Clifford Algebras And Spinor Structures

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COOLEY MILES

Advances in Analysis and Geometry Springer Science & Business Media
The first part of a two-volume set concerning the field of Clifford (geometric) algebra, this work consists of thematically organized chapters that provide a broad overview of cutting-edge topics in mathematical physics and the physical applications of Clifford algebras. algebras and their applications in physics. Algebraic geometry, cohomology, non-communicative spaces, q-deformations and the related quantum groups, and projective geometry provide the basis for algebraic topics covered. Physical applications and extensions of physical theories such as the theory of quaternionic spin, a projective theory of hadron transformation laws, and electron scattering are also presented, showing the broad applicability of Clifford geometric algebras in solving physical problems. Treatment of the structure theory of quantum Clifford algebras, the connection to logic, group representations, and computational techniques including symbolic calculations and theorem proving rounds out the presentation.
Applications to Mathematics, Physics, and Engineering World Scientific
Examines the Dirac operator on Riemannian manifolds, especially its connection with the underlying geometry and topology of the manifold. The presentation includes a review of Clifford algebras, spin groups and the spin representation, as well as a review of spin structures and spin [superscript C] structures. With this foundation established, the Dirac operator is defined and studied, with special attention to the cases of Hermitian manifolds and

symmetric spaces. Then, certain analytic properties are established, including self-adjointness and the Fredholm property. An important link between the geometry and the analysis is provided by estimates for the eigenvalues of the Dirac operator in terms of the scalar curvature and the sectional curvature. Considerations of Killing spinors and solutions of the twistor equation on M lead to results about whether M is an Einstein manifold or conformally equivalent to one. Finally, in an appendix, Friedrich gives a concise introduction to the Seiberg-Witten invariants, which are a powerful tool for the study of four-manifolds. There is also an appendix reviewing principal bundles and connections.

Clifford Algebra to Geometric Calculus World Scientific

A straightforward introduction to Clifford algebras, providing the necessary background material and many applications in mathematics and physics.

Clifford Algebras and their Applications in Mathematical Physics CRC Press

The plausible relativistic physical variables describing a spinning, charged and massive particle are, besides the charge itself, its Minkowski (four) po sition X, its relativistic linear (four) momentum P and also its so-called Lorentz (four) angular momentum E # 0, the latter forming four trans lation invariant part of its total angular (four) momentum M. Expressing these variables in terms of Poincare covariant real valued functions defined on an extended relativistic phase space [2, 7J means that the mutual Pois son bracket relations among the total angular momentum functions Mab and the linear momentum functions pa have to represent the commutation relations of the Poincare algebra. On any such an extended relativistic phase space, as shown by Zakrzewski [2, 7], the (natural?) Poisson bracket relations (1. 1) imply that for the splitting of the total angular momentum into its orbital and its spin part (1. 2) one necessarily obtains (1. 3) On the other hand it is always possible to shift (translate) the commuting (see (1. 1)) four position xa by a four vector ~Xa (1. 4) so that the total angular four momentum splits instead into a new orbital and a new (Pauli-Lubanski) spin part (1. 5) in such a way that (1. 6) However, as proved by Zakrzewski [2, 7J, the so-defined new shifted four a position functions X must fulfill the following Poisson bracket relations: (1.

Clifford Algebras and Lie Theory Springer Science & Business Media

An in depth exploration of how Clifford algebras and spinors have been sparking collaboration and bridging the gap between Physics and Mathematics. This collaboration has been the consequence of a growing awareness of the importance of algebraic and geometric properties in many physical phenomena, and of the discovery of common ground through various touch points: relating Clifford algebras and the arising geometry to so-called spinors, and to their three definitions (both from the mathematical and physical viewpoint). The main points of contact are the representations of Clifford algebras and the periodicity theorems. Clifford algebras also constitute a highly intuitive formalism, having an intimate relationship to quantum field theory. The text strives to seamlessly combine these various viewpoints and is devoted to a wider audience of both physicists and mathematicians. Among the existing approaches to Clifford algebras and spinors this book is unique in that it provides a

didactical presentation of the topic and is accessible to both students and researchers. It emphasizes the formal character and the deep algebraic and geometric completeness, and merges them with the physical applications.

Spinors, Twistors, Clifford Algebras and Quantum Deformations Springer Science & Business Media

This volume describes the substantial developments in Clifford analysis which have taken place during the last decade and, in particular, the role of the spin group in the study of null solutions of real and complexified Dirac and Laplace operators. The book has six main chapters. The first two (Chapters 0 and I) present classical results on real and complex Clifford algebras and show how lower-dimensional real Clifford algebras are well-suited for describing basic geometric notions in Euclidean space. Chapters II and III illustrate how Clifford analysis extends and refines the computational tools available in complex analysis in the plane or harmonic analysis in space. In Chapter IV the concept of monogenic differential forms is generalized to the case of spin-manifolds. Chapter V deals with analysis on homogeneous spaces, and shows how Clifford analysis may be connected with the Penrose transform. The volume concludes with some Appendices which present basic results relating to the algebraic and analytic structures discussed. These are made accessible for computational purposes by means of computer algebra programmes written in REDUCE and are contained on an accompanying floppy disk.

Dirac Operators in Riemannian Geometry Springer

Clifford Algebras and Spinor StructuresA Special Volume Dedicated to the Memory of Albert Crumeyrolle (1919–1992)Springer Science & Business Media

Clifford Algebras and Spinors American Mathematical Soc.

This unique book complements traditional textbooks by providing a visual yet rigorous survey of the mathematics used in theoretical physics beyond that typically covered in undergraduate math and physics courses. The exposition is pedagogical but compact, and the emphasis is on defining and visualizing concepts and relationships between them, as well as listing common confusions, alternative notations and jargon, and relevant facts and theorems. Special attention is given to detailed figures and geometric viewpoints. Certain topics which are well covered in textbooks, such as historical motivations, proofs and derivations, and tools for practical calculations, are avoided. The primary physical models targeted are general relativity, spinors, and gauge theories, with notable chapters on Riemannian geometry, Clifford algebras, and fiber bundles.

Clifford Algebras Springer Science & Business Media

In the first century after its discovery, the electron has come to be a fundamental element in the analysis of physical aspects of nature. This book is devoted to the construction of a deductive theory of the electron, starting from first principles and using a simple mathematical tool, geometric analysis. Its purpose is to present a comprehensive theory of the electron to the point where a connection can be made with the main approaches to the study of the electron in physics. The introduction describes the methodology. Chapter 2 presents the concept of space-time-action relativity theory and in chapter 3 the mathematical structures describing action are analyzed. Chapters 4, 5, and 6 deal with the theory of the electron in a series of aspects where

the geometrical analysis is more relevant. Finally in chapter 7 the form of geometrical analysis used in the book is presented to elucidate the broad range of topics which are covered and the range of mathematical structures which are implicitly or explicitly included. The book is directed to two different audiences of graduate students and research scientists: primarily to theoretical physicists in the field of electron physics as well as those in the more general field of quantum mechanics, elementary particle physics, and general relativity; secondly, to mathematicians in the field of geometric analysis.

Geometric Science of Information Springer Science & Business Media

This book constitutes the proceedings of the 4th International Conference on Geometric Science of Information, GSI 2019, held in Toulouse, France, in August 2019. The 79 full papers presented in this volume were carefully reviewed and selected from 105 submissions. They cover all the main topics and highlights in the domain of geometric science of information, including information geometry manifolds of structured data/information and their advanced applications.

A Function Theory for the Dirac Operator Cambridge University Press

William Kingdon Clifford published the paper defining his "geometric algebras" in 1878, the year before his death. Clifford algebra is a generalisation to n-dimensional space of quaternions, which Hamilton used to represent scalars and vectors in real three-space: it is also a development of Grassmann's algebra, incorporating in the fundamental relations inner products defined in terms of the metric of the space. It is a strange fact that the Gibbs Heaviside vector techniques came to dominate in scientific and technical literature, while quaternions and Clifford algebras, the true associative algebras of inner-product spaces, were regarded for nearly a century simply as interesting mathematical curiosities. During this period, Pauli, Dirac and Majorana used the algebras which bear their names to describe properties of elementary particles, their spin in particular. It seems likely that none of these eminent mathematical physicists realised that they were using Clifford algebras. A few research workers such as Fueter realised the power of this algebraic scheme, but the subject only began to be appreciated more widely after the publication of Chevalley's book, 'The Algebraic Theory of Spinors' in 1954, and of Marcel Riesz' Maryland Lectures in 1959. Some of the contributors to this volume, Georges Deschamps, Erik Folke Bolinder, Albert Crumeyrolle and David Hestenes were working in this field around that time, and in their turn have persuaded others of the importance of the subject.

An Introduction to Clifford Algebras and Spinors Springer Science & Business Media

At the heart of Clifford analysis is the study of systems of special partial differential operators that arise naturally from the use of Clifford algebra as a calculus tool. This book focuses on the study of Dirac operators and related ones, together with applications in mathematics, physics and engineering. This book collects refereed papers from a satellite conference to the ICM 2002, plus invited contributions. All articles contain unpublished new results.

Applications to Mathematics, Physics, and Engineering Springer Science & Business Media

Geometric algebra has been presented in many different guises

since its invention by William Kingdon Clifford shortly before his death in 1879. Our guiding principle is that it should be fully integrated into the foundations of mathematics, and in this regard nothing is more fundamental than the concept of number itself. In this book we fully integrate the ideas of geometric algebra directly into the fabric of matrix linear algebra. A geometric matrix is a real or complex matrix which is identified with a unique geometric number. The matrix product of two geometric matrices is just the product of the corresponding geometric numbers. Any equation can be either interpreted as a matrix equation or an equation in geometric algebra, thus fully unifying the two languages. The first 6 chapters provide an introduction to geometric algebra, and the classification of all such algebras. Exercises are provided. The last 3 chapters explore more advanced topics in the application of geometric algebras to Pauli and Dirac spinors, special relativity, Maxwell's equations, quaternions, split quaternions, and group manifolds. They are included to highlight the great variety of topics that are imbued with new geometric insight when expressed in geometric algebra. The usefulness of these later chapters will depend on the background and previous knowledge of the reader.Matrix Gateway to Geometric Algebra will be of interest to undergraduate and graduate students in mathematics, physics and the engineering sciences, who are looking for a unified treatment of geometric ideas arising in these areas at all levels. It should also be of interest to specialists in linear and multilinear algebra, and to mathematical historians interested in the development of geometric number systems.

Spinor Construction of Vertex Operator Algebras, Triality, and E8(1) Cambridge University Press

This volume is an outgrowth of the 1995 Summer School on Theoretical Physics of the Canadian Association of Physicists (CAP), held in Banff, Alberta, in the Canadian Rockies, from July 30 to August 12,1995. The chapters, based on lectures given at the School, are designed to be tutorial in nature, and many include exercises to assist the learning process. Most lecturers gave three or four fifty-minute lectures aimed at relative novices in the field. More emphasis is therefore placed on pedagogy and establishing comprehension than on erudition and superior scholarship. Of course, new and exciting results are presented in applications of Clifford algebras, but in a coherent and user-friendly way to the nonspecialist. The subject area of the volume is Clifford algebra and its applications. Through the geometric language of the Clifford-algebra approach, many concepts in physics are clarified, united, and extended in new and sometimes surprising directions. In particular, the approach eliminates the formal gaps that traditionally separate clas sical, quantum, and relativistic physics. It thereby makes the study of physics more efficient and the research more penetrating, and it suggests resolutions to a major physics problem of the twentieth century, namely how to unite quantum theory and gravity. The term "geometric algebra" was used by Clifford himself, and David Hestenes has suggested its use in order to emphasize its wide applicability, and b& cause the developments by Clifford were themselves based heavily on previous work by Grassmann, Hamilton, Rodrigues, Gauss, and others.

Clifford Algebras and Their Application in Mathematical Physics Springer Science & Business Media

In addition, attention is paid to the algebraic and Lie-theoretic applications of Clifford algebras---particularly their intersection with Hopf algebras, Lie algebras and representations, graded algebras, and associated mathematical structures. Symplectic Clifford algebras are also discussed. Finally, Clifford algebras play a strong role in both physics and engineering. The physics section features an investigation of geometric algebras, chiral Dirac equations, spinors and Fermions, and applications of Clifford algebras in classical mechanics and general relativity. Twistor and octonionic methods, electromagnetism and gravity, elementary particle physics, noncommutative physics, Dirac's equation, quantum spheres, and the Standard Model are among topics considered at length.

A Function Theory for the Dirac Operator World Scientific

This International Conference on Clifford AlgebrfU and Their Application, in Math ematical Phy,ic, is the third in a series of conferences on this theme, which started at the Univer,ity of Kent in Canterbury in 1985 and was continued at the Univer,iU de, Science, et Technique, du Languedoc in Montpellier in 1989. Since the start of this series of Conferences the research fields under consideration have evolved quite a lot. The number of scientific papers on Clifford Algebra, Clifford Analysis and their impact on the modelling of physics phenomena have increased tremendously and several new books on these topics were published. We were very pleased to see old friends back and to wellcome new guests who by their inspiring talks contributed fundamentally to tracing new paths for the future development of this research area. The Conference was organized in Deinze, a small rural town in the vicinity of the University town Gent. It was hosted by De Ceder, a vacation and seminar center in a green area, a typical landscape of Flanders's "plat pays" . The Conference was attended by 61 participants coming from 18 countries; there were 10 main talks on invitation, 37 contributions accepted by the Organizing Com mittee and a poster session. There was also a book display of Kluwer Academic Publishers. As in the Proceedings of the Canterbury and Montpellier conferences we have grouped the papers accordingly to the themes they are related to: Clifford Algebra, Clifford Analysis, Classical Mechanics, Mathematical Physics and Physics Models.

Proceedings of the Second Max Born Symposium held near Wrocław, Poland, September 1992 Springer Science & Business Media

This volume comprises original and review articles on the frontier problems of the gravitation theory, theoretical and mathematical physics. The volume is dedicated to the memory of Professor Dmitri Ivanenko who made the great contribution to the physical science of the twentieth century.

Proceedings of the Third Conference held at Deinze, Belgium, 1993 Oxford University Press

This text explores how Clifford algebras and spinors have been sparking a collaboration and bridging a gap between Physics and Mathematics. This collaboration has been the consequence of a growing awareness of the importance of algebraic and geometric properties in many physical phenomena, and of the discovery of common ground through various touch points: relating Clifford algebras and the arising geometry to so-called spinors, and to their three definitions (both from the mathematical and physical

viewpoint). The main point of contact are the representations of Clifford algebras and the periodicity theorems. Clifford algebras also constitute a highly intuitive formalism, having an intimate relationship to quantum field theory. The text strives to seamlessly combine these various viewpoints and is devoted to a wider audience of both physicists and mathematicians. Among the existing approaches to Clifford algebras and spinors this book is unique in that it provides a didactical presentation of the topic and is accessible to both students and researchers. It emphasizes the formal character and the deep algebraic and geometric completeness, and merges them with the physical applications. The style is clear and precise, but not pedantic. The sole pre-requisites is a course in Linear Algebra which most students of Physics, Mathematics or Engineering will have covered as part of their undergraduate studies.

Spinor Structures Springer Science & Business Media

In its traditional form, Clifford analysis provides the function theory for solutions of the Dirac equation. From the beginning, however, the theory was used and applied to problems in other fields of mathematics, numerical analysis, and mathematical physics. recently, the theory has enlarged its scope considerably by incorporating geometrical methods from global analysis on manifolds and methods from representation theory. New, interesting branches of the theory are based on conformally invariant, first-order systems other than the Dirac equation, or systems that are invariant with respect to a group other than the conformal group. This book represents an up-to-date review of Clifford analysis in its present form, its applications, and directions for future research. Readership: Mathematicians and theoretical physicists interested in Clifford analysis itself, or in its applications to other fields.

Clifford Algebras Oxford University Press

Experimental Techniques in High-Energy Nuclear and Particle Physics is a compilation of outstanding technical papers and reviews of the ingenious methods developed for experimentation in modern nuclear and particle physics. This book, a second edition, provides a balanced view of the major tools and technical concepts currently in use, and elucidates the basic principles that underly the detection devices. Several of the articles in this volume have never been published, or have appeared in relatively inaccessible journals. Although the emphasis is on charged-particle tracking and calorimetry, general reviews of ionization detectors and Monte Carlo techniques are also included.This book serves as a compact source of reference for graduate students and experimenters in the fields of nuclear and particle physics, seeking information on some of the major ideas and techniques developed for modern experiments in these fields.