UNDERSTANDING RELATIVITY

· Stanley Goldberg ·

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Origin
and Impact
of a
Scientific
Revolution

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To my mother, Sarah Belle Talisman Goldberg.

And to Frank Weissman, Ollie Loud and Trevor Coombe:
Though miles, even light years apart, they have kept their
eyes on the same star:
The Dignity of People.

Contents

Preface

The central subject matter of this book is Einstein's special theory of relativity. While it is a book that is written primarily for a lay audience this does not necessarily mean an audience not versed in the ways of doing science. Rather, this book is written for anyone wishing to consider the nature of the scientific enterprise: where ideas come from, how they become established and accepted, what the relationships are among theories, predictions, and measurements, or the relationship between ideas in a scientific theory and the values held to be important within the larger culture.

Some readers will find it strange that I raise any of these issues. It is a common view in our culture that the status of knowledge within science is totally different from the status of knowledge in other areas of human endeavor. The word "science" stems from the Latin word meaning "to know" and indeed, knowledge which scientists acquire in their work is commonly held to be certain, unyielding, and absolute. Consider how we use the adjective "scientific." There are investors and there are scientific investors. There are socialists and there are scientific socialists. There are exterminators and there are scientific exterminators. We all know how the modifier "scientific" intrudes in our daily life. It is the purpose of this book to challenge the belief that scientific knowledge is different from other kinds of knowledge.

Other readers are no doubt aware that scientific theories that at one time are generally accepted are later rejected as insufficient or inaccurate. This does not affect the commitment of many of these readers to the notion that scientific knowledge is special and more certain than other kinds of knowledge, for they believe that the reason for the replacement of one theory by another is the result of the improvement in measurement or the discovery of hitherto unknown phenomena. The bedrock on which theories rest is experiments and measurements. The results of the experiments and the measurements persist regardless of how theories change. Thus the succession of one theory by another is seen as part of an evolutionary process in which agreement between prediction and measurement become closer and closer and, in the process, an ever-growing number of phenomena are included within the widened perimeter of that which the new theory explains. These views will also be challenged in this book.

The premise underlying the views that are being challenged here is the belief that there is such a thing as "scientific thinking," which is essentially different from thinking in other spheres of human activity. Scientific thinking is different, according to this view, because of the use of something called "the scientific method." This scientific method is supposed to make knowledge in science logical and inevitable. In fact, in some circles science is considered a branch of logic. The premise that "scientific thinking" is different from other kinds of thinking by virtue of the application of the scientific method, will be challenged as a myth in this book. There is no magic formula such as the scientific method and science is not a branch of logic. In fact, when formalized, the relationship between measurements and the scientific theories which are supposed to explain those measurements contains a logical fallacy which Aristotle recognized as "affirming the consequent." Whereas it is true that in practicing science one should be logical, being logical is not the same as using formal logic. Regardless of which problem a person is working on, be it a problem in science, cooking, banking, driving an automobile or train, one should always be logical. To say that in doing science one should be logical is to say little.

Not only are the generally accepted views about the status of scientific knowledge challenged in this book, but also called into question are the commonly held notions about the niche occupied by science as a social institution within the matrix of institutions that make up a culture. For example, the glib claim that it is necessary to do science in order to fuel the fires of technological progress will be scrutinized and found wanting. In fact, it seems to be the case that more often than not, it is technological innovation that suggests the questions on which scientists should be working and which make it possible to ask questions that are unanswered. Even today, technological innovation is largely *sui generis,* requiring only prior technological innovation.

At this point it might well be asked what these points have to do with the special theory of relativity. The ideas and experiments associated with the special theory of relativity, their development, early reception, and assimilation, will be used as a case study to illustrate and support the general argument. In many ways, the development of the special theory of relativity is typical, it is claimed, of the development of any scientific theory. But there are features of the special theory of relativity and its development which make it particularly suited for our purposes. Although there has been an enormous mystique surrounding the theory and its creator, the special theory of relativity is an exceedingly simple theory. The core of the theory is understandable without great mathematical development. This understanding will allow an examination of the relationship between the ideas in the theory and the mathematical development which is normally associated with the theory and will help to give some insight into the role of a formal language such as mathematics in scientific theories.

The special theory of relativity is a modern theory. Very often, when the issues that are raised here have been discussed, the illustrative examples have arisen from earlier periods in the history of science: for example, the Copernican revolution of the sixteenth century, the Newtonian synthesis of the late seventeenth and early eighteenth century, or Dalton's atomic theory in the early nineteenth century. This has allowed some to argue that, whereas social factors might have been a consideration earlier, they are no longer and the nature of science has changed since the early modern period. That this is not the case will be one of the major focuses of this study.

Among the motivations for writing this book is the belief that these issues have a direct bearing on public policy in the sciences. If the public is to actively participate in policy decisions, there must be an understanding of the issues about which policy is being made. Regarding the sciences, this means understanding substantive issues in science. We are investigating the content and reaction to the special theory of relativity not only because it represents interesting and beautiful intellectual puzzles, but also because the contemplation of the issues can provide insight into current social questions about which science has a bearing. The first part of this book, therefore, is devoted to describing the intellectual content of the theory and making it understandable and accessible to anyone who can read and wishes to work at thinking about the problems that the theory addresses. The first part of this work is intended to *demystify* the substantive content of the special theory of relativity. To that end, the development of the ideas has been placed into an historical context. In order not to break the flow of ideas, technical asides, generally the formal developments that one might want to examine for completeness, have been placed in a set of appendices. They are not crucial to an understanding of the intellectual content of the special theory of relativity nor the contents of the book.

The second part of the book is devoted to an examination of how the special theory of relativity was received in the four cultures responsible for more than ninety-nine percent of the literature about it in the years following publication by Albert Einstein in September, 1905. We can identify within the matrix of the responses of the scientists in the four countries, something which we will call "national styles" about how the theory was understood. We can also learn how those national styles are comprehensible within traditional ways of practicing science in those cultures as well as being compatible with other facets of the social institutions of those cultures.

In the third part of this work, we raise the question of how the theory, which was initially found unacceptable in all four of the cultures, was assimilated not only within the scientific communities but within the general societies. Rather than examine the history of that assimilation in each of the four countries, the assimilation of relativity in the United States is used as an exemplar. The claim is not that the substantive understanding of the special theory of relativity acquired within American culture is typical but that the process of assimilation is representative. This study reveals that one of the purposes of scientific social institutions is to provide mechanisms for interpreting new scientific theories to insure the survival of traditional cultural views about the nature of science and its value to the society.

This raises the question of the precise nature of scientific revolutions. Do we toss out old theories that have been found wanting and, albeit with a significant struggle, embrace newer revolutionary views? On the other hand, if the role of our social institutions in science is to shield us from changing our minds about the nature of the universe, how are new ideas introduced?

Throughout, although the style suggests that all the answers are here, it should be emphasized that the intent is exploratory, tentative and heuristic. The issues are important for our culture and they have always been important. There is no illusion that this work represents the final word. On the contrary, the answers are not as important as the elaborative process that we undertake to address the questions that are being asked.

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There are three mentors I wish to cite for shaping my outlook on these matters. I am sure we no longer agree on the details, yet that, after all, is part of the fun.

Vernon C. Cannon was my first teacher of physics. He made an incredibly difficult although beautiful subject acceptable and understandable. It was watching him build physical models out of the air between his hands that gave me the clue that physics modelled the universe of our experience. And it was by standing at the blackboard with him, sometimes for hours, trying to understand the most trivial formal statement about the motion of an hypothesized mass point, that made me realize the joy to be gained from considering abstractions.

Gerald Holton was the director of my doctoral work in the history of the early reception of Einstein's special theory of relativity. This subject is considered mostly in the second part of this book. That work was completed about fourteen years ago. It brings to mind something that Holton said to me as we began the project: "Whatever you do," he said, "there are two things to bear in mind. It should be something you love because you are going to be working on it for some time. And it should be considered a beginning and not an end." No teacher ever gave better, sounder, more sensible advice. And no teacher was ever more generous in introducing an important part of the garden of material that was to be part of the work. In addition, Holton's intellectual prowess has been a source of inspiration and guidance. Even when we disagreed, his critiques have been instrumental in tempering my outlook.

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In citing the help of these individuals and institutions I am not suggesting that they will find this work satisfactory, or even acceptable. It is I who bear responsibility for what follows. May He or She who is responsible for these sorts of things have mercy when it comes time for The Great Accounting.