Preface

So einfach wie möglich, aber nicht einfacher.

As simple as possible, but not simpler. This guideline of Albert Einstein obliges in particular each presentation of relativistic physics, a subject which often puzzles laymen, stirs their imagination, and tantalizes their comprehension, unnecessarily, because relativistic physics relies on simple geometric notions.

If one wants to understand the basic features of the theory of relativity then one does not need coordinates or virtual systems of clocks, which fill the universe, no more than millimeter paper and coordinate axes are required for Euclidean geometry. One only has to consider what observers see rather than to argue that this or that observer is right. Relativity is a physical, not a judicial theory.

The slowdown of moving clocks and the shortening of a moving measuring rod unfold naturally from the principle of relativity, just as a tilted ladder is less high than an upright ladder. Clocks are no more mysterious than mileage meters, and show a distance between start and end which depends on the way in between. This is the unspectacular answer to the seemingly paradoxical aging of twins. Just as no one is puzzled by a triangle, where the straight line between two edges is shorter than the detour over the third edge, no one should be shocked by the conclusion and experimental verification, that a clock picks up more time on a straight history as compared to the twin clock of a traveler who takes a detour.

The first two chapters are intended to be understandable in essence also to non-physicists with little mathematical knowledge. Their simplicity, however, may be deceptive. Real understanding requires careful consideration of the arguments, the equations, and the diagrams, preferably by reading equipped with a pencil and paper.

The following chapters presume mathematical knowledge which physicists and mathematicians acquire during their undergraduate years. To clarify more complicated questions we introduce coordinates as functions of the measured times and directions of light rays and deduce the Lorentz transformations which relate these values to the ones which moving observers measure. These transformations determine how velocities combine, what pictures are seen by moving observers, and how the energy and momentum of a particle depend on its velocity.

Chapter 4 assembles the basics of mechanics and applies them to relativistic particles. Stress is laid on the correspondence between physics and geometry, between conserved quantities like energy, momentum and angular momentum, and symmetries like a shift in time or space or a rotation or a Lorentz transformation. Jet spaces, which are introduced and used in this investigation, may strike the reader as an unnecessary complication. But they provide the clearest and therefore simplest setting to exhibit the correspondence of conserved quantities and infinitesimal symmetries.

Chapter 5 presents electrodynamics as a relativistic field theory and in particular shows that changes of the electric charges cause changes of the electromagnetic fields with the speed of light. The electrodynamic interactions are invariant under dilations, which is why they cannot explain the particular values of particle masses or the particular sizes of atoms.

In the last chapter we discuss the mathematical properties of the Lorentz group. It acts on the directions of light rays just as the Möbius transformations act on the Riemann sphere.

The text originated from courses which I taught on the subject and from my answers to questions which were frequently asked in the newsgroup de.sci.physik. After a few years the notes changed nearly no more and slumbered on my homepage with a few hundred interested visitors per year until Christian Caron from Springer Verlag encouraged me to have them published. Whether this kiss of a prince awoke a sleeping beauty or a frog, still to be thrown against the wall, is the reader to judge.

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