Clifford Algebra And Spinor Valued Functions A Function Theory For The Dirac Operator Mathematics And Its Applications Volume 53

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.

This new book contains the most up-to-date and focused description of the applications of Clifford algebras in analysis, particularly classical harmonic analysis. It is the first single volume devoted to applications of Clifford analysis to other aspects of analysis. All chapters are written by world authorities in the area. Of particular interest is the contribution of Professor Alan McIntosh. He gives a detailed account of the links between Clifford algebras, monogenic and harmonic functions and the correspondence between monogenic functions and holomorphic functions of several complex variables under Fourier transforms. He describes the correspondence between algebras of singular integrals on Lipschitz surfaces and functional calculi of Dirac operators on these surfaces. He also discusses links with boundary value problems over Lipschitz domains. Other specific topics include Hardy spaces and compensated compactness in Euclidean space; applications to acoustic scattering and Galerkin estimates; scattering theory for orthogonal wavelets; applications of the conformal group and Vahalen matrices; Newmann type problems for the Dirac operator; plus much, much more! Clifford Algebras in Analysis and Related Topics also contains the most comprehensive section on open problems available. The book presents the most detailed link between Clifford analysis and classical harmonic analysis. It is a refreshing break from the many expensive and lengthy volumes currently found on the subject.

This edited survey book consists of 20 chapters showing application of Clifford algebra in quantum mechanics, field

theory, spinor calculations, projective geometry, Hypercomplex algebra, function theory and crystallography. Many examples of computations performed with a variety of readily available software programs are presented in detail.
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.
Clifford Algebras continues to be a fast-growing discipline, with ever-increasing applications in many scientific fields. This volume contains the lectures given at the Fourth Conference on Clifford Algebras and their Applications in Mathematical Physics, held at RWTH Aachen in May 1996. The papers represent an excellent survey of the newest developments around Clifford Analysis and its applications to theoretical physics. Audience: This book should appeal to physicists and mathematicians working in areas involving functions of complex variables, associative rings and algebras, integral transforms, operational calculus, partial differential equations, and the mathematics of physics.
ZBIGNIEW OZIEWICZ University of Wroclaw, Poland December 1992 The First Max Born Symposium in Theoretical and Mathematical Phy sics, organized by the University of Wrodaw, was held in September 1991 with the intent that it would become an annual event. It is the outgrowth of the annual Seminars organized jointly since 1972 with the University of Leipzig. The name of the Symposia was proposed by Professor Jan Lopu szanski. Max Born, an outstanding German theoretical physicist, was born in 1883 in Breslau (the German name of Wrodaw) and educated here. The Second Max Born Symposium was held during the four days 24- 27 September 1992 in an old Sobotka Castle 30 km west of Wrodaw. The Sobotka Castle was built in the eleventh century. The dates engraved on the walls of the Castle are 1024, 1140, and

at the last rebuilding, 1885. The castle served as a cloister until the end of the sixteenth century.

The second 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. from applications such as complex-distance potential theory, supersymmetry, and fluid dynamics to Fourier analysis, the study of boundary value problems, and applications, to mathematical physics and Schwarzian derivatives in Euclidean space. Among the mathematical topics examined are generalized Dirac operators, holonomy groups, monogenic and hypermonogenic functions and their derivatives, quaternionic Beltrami equations, Fourier theory under Mobius transformations, Cauchy-Reimann operators, and Cauchy type integrals.

Examines functions on Rn (rather than spinor-valued functions) with values in the Clifford algebra in higher dimensions Two different methods are presented in parallel for describing function theory for higher spin equations: one based on Clifford analysis, the other on differential geometry For grad students and researchers in analysis, geometry, PDEs, and math physics (electrodynamics, higher spin physics, and string theory)

The Second International Workshop on Automated Deduction in Geometry (ADG '98) was held in Beijing, China, August 1–3, 1998. An increase of interest in ADG '98 over the previous workshop ADG '96 is represented by the notable number of more than 40 participants from ten countries and the strong tech- cal program of 25 presentations, of which two one-hour invited talks were given by Professors Wen-tsun ? Wu and Jing-Zhong Zhang. The workshop provided the participants with a well-focused forum for e?ective exchange of new ideas and timely report of research progress. Insight surveys, algorithmic developments, and applications in CAGD/CAD and computer vision presented by active - searchers, together with geometry software demos, shed light on the features of this second workshop. ADG '98 was hosted by the Mathematics Mechanization Research Center (MMRC) with ?nancial support from the Chinese Academy of Sciences and the French National Center for Scienti?c Research (CNRS), and was organized by the three co-editors of this proceedings volume. The papers contained in the volume were selected, under a strict refereeing procedure, from those presented at ADG '98 and submitted afterwards. Most of the 14 accepted papers were carefully revised and some of the revised versions were checked again by external reviewers. We hope that these papers cover some of the most recent and signi?cant research results and developments and re?ect the current state-of-the-art of ADG.

Matrix algebra has been called "the arithmetic of higher mathematics" [Be]. We think the basis for a better arithmetic has long been available, but its versatility has hardly been appreciated, and it has not yet been integrated into the mainstream of mathematics. We refer to the system commonly called 'Clifford Algebra', though we prefer the name 'Geometric Algebm' suggested by Clifford himself. Many distinct algebraic systems have been adapted or developed to express geometric relations and describe geometric structures. Especially notable are those algebras which have been used for this purpose in physics, in particular, the system of complex numbers, the quatemions, matrix algebra, vector, tensor and spinor algebras and the algebra of

differential forms. Each of these geometric algebras has some significant advantage over the others in certain applications, so no one of them provides an adequate algebraic structure for all purposes of geometry and physics. At the same time, the algebras overlap considerably, so they provide several different mathematical representations for individual geometrical or physical ideas.
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.
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.
The subject of Clifford (geometric) algebras offers a unified algebraic framework for the direct expression of the geometric concepts in algebra, geometry, and physics. This bird's-eye view of the discipline is presented by six of the world's leading experts in the field; it features an introductory chapter on Clifford algebras, followed by extensive explorations of their applications to physics, computer science, and differential geometry. The book is ideal for graduate students in mathematics, physics, and computer science; it is appropriate both for newcomers who have little prior knowledge of the field and professionals who wish to keep abreast of the latest applications.
The invited papers in this volume provide a detailed examination of Clifford algebras and their significance to analysis, geometry,

mathematical structures, physics, and applications in engineering. While the papers collected in this volume require that the reader possess a solid knowledge of appropriate background material, they lead to the most current research topics. With its wide range of topics, well-established contributors, and excellent references and index, this book will appeal to graduate students and researchers.

In this volume, we report new results about various theories and methods of integral equation, boundary value problems for partial differential equations and functional equations, and integral operators including singular integral equations, applications of boundary value problems and integral equations to mechanics and physics, numerical methods of integral equations and boundary value problems, theories and methods for inverse problems of mathematical physics, Clifford analysis and related problems.

This is the second edition of a popular work offering a unique introduction to Clifford algebras and spinors. The beginning chapters could be read by undergraduates; vectors, complex numbers and quaternions are introduced with an eye on Clifford algebras. The next chapters will also interest physicists, and include treatments of the quantum mechanics of the electron, electromagnetism and special relativity with a flavour of Clifford algebras. This edition has three new chapters, including material on conformal invariance and a history of Clifford algebras.

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.

This proceedings volume gathers selected, peer-reviewed papers from the "Modern Methods, Problems and Applications of Operator Theory and Harmonic Analysis VIII" (OTHA 2018) conference, which was held in Rostov-on-Don, Russia, in April 2018. The book covers a diverse range of topics in advanced mathematics, including harmonic analysis, functional analysis, operator theory, function theory, differential equations and fractional analysis – all fields that have been intensively developed in recent decades. Direct and inverse problems arising in mathematical physics are studied and new methods for solving them are presented. Complex multiparameter objects that require the involvement of operators with variable parameters and functional spaces, with fractional and even variable exponents, make these approaches all the more relevant. Given its scope, the book will especially benefit researchers with an interest in new trends in harmonic analysis and operator theory, though it will also appeal to graduate students seeking new and intriguing topics for further investigation.

This book, intended to commemorate the work of Paul Dirac, highlights new developments in the main directions of Clifford analysis. Just as complex analysis is based on the algebra of the complex numbers, Clifford analysis is based on the geometric Clifford algebras. Many methods and theorems from complex analysis generalize to higher dimensions in

various ways. However, many new features emerge in the process, and much of this work is still in its infancy. Some of the leading mathematicians working in this field have contributed to this book in conjunction with “Clifford Analysis and Related Topics: a conference in honor of Paul A.M. Dirac,” which was held at Florida State University, Tallahassee, on December 15-17, 2014. The content reflects talks given at the conference, as well as contributions from mathematicians who were invited but were unable to attend. Hence much of the mathematics presented here is not only highly topical, but also cannot be found elsewhere in print. Given its scope, the book will be of interest to mathematicians and physicists working in these areas, as well as students seeking to catch up on the latest developments.

The purpose of the volume is to bring forward recent trends of research in hypercomplex analysis. The list of contributors includes first rate mathematicians and young researchers working on several different aspects in quaternionic and Clifford analysis. Besides original research papers, there are papers providing the state-of-the-art of a specific topic, sometimes containing interdisciplinary fields. The intended audience includes researchers, PhD students, postgraduate students who are interested in the field and in possible connection between hypercomplex analysis and other disciplines, including mathematical analysis, mathematical physics, algebra.

This book offers basic theory on hypercomplex-analytic automorphic forms and functions for arithmetic subgroups of the Vahlen group in higher dimensional spaces. Vector- and Clifford algebra-valued Eisenstein and Poincaré series are constructed within this framework and a detailed description of their analytic and number theoretical properties is provided. It establishes explicit relationships to generalized variants of the Riemann zeta function and Dirichlet L-series, and introduces hypercomplex multiplication of lattices.

This volume is intended to collect important research results to the lectures and discussions which took Place in Rome, at the INdAM Workshop on Different Notions of Regularity for Functions of Quaternionic Variables in September 2010. This volume will collect recent and new results, which are connected to the topic covered during the workshop. The work aims at bringing together international leading specialists in the field of Quaternionic and Clifford Analysis, as well as young researchers interested in the subject, with the idea of presenting and discussing recent results, analyzing new trends and techniques in the area and, in general, of promoting scientific collaboration. Particular attention is paid to the presentation of different notions of regularity for functions of hypercomplex variables, and to the study of the main features of the theories that they originate.

Marcellliesz's lectures delivered on October 1957 -January 1958 at the Uni versity of Maryland, College Park, have been previously published only infor mally as a manuscript entitled CLIFFORD NUMBERS AND SPINORS (Chap ters I - IV). As the title says, the lecture notes consist of four Chapters I, II, III and IV. However, in the preface of the lecture notes

lliesz refers to Chapters V and VI which he could not finish. Chapter VI is mentioned on pages 1, 3, 16, 38 and 156, which makes it plausible that lliesz was well aware of what he was going to include in the final missing chapters. The present book makes lliesz's classic lecture notes generally available to a wider audience and tries somewhat to fill in one of the last missing chapters. This book also tries to evaluate lliesz's influence on the present research on Clifford algebras and draws special attention to lliesz's contributions in this field - often misunderstood.

The chapters on Clifford algebra and differential geometry can be used as an introduction to the topics, and are suitable for senior undergraduates and graduates. The other chapters are also accessible at this level.; This self-contained book requires very little previous knowledge of the domains covered, although the reader will benefit from knowledge of complex analysis, which gives the basic example of a Dirac operator.; The more advanced reader will appreciate the fresh approach to the theory, as well as the new results on boundary value theory.; Concise, but self-contained text at the introductory grad level. Systematic exposition.; Clusters well with other Birkhäuser titles in mathematical physics.; Appendix. General Manifolds * List of Symbols * Bibliography * Index

International ISAAC (International Society for Analysis, its Applications and Computation) Congresses have been held every second year since 1997. The proceedings report on a regular basis on the progresses of the field in recent years, where the most active areas in analysis, its applications and computation are covered. Plenary lectures also highlight recent results. This volume concentrates mainly on partial differential equations, but also includes function spaces, operator theory, integral transforms and equations, potential theory, complex analysis and generalizations, stochastic analysis, inverse problems, homogenization, continuum mechanics, mathematical biology and medicine. With over 350 participants attending the congress, the book comprises 140 papers from 211 authors. The volume also serves for transferring personal information about the ISAAC and its members. This volume includes citations for O Besov, V Burenkov and R P Gilbert on the occasion of their anniversaries.

Complex analysis nowadays has higher-dimensional analoga: the algebra of complex numbers is replaced then by the non-commutative algebra of real quaternions or by Clifford algebras. During the last 30 years the so-called quaternionic and Clifford or hypercomplex analysis successfully developed to a powerful theory with many applications in analysis, engineering and mathematical physics. This textbook introduces both to classical and higher-dimensional results based on a uniform notion of holomorphy. Historical remarks, lots of examples, figures and exercises accompany each chapter.

The demand for more reliable geometric computing in robotics, computer vision and graphics has revitalized many venerable algebraic subjects in mathematics OCo among them, GrassmannOCoCayley algebra and Geometric Algebra. Nowadays, they are used as powerful languages for projective, Euclidean and other classical geometries. This book contains the author and his collaborators' most recent, original development of GrassmannOCoCayley algebra and Geometric Algebra and their applications in automated reasoning of classical geometries. It includes two of the three advanced invariant algebras OCo Cayley bracket algebra, conformal geometric algebra, and null bracket algebra OCo for highly efficient geometric computing. They form the theory of advanced invariants, and capture the intrinsic beauty of geometric languages and geometric computing. Apart from their applications in discrete and computational geometry, the new languages are

currently being used in computer vision, graphics and robotics by many researchers worldwide. Sample Chapter(s). Chapter 1: Introduction (252 KB). Contents: Projective Space, Bracket Algebra and GrassmannOCoCayley Algebra; Projective Incidence Geometry with Cayley Bracket Algebra; Projective Conic Geometry with Bracket Algebra and Quadratic Grassmann-Cayley Algebra; Inner-product Bracket Algebra and Clifford Algebra; Geometric Algebra; Euclidean Geometry and Conformal GrassmannOCoCayley Algebra; Conformal Clifford Algebra and Classical Geometries. Readership: Graduate students in discrete and computational geometry, and computer mathematics; mathematicians and computer scientists.

This book contains a selection of papers presented at the session "Quaternionic and Clifford Analysis" at the 10th ISAAC Congress held in Macau in August 2015. The covered topics represent the state-of-the-art as well as new trends in hypercomplex analysis and its applications.

The application of geometric algebra to the engineering sciences is a young, active subject of research. The promise of this field is that the mathematical structure of geometric algebra together with its descriptive power will result in intuitive and more robust algorithms. This book examines all aspects essential for a successful application of geometric algebra: the theoretical foundations, the representation of geometric constraints, and the numerical estimation from uncertain data. Formally, the book consists of two parts: theoretical foundations and applications. The first part includes chapters on random variables in geometric algebra, linear estimation methods that incorporate the uncertainty of algebraic elements, and the representation of geometry in Euclidean, projective, conformal and conic space. The second part is dedicated to applications of geometric algebra, which include uncertain geometry and transformations, a generalized camera model, and pose estimation. Graduate students, scientists, researchers and practitioners will benefit from this book. The examples given in the text are mostly recent research results, so practitioners can see how to apply geometric algebra to real tasks, while researchers note starting points for future investigations. Students will profit from the detailed introduction to geometric algebra, while the text is supported by the author's visualization software, CLUCalc, freely available online, and a website that includes downloadable exercises, slides and tutorials.

The goal of this book is to present a unified mathematical treatment of diverse problems in mathematics, physics, computer science, and engineer ing using geometric algebra. Geometric algebra was invented by William Kingdon Clifford in 1878 as a unification and generalization of the works of Grassmann and Hamilton, which came more than a quarter of a century before. Whereas the algebras of Clifford and Grassmann are well known in advanced mathematics and physics, they have never made an impact in elementary textbooks where the vector algebra of Gibbs-Heaviside still predominates. The approach to Clifford algebra adopted in most of the ar ticles here was pioneered in the 1960s by David Hestenes. Later, together with Garret Sobczyk, he developed it into a unified language for math ematics and physics. Sobczyk first learned about the power of geometric algebra in classes in electrodynamics and relativity taught by Hestenes at Arizona State University from 1966 to 1967. He still vividly remembers a feeling of disbelief that the fundamental geometric product of vectors could have been left out of his undergraduate mathematics education. Geometric algebra provides a rich, general mathematical framework for the develop ment of multilinear algebra, projective and affine geometry, calculus on a manifold, the representation of Lie groups and Lie algebras, the use of the horosphere and many other areas. This book is addressed to a broad audience of applied mathematicians, physicists, computer scientists, and engineers.

This useful text offers new insights and solutions for the development of theorems, algorithms and advanced methods for real-time applications across a range of disciplines. Its accessible style is enhanced by examples, figures and experimental analysis.

Clifford Algebra and Spinor-Valued FunctionsA Function Theory for the Dirac OperatorSpringer 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.

In this volume, we report new results about various boundary value problems for partial differential equations and functional equations, theory and methods of integral equations and integral operators including singular integral equations, applications of boundary value problems and integral equations to mechanics and physics, numerical methods of integral equations and boundary value problems, theory and methods for inverse problems of mathematical physics, Clifford analysis and related problems. Contributors include: L Baratchart, B L Chen, D C Chen, S S Ding, K Q Lan, A Farajzadeh, M G Fei, T Kosztolowicz, A Makin, T Qian, J M Rassias, J Ryan, C-Q Ru, P Schiavone, P Wang, Q S Zhang, X Y Zhang, S Y Du, H Y Gao, X Li, Y Y Qiao, G C Wen, Z T Zhang, etc.

This volume is dedicated to the memory of Albert Crumeyrolle, who died on June 17, 1992. In organizing the volume we gave priority to: articles summarizing Crumeyrolle's own work in differential geometry, general relativity and spinors, articles which give the reader an idea of the depth and breadth of Crumeyrolle's research interests and influence in the field, articles of high scientific quality which would be of general interest. In each of the areas to which Crumeyrolle made significant contribution - Clifford and exterior algebras, Weyl and pure spinors, spin structures on manifolds, principle of triality, conformal geometry - there has been substantial progress. Our hope is that the volume conveys the originality of Crumeyrolle's own work, the continuing vitality of the field he influenced, and the enduring respect for, and tribute to, him and his accomplishments in the mathematical community. It isour pleasure to thank Peter Morgan, Artibano Micali, Joseph Grifone, Marie Crumeyrolle and Kluwer Academic Publishers for their help in preparingthis volume.

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.

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.