Stimulating creativity

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.

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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-