
Preamble

This book presents Special Relativity (SR) in language accessible to students while avoiding the burden of geometry, tensor calculus, and space-time symmetries, yet advancing in highly contemporary context all the way to research frontiers. I further take into consideration the way Einstein saw SR after 1915 as a part of the more general scientific context, with the newly formulated General Relativity (GR) influencing the way SR was understood. This is complemented by the current cosmological perspective and connected to present day research topics. SR is presented such that nothing remains a paradox or just apparent, but rather everything is explained.

We first develop the basic principles of SR, and explore and discuss alternatives. Much of the first half of the book has the format of a discussion in which the teacher, and in particular his graduate student, will be challenged by a brilliant but web-self-taught student called ‘Simplicius’.¹

These conversations are representative of both the foundational concepts in SR and how students have challenged this author over the years. These conversations present the opportunity to explore what often remains unsaid when teaching SR and often explain how one should think about SR. They are also in response to the realization that many ‘Modern Physics’ texts contain serious misunderstandings of the principles of SR. These find their way into web-based, and even some classroom teaching.

As the book progresses, the qualitative and historical discussion turns into textbook-style presentation, and at the end evolves into the concise and precise format of a physics research book. The final 100 pages reveal research topics and unresolved questions related to relativistic charged particle dynamics. The reader reaching the middle of this book

¹Simplicio appears in Galileo Galilei’s *Dialogue Concerning the Two Chief World Systems* (1632) comparing the Copernican with the Ptolemaic paradigm. The book is presented as a series of discussions among two philosophers and Simplicio, layman defender of the Aristotelian geocentric view on astronomy. Simplicius of Cilicia, c.490–c.560, was a Greco-Roman mathematician and philosopher who wrote extensively on the works of Aristotle.

needs a good command of elementary algebra and the basic knowledge of calculus along with introductory knowledge of classical mechanics and, ultimately, electrodynamics at the level of Maxwell's equations.

A text of similar character, content, scope, has not been presented before. The search for clarity in the fundamental questions about SR, the developments after 1905, and the strong connection to current research topics are, in my view, the most important and original assets of this book. Readers should keep in mind that I do not invent relativity, but report and interpret the development and the progress of the theoretical framework, with many conceptual developments reaching far beyond the initial ideas. Those who cherish Special Relativity of 1905 vintage should remember that in 1918–1922 Einstein disavowed publication of his 1912 Special Relativity review, which had been delayed by the outbreak of WWI. Looking at this manuscript² after reading this book, the answer to 'why' should be clear: by 1920 the scientific context had evolved. Today, of course, it has evolved further.

Background remarks

In the early 1980s when teaching at University of Frankfurt I wrote my first book on SR.³ Published in Walter Greiner's "Theoretical Physics" series, this volume was well received in three editions. Walter knew there were significant problems in many texts explaining SR; thus he encouraged and supported this project. Looking today at this 1980–1990 effort, it was good but not complete. The current volume is very different, but has its basis in that first experience.

A few years later I asked John S. Bell, a friend and mentor, which English language book to use to teach relativity. I reproduce his letter and some key words are here: John said "...recommend ... my own paper ... Einstein approach is ... pedagogically dangerous...". Between the lines John argues that the book I was seeking needed to be written. I of course agreed as my German language relativity book aligned well with Bell's thinking. In the past 25+ years I was on-off in respect to writing a new text, and I made sure to take John's advice to follow the historical approach, clarifying why Einstein's relativistically invariant æther is different from the Lorentz and Larmor points of view.

²The manuscript is published as a facsimile of the original hand written document, with English translation and historical introduction: A. Einstein and H. Gutfreund, *Einstein's 1912 Manuscript on the Special Theory of Relativity*, ISBN 0807615323 (George Braziller 2004).

³*Spezielle Relativitätstheorie*, Verlag Harri Deutsch, Frankfurt (1984, ISBN3-87144-711-0; 1989, ISBN 3-97171-1063-4; and 1992 ISBN 3-8171-1205-X).

CERN

1985 March 12

Dear Johann, the only thing I can thoroughly recommend on relativity is my own paper. I enclose a copy. I refer there to the book of Janossy. But it is very long, and insufficiently explicit that the Einsteinian approach is perfectly sound, and very elegant and powerful, (but pedagogically dangerous, in my opinion). What Rindler says, in the extract you send me, seems OK to me. There is a reference to Rindler in my paper. If you look it up you will see that he agrees with the possibility of presenting things the way I advocate. I disagree with him only on pedagogy and history (his remarks about Larmor not understanding time-dilation is astonishing to me).

Best wishes
John

John S Bell's answer of March 12, 1985 about "How to teach Special Relativity", the title of the lengthy conference paper he sent along with the letter.

Acknowledgments

During the past three decades, each time I taught a SR related class, I made progress in this new text. Several students contributed to the writing and vetting of this book. I thank in particular, (alphabetically) Jessica Bernier, Rebekah Cross, Stefan Evans, Martin Formanek, Kiel Howe, Taylor Kessinger, Will Parker, Daniel Rosser, and Per Schmidt. Kiel Howe helped with some of the graphic material in the book, and challenged me in the way that led to the creation of the conversation contents. I thank Victoria Grossack for her encouragement and editorial support over the past decade.

I benefited greatly from a long list of critical comments prepared in 2010 "all summer long" by Iwo Bialynicki-Birula, of the Centrum Fizyki Teoretycznej, Polish Academy of Sciences in Warsaw. Iwo's crisp and critical mind was an invaluable help for me in

realizing why the 2010 version of this book could be considerably improved. Iwo took deep interest in this manuscript; his criticism, comments, and questions influenced the precise final format of this volume.

I thank all those involved for their kind help and interest. I am alone responsible for any errors, omissions, and personal historical remarks and anecdotes in the contents presented here.

Tucson, Arizona, USA
Summer 2016

Johann Rafelski

<http://www.springer.com/978-3-319-51230-3>

Relativity Matters

From Einstein's EMC2 to Laser Particle Acceleration and
Quark-Gluon Plasma

Rafelski, J.

2017, XXV, 468 p. 85 illus., 63 illus. in color., Softcover

ISBN: 978-3-319-51230-3