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)

Overview

A. The Historical and Physical Context of Relativity Theory

1. Introduction and Overview
2. Space, Time, and Inertial Frames
3. The Nontrivial Pursuit of Earth's Absolute Motion
4. On the Right Track: Voigt, Lorentz, and Larmor
5. The Contributions of Poincaré
6. The Novel Creation of the Young Einstein

B. A Broader View of Relativity: The Central Role of the Principle of Relativity

7. Relativity Based Solely on the Principle of Relativity
8. Common Relativity
9. Experimental Tests I
10. Experimental Tests II
11. Group Properties of Taiji Relativity and Common Relativity
12. Invariant Actions in Relativity Theories and Truly Universal and Fundamental Constants
13. Common Relativity and Many-Body Systems
14. Common Relativity and the 3K Cosmic Microwave Background
15. Common Relativity and Quantum Mechanics
16. Common Relativity and Fuzzy Quantum Field Theory
17. Extended Relativity: A Weaker Postulate for the Speed of Light

C. The Role of the Principle of Relativity in the Physics of Accelerated Frames

18. The Principle of Limiting Lorentz and Poincaré Invariance
19. Extended Lorentz Transformations for Frames with Constant-Linear-Accelerations
20. Physical Properties of Spacetime in Accelerated Frames
21. Extended Lorentz Transformations for Accelerated Frames and a Resolution to the "Two-Spaceship Paradox"
22. Dynamics of Classical and Quantum Particles in Constant-Linear-Acceleration Frames
23. Quantization of Scalar, Spinor, and Electromagnetic Fields in Constant-Linear-Acceleration Frames
24. Group and Lie Algebra Properties of Accelerated Spacetime Transformations
25. Coordinate Transformations for Frames with a General-Linear-Acceleration
26. A Taiji Rotational Transformation with Limiting 4-Dimensional Symmetry
27. Epilogue

D. Appendices

- A. Systems of Units and the Development of Relativity Theories
- B. Can One Derive the Lorentz Transformation From Precision Experiments?
- C. Quantum Electrodynamics in Inertial and Non-Inertial Frames
- D. Yang-Mills Gravity with Translation Gauge Symmetry in Inertial and Non-inertial Frames

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Contents

Preface	ix
Preface to the First Edition	xi
(A) The Historical and Physical Context of Relativity Theory	1
1. Introduction and Overview	3
1a. Special relativity is NOT incorrect!	3
1b. Idea #1: Einstein's first postulate of relativity (the principle of relativity) is the only necessary ingredient of a viable theory	4
1c. Idea #2: The principle of relativity is useful as a limiting principle in the discussion of the physics of accelerated frames	7
2. Space, Time and Inertial Frames	12
2a. Space	12
2b. Time	13
2c. Inertial frames of reference	14
2d. Coordinate transformations	15
2e. Units of space and time	16
3. The Nontrivial Pursuit of Earth's Absolute Motion	19
3a. Newton's frame of absolute rest	19
3b. Measuring Earth's velocity	22
4. On the Right Track: Voigt, Lorentz, and Larmor	27
4a. Lorentz's heuristic local time	27
4b. Development of the Lorentz transformations	29
5. The Contributions of Poincaré	36
5a. Poincaré's insight into physical time	36
5b. Poincaré and the principle of relativity	38
5c. Poincaré's theory of relativity	41
5d. Conformal transformations and a frame of 'absolute rest'	47
5e. Poincaré's impact on relativity and symmetry principles	51
5f. Retro physics: Past and present views of the ether	54
6. The Novel Creation of the Young Einstein	64
6a. Fresh thoughts from a young mind	64
6b. The theory of special relativity	65
6c. Derivation of the Lorentz transformation	66
6d. Relativity of space and time	68
6e. The completion of special relativity by Minkowski's idea of 4-dimensional spacetime	73
6f. Einstein and Poincaré	75

(B) A Broader View of Relativity: The Central Role of the Principle of Relativity	85
7. Relativity Based Solely on the Principle of Relativity	87
7a. Motivation	87
7b. A brief digression: natural units and their physical basis	88
7c. Taiji relativity: A relativity theory based solely on the principle of relativity	89
7d. Realization of taiji time	92
7e. The conceptual difference between taiji relativity and special relativity	93
7f. The role of a second postulate	95
8. Common Relativity	100
8a. A new unit for time	100
8b. Operationalizing the common-second and the equivalence of inertial frames	102
8c. Coordinate transformations in common relativity	104
8d. Physical interpretation of the ligh function b	106
8e. Implications of common time	109
9. Experimental Tests I	114
9a. Time intervals versus optical path length	114
9b. The Michelson-Morley experiment	114
9c. The Kennedy-Thorndike experiment	118
9d. The Fizeau experiment	121
10. Experimental Tests II	128
10a. The Ives-Stilwell experiment	128
10b. Atomic energy levels and Doppler shifts in taiji relativity	128
10c. Atomic energy levels and Doppler shifts in common relativity	130
10d. Lifetime dilation of cosmic-ray muons	133
10e. The cosmic-ray muon experiment and taiji relativity	134
10f. Decay-length dilation in quantum field theory and taiji relativity	135
10g. Cosmic-ray muons and common relativity	138
10h. Quantum field theory and the decay length in common relativity	140
11. Group Properties of Taiji Relativity and Common Relativity	143
11a. General group properties	143
11b. Lorentz group properties	146
11c. Poincaré group properties	152
12. Invariant Actions in Relativity Theories and Truly Fundamental Constants	158
12a. Invariant actions for classical electrodynamics in relativity theories	158
12b. Universal constants and invariant actions	163
12c. Dirac's conjecture regarding the fundamental constants	165
12d. Truly fundamental constants	166
13. Common Relativity and Many-Body Systems	170
13a. Advantages of common time	170
13b. Hamiltonian dynamics in common relativity	173

13c.	Invariant kinetic theory of gases	178
13d.	Invariant Liouville equation	182
13e.	Invariant entropy, temperature and the Maxwell-Boltzmann distribution	184
13f.	Invariant Boltzmann-Vlasov equation	186
13g.	Boltzmann's transport equation with 4-dimensional symmetry	192
13h.	Boltzmann's H theorem with 4-dimensional symmetry	195
14.	Common Relativity and the 3K Cosmic Microwave Background	200
14a.	Implications of an invariant and non-invariant Planck's law for blackbody radiation	200
14b.	Invariant partition function	200
14c.	Covariant thermodynamics	202
14d.	The canonical distribution and blackbody radiation	205
14e.	The question of Earth's "absolute" motion relative to the 3K cosmic microwave background	208
15.	Common Relativity and Quantum Mechanics	213
15a.	Fuzziness at short distances and the invariant genenergy	213
15b.	Fuzzy quantum mechanics with an inherent fuzziness in the position of a point particle	215
15c.	Fuzzy point and modified Coulomb potential at short distances	220
15d.	Suppression of the contribution of large momentum states to physical processes	222
16.	Common Relativity and Fuzzy Quantum Field Theory	225
16a.	Fuzzy quantum field theories	225
16b.	Fuzzy quantum electrodynamics based on common relativity	231
16c.	Experimental tests of the 4-dimensional symmetry of special relativity at very high energies	235
17.	Extended Relativity: A Weaker Postulate for the Speed of Light	240
17a.	Four-dimensional symmetry as a guiding principle	240
17b.	Edwards' transformation with Reichenbach's time	242
17c.	Difficulties of Edwards' transformation	245
17d.	Extended relativity: A 4-dimensional theory with Reichenbach's time (a universal 2-way speed of light)	247
17e.	The two basic postulates of extended relativity	251
17f.	Invariant action for a free particle in extended relativity	254
17g.	Comparison of extended relativity and special relativity	256
17h.	An unpassable limit and a non-constant speed of light	258
17i.	Lorentz group and the space-lighttime transformations	259
17j.	Decay rate and "lifetime dilation" of unstable particles	261
(C)	The Role of the Principle of Relativity in the Physics of Accelerated Frames	265
18.	The Principle of Limiting Lorentz and Poincaré Invariance	267
18a.	An answer to the young Einstein's question and its implications	267
18b.	Generalizing Lorentz transformations from inertial frames to accelerated frames	271

18c.	Physical time and 'spacetime clocks' in linearly accelerated frames	274
18d.	Møller's gravitational approach to accelerated transformations	275
18e.	Accelerated transformations with the limiting Lorentz and Poincaré invariance	279
19.	Extended Lorentz Transformations for Frames with Constant-Linear-Accelerations	284
19a.	Generalized Møller-Wu-Lee transformation	284
19b.	Minimal generalization of the Lorentz transformation: The Wu transformations	288
19c.	A comparison of the generalized MWL and Wu transformations	290
19d.	Four-momentum and constant-linear-acceleration of an accelerated particle	292
19e.	Experiments on Wu-Doppler effects of waves emitted from accelerated atoms	294
20.	Physical Properties of Spacetime in Accelerated Frames	297
20a.	A general transformation for a CLA frame with an arbitrary $\beta(w)$	297
20b.	The singular wall and horizons in the Wu transformation	300
20c.	Generalized Møller-Wu-Lee transformation for an accelerated frame	305
20d.	Decay-length dilations due to particle acceleration	310
20e.	Discussions	314
21.	Extended Lorentz Transformations for Accelerated Frames and a Resolution to the "Two-Spaceship Paradox"	319
21a.	The two-spaceship paradox	319
21b.	Generalized Møller and Wu transformations	321
21c.	Motion and length contraction involving accelerations	324
21d.	Discussion	326
22.	Dynamics of Classical and Quantum Particles in Constant-Linear-Acceleration Frames	330
22a.	Classical electrodynamics in constant-linear-acceleration frames	330
22b.	Quantum particles and Dirac's equation in a CLA frame	334
22c.	Stability of atomic levels against constant accelerations	336
22d.	Electromagnetic fields produced by a charge with a constant-linear-acceleration	340
22e.	Covariant radiative reaction force in special relativity and common relativity	349
23.	Quantizations of Scalar, Spinor, and Electromagnetic Fields In Constant-Linear-Acceleration Frames	356
23a.	Scalar field in constant-linear-acceleration frames	356
23b.	Quantization of scalar fields in CLA frames	359
23c.	Quantization of spinor fields in CLA frames	366
23d.	Quantization of the electromagnetic field in CLA frames	373
24.	Group and Lie Algebra Properties of Accelerated Spacetime Transformations	378
24a.	The Wu transformation with acceleration in an arbitrary direction	378

24b. Generators of the Wu transformation in cotangent spacetime	380
24c. The Wu algebra in a modified momentum space and the classification of particles	384
25. Coordinate Transformations for Frames with a General-Linear Acceleration	389
25a. Spacetime transformations based on limiting Lorentz and Poincaré invariance	389
25b. Physical implications and discussion	396
26. A Taiji Rotational Transformation with Limiting 4-Dimensional Symmetry	402
26a. A smooth connection between rotational and inertial frames	402
26b. A taiji rotational transformation with limiting 4-dimensional symmetry	403
26c. Physical properties of the taiji rotational transformation	406
26d. The metric tensors for the spacetime of rotating frames	408
26e. The invariant action for electromagnetic fields and charged particles in rotating frames and truly fundamental constants	410
26f. The 4-momentum and the 'lifetime dilation' of a particle at rest in a rotating frame	412
27. Epilogue	416
 (D) Appendices	 423
 A. Systems of Units and the Development of Relativity Theories	 425
Aa. Units, convenience and physical necessity	425
Ab. Time, length and mass	426
Ac. Other SI base units	430
Ad. Other units	434
Ae. Status of the fundamental constants	434
Af. Discussion and conclusion	436
B. Can one Derive the Lorentz Transformation from Precision Experiments?	441
Ba. Introduction	442
Bb. Three classical tests of special relativity	443
Bc. Deriving the Lorentz transformation?	446
Bd. A more general form	455
Be. Discussions and conclusions	462
C. Quantum Electrodynamics in Both Linearly Accelerated and Inertial Frames	465
Ca. Quantum electrodynamics based on taiji relativity	465
Cb. Experimental measurements of dilations of decay-lengths and decay-lifetimes in inertial frames	470
Cc. Quantum electrodynamics of bosons in accelerated and inertial frames	470

Cd. Feynman rules for QED with fermions in both CLA and inertial frames	476
Ce. Some QED results in both CLA and inertial frames	478
D. Yang-Mills Gravity with Translation Gauge Symmetry in Inertial and Non-inertial Frames	483
Da. Translation gauge transformations and an 'effective metric tensor' in flat spacetime	483
Db. Yang-Mills theory with translation gauge symmetry	489
Dc. Gravitational action with quadratic gauge-curvature	490
Dd. Linearized equations of the tensor field and the Hamilton-Jacobi equation for particles	492
De. The gauge field equation in inertial and non-inertial frames	494
Df. Perihelion shifts and bending of light	498
Dg. The Yang-Mills gravitational force	504
Author Index	509
Subject Index	513