

covers much of the same ground. It is a pleasure to record here the fact that both men obviously possess literary talent in addition to their already acknowledged scientific abilities.

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Einstein's Vision

By John A. Wheeler

(In German) 108 pp. Springer-Verlag, New York, 1968. \$4.95

According to Albert Einstein's general theory of relativity, the observable geometry of spacetime is not rigidly given but is a physical field, subject to changes governed by field equations; gravity is but one aspect of this variable geometry.

One is faced, then, with at least two alternatives: One may either consider the geometry as a classical, macroscopic field or as a field subject to quantization; independently, one may imagine the geometry as one among several fields, or venture the bold hypothesis that "geometry is everything." It is well known that Einstein himself emphatically preferred a classical geometry that represents "everything;" he always considered an inhomogeneous field equation, with an energy tensor as a source, as provisional.

In his book *Einstein's Vision*, John A. Wheeler follows Einstein in adopting the hypothesis that "physics is geometry," that matter is but a manifestation of geometric structures. However, he takes "quantum geometrodynamics" as basic, and views classical geometrodynamics only as an approximation. The subject of the book is an

exposition of the main ideas and problems of this (vision of a) theory.

After a brief review of the possibilities for representing massive objects ("geons"), their motion, and electric charges ("wormholes") by classical, source-free Einstein-Maxwell fields, Wheeler turns to his central theme: superspace. This basic entity of quantum geometrodynamics is a "space" whose elements are all three dimensional (probably) oriented, compact Riemannian spin manifolds, that is with positive and definite metric manifolds. This superspace S is asserted, at least if space multiplicity is disregarded, to carry the structures of a Banachable manifold and an indefinite, semi-Riemannian metric. A physical state is represented by a complex-valued functional on S , satisfying an Einstein-Schrödinger functional equation of which, so far, only its WKB approximation (the Einstein-Hamilton-Jacobi equation) is known.

One such functional determines the probabilities with which various 3-geometries occur in a dynamically possible history. A localized wave packet (in S) determines a family of most probable 3-geometries that fit into a single Riemann-Einstein spacetime. The finite extension of any wave packet means, however, that "really" the geometry resonates between many topologically, metrically, and spin-wise different configurations.

This picture is vividly elaborated, with many illuminating analogies and ten "Wheelerian" figures. Wheeler speculates about possibilities for understanding the existence of electric charge, elementary particles and spin. He discusses the possibly fundamental importance of the Planck length, $L = 1.6 \times 10^{-33}$ cm, in connection with quantum-field fluctuations, and the breakdown of the classical spacetime concept during the final stages of gravitational collapse.

The discussion is mainly qualitative, except for order-of-magnitude estimates and some considerations about the relativistic Hamilton-Jacobi equation and the initial-value problem. Superficially the book might appear to be semipopular, but in fact only a reader with a good background in classical and quantum physics, general relativity, and some familiarity with modern geometry will appreciate the depth, difficulties, and subtleties of these considerations.

Some technical details would per-

haps have been welcomed by many readers, as well as a comparison with other approaches to the problem of quantizing general relativity. A more serious drawback is the lack of hints as to how this theory could make contact with specific observable phenomena, or even how such a quantum-geometrical formalism could be interpreted physically in the sense of a theory of measurement. Nevertheless, a reader who lets himself be carried away by Wheeler's fascinating, enthusiastic journey into the unknown will have some thought-provoking hours, and he is offered one coherent way of thinking about the role of spacetime geometry in physics.

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Handbook of Techniques In High-Pressure Research And Engineering

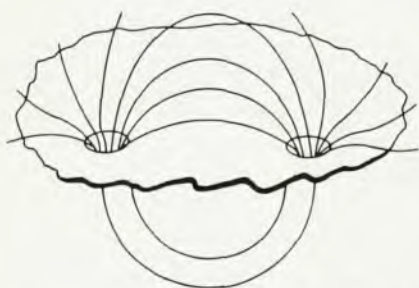
By Daniil S. Tsiklis

(Trans. from Russian), 504 pp. Plenum, New York, 1968. \$35.00

Anyone involved even peripherally with high-pressure research is certain to be aware of the extensive Russian work extending over many decades. It is especially gratifying, therefore, to have available an English translation of the third edition of a handbook written by a recognized Russian authority.

D. S. Tsiklis has long been active in many aspects of high-pressure research and has made numerous contributions to apparatus design. The translation by Albert Peabody appears of excellent quality, and the final product has also benefited significantly from the attention of the editor, Alfred Bobrowsky, who, from his own extensive knowledge of the field, has added numerous footnotes and comments in the text.

The book is, precisely as the title claims, a handbook of techniques. There are certain limitations. In order that no one be misled, it is advised that "Russian" be mentally prefixed to the title as an adjective. Most of the apparatus described is Russian. The bibliography of Russian literature is extensive, if not complete, through early 1965, but selections from the remainder of the world literature are highly incomplete and appear to have been made only from ne-



WORMHOLES are to the topological explanation of electric charge what geons are to the geometrodynamics model of mass. (From *Einstein's Vision*.)

cessity or upon the author's whim. As a practical matter, another problem for the foreign reader is the occurrence of Russian designations for materials—for example, the steels used in pressure vessels. The editor has endeavored to alleviate as much of this suffering as possible (a table in the appendix giving the composition of Russian steels allows one to determine the nearest US equivalent).

Although the book is concerned with apparatus and technique and not the results of research, the selection of apparatus is slanted in the direction of engineering and thermodynamic studies. Phase equilibria, compressibility of gases and liquids (nothing on solids), flow and surface tension receive extensive treatment. Apparatus for optical, x-ray and simple electrical measurements receive only cursory mention at the end, and there is nothing dealing directly with low-temperature-high-pressure studies or any of a great variety of other investigations in physics and chemistry that have been extended into the high-pressure realm in recent years.

Within these limitations, what remains is nonetheless a valuable book that is exceedingly thorough in treatment of its intended subject matter. The pressure-range coverage extends from equipment designed for experiments at less than a kilobar to ultra-high-pressure anvil and belt devices operating at the upper limits of present capability. There is a wealth of information on design considerations (including mathematical analysis) and lucid descriptions of actual equipment. Perhaps the most valuable feature of the book is the 320 figures, which are usually drawn to scale and reproduced in large size with important parts labeled and identified in the captions. Many of these figures occupy an entire page even though the book is printed on oversized pages. There are a few errors in the figures, but these are usually minor and obvious. All the standard paraphernalia of the high-pressure laboratory are covered: valves, seals, fittings, joints, windows, cylinders, pistons, compressors, pumps, intensifiers, manometers, electrical leads, even building construction. There are detailed instructions and tips on machining, heat treating, shrink fitting, safety precautions, and a variety of other problems. The chapters on valves and pressure measurement are exceptionally thorough.

The approach to problems may at times be accused of being old fashioned. For example, mirror arrangements are described for viewing gauges and the like placed behind walls in the high-pressure room, whereas the modern approach would more likely be to use closed-circuit television. In the same vein, the discussion of apparatus for compressibility measurements was devoid of any reference to recent electronic advances in capacitance measurement that give the capacitance technique great advantages over practically all others in many cases.

It was surprising to find only one reference to epoxies that have become very popular with American researchers for constructing electrical seals. However, except for the introduction of new materials, the high-pressure business changes slowly. Basic design concepts have been substantially the same for half a century and are likely to remain valid for the foreseeable future, and it is these with which the book is primarily concerned.

The modern, affluent researcher interested in high pressure only as a tool and willing to buy his apparatus can probably do without this book. For the man who must do it himself or who simply wants to know what has been done and the best alternative for his particular needs, I can not recommend a single book that is better suited to answer his questions, although I would recommend a few in addition.

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The Acoustical Foundations of Music

By John Backus
312 pp. Norton, New York, 1969.
\$7.95

The cultural gap between artists and scientists is bridged in many places, but especially by the interest that many scientists have in music. All scientists have been exposed to music; a good many of them have in their early years devoted long hours (perhaps unwillingly) to learning to play a musical instrument, and some have achieved a mastery quite comparable with that of the professional music student. The converse is much rarer; relatively few music students have had a similar exposure to the content

and techniques of physical science. John Backus's own interest in music has led him to work in a somewhat neglected area of physics—the acoustics of musical instruments. More than this, he has attempted to stimulate an interchange between the two cultures by teaching to music students at the University of Southern California a course designed to give them some insight into the nature of the physical mechanisms that underlie the art they pursue.

The Acoustical Foundations of Music brings together the material that Backus would, if time permitted, like to present in such a course. It is, however, much more than an exposition of physics for musicians. It is likely to attract an even wider readership among those scientists who have an interest in music and a familiarity with musical instruments, but who have never had the opportunity to relate their knowledge of physics to the behavior of these instruments and the sounds they produce. They may be surprised to find that those working in this field must admit to many areas of ignorance. Compounding the difficulty is the large amount of mythology and nonsense handed down for hundreds of years, usually by artists and instrument makers, but not infrequently by scientists who have been too hasty in jumping to conclusions and too ready to accept earlier work.

The first four chapters of the book are designed to give the music student enough background in physical acoustics to carry him through the subsequent discussions. These chapters may be safely skipped by those of us on the wrong side of the cultural fence. There follows a discussion of hearing and of tone quality that reveals how much we have yet to learn. Oscillograms and harmonic spectra of tones from adjacent notes on wind instruments vary widely, yet the ear easily identifies the instrument. The ear is relatively insensitive to changes in sound intensity, but its remarkable sensitivity to frequency (0.25%) remains the subject of much research.

Those who have a flair for numbers will enjoy the discussion of musical scales and temperament. Here mathematicians and numerologists have been most diligent, and have generated at least four well recognized ways of dividing the octave into 12 intervals. The sensible scientist will immediately vote for equal temperament, a scale of uniform logarithmic