Einstein's lost frame

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Foreword

This book is closely related to *Luzboa*, the international biennial of light in Lisboa. The purpose of Luzboa is to promote Light in all its forms, by a multidisciplinary exchange between different approaches, such as those of Art, Culture, Science and Architecture. Light is a metaphor of knowledge. Light is a crucial aspect of modern society. Light is essential in urban design. Luzboa aims to make Lisboa the epicenter of a Culture of Light. Further information on the event can be found in http://www.luzboa.com.

The first edition of Luzboa took place in 2004, organized by the cultural association *extra]muros[* together with the *Institut Franco-Portugais* and the French Embassy in Lisboa. The authors of this book have met during the science session of this first edition, in which Gustavo Homem and Rodrigo de Abreu have presented some of the ideas developed here. With the discussion that followed, the authors have decided to work together in the present project, looking in depth to the foundations of Einstein's Special Relativity and to the differences and similarities between the approaches of Einstein and of Poincaré and Lorentz.

extra]muros[has encouraged the idea from the beginning. As the outcome of the subsequent enthusiasm, the book will be presented and debated during the 2006 edition of Luzboa, although it sees the light of the day in the centennial of Einstein's miraculous year. The connection to the biennial of light was extended as well to the *Institut Franco-Portugais* and to the French Embassy in Lisboa, with the vital support from Marc Pottier and Alain Derevier, Cultural Attaché and Scientific Advisor of the French Embassy in Lisboa, respectively, which is deeply acknowledged.

Mário Caeiro
extra]muros[

Lisboa, November 2005

Chapter 1

Introduction

> Physics is the most fundamental and all-inclusive of the sciences and has had a profound effect on all scientific development. In fact, physics is the present day equivalent of what used to be called *natural philosophy*, from which most of modern sciences arose.
>
> R. Feynman

The book opens with a quote from Richard Feynman, an outstanding physicist who let to mankind much more than his pure scientific work. He was a true *physicist*, and as such has taught how to approach, how to think, how to question, how to argue, and how to explain physics. Not only the complex details of an advanced theory, but as well the very fundamental ideas and results of no matter what basic field. Physics is indeed the most fundamental of all sciences, with ramifications into chemistry, biology, astronomy, geology and psychology, for instance, and a strong relation to engineering, industry, and mathematics.

Of most interest here is the relationship between physics and mathematics. Mathematics is not a science, at least not a natural science, since the test of its validity is not experiment. It is nevertheless strongly connected to physics. In Galileo's words,

> Philosophy is written in this grand book, the universe, which stands continually open to our gaze. But the book cannot be understood unless one first learns to comprehend the language and read the characters in which it is written. It is written in the language of mathematics.

With the development of ever more elaborated physical theories, the mathematics required to their description became more and more advanced. This evolution lead to a growing number of high level mathematicians working on physics. As a consequence, one witnesses an evolution in the way of discussing the principles and foundations of physics, towards a more abstract and even technical level. Unfortunately, here and then this evolution has gone too far, by focusing the discussion in the mathematical internal consistency of the theories, while forgetting to some extent the underlying physical reality. To "understand" a physical theory has became gradually synonym of "knowing how to perform the calculations", and the theories are often presented to students without a careful discussion of its premises. However, as noted by J. Resina Rodrigues [1], the role of mathematics is not to establish the fundamental aspects of reality, but rather to create rigorous formalisms, sets of conclusions derived from *axioms*, valid by themselves as a creation of reason and that can be used as tools by the sciences. On the other hand, physics has no certitude about anything, but has very good *hypothesis*. These hypothesis can be written in terms of elegant mathematics, but do not have the pretension of being the ultimate description of reality. On the contrary, it is assumed the description of nature is always an approximation to the complete truth. Hence, there is a very big difference between the purpose and approach of mathematics and physics! Mathematics makes deductions from a set of axioms, but it does not make sense to ask if these axioms are "valid" in the real world. Unfortunately, this way of thinking has already partly invaded physics. Nonetheless, and quite on the contrary, physics should indeed question its own "axioms", often named principles, and its hypothesis. This is what is done in this book, on the subject of special relativity.

Einstein's celebrated article "On the electrodynamics of moving bodies" [2] was published precisely 100 years ago. During this time, special theory of relativity established itself as one of the most exciting topics in physics. The striking effects it predicts are noticeable only when the involved speeds are close to the speed of light, and this is why they remain unfamiliar to most of us. But its challenges and results are so stimulating that it keeps attracting the attention of physicists and philosophers, fascinating the general public as well. The centenary of special relativity and the 2005 World Year of Physics provide the perfect occasion to investigate and discuss carefully its foundations, with an open mind and no prejudice. In this work we intend to revisit and look in depth to the questions of *absolute space* and *relativity*. In particular, we provide an alternative derivation of the effects described by special relativity, based on a description that assumes a privileged reference frame, as considered by several eminent scientists, such as Poincaré and Lorentz, contemporary with Einstein, and abandons Einstein's idea of "equivalence" of all inertial frames. This approach was partly suggested by John Bell [3], another remarkable physicist of the 20^{th} century, but its development led us much beyond Bell's original proposal. He has noted that

> Many students never realize, it seems to me, that this primitive attitude, admitting a special system of reference which is experimentally inaccessible, is consistent.

From our experience, this is not a question of students only, as *most scientists* never realize it either! This is true even for established relativists with a certain reputation. When we asked the opinion of one such colleague, which is a regular referee on relativity, his first position was that with an approach based on a privileged reference frame we could not explain the reality of reciprocity of the effects of length contraction and time dilation. He further argued that the muon experiment confirms the reality of the reciprocity of length contraction and time dilation and that the proposed theory cannot explain this experiment. These allegations are false, as it will be clearly demonstrated along this text. In any case, contrary to most of our colleagues, John Bell was most aware of this fact. On the same paper he has made additional remarks as follows (italics added in one sentence):

> It is found that if physical laws are Lorentz invariant [*cf.* chapters 3 and 4], such moving observers will be unable to detect their motion. As a result it is not possible experimentally to determine which, if either, of two uniformly moving systems, is really at rest, and which is moving.
>
> The approach of Einstein differs from that of Lorentz in two major ways. There is a difference of philosophy, and a difference of style.
>
> The difference of philosophy is this. Since it is experimentally impossible to say which of two uniformly moving systems is *really* at rest, Einstein declares the notions of 'really resting' and 'really moving' as meaningless. For him only *relative* motion of two or more uniformly moving objects is real. Lorentz, on the other hand, preferred the view that there is indeed a state of *real* rest, defined by the 'aether', even though the laws of physics

> conspire to prevent us identifying it experimentally. *The facts of physics do not oblige us to accept one philosophy rather than the other.* And we need not accept Lorentz's philosophy to accept a Lorentzian pedagogy. Its special merit is to drive home lessons that the laws of physics in any *one* reference frame account for all physical phenomena, including the observations of moving observers. And it is often simpler to work in a single frame, rather than to hurry after each moving object in turn.
>
> The difference in style is that instead of inferring the experience of moving observers from known and conjectured laws of physics, Einstein starts from the *hypothesis* that the laws will look the same to all observers in uniform motion.

It is striking the unease revealed by most scientists when discussing the foundations of special relativity and confronted with the compatibility between Einstein's results – based on the notion of *relative* motion – and the existence of a preferred reference frame – with its associated idea of *absolute* motion. In this work we adopt not only the Lorentzian pedagogy, but truly Lorentz's philosophy. Those who may feel already the discomfort of advancing through a theory in *absolute* space are urged to read Bell's quote again and to enter this book without any preconceived ideas.

Our starting point is related to Einstein's postulate of the constancy of the speed of light in all inertial frames, which seems to be confirmed by the historical Michelson-Morley experiment (discussed in sections 2.2, 3.6 and 6.4). However, this crucial experiment says nothing about the *one-way* value of the speed of light and only establishes the constancy of its *two-way* value (its average speed on a round trip) in vacuum. In chapter 2 it is assumed that there is one frame where the one-way speed of light in vacuum is the same in all directions of space and equal to c. This frame is identified with the rest system, and it is shown this frame is unique. Since Einstein gave a precise definition of the "rest system", we have denoted it by *Einstein's frame*.

In chapter 3 it is established that the one-way speed of light in vacuum in moving inertial frames is not c (the two-way speed of light of course it is). Furthermore, simultaneity is absolute, contrary to what says Einstein's relativity. The general expressions for the transformation of coordinates between inertial frames are obtained. They are given by the so-called "synchronized transformation", which differs from the celebrated Lorentz transformation of special relativity. The postulates of the theory are revealed to be strongly related to the conceptualization of the very notion of time: the present theory is actually a "theory of time".

The meaning of the Principle of Relativity is elucidated and discussed in detail in chapter 4. In particular, it is shown that the Principle of Relativity is not incompatible with the existence of a preferred, absolute, frame. As mentioned already, simultaneity is absolute and the same is true for the phenomena of time dilation and space contraction. Accordingly, there is no "reciprocity" of these effects, being nonetheless explained how and why these absolute phenomena may *appear* to be symmetrical. Although this was stated by John Bell, among others, it is still very puzzling and even considered to be wrong by many physicists and scientists. However, the Lorentz transformation is shown to be *mathematically equivalent* to the synchronized transformation. It is possible and easy to change from "synchronized coordinates" (the description of the phenomena made with the synchronized transformation of coordinates) to "Lorentz coordinates", and vice-versa. Even so, the *physical meaning* of different quantities expressed with both types of coordinates - such as time, speed, simultaneity and synchronization - is quite different. However, perplexing this may look at first sight, pushing the argumentation to an extreme, the present theory can be considered the same as Einstein's theory! And yet what is being said seems very different! How can it be? After all, is motion absolute or only relative? Are two distant events simultaneous for all observers or not? Is the one-way speed of light always c or not?

There is a demanding problem of *language*. In any field of physics a considerable amount of preparatory training is necessary even to learn what the *words* mean. This is often associated with the mathematics used to describe the laws of physics. In the present case the situation is more complex, as *what special relativity says is not what usually it is thought it says.* Within Einstein's relativity, the words "time" and "speed", for instance, should be used with a certain sense, perfectly defined by Einstein, but which does not correspond to their intuitive meaning and generally induces an erroneous interpretation of the results. Using carefully and correctly and precise language, problems and paradoxes are immediately avoided. As a matter of fact, reality is not changed by the choice one makes to *describe* it! Interpretation problems only arise because words are used in a sense which is often not correct under the chosen description. The core of the problem is related to the old question of synchronization of distant clocks. Usually, the subject is discussed in rather abstract terms, and physics is partially lost. Because if it is kept in mind that *reality* is being described, and not simply some kind of "game", everything becomes clear, unambiguous, and of an astonishing simplicity. Actually, one can set or "synchronize" his own clocks as it most pleases him, but reality is not changed by the way the clocks have been set! Hence, we fight the ideas of "conventionalism" and of "operationalism", shortly discussed in appendix C. According to this view, only directly measurable quantities have a physical meaning, the others can *only* be "determined" (or "stipulated", in Einstein's words) by human convention. As an example, our colleague mentioned above added that

> The consensus among scientists is that the one-way velocity of light cannot be measured in principle and for this reason its definition is a matter of convention. This means that there is nothing in the external world that corresponds to that concept.

Of course we strongly disagree with this conception of reality, which considers that since up to now one cannot measure the one-way speed of light, it simply does not exist (!!!). On the contrary, we find it obvious that the one-way speed of light does exist, even if we cannot measure it. The meaning of speed does not disappear simply because we do not know how to measure it: it is the distance divided by the "time of the journey". We admit the following questions: what is the time of the journey? What is the speed of light? The two interrogations are of course interconnected, and rely on the determination of the "common time" of the clocks. The latter question cannot be answered by stating by decree it is c, its measured two-way value. This can hardly be seen as an answer. What can be done is to admit that there is an indetermination: we do not know.

Still in chapter 4, the impressive and historic contribution of Henri Poincaré to this discussion is emphasized. Poincaré has stated correctly the principle of relativity before Einstein. Moreover, while admitting the existence of a preferred frame, he understood why all inertial frames appear to be "equivalent". Unfortunately, his role in the formulation of this principle has been forgotten to a big extent. The chapter ends by showing that special relativity is incomplete and undetermined unless one really knows the one-way speed of light or, which is the same, unless the privileged Einstein's frame has been identified.

Chapter 5 illustrates the presented theory with several classic examples, such as relativity of "simultaneity", the twin and length paradoxes, the propagation of electromagnetic spherical waves and the electric field created by a moving point charge, which are reanalyzed and interpreted. The last two examples show that the present theory, although presented in a quite simple and accessible way, based on very fundamental examples, is not restricted to kinematics. On the contrary, its application to dynamics and electromagnetism is straightforward, as briefly outlined in appendix B.

Finally, the last chapter deals with some attempts made so far to identify the preferred frame. Such efforts started at least as early as 1887, by Michelson and Morley, and continue nowadays, with the high-tech experiments proposed by Maurizio Consoli already in 2005. Other important early contributions came from the french school, with Augustin-Jean Fresnel and his idea of an "aether drag", M. G. Sagnac, and Armand Fizeau. The latter performed one of the experiments that most impressed Einstein. In the last few years, Reginald Cahill and Maurizio Consoli have been independently and systematically analyzing the available historical experimental data and the more recent and sophisticated versions of the famous experiment performed by Michelson and Morley more than 100 years ago. The experiment is usually said to have given a "null-result", as it should be according to special relativity, but this was not actually the case. It gave a small result, distant from what was expected, but not a null one. It was assumed at the time that this small result was simply within the error margin of the procedure and could be taken as zero. However, the successive repetition of the experiment by several authors, starting with Morley and Miller in 1905, passing through the exceptional work of Miller in the 30s and continuing up to now, have confirmed the original non-null result. These experiments are analyzed in section 6.4. Although to date a completely satisfactory explanation of the results does not exist, it is suggested it is probably possible to identify the preferred frame, which would complete the theory. This is evidently a very polemic suggestion, but we believe it is well supported and strongly increases the interest of the book.

It is a question of elementary justice to mention the very good work of Franco Selleri. We have discovered it only very recently. Quite remarkably, Selleri proposes a theory that goes exactly on the same line as the present one. It is noteworthy that completely independent investigations drove different scientists to very similar conclusions. And it confirms to some extent that the ideas justify at least further inspection. The contribution of Franco Selleri is briefly reviewed in section 6.2.

The book is written with very basic mathematics and can be read by all literate non-specialists. We have used a color code as follows. Many sections involve only the discussion of the meaning of fundamental physical concepts and effects. These sections are identified with black titles and can be read by any interested reader, regardless of his formation. Other sections, with orange titles, involve some mathematics at high-school level. They are not as easy to read as the black sections, but can still be read by anyone with basic knowledge on mathematics. Finally, a couple of red sections is written in a more formal way, close to the style of university textbooks. We believe the book can also be used as a complementary textbook by physics teachers and physics students at the university. Our teaching experience shows that the proposed approach is easily ,accepted by physics students, while opening hot debates. We think that even in the case the book is not used as a textbook, its reading certainly forces teachers and students to consider a different point of view.

To our knowledge this book is unique in its contents, presenting special relativity in a completely innovative and non-orthodox way. It brings a new physical insight into special relativity and the fundamental notions of space and time, providing a new physical interpretation of some well known effects. The book is written in a very assertive way, proposing firmly a rather "heretic" interpretation of special relativity, which readers already familiar with it may eventually find as somewhat provocative. Nevertheless, after reading the book they will certainly look at special relativity with different eyes. Other readers are likely to find the present formulation and interpretation easier and simpler than the classic one. At least we expect those who will take the time go through this work to have fun while considering the possibilities it suggests. We had while writing it.

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