

Bridging the gap between relativity and the undergraduate

Essential Relativity: Special, General and Cosmological

By Wolfgang Rindler

319 pp. Van Nostrand Reinhold, New York, 1969. \$11.50

Reviewed by KENNETH C. JACOBS

The knowledgeable reader may be inclined to say, as did this reviewer, "What! Another textbook on relativity theory?" Such an initial reaction seems appropriate for this apparently abstruse subject that has generated so many texts in the past. Wolfgang Rindler's new book, however, deserves much more attention than the casual phrase above, for it represents a refreshingly modern approach to the critical problem of *teaching* relativity theory. To put both the subject and the book in the proper perspective, let us review the rather checkered history of the teaching of new world pictures.

Since the beginning of recorded history, Man's *Weltanschauung*—his concept of the universe and of his place within it—has altered and even determined the course of that history. Though the descriptive mode of the world picture changed from magical to religious to scientific, the dissemination of a contemporary viewpoint inevitably devolved upon an exceedingly small minority of specialists. The historical impact of any world picture is therefore partially attributable to the zeal of the promulgators and to the efficacy of their teachings.

Albert Einstein's revolutionary picture of the physical world, presented in his theories of special (1905) and general (1915) relativity, has led to technological consequences that far overshadow man's exposure to and psychological acceptance of the philosophical implications of the revolution. Since their inception, Einstein's theories have suffered from the mystique that they are too abstract for the common man to comprehend. As a result, we presently find relativity theory presented almost exclusively to graduate students, with special relativity being served up as rote formalism stripped of its essential philosophical attire, and with general relativity being reserved for a tiny group of mathematical specialists.

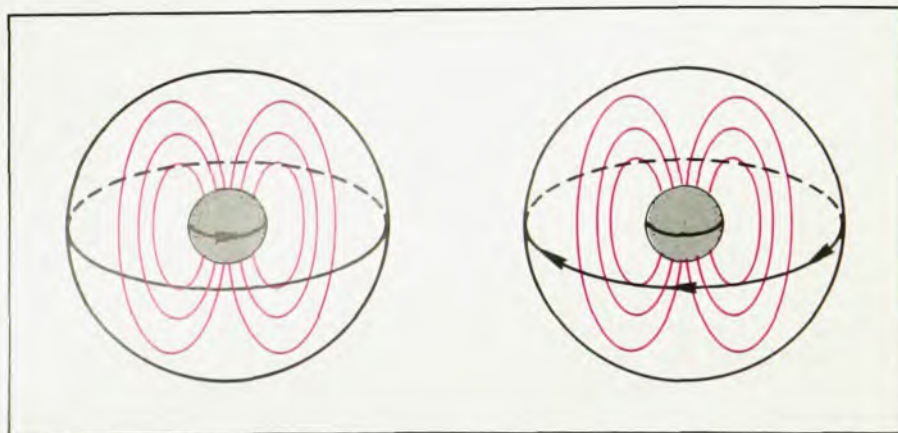
With the improvement in undergraduate science education during the post-Sputnik era, special relativity began to take its rightful place in the undergraduate curriculum. General relativity has remained an aloof outcast, though the discoveries of the cosmic background radiation, the quasars and the pulsars in the 1960's contributed significantly toward hastening the day when Einstein's gravitational concepts would be acceptable food for undergraduate thought. Partly because of these encouraging signs, all workers in relativity theory are now acutely aware of the need for definitive *modern* texts on relativity theory, especially at the undergraduate level.

His earlier text (*Special Relativity*, Interscience, second edition, 1966) established Rindler as an excellent writer and communicator of ideas on the graduate level, although that book is still not widely known or used. Now, in an effort to bridge the immense gap between relativity theory and the undergraduate student, he has written the present textbook expressly for the undergraduate. It is a tribute to his pedagogical and literary ability that Rindler has succeeded in this difficult self-imposed task; I am aware of no other text covering the same material at this level that is even comparable.

From the beginning, Rindler bases his approach to relativity theory upon

the unifying concepts of the local inertial frame of reference, the equivalence principle and "Mach's principle." The book is presented in three roughly equal parts: special relativity, general relativity and cosmology. As a teaching aid, this work appears ideal as the principal text for an intensive one-semester undergraduate course or as the introductory reference text for a graduate-level course. The level of mathematical complexity is everywhere readily accessible to the fourth-year undergraduate science student. In terms of general clarity and freshness of approach, the text may profitably be compared with Einstein's own semipopular writings on relativity theory or with Richard P. Feynman's *Lectures in Physics*. At every turn the reader is exposed to the philosophical concepts of relativity theory by means of lucid thought experiments, clever heuristic derivations and examples and illuminating illustrations. Rindler has given us a text that will be most useful to upper-undergraduate and graduate students, and that may be read for an enjoyable overview both by younger undergraduates and mature scientists. Although he has not bridged any cultural abyss, Rindler has brought relativity one step closer to the common man.

Though I enthusiastically recommend this book to all who are interested in relativity theory, a critique of its few



Two views of a positively charged nonconducting sphere inside a "universe." In the conventional view (left) the sphere rotates; in the Mach-equivalent view (right) the universe rotates. In each case there is a magnetic field. (From *Essential Relativity*.)

shortcomings is in order to prevent this review from becoming lopsided. Careful perusal reveals only six typographical errors (none critical) in the entire book. There appear to be no errors of fact, but some of the footnotes (see pages 106 and 268) are moderately confusing. The important term "contravariant" appears on page 123, long before it is defined or explained, and neither it nor "covariant" are adequately explained. The listing of "cosmological facts" on pages 218-19 is excessively cursory and somewhat confusing, and the poor dimensional notation (for example, "km/sec/megaparsec," which should read " $\text{km sec}^{-1}\text{Mpc}^{-1}$ ") only accentuates the confusion.

The collection of problems at the end of the book is excellent, though some of the harder problems may strain the capacity of even the most brilliant undergraduate. Finally the index is quite short, but I could find no fault with it whatsoever.

In summary, Rindler's *Essential Relativity* should become a household word among undergraduate science students. Only the appearance of a better text at this level can displace it from its rightful place on the bookshelves of the scientifically inclined, and we have yet to see that better text.

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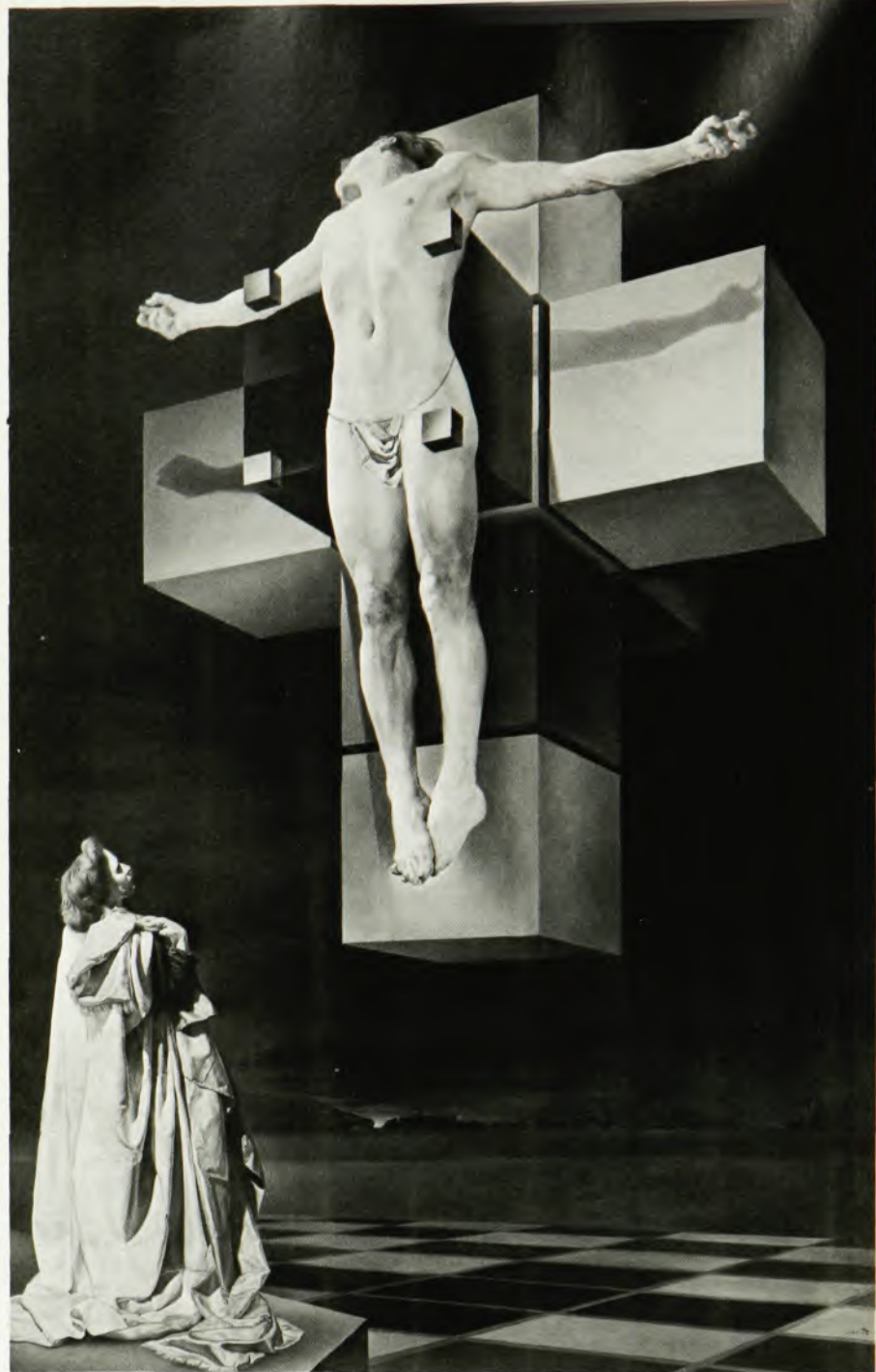
The reviewer, assistant professor of astronomy at the University of Virginia, Charlottesville, specializes in general-relativistic astrophysics and cosmology.

Behind Appearance: A Study Of Relations Between Painting and Natural Sciences in This Century

By C. H. Waddington
256 pp. MIT Press, Cambridge, Mass., 1970. \$25.00

The author of this book, Conrad H. Waddington, is professor of animal genetics at the University of Edinburgh. He also has a host of friends within the art world and is, in addition, a frequent visitor to the art galleries and museums. It is from this interest and knowledge of the arts that the author draws his ideas about painting. As might be expected, his theory extols science in claiming that painting and science share a common tendency toward probing *behind appearance* into the underlying structure of things and that science has consciously and unconsciously affected the work of many painters.

The book, in addition to expounding this theory of painting, also contains a well written account, intended for scientists, of the mainstreams of modern



Salvador Dali's "Crucifixion." (Courtesy of the Metropolitan Museum of Art.)

art since 1960 and a somewhat historical and slightly technical explanation, intended for artists, of the important scientific discoveries in biology and physics. In essence, the author has attempted to write a book for both artists and scientists about art as viewed through the author's scientific eyes.

Waddington has an ability to write such intricately involved sentences and paragraphs that it is extremely difficult at times to unravel his ideas and theories. The real fun in reading his book is in this unraveling and in attempting to understand just exactly what he might have meant. Although some readers might enjoy this "do-it-

yourself" approach, it does make reviewing somewhat difficult. But reviewing we must!

In my opinion, this book is best described as a confusing melange of unintentionally misleading information and deeply imbedded contradictions. The author chides artists for using scientific terminology falsely and misleadingly in explaining their art. But Waddington then presents confusing information about such scientific things as the fourth dimension and quantum mechanics. Worse yet, he too falls into the trap of using pseudoscientific gibberish in artistic explanations, for example, "The scientific 'true reality' with