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

Galileo Unbound traces the journey that brought us from Galileo's law of free fall to today's geneticists measuring evolutionary drift, entangled quantum particles moving among many worlds, and our lives as trajectories traversing a health space with thousands of dimensions. Remarkably, common themes persist that predict the evolution of species as readily as the orbits of planets or the collapse of stars into black holes. This book tells the history of spaces of expanding dimension and increasing abstraction and how they continue today to give new insight into the physics of complex systems. Galileo published the first modern law of motion, the Law of Fall, that was ideal and simple, laying the foundation upon which Newton built the first theory of dynamics. Early in the twentieth century, geometry became the cause of motion rather than the result when Einstein envisioned the fabric of space-time warped by mass and energy, forcing light rays to bend past the Sun. Possibly more radical was Feynman's dilemma of quantum particles taking all paths at once — setting the stage for the modern fields of quantum field theory and quantum computing. Yet as concepts of motion have evolved, one thing has remained constant, the need to track ever more complex changes and to capture their essence, to find patterns in the chaos as we try to predict and control our world.

Hyperbolic Dynamics and Brownian Motion illustrates the interplay between distinct domains of mathematics. There is no assumption that the reader is a specialist in any of these domains: only basic knowledge of linear algebra, calculus and probability theory is required. The content can be summarized in three ways: Firstly, this book provides an introduction to hyperbolic geometry, based on the Lorentz group. The Lorentz group plays, in relativistic space-time, a role analogue to the rotations in Euclidean space. The hyperbolic geometry is the geometry of the unit pseudo-sphere. The boundary of the hyperbolic space is defined as the set of light rays. Special attention is given to the geodesic and horocyclic flows. Hyperbolic geometry is presented via special relativity to benefit from the physical intuition. Secondly, this book introduces basic notions of stochastic analysis: the Wiener process, Itô's stochastic integral, and calculus. This introduction allows study in linear stochastic differential equations on groups of matrices. In this way the spherical and hyperbolic Brownian motions, diffusions on the stable leaves, and the relativistic diffusion are constructed. Thirdly, quotients of the hyperbolic space under a discrete group of isometries are introduced. In this framework some elements of hyperbolic dynamics are presented, as the ergodicity of the geodesic and horocyclic flows. This book culminates with an analysis of the chaotic behaviour of the geodesic flow, performed using stochastic analysis methods. This main result is known as Sinai's central limit theorem.

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.
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 singularities under certain conditions. A discussion of the Cauchy problem for General Relativity is also included in this 1973 book.

This book unfolds the subject of Relativity for undergraduate students of physics. It is intended to allow an undergraduate physics course to extend somewhat further and wider in this area than has traditionally been the case, while ensuring that the mainstream of students can handle the material. Introducing Lorentz invariants and four-vectors early on, but postponing tensor notation till it is needed, the aim is to make manageable what would otherwise beregarded as hard; to make derivations as simple as possible and physical ideas as transparent as possible.

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.

This book takes the reader from the preliminary ideas of the Special Theory of Relativity (STR) to the doorsteps of the General Theory of Relativity (GTR).The first part explains the main concepts in a layman's language, including STR, the Lorentz transformation, relativistic mechanics. Thereafter the concept of tensors is built up in detail, especially Maxwell's stress tensor with illustrative examples, culminating in the energy-momentum conservation in electromagnetic fields. Mathematical structure of Minkowski's space-time is constructed and explained graphically. The equation of motion is formulated and then illustrated by the example of relativistic rocket. The principle of covariance is explained with the covariant equations of classical electrodynamics. Finally, the book constructs the energy tensor which constitutes the source term in Einstein's field equation, which clears the passage to the GTR.In the book, the concepts of tensors are developed carefully and a large number of numerical examples taken from atomic and nuclear physics. The graphs of important equations are included. This is suitable for studies in classical electrodynamics, modern physics, and relativity.

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

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.

Special Relativity (SR) is essentially grounded on the properties of space-time, i.e. isotropy of space and homogeneity of space and time (as a consequence of

the equivalence of inertial frames) and on the Galilei principle of relativity.
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
This introductory textbook on the general theory of relativity presents a solid foundation for those who want to learn about relativity. The subject is presented in a physically intuitive, but mathematically rigorous style. The topic of relativity is covered in a broad and deep manner. Besides, the aim is that after reading the book a student should not feel discouraged when she opens advanced texts on general relativity for further reading. The book consists of three parts: An introduction to the general theory of relativity. Geometrical mathematical background material. Topics that include the action principle, weak gravitational fields and gravitational waves, Schwarzschild and Kerr solution, and the Friedman equation in cosmology. The book is suitable for advanced graduates and graduates, but also for established researchers wishing to be educated about the field.
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.

This unique book presents a particularly beautiful way of looking at special relativity. The author encourages students to see beyond the formulas to the deeper structure. The unification of space and time introduced by Einstein's special theory of relativity is one of the cornerstones of the modern scientific description of the universe. Yet the unification is counterintuitive because we perceive time very differently from space. Even in relativity, time is not just another dimension, it is one with different properties The book treats the geometry of hyperbolas as the key to understanding special relativity. The author simplifies the formulas and emphasizes their geometric content. Many important relations, including the famous relativistic addition formula for velocities, then follow directly from the appropriate (hyperbolic) trigonometric addition formulas. Prior mastery of (ordinary) trigonometry is sufficient for most of the material presented, although occasional use is made of elementary differential calculus, and the chapter on electromagnetism assumes some more advanced knowledge. Changes to the Second Edition The treatment of Minkowski space and spacetime diagrams has been expanded. Several new topics have been added, including a geometric derivation of Lorentz transformations, a discussion of three-dimensional spacetime diagrams, and a brief geometric description of "area" and how it can be used to measure time and distance. Minor notational changes were made to avoid conflict with existing usage in the literature. Table of Contents Preface 1. Introduction. 2. The Physics of Special Relativity. 3. Circle Geometry. 4. Hyperbola Geometry. 5. The Geometry of Special Relativity. 6. Applications. 7. Problems III. 8. Paradoxes. 9. Relativistic Mechanics. 10. Problems II. 11. Relativistic Electromagnetism. 12. Problems III. 13. Beyond Special Relativity. 14. Three-Dimensional Spacetime Diagrams. 15. Minkowski Area via Light Boxes. 16. Hyperbolic Geometry. 17. Calculus. Bibliography. Author Biography Tevian Dray is a Professor of Mathematics at Oregon State University. His research lies at the interface between mathematics and physics, involving differential geometry and general relativity, as well as nonassociative algebra and particle physics; he also studies student understanding of "middle-division" mathematics and physics content. Educated at MIT and Berkeley, he held postdoctoral positions in both mathematics and physics in several countries prior to coming to OSU in 1988. Professor Dray is a Fellow of the American Physical Society for his work in relativity, and an award-winning teacher.

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
Progress in Physics has been created for publications on advanced studies in theoretical and experimental physics, including related themes from mathematics. Quantum physics has been highly successful for more than 90 years. Nevertheless, a rigorous construction of interacting quantum field theory is still missing. Moreover, it is still unclear how to combine quantum physics and general relativity in a unified physical theory. Attacking these challenging problems of contemporary physics requires highly advanced mathematical methods as well as radically new physical concepts. This book presents different physical ideas and mathematical approaches in this direction. It contains a carefully selected cross-section of lectures which took place in autumn 2014 at the sixth conference ``Quantum Mathematical Physics - A Bridge between Mathematics and

Physics" in Regensburg, Germany. In the tradition of the other proceedings covering this series of conferences, a special feature of this book is the exposition of a wide variety of approaches, with the intention to facilitate a comparison. The book is mainly addressed to mathematicians and physicists who are interested in fundamental questions of mathematical physics. It allows the reader to obtain a broad and up-to-date overview of a fascinating active research area.

This book provides readers with the tools needed to understand the physical basis of special relativity and will enable a confident mathematical understanding of Minkowski's picture of space-time. It features a large number of examples and exercises, ranging from the rather simple through to the more involved and challenging. Coverage includes acceleration and tensors and has an emphasis on space-time diagrams.

The aim of this work is to provide a proof of the nonlinear gravitational stability of the Minkowski space-time. More precisely, the book offers a constructive proof of global, smooth solutions to the Einstein Vacuum Equations, which look, in the large, like the Minkowski space-time. In particular, these solutions are free of black holes and singularities. The work contains a detailed description of the sense in which these solutions are close to the Minkowski space-time, in all directions. It thus provides the mathematical framework in which we can give a rigorous derivation of the laws of gravitation proposed by Bondi. Moreover, it establishes other important conclusions concerning the nonlinear character of gravitational radiation. The authors obtain their solutions as dynamic developments of all initial data sets, which are close, in a precise manner, to the flat initial data set corresponding to the Minkowski space-time. They thus establish the global dynamic stability of the latter. Originally published in 1994. 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.

Einstein's general theory of relativity is widely considered to be one of the most elegant and successful scientific theories ever developed, and it is increasingly being taught in a simplified form at advanced undergraduate level within both physics and mathematics departments. Due to the increasing interest in gravitational physics, in both the academic and the public sphere, driven largely by widely-publicised developments such as the recent observations of gravitational waves, general relativity is also one of the most popular scientific topics pursued through self-study. Modern General Relativity introduces the reader to the general theory of relativity using an example-based approach, before describing some of its most important applications in cosmology and astrophysics, such as gamma-ray bursts, neutron stars, black holes, and gravitational waves. With hundreds of worked examples, explanatory boxes, and end-of-chapter problems, this textbook provides a solid foundation for understanding one of the towering achievements of twentieth-century physics.

The book aims to give a mathematical presentation of the theory of general relativity (that is, spacetime-geometry-based gravitation theory) to advanced undergraduate mathematics students.

Mathematicians will find spacetime physics presented in the definition-theorem-proof format familiar to them. The given precise mathematical definitions of physical notions help avoiding pitfalls, especially in the context of spacetime physics describing phenomena that are counter-intuitive to everyday experiences.In the first part, the differential geometry of smooth manifolds, which is needed to present the spacetime-based gravitation theory, is developed from scratch. Here, many of the illustrating examples are the Lorentzian manifolds which later serve as spacetime models. This has the twofold purpose of making the physics forthcoming in the second part relatable, and the mathematics learnt in the first part less dry. The book uses the modern coordinate-free language of semi-Riemannian geometry. Nevertheless, to familiarise the reader with the useful tool of coordinates for computations, and to bridge the gap with the physics literature, the link to coordinates is made through exercises, and via frequent remarks on how the two languages are related.In the second part, the focus is on physics, covering essential material of the 20th century spacetime-based view of gravity: energy-momentum tensor field of matter, field equation, spacetime examples, Newtonian approximation, geodesics, tests of the theory, black holes, and cosmological models of the universe.Prior knowledge of differential geometry or physics is not assumed. The book is intended for self-study, and the solutions to the (over 200) exercises are included.

This book is devoted to the Einstein's field equations of general relativity for self-gravitating massive scalar fields. We formulate the initial value problem when the initial data set is a perturbation of an asymptotically flat, spacelike hypersurface in Minkowski spacetime. We then establish the existence of an Einstein development associated with this initial data set, which is proven to be an asymptotically flat and future geodesically complete spacetime. Contents: IntroductionOverview of the Hyperboloidal Foliation MethodFunctional Analysis on Hyperboloids of Minkowski SpacetimeQuasi-Null Structure of the Einstein-Massive Field System on HyperboloidsInitialization of the Bootstrap ArgumentDirect Control of Nonlinearities in the Einstein EquationsDirect Consequences of the Wave Gauge ConditionSecond-Order Derivatives of the Spacetime MetricSup-Norm Estimate Based on CharacteristicsLow-Order Refined Energy Estimate for the Spacetime MetricLow-Order Refined Sup-Norm Estimate for the Metric and Scalar FieldHigh-Order Refined L^2 EstimatesHigh-Order Refined Sup-Norm EstimatesLow-Order Refined Energy Estimate for the Scalar FieldAppendices: Revisiting the Wave-Klein-Gordon ModelSup-Norm Estimate for the Wave EquationsSup-Norm Estimate for the Klein-Gordon EquationCommutator Estimates for the Hyperboloidal FrameBibliography Readership: Graduate students and researchers interested in mathematical general relativity. Keywords: General Relativity;Einstein Equations;Massive Field;Minkowski Space;Nonlinear Global Stability;Hyperboloidal Foliation MethodReview: Key Features: This is the first mathematical result on the global nonlinear stability of matter fields in general relativityProvide a framework to treat other matter

fields such as the massive Yang-Mills fields which are of particular importance in physics
Writing a new book on the classic subject of Special Relativity, on which numerous important physicists have contributed and many books have already been written, can be like adding another epicycle to the Ptolemaic cosmology. Furthermore, it is our belief that if a book has no new elements, but simply repeats what is written in the existing literature, perhaps with a different style, then this is not enough to justify its publication. However, after having spent a number of years, both in class and research with relativity, I have come to the conclusion that there exists a place for a new book. Since it appears that somewhere along the way, mathem- ics may have obscured and prevailed to the degree that we tend to teach relativity (and I believe, theoretical physics) simply using "heavier" mathematics without the inspiration and the mastery of the classic physicists of the last century. Moreover current trends encourage the application of techniques in producing quick results and not tedious conceptual approaches resulting in long-lasting reasoning. On the other hand, physics cannot be done a ? la carte stripped from philosophy, or, to put it in a simple but dramatic context A building is not an accumulation of stones! As a result of the above, a major aim in the writing of this book has been the distinction between the mathematics of Minkowski space and the physics of

r- ativity.

In Minkowski-Space the space-time of special relativity is discussed on the basis of fundamental results of space-time theory. This idea has the consequence that the Minkowski-space can be characterized by 5 axioms, which determine its geometrical and kinematical structure completely. In this sense Minkowski-Space is a prolegomenon for the formulation of other branches of special relativity, like mechanics, electrodynamics, thermodynamics etc. But these applications are not subjects of this book. Contents Basic properties of special relativity Further properties of Lorentz matrices Further properties of Lorentz transformations Decomposition of Lorentz matrices and Lorentz transformations Further structures on Ms Tangent vectors in Ms Orientation Kinematics on Ms Some basic notions of relativistic theories

This book arose out of original research on the extension of well-established applications of complex numbers related to Euclidean geometry and to the space-time symmetry of two-dimensional Special Relativity. The system of hyperbolic numbers is extensively studied, and a plain exposition of space-time geometry and trigonometry is given. Commutative hypercomplex systems with four unities are studied and attention is drawn to their interesting properties.

The first comprehensive treatment of Minkowski

geometry since the 1940's
This book explains the Lorentz mathematical group in a language familiar to physicists. While the three-dimensional rotation group is one of the standard mathematical tools in physics, the Lorentz group of the four-dimensional Minkowski space is still very strange to most present-day physicists. It plays an essential role in understanding particles moving at close to light speed and is becoming the essential language for quantum optics, classical optics, and information science. The book is based on papers and books published by the authors on the representations of the Lorentz group based on harmonic oscillators and their applications to high-energy physics and to Wigner functions applicable to quantum optics. It also covers the two-by-two representations of the Lorentz group applicable to ray optics, including cavity, multilayer and lens optics, as well as representations of the Lorentz group applicable to Stokes parameters and the Poincaré sphere on polarization optics.
Mathematical Cosmology and Extragalactic Astronomy
Celebrating the one hundredth anniversary of the 1909 publication of Minkowski’s seminal paper "Space and Time", this volume includes a fresh translation as well as the original in German, and a number of contributed papers on the still-controversial subject.

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.

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.

Exposition of fourth dimension, concepts of relativity as Flatland characters continue adventures. Topics include curved space time as a higher dimension, special relativity, and shape of space-time. Includes 141 illustrations.

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.

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.
The primary aim of this monograph is to clarify the undefined primitive concepts and the axioms which form the basis of Einstein's theory of special relativity. Minkowski space-time is developed from a set of independent axioms, stated in terms of a single relation of betweenness. It is shown that all models are isomorphic to the usual coordinate model, and the axioms are consistent relative to the reals.
This volume presents surveys, written by experts in the field, on various classical and modern aspects of Hilbert geometry. They assume several points of view: Finsler geometry, calculus of variations, projective geometry, dynamical systems, and others.

Some fruitful relations between Hilbert geometry and other subjects in mathematics are emphasized, including Teichmuller spaces, convexity theory, Perron-Frobenius theory, representation theory, partial differential equations, coarse geometry, ergodic theory, algebraic groups, Coxeter groups, geometric group theory, Lie groups and discrete group actions. This book is addressed to both students who want to learn the theory and researchers in this area.