develops the physical and mathematical apparatus and the results of special relativity. The basic problems and applications are treated: the Lorentz transformation equations, the addition of velocities, momentum, and mass, the equivalence of mass and energy, the behavior of charged particles in an electromagnetic field, and so on. The discussion is clear and is always within a philosophical framework in which the reasons for the ambiguities of classical physics are made plain. The problems are looked at from several points of view, physical, analytical, and geometrical, and the reader's understanding is thereby broadened. Particular attention is paid to the use of the geometric method based on the "Minkowski diagram" for space and time; the "K calculus", an ingenious and illuminating method, provides additional insights into the meaning of the theory.

The philosophical framework within which Bohm writes is indicated by a quotation from his preface, "... a great deal of attention is paid quite generally to the habitual tendency to regard older modes of thought as inevitable, a tendency that has greatly impeded the development of new ideas in science. The notion of absolute truth is analyzed in some detail in this book, and it is shown to be in poor correspondence with the actual development of science. Instead, it is shown that scientific truths are better regarded as relationships holding in some limited domain, the extent of which can be delineated only with the aid of future experimental and theoretical discoveries". Although few of us would disagree with this statement in principle, we too often forget it in practice.

The book ends with an Appendix, 45 pages long, entitled "Physics and Perception". Here Bohm discusses recent research in experimental psychology on the nature of perception. Psychologists have been studying the development of ideas of space and time in infants and young children, and Bohm thinks, on the basis of this work, that our actual mode of perception of the world (seeing it, hearing it, touching it, etc.) is much closer in character and general structure to what is suggested by relativistic physics than it is to what is suggested by prerelativistic physics. He concludes that, "In light of this evidence it would seem that nonrelativistic notions appear more natural to us than relativistic notions, mainly because of our limited and inadequate understanding of the *domain of common experience*, rather than because of any inherent inevitability of our habitual mode of apprehending this domain".

I am not qualified to comment on the ideas developed in the Appendix, but they appear reasonable and are interesting and challenging. They may have significant influence on how some of us may teach physics and write about it in the future. They are certainly worth reading and thinking about.

Irving Kaplan is Professor of Nuclear Engineering at Massachusetts Institute of Technology and the author of a well-known textbook, Nuclear Physics *(Addison-Wesley Publishing Co., 1955). Until 1958, he was Head of the Reactor Physics Division of the Nuclear Engineering Department at Brookhaven National Laboratory and one of the first members of the scientific staff of that laboratory. During World War II he worked on isotope separation at the S.A.M. Laboratories (Columbia University) and on reactor design at the Metallurgical Laboratory under the Manhattan District. A Fellow of the American Nuclear Society, he received his academic training through the PhD degree (in chemistry) at Columbia University.*

A RAPIDLY EXPANDING FIELD

Title Thermodynamic and Transport Properties of Uranium Dioxide and Related Phases

Editor Charles Holley

Publisher International Atomic Energy Agency, 1965, (Technical Report Series No. 39)

Pages 105

Price $2.50

Reviewer W. Kermit Anderson

The foreleaf on this small volume states that it is the "Report of the Panel on Thermodynamic and Transport Properties of Uranium Dioxide and Related Phases, Held in Vienna 16-20 March 1964". A glance at the table of contents shows that besides the usual introduction, major attention was directed toward: structure, thermodynamic properties, surface and oxidative properties, physical properties, practical implications of thermodynamic and transport properties, and conclusions.

The introduction contains a brief summary of the state-of-the-art circa 1963 anent phase relationships of the oxygen-uranium system, and a very good discussion of the structure of $UO_{2\pm x}$ as determined by x-ray and neutron diffraction. Of practical interest is the tabulation of linear expansion coefficients. Conclusions drawn from the diffraction results include a list of additional unsolved problems, which should be of interest to workers in the field.

The treatment of the thermodynamic properties, though brief, is quite good. The older American readers may miss the familiar notation of Gilbert Newton Lewis in the discussion of free energy, but this fault is not serious and undoubtedly is a virtue in a book designed for international use. The critical selection of values for standard enthalpy and entropy changes is certainly a contribution to the practical arts, as is the discussion of the heat capacity of the uranium-oxygen materials. Engineering evaluation of UO_2 fuels should be aided by the discussion of vaporization processes.

Of most interest to the engineer bent on design of a fuel rod containing UO_2 is the section on physical properties, especially the discussion of the thermal conductivity. The shortness of this discussion coupled with omission of tables or curves of thermal conductivity at higher temperatures detracts from the utility of the book. Since thermal conductivity is probably the most important single physical property to the fuel design engineer, inclusion and critical evaluation of this property would have been an extremely valuable feature. However, from the standpoint of raising unsettled questions as to the magnitude of the contribution to k(T) by the several modes of heat conduction through $UO_{2\pm x}$ material, the discussion is valuable, though somewhat out of date.

Data on electrical conduction and related properties are handled somewhat better. Certainly those scientists or engineers interested in thermoelectric devices or other applications, where the semiconductive behavior of UO_2 material is of interest, should be familiar with the material covered. More data are included in this section, including an article on the effect of radiation on electrical conductivity.

The section on diffusional properties is adequate considering the purposes of the report. It serves as a good critical review of the literature up to the cutoff date at which the reporting panel was convened.

Chapter VI, "Practical Implications", is quite brief for so important a subject. However, the panel has managed to summarize a number or very important aspects of urania fuel systems in an acceptable fashion. The discussion of clad-fuel interaction with the related aspects of thermal cracking and accommodation of strain by plastic deformation is worthy of thoughtful perusal by any fuel technologist. The discussion of fission-induced swelling was obviously written with fuels of low enrichment in mind and is already hopelessly out of date. The behavior of fission gases is barely touched upon. The "Symposium on Release of Fission Gases from UO_2" held at the 11th Annual Meeting of the ANS at Gatlinburg, June 22, 1965, brings this important subject up to date and extends the summarized information in Chapter VI. One paragraph, however, still stands out as a major piece of foresight; this is one in which emphasis is put upon need for definitive in-pile work in the fields of thermal conductivity, phase equilibria, and material transport processes. To these, this reviewer would add the additional need for contact conductance measurements, studies of urania disproportionation, and more especially strong efforts to establish values of plastic or viscous flow strength and kindred mechanical properties of uranium as a function of temperature, fission rate, and depletion. These important properties were not considered by the panel in their report.

The brief chapter (VII, 2 pages) labeled "Conclusions" is a very good statement of the problems existing in 1963. Most of these problems have continued to the present time and give promise of vexing designers well into the future. As a final statement this reviewer might reiterate his regret that the panel limited its deliberations to such a narrow scope, leaving out many of the practical accumulations of data that were available even two years ago. Critical evaluation of existing high-temperature thermal-conductivity data, as an example, is a job that sorely needs doing. The major regret, however, is the unavoidable feeling that the field ran away from the panel before they could finish their deliberations; this is not to their discredit, but it is rather an expression of the fantastic rate at which all the nuclear arts are progressing in our sometimes confusing modern world.

W. Kermit Anderson is a Consultant in Nuclear Materials Engineering at the Knolls Atomic Power Laboratory, General Electric Co., Schenectady, N. Y. His current interests lie in the field of computer analysis of fuel systems, particularly in the fields of thermal and stress analyses of UO_2 bearing rods. Past interests led him to work on metal hydrides as moderators, shielding materials, structural materials for water-lubricated mechanisms, organic coolants for reactors, fuels for both water- and liquid-metal-cooled systems, and especially the development of neutron absorber materials for reactor control. For this latter work, especially for publishing "the definitive work in this field", he was cited at the 11th National Meeting of ANS at Gatlinburg, Tenn. His education, including the PhD degree was at Texas A and M College. Prior to coming to KAPL in 1954 he was at Argonne National Laboratory, where he moved in 1951 from Oak Ridge.

A PRACTICAL WORKING TOOL

Title Fundamentals of Vacuum Science and Technology

Author Gerhard Lewin

Publisher McGraw-Hill Book Co., 1965

Pages xiii + 248

Price $11.50

Reviewer R. L. Jepsen

Despite the relative spate of recent books on various aspects of vacuum science and technology, Lewin's book contains a sufficient amount of additional and supplemental information to make it a worthwhile acquisition for many personal and laboratory libraries. To a considerable extent the book appears to mirror the author's own personal work experience in high and ultrahigh vacuum as applied to plasma physics and thermonuclear fusion. It is intended primarily as a practical working tool rather than as an exhaustive and scholarly treatise.

Any user of vacuum soon discovers that the pumpdown of a vacuum system proceeds much more slowly through the high and ultrahigh vacuum regions than would be expected on the basis of pumping speed and system volume. The reason for this is that desorption of 'surface' gas predominates—often by many orders of magnitude—over 'volume' gas. An illuminating illustration of this point is given on page 2 of the "Introduction".