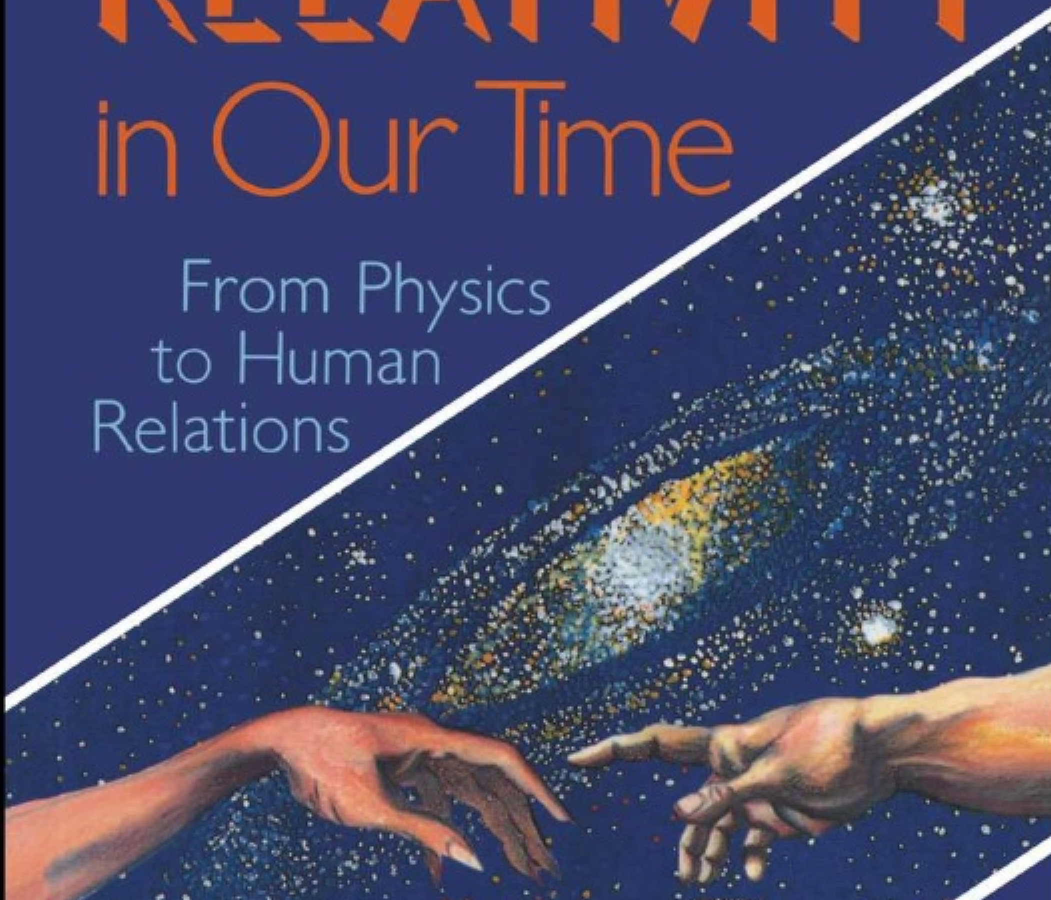
MENDEL SACHS

RELATIVITY in Our Time

From Physics to Human Relations



Taylor & Francis

Relativity in Our Time

To the Memory of My Father
Samuel Sachs

Relativity in Our Time

From Physics to Human Relations

Mendel Sachs
Department of Physics and Astronomy
State University of New York at Buffalo

Taylor & Francis
London • Washington, DC

UK Taylor & Francis Ltd, 4 John St, London WC1N 2ET

USA Taylor & Francis Inc., 1900 Frost Road, Suite 101, Bristol, PA 19007

This edition published in the Taylor & Francis e-Library, 2005.

"To purchase your own copy of this or any of Taylor & Francis or Routledge's collection of thousands of eBooks please go to www.eBookstore.tandf.co.uk."

British Library Cataloguing in Publication Data
A catalogue record for this book is available from the British Library

ISBN 0-203-22373-X Master e-book ISBN

ISBN 0-203-27788-0 (Adobe eReader Format)
ISBN 0-7484-0117-2 (cased)
0-7484-0118-0 (paper)

Library of Congress Cataloging-in-Publication Data are available

Cover design by John Leath, illustration by Daniel E.Sachs

Contents

Preface

One of the most significant advances in twentieth century physics, indeed in the entire history of science, was Albert Einstein's discovery of the theory of relativity. Though its mathematical implications have been necessary in much of modern physics, there are some widespread misconceptions about the meaning of this theory. In this monograph I explain my view of the fundamental meaning of this scientific theory—the meaning which I believe Einstein intended, according to his own writings, especially after it had matured to the stage of general relativity[1].

In addition to the implications of the theory of relativity with regard to the 'inanimate' features of the universe—the science of physics—the underlying philosophy, when followed to its logical extreme, seems to me to carry over to the field of human relations. For it is a philosophy that implies a unification of man with nature, humanism, and mutual respect between all components of the world.

I will attempt to convince the reader of this conclusion throughout the text, and thus as we proceed with the exposition of ideas in this book, I will relate this philosophy, not only to the applications to the physical world of inanimate objects, but also to implications with regard to human relations —as seen through the eyes of a physical scientist, rather than from the views of a professional sociologist or psychologist.

It would be presumptuous of me to allude to any real expertise in the various fields of human relations. Still, I do feel that as a member of the human race it might be of benefit to our understanding of the world if the physical scientist spent a part of his or her thinking time on problems that underlie the social sciences, just as I feel that it could benefit the social scientist's quest for further understanding with regard to human relations, to look (just as non-professionally!) at some of the ideas that underlie the physical sciences. These reflections are based, in part, on my belief in the Spinozist view of the oneness of man with nature—in fundamental terms —implying that the more we can unify the theories about man's behaviour in society with those we have discovered concerned with the physical universe, the closer will we be to a valid understanding of the real world[2].

This is not to say that thus far our search for fundamental truths about the natural world has not had an important practical impact on our way of life, our attitudes and well-being. Indeed, the slightest glimpse at the history of the human race reveals that great practical advances have been made: in medicine, to prolong life with years of better health and comfort; in technology, to provide us with a more affluent life, more leisure and, unfortunately, a more efficient means of self-destruction!

But aside from practical by-products, the scientist trying to understand the physical world, for the sake of understanding itself, would maintain that the philosophical insights gained by humankind have raised our cultural sights; they have opened the door to increased understanding of ourselves, as inseparable components of the world, hopefully toward a life of peace, mutual respect and oneness.

Many express doubts that the advantages I claim really do follow from purely intellectual endeavours, and ask: What is 'pure knowledge' really good for? To answer that we seek a basic understanding of the world because history teaches us that such studies have always (eventually) led to practical applications, contradicts my initial assertion that this is a pursuit of understanding for the sake of understanding itself! Indeed, with the motivation of practical applications in mind—no matter how far in the future they may come—science, as any other pursuit of ideas, would slowly become corrupted of its original purpose, until it would be dead! This can be likened to the gradual petrification of a tree—it may look like a living tree after the process has been completed, but in fact it would then only be inorganic, dead stone!

I believe that the answer to the question is in part subjective. My answer is that society should support the activities of purely intellectual pursuit, because it is natural for the human being to explore his or her curiosity, and in my view, this has positive value. The act of killing another human being may also be a natural function, but in my view it has negative value! My criteria for distinguishing positive from negative values are that positive actions relate to: the well-being of society, of which the individual is an integral, inseparable component, rather than a dispensable 'part'; to humanism; and to the holistic concept of the oneness of all of nature.

Further implications follow from these criteria. One is the positive value of the freedom of the individual—to the extent that an individual's actions neither harm nor restrict the freedom of others. Another is the rejection of the (in my view) negative value of the policy that 'the end justifies the means'. I do not look at the world, fundamentally, in terms of a time-evolving entity. I see it, rather, as a basic existent, of which humankind is a particular manifestation, with the feature of 'influencing' and 'being influenced' at one stroke. With this view, then, all our actions that would be positive must be for the well-being of the world, as it exists. Actions that lead to the removal of freedom and inhumane treatments of fellow members of the human society, as well as self-motivated destruction of our natural environment, cannot be justified at any time, no matter what ends are claimed! If we are to learn anything from the history of our society, the first lesson is that a policy based on this notion that the 'end justifies the means' can only lead to failure in reaching the ultimate (sometimes well-intentioned) goals. This route has led mostly to the attainment of totalitarian control in the hands of a few leaders, exploiting their populace in order to maintain power, while paying lip-service to altruistic principles[3]!

The existential view of the world, that I take, is not that it is a physical system in space and time. Rather, it is based most fundamentally on an underlying order, in terms of the mutuality of its (inseparable) components. This view implies, to me, that every action in every day of one's life must be considered from the standpoint of the entire society. I do not claim that such a Utopian society can be achieved, but I do believe that it would be progressive to strive toward the attainment of attitudes in this direction.

One of the important developments of 20th century science that teaches this philosophy is the theory of relativity, when expressed in its full form. For, with the approach of this theory, we have the implication that the world is continuously one—a closed system of inseparable components. However, to convince our fellow human beings of the truth of this assertion, it is necessary to do more than philosophize. We must exploit this philosophy in a precise way in order to demonstrate the truth of its assertions. If this can be done with regard to the 'inanimate' aspects of the world—the apparent things that we see and experience about us—from the cosmological domain of the universe as a whole to the microscopic domain of elementary particle physics, then we would have at least made a start toward extending these principles to the domain of human relations.

The main discussion of this book is based on a seminar course, designed for undergraduates from the sciences *and* the humanities, on the underlying philosophy of Einstein's relativity theory. The inclusion of students from the humanities always enlivened the atmosphere with the sorts of questions and comments that science students do not generally raise, regarding some of the implications of this philosophy in societal problems. My answers to their questions, as well as the comments of the other participants in the seminars, were not those of professionals in sociology, anthropology or psychology. Rather, they were the natural responses of lay people or students in these fields, who are generally interested in the implications of the pursuit of ideas that may eventually be applicable to understanding ourselves more completely and in satisfying our natural curiosity about the world in general. I have incorporated some of this discussion in the body of the text, but most is in the form of Question-Reply sections towards the end of the chapters.

When each set of seminars was completed, I felt that most participants indeed came away with some basic understanding of the ideas that underlie the theory of relativity—not its mathematical structure which, of course, is necessary for the professional physicist to exploit technically the theory further—but rather the logical connection of ideas that underlie this very great discovery in contemporary science. I believe (perhaps wishfully!) that most participants were convinced that pure science, for its own sake, is indeed relevant to society, primarily with regard to a broadening of our culture. This activity, in my view, leads to an enrichment of human values and helps to reveal to individuals their true authenticity, through the climate of freedom that it creates. My main aim in writing this book is for the same sort of enthusiasm to carry over to the reader.

Mendel Sachs
Buffalo, New York

NOTES

1 A clear statement of Einstein's interpretation of the theory of relativity, that he had settled on as his theory matured, is given in his *Autobiographical Notes,* in *Albert Einstein—Philosopher-Scientist* (edited by P.A.Schilpp) (Open Court, 1949).

2 Spinoza's main philosophical views were expressed in: B.Spinoza, *Ethics,* R.H. M.Elwes, transl. (Dover, 1955). Also see: H.A.Wolfson, *The Philosophy of Spinoza* (Schocken, 1969).

3 A well-known contemporary political philosophy that maintains the policy that 'the end justifies the means' is Communism. It is indeed apropos that in our own time, in 1991, one of the most powerful nations in the world, whose government professed to be based on this political philosophy—the Soviet Union—has abandoned it, renouncing Communism and its totalitarian approach. This was not only because of its lack of humanism, but also for the pragmatic reason that it did not work! It took 74 years for the Communist form of government of the USSR to break down—as an ultimate consequence of its ideology.

1
Introduction

Before coming to the main text of this monograph, I would like to make three preliminary remarks about relativity theory. First, in the context of the history of science, Einstein's theory of relativity did not appear at a particular point in time, disconnected from all preceding developments of ideas in physics. Indeed, this theory has some very important roots in classical physics and in the ideas of the ancient times.

Some of the most important precursors for Einstein's theory of relativity are:

- Galileo's principle of inertia[1];
- Galileo's concept of the subjectivity of all motion and spatial measure to underlie the objectivity of a law of moving matter, called, 'Galileo's principle of relativity'[2];
- Newton's third law of motion, implying the elementarity of a closed system of matter and the relativity of the reference frame of one component of matter in mutual interaction with another, in accordance with the statement of his law: for every force exerted by one body of matter on another, there is an equal and oppositely directed force exerted by the latter body on the former; and
- important precursors for the theory of relativity in ancient Greece i.e. concepts of invariance that one may see (in abstract form) in the metaphysical views of Plato—his concept of 'forms'—and the holistic view of Parmenides, as well as the elementarity of process in Heraclitus[3].

Second, while the mathematical expressions can become quite complicated, especially in its most general form (in general relativity), this theory is extremely simple from the conceptual point of view. It is the purpose of this monograph to discuss the conceptual and logical structure of the theory, rather than its mathematical language. For to comprehend its conceptual content is to understand the theory of relativity. It was Einstein's contention, as I will attempt to demonstrate below, that because of its extreme conceptual simplicity, the theory of relativity should be comprehensible to not only the students and professionals in physics, but also to any lay readers who wish to broaden their comprehension of the natural world.

Therein lies a major confusion among contemporary scientists, as well as the lay public—a confusion between 'mathematical simplicity', on the one hand, and 'conceptual simplicity' on the other. That the theory of relativity is not mathematically simple, in all of its ramifications, does not imply that it is equally unsimple from its conceptual side!

Indeed, one of Einstein's primary reasons for his strong faith in the objective truth of the theory of relativity is its logical simplicity (not its mathematical simplicity!). In a letter that Einstein wrote to Louis de Broglie in 1954, he said[4]:

> Die gravitationsgleichungen waren nur auffindbar auf Grund eines rein formalen Prinzips (allgemeine Kovarianz), d.h. auf Grund des Vetrauens auf die denkbar in grösste logische Einfachheit der Naturgesetze.
>
> [The equations of gravitation were able to be discovered only on the basis of a purely formal principle (general covariance) that is to say on the basis of the conviction that the laws of nature have the greatest imaginable logical simplicity.]

Third, Einstein's meaning of relativity theory evolved from his earlier conception, 'special relativity', to an entirely different conceptual view, when 'general relativity' appeared. His conception of special relativity was based on an epistemological stand of operationalism and positivism— asserting that the only meaningful statements about the world must be directly tied to empirical or operational responses that human beings may have—and where the model of matter is in terms of atomism. His later epistemological stand in general relativity is based on the view of realism —wherein the assumption is made that there is a real world, independent of whether or not there are human beings around to perceive its features —and where the model of matter is most fundamentally in terms of continuity rather than atomism. In this view, it is indeed possible to draw conclusions about the real world that are not directly tied to empirical evidences, though these statements may lead, in a logical chain of conclusions, to empirical predictions[5].

THE BASIC PREMISE OF RELATIVITY—THE PRINCIPLE OF COVARIANCE

The basic idea of the theory of relativity that convinced Einstein of its extreme simplicity is his principle of covariance, also referred to as the principle of relativity.

This principle asserts that the laws of nature must have expressions independent of the frame of reference in which they are represented—from any particular observer's view. This is equivalent to saying that the laws of nature are totally objective.

We see, then, that the theory of relativity is based on a premise that is a law about laws, rather than a law that deals directly with physical phenomena. The idea about the objectivity of the laws of nature is, however, not really that new! For how could a law be a law, by definition of the word 'law', if it were not totally objective?

Thus it seems at this stage of the discussion that the theory of relativity is based on a premise that is tautological—such as the statement that 'woman is female'! If this were indeed the case, then Einstein's theory of relativity would not be a scientific theory, for a scientific truth must be contingent on nature, whereas a tautological truth is a 'necessary truth'— it cannot be anything other than what it asserts.

Nevertheless, the principle of covariance of relativity theory is not really a tautology because it depends on two tacit assumptions that are indeed contingent on nature:

- there exist universal scientific laws that prescribe the logical connections between causes and effects; and
- these scientific laws may be comprehended by us and expressed in a precise way—sufficiently so as to allow us to test their conclusions in experimentation as well as testing their logical consistency.

The first of these tacit assumptions is based on an idea sometimes referred to as 'the principle of total causality'—the idea that for every physical effect in the world there is a logically connected physical cause. Of course, this assertion is not necessarily true. However, it seems to me that it is the credo of the scientists, since it is their very purpose, as scientists, to search for the causal connections of the physical manifestations of the universe, in any of its domains, in order, in turn, to gain in our comprehension of the fundamental nature of matter.

The second tacit assumption—the idea that we can comprehend and express the physical laws—is also not necessarily true. Perhaps it is arrogant for us, the human beings on this planet Earth, here in this rather insignificant corner of the universe, to make such a bold claim. Nevertheless, I believe that the history of science attests to the fact that indeed we have made some progress in the direction of increased understanding of the infinite universe, over the past millennia. Thus we have some confidence that it is possible for us to attain increased understanding of the objective physical laws of the universe—miniscule as our accumulated understanding may be at any particular stage of our history (including the present!), compared with all that there is to understand. This assertion is along the same line of thought as Einstein's, when he said: 'The most incomprehensible thing to me is that we can comprehend anything about the universe!' Thus he had confidence that we can indeed comprehend something of objective reality, small as this understanding may be compared with a total understanding—which we could never achieve, because of our finiteness. Nevertheless, it is our obligation, as scientists, to continue with the task of gaining in our understanding of the real world.

THE ROLE OF SPACE AND TIME IN RELATIVITY THEORY

The assumption that we can express the laws of nature, means that we can find an appropriate language for a precise way to represent the laws. This idea has led to the introduction of the space-time in the theory that is different than its use in the earlier physical theories. For in the classical views, space and time are there, whether or not matter is present. One then 'puts matter into space and time', as one might put socks into an empty drawer. But in the view of relativity theory, space and time are not 'things-in-themselves'—rather they are only related to a language that is invented for the purpose of facilitating an expression of the laws of matter.

The most convenient language that we have discovered so far in the history of physics, to represent the laws of motion, is in terms of four continuously variable parameters, playing the role of the 'words' of this language, and a logic that connects them (analogous to the syntax of verbal language, such as the 'subject-predicate' relation), to give meaning to the expressions of this language. The logic of the space-time language of relativity theory is in two parts: algebra and geometry. [At the present stage of Mathematics, mathematicians believe that all theorems of algebra and geometry merge into a common set of theorems, and thus their actual separation is artificial. However, for the purposes of this exposition it will be convenient to consider them separately.]

The principle of covariance asserts that the laws of nature must be totally objective—meaning that their forms must be independent of the space-time reference frame in which they are expressed, from any particular observer's point of view. The space-time language itself is relative to the reference frame in which it is expressed—hence the name of this theory! Still, the primary focus of the principle of covariance is on something that is absolute rather than relative—this is the invariant law of nature itself.

In the early stages of this theory, its name led to the erroneous impression that this approach in science is based on the philosophic view of 'relativism' —the idea that all knowledge is relative only to the 'knower'—i.e., that there is no objective knowledge to talk about. Of course, Einstein never had this view in mind—his approach was just the opposite, where one focuses on the invariant (objective) law of nature. To avoid the confusion, Einstein tried to rename his theory 'invariententheorie' (theory of invariants), implying a focus of this theory on absoluteness rather than relativeness. However, he eventually rejected the name change because of further confusion he thought it might entail[6].

The role of space and time in relativity theory is then to serve as a language whose sole purpose is to facilitate a subjective expression (i.e. relative to the reference frame) for objective laws of nature (i.e. laws that are in one-to-one correspondence in regard to their expressions in all possible frames of reference.

To exemplify the notion that not everything is relative, we note that one thing that cannot be relative is the universe itself. For the universe, by definition, is all that there is, therefore there is nothing else to be relative to! This absoluteness of the universe, in turn, entails the absoluteness of its basic characteristics, as expressed in the laws of nature. Thus we see that, logically, the absoluteness of the universe as a whole implies that the laws of nature must have forms that are absolute—that they are 'covariant' with respect to changes to any reference frame—that is, any scientific investigator would see that the law for any particular phenomenon in all possible reference frames relative to his own must be in exact correspondence. But this is just Einstein's starting premise of the theory of relativity—the principle of covariance.

This idea is entirely analogous to the subjectivity of verbal languages in order to express objective meanings. For example, before Newton's discovery of the law of universal gravitation, the English may have expressed the law of gravity as: 'Whatever goes up, must come down'. The French, to express the same meaning, would have said: 'ce qui s'élève doit descendre'. The languages are different, but they express precisely the same idea.

Einstein's principle of covariance then asserts that if a particular set of relations is indeed a universal law of nature, it must be independent of the reference frame in which it is expressed. If, in the preceding example, the English would have said something slightly different, such as: 'Whatever goes up usually comes down', but the French said the same thing as before, the principle of covariance would be in violation, implying that the scientists from both 'frames of reference' should investigate further until they could come up with an objective statement about 'things that go up'.

The language translations between English and French in this example, applied to all other possible statements, so as to preserve the meanings of the sentences (in one-to-one correspondence) then forms a 'transformation group'—in the language of algebra.

It is interesting to note that the full set of such 'translations' of the mathematical space-time language in physics is more precise than the translations of verbal languages to preserve the meanings of sentences, e.g. between English and French. This is because the translations of verbal languages entail meanings expressed with words and body gestures of one language that are tied to a particular culture that is not easily translatable into ideas in terms of words and body gestures of the language of a different culture. But there is no such difficulty encountered in the translation of mathematical languages because of their increased precision, and because they are all based on a single (scientific) culture. Even so, the mathematical languages are not as rich as verbal languages, certainly not at our stage of development of the human culture. [I believe that they will never match, because human feelings will probably never be expressible in mathematical terms!]