A Broader View of Relativity

General Implications of Lorentz and Poincaré Invariance

2nd Edition

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Volume

10

A Broader View of Relativity

General Implications of
Lorentz and Poincaré Invariance

2nd Edition

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A Broader View

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To

Bonnie Mei-Chu and Leslie

A Broader View of Relativity

A Broader View of Relativity

A Broader View of Relativity

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A Broader View

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"Those who from time to time send to *Nature*, as manuscripts intended for publication, proofs that the special theory of relativity must be wrong will in future, at least in the first instance, be referred to the issue of *Il Nuovo Cimento* (74B, 67; 1983) in which Dr. J. P. Hsu from the National Aeronautics and Space Administration's Goddard Space Flight Center* works out some of the consequences of rejecting the notion that the velocity of light is the same in all frames of reference moving relative to each other (or, more strictly, in all inertial frames). For, although Dr. Hsu's professed object is to demonstrate that some "fundamental" constants are more fundamental than others, he embarks on his argument by throwing away the assumption that the velocity of light is constant (and isotropic) for the sake of a system for measuring time which satisfies one of the rudimentary goals of the anti-relativists---doing away with the problem of simultaneity.

Hsu's starting point, explicitly and emphatically not that of an anti-relativist, is that it should be philosophically permissible to require a system for the measurement of what he calls "common time" that should be valid in all relatively moving frames of reference. The procedure is straightforward, and follows Einstein's original discussion of the problem. ..."

NEWS AND VIEWS

Nature Editorial

*It should read "Marshall Space Flight Center"

303, 129 (1983).

"We are not saying that special relativity is wrong in some way. Instead, taiji relativity shows that relativistic time, or any particular time system for that matter, is not a necessary ingredient of a theory for it to correctly reproduce all known experimental results. The four-dimensional symmetry (i.e., Lorentz and Poincaré invariance) of the physical framework is all that matter."

J. P. Hsu and Leonardo Hsu

Physics Letters A, 196, 1 (1994), p. 3

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Preface

In this book, we present a broader view of relativity in order to understand the fundamental concepts of space, time, and truly universal constants based on the smallest number of postulates. Certain new viewpoints, such as the use of a common time for all observers within a four-dimensional symmetry framework, are non-trivial and need time to digest. The impetus for many of the ideas in this book arose from a term paper (see Appendix B) written by LH for a college physics seminar course in the Fall of 1990. The purpose of that paper was to explore the long-standing question of whether the Lorentz transformation could be unambiguously determined from the results of various experiments. The answer turned out to be negative and this result stimulated our collaboration to step back and look at the big picture of relativity and to explore the physical implications of the principle of relativity — a basic theme of this book.

The distinct features of this book are to stress

- (A) a broader view of the relationship between the principle of relativity and our concept of time,
- (B) a unification of the spacetime transformations for inertial and non-inertial frames based on limiting Lorentz and Poincaré invariance, and
- (C) the truly universal and fundamental constants in both inertial and non-inertial frames.

The title of this edition has been changed to “A Broader View of Relativity — General Implications of Lorentz and Poincaré Invariance” to reflect the focus and the main ideas expounded in the book. The revision for this second edition summarizes our collaborative work performed over the past 15 years. In addition to the new chapters 1, 7, 9, 10, 20, 21, 24, 25 and 27, and new appendices A, B and D, many updates and corrections were made. Moreover, the book has been largely rewritten to reflect updates in our understanding of the conceptual basis of taiji and common relativity including the role that human defined systems of units play in those theories.

Much of the new material is related to the physics of accelerated frames. The physics and spacetime properties of accelerated frames are smoothly connected to those of inertial frames through the limiting Lorentz and Poincaré

invariance because all accelerated frames become inertial frames in the limit of zero accelerations. Quantum electrodynamics and gravity as a (generalized) Yang-Mills theory are discussed in both inertial and non-inertial frames.

Special acknowledgment is made to Andreas Ernst who helped to correct many typos and translated the original book into German and to Mei-Chu for her tireless support throughout our lives.

This work was supported in part by the Potz Science Fund and the Jing Shin Research Fund of the UMassD Foundation.

Jong-Ping Hsu
(Univ. of Massachusetts Dartmouth)
Leonardo Hsu
(Univ. of Minnesota, Twin Cities)

Preface to the First Edition

The purpose of this book is primarily to expound the idea that the first principle of relativity (i.e., the form of a physical law is the same in any inertial frame) taken by itself, implies a new theoretical framework which is consistent with the Lorentz and Poincaré group properties and with all previous experiments. The motivation of this work is *not* to show that special relativity is wrong in some way, but instead to show that special relativity is in some sense over specified and that removal of the over specification leads to a fresh view of the physical world with new concepts and results which are unobtainable through special relativity.

This new framework uses a four-dimensional symmetry formalism in which the three spatial variables as well as the temporal variable are all expressed in units of length. Furthermore, because it is based on only one postulate, it is the logically simplest theory which has Lorentz and Poincaré invariance. This is important because it is absolutely essential to insist that a fundamental physical theory should be derivable from the smallest possible set of basic principles. The 4-dimensional symmetry by itself dictates the kinematics of particles and fields in inertial frames in a manner which can also be extended to non-inertial frames through a limiting procedure.

Three aspects related to this simplest 4-dimensional symmetry framework are discussed:

(A) The first principle of relativity is shown to be the essence of relativity theory. All previous experimental results related to Einstein's theory of special relativity can be derived and understood based solely on this symmetry principle, without invoking an additional postulate regarding the universal constancy of the speed of light. We call such a theory "taiji relativity." As a result, we also find that the number of truly universal and fundamental constants in inertial frames is reduced to two, the atomic fine structure constant $\alpha_e = 1/137.03604$ and a second constant $J = 3.51773 \times 10^{-38}$ gram·cm. The speed of light (measured in cm/sec) and the Planck constant are found not to be truly fundamental.

(B) The renaissance of the common-sense concept of time $t=t'$ is shown to be possible. By embedding this "common time" in a 4-dimensional symmetry framework of the Lorentz and Poincaré groups, rather than the 3-dimensional framework of the Galilean group, we can construct a viable theory ("common

relativity") which is consistent with all known experiments. Such a theory has certain advantages over special relativity in that we can introduce the notion of the canonical evolution for a system of N particles and derive the invariant Liouville equation, a basic equation of the statistical physics. This cannot be done, in principle, in special relativity because each particle has its own relativistic time, so that one cannot have a canonical evolution and can only derive N *one-particle* Liouville equations rather than one single invariant Liouville equation for N particles.

(C) The first principle of relativity can also lead to an 'absolute' theory of spacetime physics in non-inertial frames undergoing a constant linear acceleration or a uniform rotation. This is accomplished on the basis of limiting 4-dimensional symmetry, the idea that transformations for non-inertial frames must smoothly reduce to the familiar 4-dimensional transformation of relativity in the limit of zero acceleration. The relativity theory of spacetime for inertial frames is simply the limiting case of such a theory of spacetime ("taiji spacetime") for non-inertial frames. Particle dynamics and quantization of fields in linearly accelerated frames are discussed. The universal constants in non-inertial frames are found to be the same as the ones in inertial frames mentioned above. Thus, α_e and J are the truly universal and fundamental constants in the physical world since almost all reference frames in the universe are, strictly speaking, non-inertial.

I want to express my gratitude to Bonnie Hsu for her patience and assistance in the preparation of this book. The writing of the book was supported in part by the Potz Science Fund and the Jing Shin Research Fund of the University of Massachusetts Dartmouth. I would like to thank the Academia Sinica and the Beijing Normal University in Beijing for their hospitality. I am indebted to Leslie Hsu, George Leung, Wolfhard Kern, John Dowd, Ed King and Kevin Smith for reading many chapters and improving the text. I would also like to thank Leonardo Hsu for his many valuable suggestions made during our discussions of the ideas presented here.

As the author, I must take sole responsibility for any mistakes in the book and would be grateful to have my attention called to them by readers.

Institute of Theoretical Physics
 Academia Sinica, Beijing
 November, 1999

J. P. Hsu
 (UMassD)

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