The Mathematics Of Minkowski Space Time With An Introduction To Commutative Hypercomplex Numbers Frontiers In Mathematics

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Independent Axioms for Minkowski Space-Time
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Space-Time Algebra
Lorentzian Geometry and Related Topics
Geometric Methods in Physics XXXVI

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An Introduction to the Mathematics of the Special Theory of Relativity Cambridge University Press
Volume 2 introduces the theory of twistors and two-spinors and shows how it can be applied. Includes a comprehensive treatment of the conformal approach to space-time infinity with results on general relativistic mass and angular momentum.
With an Introduction to Commutative Hypercomplex Numbers Springer Science & Business Media
This volume provides a detailed discussion of the mathematical aspects and physical applications of a new geometrical structure of space-time, based on a generalization ("deformation") of the usual Minkowski space, as supposed to be endowed with a metric whose coefficients depend on the energy. This new five-dimensional scheme (Deformed Relativity in Five Dimensions, DR5) represents a true generalization of the usual Kaluza-Klein (KK) formalism.
Minkowski Space Princeton University Press
A famous result of Christodoulou and Klainerman is the global nonlinear stability of Minkowski spacetime. In this book, Bieri and Zipser provide two extensions to this result. In the first part, Bieri solves the Cauchy problem for the Einstein vacuum equations with more general, asymptotically flat initial data, and describes precisely the asymptotic behavior. In particular, she assumes less decay in the power of r and one less derivative than in the Christodoulou-Klainerman result. She proves that in this case, too, the initial data, being globally close to the trivial data, yields a solution which is a complete spacetime, tending to the Minkowski spacetime at infinity along any geodesic. In contrast to the original

situation, certain estimates in this proof are borderline in view of decay, indicating that the conditions in the main theorem on the decay at infinity on the initial data are sharp. In the second part, Zipser proves the existence of smooth, global solutions to the Einstein-Maxwell equations. A nontrivial solution of these equations is a curved spacetime with an electromagnetic field. To prove the existence of solutions to the Einstein-Maxwell equations, Zipser follows the argument and methodology introduced by Christodoulou and Klainerman. To generalize the original results, she needs to contend with the additional curvature terms that arise due to the presence of the electromagnetic field F; in her case the Ricci curvature of the spacetime is not identically zero but rather represented by a quadratic in the components of F. In particular the Ricci curvature is a constant multiple of the stress-energy tensor for F. Furthermore, the traceless part of the Riemann curvature tensor no longer satisfies the homogeneous Bianchi equations but rather inhomogeneous equations including components of the spacetime Ricci curvature. Therefore, the second part of this book focuses primarily on the derivation of estimates for the new terms that arise due to the presence of the electromagnetic field.

The Special Theory of Relativity
Cambridge University Press
This concise book introduces nonphysicists to the core philosophical issues surrounding the nature and structure of space and time, and is also an ideal resource for physicists interested in the conceptual foundations of space-time theory. Tim Maudlin's broad historical overview examines Aristotelian and Newtonian accounts of space and time, and traces how Galileo's conceptions of relativity and space-time led to Einstein's special and general theories of relativity. Maudlin explains special relativity with enough detail to solve concrete physical problems while presenting general relativity in more qualitative terms. Additional topics include the Twins Paradox, the physical aspects of the Lorentz-FitzGerald contraction, the constancy of the speed of light, time travel, the direction of time, and more. Introduces nonphysicists to the philosophical foundations of space-time theory Provides a broad historical overview, from Aristotle to Einstein Explains special relativity geometrically, emphasizing the intrinsic structure of space-time Covers the Twins Paradox, Galilean relativity, time travel, and more Requires only basic algebra and no formal knowledge of physics

The Geometry of Numbers Springer
One of the problems facing mathematics and physics is that mathematicians and physicists speak languages that the others find hard to understand. These notes take a fundamental part of physics, the special theory of relativity and describe it in terms that can be understood by mathematics students who have studied the two basic undergraduate topics, linear algebra and multivariable calculus. It gives a full description of the geometry of space-time and the foundations of the theory of electromagnetism in terms they are familiar with. Contents:Space and TimeMinkowski SpacesThe Principle of RelativitySpecial Relativity in the Real WorldNotationsThe Tensor Product of Vector SpacesElectromagnetism 1Dual Spaces and Covariant TensorsThe Theory of Minkowski SpacesElectromagnetism 2 Readership: Mathematicians and undergraduate mathematics students. Keywords:Special Theory;Relativity;Space;Time;Speed of Light;Minkowski Space;Electromagnetism;Maxwell&s EquationsReview: “The exhibition of the theory is very detailed. No deeper background in physics is necessary to understand the contents of this book. From this point of view the book can be recommended to students of mathematics who want to get insight into some basic theories of physics.” Bernd Wegner Mathematics Abstracts, 1992

General Relativity for Mathematicians
Birkhäuser
The authors present a rigorous treatment of the first principles of the algebraic and analytic core of quantum field theory. Their aim is to correlate modern mathematical theory with the explanation of the observed process of particle production and of particle-wave duality that heuristic quantum field theory provides. Many topics are treated here in book form for the first time, from the origins of complex structures to the quantization of tachyons and domains of dependence for quantized wave equations. This work begins with a comprehensive analysis, in a universal format, of the structure and characterization of free fields, which is illustrated by applications to specific fields. Nonlinear local functions of both free fields (or Wick products) and interacting fields are established mathematically in a way that is consistent with the basic physical constraints and practice. Among other topics discussed are functional integration, Fourier transforms in Hilbert space, and implementability of canonical transformations. The authors address readers interested in fundamental mathematical physics and who have at least the training of an entering graduate student. A series of lexicons connects the mathematical development with the underlying physical motivation or interpretation. The examples and problems illustrate the theory and relate it to the scientific literature. Originally published in 1992. The Princeton Legacy Library uses the latest print-on-demand technology to again make available previously out-of-print books from the distinguished backlist of Princeton University Press. These editions preserve the original texts of these important books while presenting them in durable paperback and hardcover editions. The goal of the Princeton Legacy Library is to vastly increase access to the rich scholarly heritage found in the thousands of books published by Princeton University Press since its founding in 1905.

The Geometry of Minkowski Spacetime
Walter de Gruyter GmbH & Co KG
This is the first publication (in German or English) of Hermann Minkowski's three papers on relativity together: The Relativity Principle - lecture given at the meeting of the Göttingen Mathematical Society on November 5, 1907. This is the first English translation. The Fundamental Equations for Electromagnetic Processes in Moving Bodies - lecture given at the meeting of the Göttingen Scientific Society on December 21, 1907. New translation. Space and Time - lecture given at the 80th Meeting of Natural Scientists in Cologne on September 21, 1908. New translation.

A revisitation of mathematical notions of quantum physics Springer Science & Business Media
A self-contained introduction to the geometry of numbers.

Geometrizing Interactions in Four and Five Dimensions World Scientific
The main goal of this work is to revisit the proof of the global stability of Minkowski space by D. Christodoulou and S. Klainerman, [Ch-Kl]. We provide a new self-contained proof of the main part of that result, which concerns the full solution of the radiation problem in vacuum, for arbitrary asymptotically flat initial data sets. This can also be interpreted as a proof of the global stability of the external region of Schwarzschild spacetime. The proof, which is a significant modification of the arguments in [Ch-Kl], is based on a double null foliation of spacetime instead of the mixed null-maximal foliation used in [Ch-Kl]. This approach is more naturally

adapted to the radiation features of the Einstein equations and leads to important technical simplifications. In the first chapter we review some basic notions of differential geometry that are sys tematically used in all the remaining chapters. We then introduce the Einstein equations and the initial data sets and discuss some of the basic features of the initial value problem in general relativity. We shall review, without proofs, well-established results concerning local and global existence and uniqueness and formulate our main result. The second chapter provides the technical motivation for the proof of our main theorem.

Space and Time Springer Nature

This unique textbook offers a mathematically rigorous presentation of the theory of relativity, emphasizing the need for a critical analysis of the foundations of general relativity in order to best study the theory and its implications. The transitions from classical mechanics to special relativity and then to general relativity are explored in detail as well, helping readers to gain a more profound and nuanced understanding of the theory as a whole. After reviewing the fundamentals of differential geometry and classical mechanics, the text introduces special relativity, first using the physical approach proposed by Einstein and then via Minkowski's mathematical model. The authors then address the relativistic thermodynamics of continua and electromagnetic fields in matter – topics which are normally covered only very briefly in other treatments – in the next two chapters. The text then turns to a discussion of general relativity by means of the authors' unique critical approach, underlining the difficulty of recognizing the physical meaning of some statements, such as the physical meaning of coordinates and the derivation of physical quantities from those of space-time. Chapters in this section cover the model of space-time proposed by Schwarzschild; black holes; the Friedman equations and the different cosmological models they describe; and the Fermi-Walker derivative. Well-suited for graduate students in physics and mathematics who have a strong foundation in real analysis, classical mechanics, and general physics, this textbook is appropriate for a variety of graduate-level courses that cover topics in relativity. Additionally, it will interest physicists and other researchers who wish to further study the subtleties of these theories and understand the contemporary scholarly discussions surrounding them.

A Relativist's Toolkit Springer Nature

A definitive proof of global nonlinear stability of Minkowski space-time as a solution of the Einstein-Klein-Gordon equations This book provides a definitive proof of global nonlinear stability of Minkowski space-time as a solution of the Einstein-Klein-Gordon equations of general relativity. Along the way, a novel robust analytical framework is developed, which extends to more general matter models. Alexandru Ionescu and Benoît Pausader prove global regularity at an appropriate level of generality of the initial data, and then prove several important asymptotic properties of the resulting space-time, such as future geodesic completeness, peeling estimates of the Riemann curvature tensor, conservation laws for the ADM tensor, and Bondi energy identities and inequalities. The book is self-contained, providing complete proofs and precise statements, which develop a refined theory for solutions of quasilinear Klein-Gordon and wave equations, including novel linear and bilinear estimates. Only mild decay assumptions are made on the scalar field and the initial metric is allowed to have nonisotropic decay consistent with the positive mass theorem. The framework incorporates analysis both in physical and Fourier space, and is compatible with previous results on other physical models such as water waves and plasma physics.

Foundations of Special Relativity: Kinematic Axioms for Minkowski Space-Time Cambridge University Press

Hermann Minkowski recast special relativity as essentially a new geometric structure for spacetime. This book looks at the ideas of both Einstein and Minkowski, and then introduces the theory of frames, surfaces and intrinsic geometry, developing the main implications of Einstein's general relativity theory.

Spacetime and Geometry Springer Science & Business Media

This volume contains a collection of research papers and useful surveys by experts in the field which provide a representative picture of the current status of this fascinating area. Based on contributions from the VIII International Meeting on Lorentzian Geometry, held at the University of Málaga, Spain, this volume covers topics such as distinguished (maximal, trapped, null, spacelike, constant mean curvature, umbilical...) submanifolds, causal completion of spacetimes, stationary regions and horizons in spacetimes, solitons in semi-Riemannian manifolds, relation between Lorentzian and Finslerian geometries and the oscillator spacetime. In the last decades Lorentzian geometry has experienced a significant impulse, which has transformed it from just a mathematical tool for general relativity to a consolidated branch of differential geometry, interesting in and of itself. Nowadays, this field provides a framework where many different mathematical techniques arise with applications to multiple parts of mathematics and physics. This book is addressed to differential geometers, mathematical physicists and relativists, and graduate students interested in the field.

Special Relativity, Tensors, And Energy Tensor: With Worked Problems Springer Science & Business Media

This mathematically rigorous treatment examines Zeeman's characterization of the causal automorphisms of Minkowski spacetime and the Penrose theorem concerning the apparent shape of a relativistically moving sphere. Other topics include the construction of a geometric theory of the electromagnetic field; an in-depth introduction to the theory of spinors; and a classification of electromagnetic fields in both tensor and spinor form. Appendixes introduce a topology for Minkowski spacetime and discuss Dirac's famous "Scissors Problem." Appropriate for graduate-level courses, this text presumes only a knowledge of linear algebra and elementary point-set topology. 1992 edition. 43 figures.

The Evolution Problem in General Relativity Springer Science & Business Media

Einstein's General Theory of Relativity leads to two remarkable predictions: first, that the ultimate destiny of many massive stars is to undergo gravitational collapse and to disappear from view, leaving behind a 'black hole' in space; and secondly, that there will exist singularities in space-time itself. These singularities are places where space-time begins or ends, and the presently known laws of physics break down. They will occur inside black holes, and in the past are what might be construed as the beginning of the universe. To show how these predictions arise, the authors discuss the General Theory of Relativity in the large. Starting with a precise formulation of the theory and an account of the necessary background of differential geometry, the significance of space-time curvature is discussed and the global properties of a number of exact solutions of Einstein's field equations are examined. The theory of the causal structure of a general space-time is developed, and is used to study black holes and to prove a number of theorems establishing the inevitability of singualarities under certain conditions. A discussion of the Cauchy problem for

General Relativity is also included in this 1973 book.

An Introduction to Twistor Theory
Minkowski Institute Press
SOFTCOVER PRINT VERSION This is a new monograph by the Ghanaian philosopher, Samuel K. K. Blankson, who gave us The Metaphysical Foundations For Physics. In less than a hundred pages, and without mathematics, he launches a blistering attach on Herman Minkowski, the foremost mathematical interpreter of Einstein's theory of Space-Time. He explains that space-time is a philosophical concept and that mathematicians are ill-equipped to interpret it properly, and gives his own interpretation of space-time as 'relation between points'. The book is written in plain language, and aimed at the intelligent general reader. There is no doubt that if Blankson is right then mathematicians have a major problem on their hands.

The Large Scale Structure of Space-Time
Cambridge University Press
This book provides an original introduction to the geometry of Minkowski space-time. A hundred years after the space-time formulation of special relativity by Hermann Minkowski, it is shown that the kinematical consequences of special relativity are merely a manifestation of space-time geometry. The book is written with the intention of providing students (and teachers) of the first years of University courses with a tool which is easy to be applied and allows the solution of any problem of relativistic kinematics at the same time. The book treats in a rigorous way, but using a non-sophisticated mathematics, the Kinematics of Special Relativity. As an example, the famous "Twin Paradox" is completely solved for all kinds of motions. The novelty of the presentation in this book consists in the extensive use of hyperbolic numbers, the simplest extension of complex numbers, for a complete formalization of the kinematics in the Minkowski space-time. Moreover, from this formalization the understanding of gravity comes as a manifestation of curvature of space-time, suggesting new research fields.

Workshop and Summer School, Białowieża, Poland, 2017 World Scientific
This is a book about physics, written for mathematicians. The readers we have in mind can be roughly described as those who: I. are mathematics graduate students with some knowledge of global differential geometry 2. have had the equivalent of freshman physics, and find popular accounts of astrophysics and cosmology interesting 3. appreciate mathematical elarity, but are willing to accept physical motiva tions for the mathematics in place of mathematical ones 4. are willing to spend time and effort mastering certain technical details, such as those in Section 1. 1. Each book disappoints so me readers. This one will disappoint: 1. physicists who want to use this book as a first course on differential geometry 2. mathematicians who think Lorentzian manifolds are wholly similar to Riemannian ones, or that, given a sufficiently good mathematical back ground, the essentials of a subject !ike cosmology can be learned without so me hard work on boring detaiis 3. those who believe vague philosophical arguments have more than historical and heuristic significance, that general relativity should somehow be "proved," or that axiomatization of this subject is useful 4. those who want an encyclopedic treatment (the books by Hawking-Ellis [1], Penrose [1], Weinberg [1], and Misner-Thorne-Wheeler [I] go further into the subject than we do; see also the survey article, Sachs-Wu [1]). 5. mathematicians who want to learn quantum physics or unified fieId theory (unfortunateIy, quantum physics texts all seem either to be for physicists, or merely concerned with formal mathematics).
Princeton University Press
From the reviews: "This attractive book provides an account of the theory of special relativity from a geometrical viewpoint, explaining the unification and insights that are given by such a treatment. [...] Can be read with profit by all who have taken a first course in relativity physics." ASLIB Book Guide

General Relativity World Scientific
Lorentz Geometry is a very important intersection between Mathematics and Physics, being the mathematical language of General Relativity. Learning this type of geometry is the first step in properly understanding questions regarding the structure of the universe, such as: What is the shape of the universe? What is a spacetime? What is the relation between gravity and curvature? Why exactly is time treated in a different manner than other spatial dimensions? Introduction to Lorentz Geometry: Curves and Surfaces intends to provide the reader with the minimum mathematical background needed to pursue these very interesting questions, by presenting the classical theory of curves and surfaces in both Euclidean and Lorentzian ambient spaces simultaneously. Features: Over 300 exercises Suitable for senior undergraduates and graduates studying Mathematics and Physics Written in an accessible style without loss of precision or mathematical rigor Solution manual available on www.routledge.com/9780367468644