

Epstein Explains Einstein

An Introduction to both the Special and the General Theory of Relativity

by David Eckstein



“As simple as possible - but not simpler !”

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Translation of the German edition by Samuel Edelstein

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Foreword by Lewis C. Epstein

Who contributes the most to progress: The mountain man who finds the first pass at 10,000 feet through a high range, or the railroad engineer who later finds a low pass at 7,000 feet which will be used by trains, motor vehicles, pipelines, electric lines and optical cables?

It is hard to answer.

In the realm of physics, all the credit, the Nobel Prize, goes to the "mountain man". In physics, the "railroad engineer's" reward is best some money from writing and selling "low pass maps", which are books that make good understanding accessible to those who for various reasons cannot go up to 10,000 feet.

I am a "railroad engineer". I found a low pass through the theoretical physics mountains into Einstein land. The pass is mapped in a picture and a story book called *Relativity Visualized*. Here David Eckstein has taken my picture story and transliterated it into kosher physics. The story pivots on an intuitive idea I called: the speed of time.

From where came this "speed of time" story? Like many post 1960 physics ideas, it just came out of the smoke, which opens the band pass filter of the mind. Through the open filter comes lots of noise, a few distant memories and unusual convolutions of thought.

Recall childhood. I remember how slow time crawled when I was kept in detention, after school going home time, because of bad spelling or bad goofing. And I remember how fast time flew on the special occasion of riding up front on a steam locomotive's footplate. The Ancients too felt earthly time ran slow and fast. Slow in summer; each daylight hour became longer. Fast in winter; each daylight hour become shorter. Even in the lower spheres of heaven, the planets pace through the zodiac was not only variable, but occasionally back stepping.

Galileo put his first thermometer into chile pepper and demonstrated that part of what had been called heat was subjective, not objective. And he suspected time might also be, in part, subjective. So he tried hard to express the falling body law in terms of objective geometry, on distance from the top. Only reluctantly did he permit time to enter the falling body law. After all, how could time, a thing without material existence, have a linear control of a material object's speed? Time was not part of the tangible world. The Good Book relates how God created the world: 1) In the beginning God created the heaven and the earth, 2), 3), 4), 5), 6), 7) And on the seventh day he took a rest. On which day did God create time? Answer: The Ancients did not think time had objective existence, so it need not to be created. Time came out of men's head.

But once permitted into physics, time soon established itself as the immutable universal independent variable which drives all physical processes. The current of time, unalterable, untouchable by any force, any motion, any environment, anything whatsoever, ruled the dynamic world for the three centuries after Galileo.

No sooner had this immaculate conception of time set hard in human intuition than along came Einstein's wild idea: different, equally valid times can simultaneously coexist in the same space. The universal independent variable view of time was only three centuries old when Einstein arrived. Three centuries is brief when you realize the ancient view of time had sufficed for six hundred centuries.

If different times can coexist, then something like the child's view of time, something akin to the ancient view, is reopened. Different times can run at different speeds relative to each other. And so the words "speed of time" are reinflated with life. What follows in this work is David Eckstein's perspective on the new life and its immediate consequences.

San Francisco, California, Summer of 2008

Lewis Carrol Epstein

Foreword by the Author

I trust to have found a way of introducing the special *and* the general theory of relativity to high-school and undergraduate students, treating most of the aspects quantitatively. A certain familiarity with elementary physics is required. Occasionally calculus at high school level comes into this presentation. However, you can delegate these calculations to an modern pocket calculator - or just put your faith in the results presented by the author.

In any case this book is not primarily about calculations. On the contrary, the aim is to develop a profound 'Anschauung', an insight into the concepts of Einstein's theories. To this end the diagrams of Lewis C. Epstein are used to visualize the phenomena. My experience is, that, after a short time, students think of these Epstein diagrams as self-evident ! Epstein diagrams are quantitatively correct, and they are simpler to draw and to read than the widely used diagrams of the Minkowski type. Furthermore, they also help us to visualize fundamental aspects of the general theory of relativity. Beginning with the basic phenomena (the relativity of synchronicity, the relativity of duration and the relativity of length), we proceed carefully, step by step, to the more abstract Lorentz transformations, eventually arriving at the Schwarzschild metric. We will be able to verify most of the famous experiments performed to test the special and the general theory of relativity.

Each chapter concludes with a page of "problems and suggestions". The detailed solutions to these problems would require more than a hundred pages in print, thus creating a monstrous and expensive book. However, these solutions (as well as other material connected with the topic) are available to everyone at "www.relativity.li". Levin Gubler has designed this beautiful website for me in such a way I needed only provide the contents. I would like to take the opportunity now to cordially thank him for his work.

This book would not exist were it not for the assistance of many individuals. First of all I think of my high-school students whose reactions forced me to reconsider certain aspects and reformulate them. Then, in particular, I am indebted to the authors of two books: One of them is the well-known Lewis C. Epstein, the other is Horst Melcher, whose name is hardly familiar to our readers. Together they helped *me* to achieve a deeper understanding of the subject.

I also owe a dept of gratitude to three friends of mine, Alfred Hepp, Hans Buchmann and Hans Walser. They did a critical reading of early versions of the text, and their input contributed vastly to an improvement in style and content. Alfred Hepp and Jonathan Gubler helped me to improve the visual layout of the book, making it more attractive to the eye.

This English version of the book would never have been born without the many hours Samuel Edelstein invested to translate it from German into English. I would like to thank him cordially for his work! However, I take full responsibility for any errors and 'strange' formulations that readers may encounter.

Further I would like to thank the Canton Thurgau and its tax payers. This small state of the Federal Republic of Switzerland provided me through means of a sabbatical the free time necessary to convert my accumulated documents and experiences into this book. It would be nice to think that many colleagues worldwide as well as their students should find it useful.

I would like to thank the ESO and the CERN for their friendly permission to use copyright protected pictures. The same goes for the cartoonists Sidney Harris and Oswald Sigg. "Insight-Press" in San Francisco generously granted permission to print the many drawings from Epstein's book. The former 'Hamburgische Electricitäts-Werke" (now Vattenfall Europe AG) granted permission for the use of the illustrations in section **F3**. Also Franz Embacher in Vienna has kindly allowed me to use his illustration of the Thirring-Lense-Effect.

I do admit that I have downloaded some pictures from the internet without legal clarification. Other illustrations were provided to me by students without indication of source (e.g. the autostereogram at the end of **E6**). For most illustrations the source is however indicated. Of course many of the drawings, photographs and computer graphics come from the author.

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"David Eckstein"

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