Energy Research Abstracts

Operads provide a universal language to relate several disciplines in mathematics and physics. The focus of this book, which is the first of its kind, is the particularly striking relation between algebra, topology and string theory that is mediated by operads of graphs and surfaces in their role as a model of the correlation functions of quantum field theory. The text supplies all the necessary background material, including discussions of the relevant aspects of operads, cell models, moduli spaces, deformation quantization, graph Feynman rules and topological and conformal field theory in their open/closed versions. The central paradigm is Deligne's conjecture on the Hochschild cohomology and its generalizations to the cyclic, the A? and the moduli space cases. Its solution is presented as a natural consequence of this operadic point of view of strings.

Topological And Geometrical Methods In Field Theory - Proceedings Of The 2nd International Symposium

This book explains the subtleties of quantum statistical mechanics in lower dimensions and their possible ramifications in quantum theory. The discussion is at a pedagogical level and is addressed to both graduate students and advanced researchers with a reasonable background in quantum and statistical mechanics. Topics in the first part of the book include the flux tube model of anyons, the braid group and a detailed discussion about the various aspects of quantum and statistical mechanics of a noninteracting anyon gas. The second part of the book includes a detailed discussion about fractional statistics from the point of view of Chern-Simons theories. Topics covered here include Chern-Simons field theories, charged vortices, anyon superconductivity and the fractional quantum Hall effect. Since the publication of the first edition of the book, an exciting possibility has emerged, that of quantum computing using anyons. A section has therefore been included on this topic in the second edition. In addition, new sections have been added about scattering of anyons with hard disk repulsion as well as fractional exclusion statistics and negative probabilities.

Proceedings of the International Congress of Mathematicians

Visionary articles explaining approaches to important problems on the interface of pure mathematics and mathematical physics.

Fractional Statistics and Quantum Theory
This book presents the (to date) most general approach to combinatorial constructions of topological quantum field theories (TQFTs) in three dimensions. The authors describe extended TQFTs as double functors between two naturally defined double categories: one of topological nature, made of 3-manifolds with corners, the other of algebraic nature, made of linear categories, functors, vector spaces and maps. Atiyah’s conventional notion of TQFTs as well as the notion of modular functor from axiomatic conformal field theory are unified in this concept. A large class of such extended modular category is constructed, assigning a double functor to every abelian modular category, which does not have to be semisimple.

Geometry and Quantum Field Theory

These lectures recount an application of stable homotopy theory to a concrete problem in low energy physics: the classification of special phases of matter. While the joint work of the author and Michael Hopkins is a focal point, a general geometric frame of reference on quantum field theory is emphasized. Early lectures describe the geometric axiom systems introduced by Graeme Segal and Michael Atiyah in the late 1980s, as well as subsequent extensions. This material provides an entry point for mathematicians to delve into quantum field theory. Classification theorems in low dimensions are proved to illustrate the framework. The later lectures turn to more specialized topics in field theory, including the relationship between invertible field theories and stable homotopy theory, extended unitarity, anomalies, and relativistic free fermion systems. The accompanying mathematical explanations touch upon (higher) category theory, duals to the sphere spectrum, equivariant spectra, differential cohomology, and Dirac operators. The outcome of computations made using the Adams spectral sequence is presented and compared to results in the condensed matter literature obtained by very different means. The general perspectives and specific applications fuse into a compelling story at the interface of contemporary mathematics and theoretical physics.

Conformal Field Theories and Tensor Categories

The motivations, goals and general culture of theoretical physics and mathematics are different. Most practitioners of either discipline have no necessity for most of the time to keep abreast of the latest developments in the other. However on occasion newly developed mathematical concepts become relevant in theoretical physics and the less rigorous theoretical physics framework may prove valuable in understanding and suggesting new theorems and approaches in pure mathematics. Such interdisciplin ary successes invariably cause much rejoicing, as over a prodigal son returned. In recent years the framework provided by quantum field theory and functional integrals, developed over half a century in theoretical physics, have proved a fertile soil for developments in low dimensional topology and especially knot theory. Given this background it was particularly pleasing that NATO was able to generously support an Advanced Research Workshop to be held in Cambridge, England from 6th to 12th September 1992 with the title Low Dimensional Topology and Quantum Field Theory. Although independently organised this overlapped as far as some speakers were concerned with a longer term programme with the same title organised by Professor M Green, Professor E Corrigan and Dr R Lickorish. The contents of this proceedings of the workshop demonstrate the breadth of topics now of interest on the interface between theoretical physics and mathematics as well as the sophistication of the mathematical tools required in current theoretical physics.

Knots, Topology And Quantum Field Theory: Proceedings Of The 13th Johns Hopkins Workshop

Nobel Symposium 129 on Neutrino Physics was held at Haga Slott in Enköping, Sweden during August 19-24, 2004. Invited to the symposium were around 40 globally leading researchers in the field of neutrino physics, both experimental and theoretical. The dominant theme of the lectures was neutrino oscillations, which after several years were recently verified by results from the Super-Kamiokande detector in Kamioka, Japan and the SNO detector in Sudbury, Canada. Discussion focused especially on effects of neutrino oscillations derived from the presence of matter and the fact that three different neutrinos exist. Since neutrino oscillations imply that neutrinos have mass, this is the first experimental observation that fundamentally deviates from the standard model of particle physics. This is a challenge to both theoretical and experimental physics. The various oscillation parameters will be determined with increased precision in new, specially designed experiments. Theoretical physics is working intensively to insert the knowledge that neutrinos have mass into the theoretical models that describe particle physics. The lectures provided a very good description of the intensive situation in the field right now. The topics discussed also included mass models for neutrinos, neutrinos in extra dimensions as well as the “seesaw mechanism,” which provides a good description of why neutrino masses are so small. This book is A4 size and in full color.
Conformal Field Theory

This volume, based on lectures and short communications at a summer school in Villa de Leyva, Colombia (July 2005), offers an introduction to some recent developments in several active topics at the interface between geometry, topology and quantum field theory. It is aimed at graduate students in physics or mathematics who might want insight in the following topics (covered in five survey lectures): Anomalies and noncommutative geometry, Deformation quantisation and Poisson algebras, Topological quantum field theory and orbifolds. These lectures are followed by nine articles on various topics at the borderline of mathematics and physics ranging from quasicrystals to invariant instantons through black holes, and involving a number of mathematical tools borrowed from geometry, algebra and analysis.

Conformal Field Theory with Gauge Symmetry

Based on lectures held at the 8th edition of the series of summer schools in Villa de Leyva since 1999, this book presents an introduction to topics of current interest at the interface of geometry, algebra, analysis, topology and theoretical physics. It is aimed at graduate students and researchers in physics or mathematics, and offers an introduction to the topics discussed in the two weeks of the summer school: operator algebras, conformal field theory, black holes, relativistic fluids, Lie groupoids and Lie algebroids, renormalization methods, spectral geometry and index theory for pseudo-differential operators.

Conformal Field Theory and Topology

Part I gives a detailed, self-contained and mathematically rigorous exposition of classical conformal symmetry in n dimensions and its quantization in two dimensions. The conformal groups are determined and the appearance of the Virasoro algebra in the context of the quantization of two-dimensional conformal symmetry is explained via the classification of central extensions of Lie algebras and groups. Part II surveys more advanced topics of conformal field theory such as the representation theory of the Virasoro algebra, conformal symmetry within string theory, an axiomatic approach to Euclidean conformally covariant quantum field theory and a mathematical interpretation of the Verlinde formula in the context of moduli spaces of holomorphic vector bundles on a Riemann surface.

Topological Field Theory, Primitive Forms and Related Topics

The first part of this book gives a self-contained and mathematically rigorous exposition of classical conformal symmetry in n dimensions and its quantization in two dimensions. The second part surveys some more advanced topics of conformal field theory.

Conformal Field Theory

The book is an introduction to quantum mechanics at a level suitable for the second year in a European university (junior or senior year in an American college). The matrix formulation of quantum mechanics is emphasized throughout, and the student is introduced to Dirac notation from the start. A number of major examples illustrate the workings of quantum mechanics. Several of these examples are taken from solid state physics, with the purpose of showing that quantum mechanics forms the common basis for understanding atoms, molecules and condensed matter. The book contains an introductory chapter which puts the concepts of quantum mechanics into a historical framework. The solid-state applications discussed in this text include the quantum Hall effect, spin waves, quantum wells and energy bands. Other examples feature the two-dimensional harmonic oscillator, coherent states, two-electron atoms, the ammonia molecule and the chemical bond. A large number of homework problems are included.

Non-Semisimple Topological Quantum Field Theories for 3-Manifolds with Corners

After an introduction to matrix models and Chern-Simons gauge theory, this book describes in detail the topological string theories that correspond to these gauge theories and develops the mathematical implication of this duality for the enumerative geometry of Calabi-Yau manifolds and knot theory.
**Topology and Field Theories**

This book provides an understanding of conformal field theory and its importance to both statistical mechanics and string theory. It introduces the Wess-Zumino-Novikov-Witten (WZNW) models and their current algebras, the affine Kac-Moody algebras.

**Proceedings of the Summer School Geometric and Topological Methods for Quantum Field Theory**

Conceptual progress in fundamental theoretical physics is linked with the search for the suitable mathematical structures that model the physical systems. Quantum field theory (QFT) has proven to be a rich source of ideas for mathematics for a long time. However, fundamental questions such as "What is a QFT?" did not have satisfactory mathematical answers, especially on spaces with arbitrary topology, fundamental for the formulation of perturbative string theory. This book contains a collection of papers highlighting the mathematical foundations of QFT and its relevance to perturbative string theory as well as the deep techniques that have been emerging in the last few years. The papers are organized under three main chapters: Foundations for Quantum Field Theory, Quantization of Field Theories, and Two-Dimensional Quantum Field Theories. An introduction, written by the editors, provides an overview of the main underlying themes that bind together the papers in the volume.

**Mathematical Aspects of Conformal and Topological Field Theories and Quantum Groups**

In the past decade, there has been a sudden and vigorous development in a number of research areas in mathematics and mathematical physics, such as theory of operator algebras, knot theory, theory of manifolds, infinite dimensional Lie algebras and quantum groups (as a new topics), etc. on the side of mathematics, quantum field theory and statistical mechanics on the side of mathematical physics. The new development is characterized by very strong relations and interactions between different research areas which were hitherto considered as remotely related. Focussing on these new developments in mathematical physics and theory of operator algebras, the International Oji Seminar on Quantum Analysis was held at the Kansai Seminar House, Kyoto, JAPAN during June 25-29, 1992 by a generous sponsorship of the Japan Society for the Promotion of Science and the Fujihara Foundation of Science, as a workshop of relatively small number of (about 50) invited participants. This was followed by an open Symposium at RIMS, described below by its organizer, A. Kishimoto. The Oji Seminar began with two key-note addresses, one by V.F.R. Jones on Spin Models in Knot Theory and von Neumann Algebras and by A. Jaffe on Where Quantum Field Theory Has Led. Subsequently topics such as Subfactors and Sector Theory, Solvable Models of Statistical Mechanics, Quantum Field Theory, Quantum Groups, and Renormalization Group Approach, are discussed. Towards the end, a panel discussion on Where Should Quantum Analysis Go? was held.

**Topological Methods In Quantum Field Theories**

This book is a collection of expository articles based on four lecture series presented during the 2012 Notre Dame Summer School in Topology and Field Theories. The four topics covered in this volume are: Construction of a local conformal field theory associated to a compact Lie group, a level and a Frobenius object in the corresponding fusion category; Field theory interpretation of certain polynomial invariants associated to knots and links; Homotopy theoretic construction of far-reaching generalizations of the topological field theories that Dijkgraf and Witten associated to finite groups; and a discussion of the action of the orthogonal group on the full subcategory of an -category consisting of the fully dualizable objects. The expository style of the articles enables non-experts to understand the basic ideas of this wide range of important topics.

**Geometric, Algebraic and Topological Methods for Quantum Field Theory**

Because of its many applications to mathematics and mathematical physics, the representation theory of infinite-dimensional Lie and quantized enveloping algebras comprises an important area of current research. This volume includes articles from the proceedings of an international conference, "Infinite-Dimensional Lie Theory and Conformal Field Theory", held at the University of Virginia. Many of the contributors to the volume are prominent researchers in the field. This conference provided an opportunity for mathematicians and physicists to interact in an active research area of mutual interest. The talks focused on recent developments in the representation theory of affine, quantum affine, and extended affine Lie algebras and Lie superalgebras. They also highlighted
applications to conformal field theory, integrable and disordered systems. Some of the articles are expository and accessible to a broad readership of mathematicians and physicists interested in this area; others are research articles that are appropriate for more advanced readers.

A Mathematical Introduction to Conformal Field Theory

The remarkable developments in differential topology and how these recent advances have been applied as a primary research tool in quantum field theory are presented here in a style reflecting the genuinely two-sided interaction between mathematical physics and applied mathematics. The author, following his previous work (Nash/Sen: Differential Topology for Physicists, Academic Press, 1983), covers elliptic differential and pseudo-differential operators, Atiyah-Singer index theory, topological quantum field theory, string theory, and knot theory. The explanatory approach serves to illuminate and clarify these theories for graduate students and research workers entering the field for the first time. Treats differential geometry, differential topology, and quantum field theory. Includes elliptic differential and pseudo-differential operators, Atiyah-Singer index theory, topological quantum field theory, string theory, and knot theory. Tackles problems of quantum field theory using differential topology as a tool.

Recent Developments in Infinite-dimensional Lie Algebras and Conformal Field Theory

Filling an important gap in the literature, this comprehensive text develops conformal field theory from first principles. The treatment is self-contained, pedagogical, and exhaustive, and includes a great deal of background material on quantum field theory, statistical mechanics, Lie algebras and affine Lie algebras. The many exercises, with a wide spectrum of difficulty and subjects, complement and in many cases extend the text. The text is thus not only an excellent tool for classroom teaching but also for individual study. Intended primarily for graduate students and researchers in theoretical high-energy physics, mathematical physics, condensed matter theory, statistical physics, the book will also be of interest in other areas of theoretical physics and mathematics. It will prepare the reader for original research in this very active field of theoretical and mathematical physics.

Non-perturbative Quantum Field Theory: Mathematical Aspects And Applications

Low-Dimensional Topology and Quantum Field Theory

This volume offers an introduction to recent developments in several active topics of research at the interface between geometry, topology and quantum field theory. These include Hopf algebras underlying renormalization schemes in quantum field theory, noncommutative geometry with applications to index theory on one hand and the study of aperiodic solids on the other, geometry and topology of low dimensional manifolds with applications to topological field theory, Chern-Simons supergravity and the anti de Sitter/conformal field theory correspondence. It comprises seven lectures organized around three main topics, noncommutative geometry, topological field theory, followed by supergravity and string theory, complemented by some short communications by young participants of the school.

Operads, Strings And Deligne's Conjecture

"Boundary conformal field theory is concerned with a class of two-dimensional quantum field theories that display a rich mathematical structure and have many applications, ranging from string theory to condensed matter physics. In particular, the framework allows discussion of strings and branes directly at the quantum level. Written by internationally renowned experts, this comprehensive introduction to boundary conformal field theory reaches from theoretical foundations to recent developments, with an emphasis on the algebraic treatment of string backgrounds. Topics covered include basic concepts in conformal field theory with and without boundaries, the mathematical description of strings and D-branes, and the geometry of strongly curved spacetime. The book offers insights into string geometry that go beyond classical notions. Describing the theory from basic concepts, and providing numerous worked examples from conformal field theory and string theory, this reference is of interest to graduate students and researchers in physics and mathematics"--
Physics, Geometry and Topology

"Based on lectures held at the 8th edition of the series of summer schools in Villa de Leyva since 1999, this book presents an introduction to topics of current interest at the interface of geometry, algebra, analysis, topology and theoretical physics. It is aimed at graduate students and researchers in physics or mathematics, and offers an introduction to the topics discussed in the two weeks of the summer school: operator algebras, conformal field theory, black holes, relativistic fluids, Lie groupoids and Lie algebroids, renormalization methods, spectral geometry and index theory for pseudo-differential operators."--Publisher's website.

Strings, Conformal Fields, and Topology

As the interaction of mathematics and theoretical physics continues to intensify, the theories developed in mathematics are being applied to physics, and conversely. This book centers around the theory of primitive forms which currently plays an active and key role in topological field theory (theoretical physics), but was originally developed as a mathematical notion to define a "good period mapping" for a family of analytic structures. The invited papers in this volume are expository in nature by participants of the Taniguchi Symposium on "Topological Field Theory, Primitive Forms and Related Topics" and the RIMS Symposium bearing the same title, both held in Kyoto. The papers reflect the broad research of some of the world's leading mathematical physicists, and should serve as an excellent resource for researchers as well as graduate students of both disciplines.

Geometric

The Banff NATO Summer School was held August 14-25, 1989 at the Banff Centre, Banff, Alberta, Canada. It was a combination of two venues: a summer school in the annual series of Summer School in Theoretical Physics sponsored by the Theoretical Physics Division, Canadian Association of Physicists, and a NATO Advanced Study Institute. The Organizing Committee for the present school was composed of G. Kunstatter (University of Winnipeg), H.C. Lee (Chalk River Laboratories and University of Western Ontario), R. Kobes (University of Winnipeg), D.I. Toms (University of Newcastle Upon Tyne) and Y.S. Wu (University of Utah). Thanks to the group of lecturers (see Contents) and the timeliness of the courses given, the school, entitled PHYSICS, GEOMETRY AND TOPOLOGY, was popular from the very outset. The number of applications outstripped the 90 places of accommodation reserved at the Banff Centre soon after the school was announced. As the eventual total number of participants was increased to 170, it was still necessary to turn away many deserving applicants. In accordance with the spirit of the school, the geometrical and topological properties in each of the wide ranging topics covered by the lectures were emphasized. A recurring theme in a number of the lectures is the Yang-Baxter relation which characterizes a very large class of integrable systems including: many state models, two-dimensional conformal field theory, quantum field theory and quantum gravity in 2 + 1 dimensions.

Chern-Simons Theory, Matrix Models, and Topological Strings

Since the first ICM was held in Zürich in 1897, it has become the pinnacle of mathematical gatherings. It aims at giving an overview of the current state of different branches of mathematics and its applications as well as an insight into the treatment of special problems of exceptional importance. The proceedings of the ICMs have provided a rich chronology of mathematical development in all its branches and a unique documentation of contemporary research. They form an indispensable part of every mathematical library. The Proceedings of the International Congress of Mathematicians 1994, held in Zürich from August 3rd to 11th, 1994, are published in two volumes. Volume I contains an account of the organization of the Congress, the list of ordinary members, the reports on the work of the Fields Medalists and the Nevanlinna Prize Winner, the plenary one-hour addresses, and the invited addresses presented at Section Meetings 1 - 6. Volume II contains the invited address for Section Meetings 7 - 19. A complete author index is included in both volumes. 'the content of these impressive two volumes sheds a certain light on the present state of mathematical sciences and anybody doing research in mathematics should look carefully at these Proceedings. For young people beginning research, this is even more important, so these are a must for any serious mathematics library. The graphical presentation is, as always with Birkhäuser, excellent.' (Revue Roumaine de Mathématiques pures et Appliquées)
Mathematical Foundations of Quantum Field Theory and Perturbative String Theory

The seventh Ettore Majorana International School of Mathematical Physics was held at the Centro della Cultura Scientifica Erice, Sicily, 1-15 July 1988. The present volume collects lecture notes on the session which was entitled Con8tructive Quantum Field Theory II. The II refers to the fact that the first such school in 1973 was devoted to the same subject. The school was a NATO Advanced Study Institute sponsored by the Italian Ministry of Scientific and Technological Research and the Regional Sicilian Government. At the time of the 1973 Erice School on Constructive Field Theory, the speakers could summarize a decade of effort on the solution of superrenormalizable models in two dimensional space-time leading to the verification of the axioms of relativistic quantum field theory for these examples. The resulting lecture notes have proved to be exceptionally useful and are still in print. In the decade and a half that have lapsed since that time, there has been much hard work with the ultimate objective of providing a rigorous mathematical foundation for the quantum field theories in four dimensional space-time that summarize a large fraction of our current understanding of elementary particle physics: QCD and the electroweak theory. The lecture notes of the 1988 school record the fact that, although this objective has not been reached, important progress has been made. The ultraviolet stability of Yang-Mills theory in four dimensions has been treated and renormalizable (not superrenormalizable) models in two dimensional space-time, Gross-Neveu models, have been solved.

Topology, Geometry And Field Theory - Proceedings Of The 31st International Taniguchi Symposium And Proceedings Of The Conference

The aim of this book is to provide the reader with an introduction to conformal field theory and its applications to topology. The author starts with a description of geometric aspects of conformal field theory based on loop groups. By means of the holonomy of conformal field theory he defines topological invariants for knots and 3-manifolds. He also gives a brief treatment of Chern-Simons perturbation theory.

Strings, Conformal Fields, and M-Theory

This book fills a gap in literature for the important interdisciplinary area of biochemical physics, adopting the chemist’s view of this topic in the process. The present status of the theory of electron spin effects in fundamental processes such as spin exchange, dipole-dipole interactions, electron transfer, triplet-triplet energy transfer, and annihilation intersystem crossing is reviewed. These effects form a basis for the understanding of the molecular mechanisms essential to chemical and biological reactions including photosynthesis and magnetic field influence, and for the creation of advanced organic magnets and catalysts, as well as the development of new methods of studying the structural and molecular dynamics of biological and non-biological objects.

Quantum and Non-Commutative Analysis

This volume offers an introduction to recent developments in several active topics of research at the interface between geometry, topology and quantum field theory. These include Hopf algebras underlying renormalization schemes in quantum field theory, noncommutative geometry with applications to index theory on one hand and the study of aperiodic solids on the other, geometry and topology of low dimensional manifolds with applications to topological field theory, Chern-Simons supergravity and the anti de Sitter/conformal field theory correspondence. It comprises seven lectures organized around three main topics, noncommutative geometry, topological field theory, followed by supergravity and string theory, complemented by some short communications by young participants of the school. Contents:Noncommutative Geometry:Hopf Algebras in Noncommutative Geometry (J C Várilly)The Noncommutative Geometry of Aperiodic Solids (J Bellissard)Noncommutative Geometry and Abstract Integration Theory (M-T Benameur)Topological Field Theory:Introduction to Quantum Invariants of 3-Manifolds, Topological Quantum Field Theories and Modular Categories (C Blanchet)An Introduction to Donaldson-Witten Theory (M Mariño)Supergravity and String Theory:(Super)-Gravities Beyond 4 Dimensions (J Zanelli)Introductory Lectures on String Theory and the AdS/CFT Correspondence (A Pankiewicz & S Theisen)Short Communications:Group Contractions and Its Consequences Upon Representations of Different Spatial Symmetry Groups (M Ayala-Sánchez & R W Haase)Phase Anomalies as Trace Anomalies in Chern-Simons Theory (A Cardona)Deligne Cohomology for Orbifolds, Discrete Torsion and B-Fields (E Lupercio & B Uribe) Readership: Graduate students and researchers in theoretical and mathematical physics, as well as geometry and topology. Keywords:

Lectures on Field Theory and Topology
The present volume is a collection of seven papers that are either based on the talks presented at the workshop "Conformal field theories and tensor categories" held June 13 to June 17, 2011 at the Beijing International Center for Mathematical Research, Peking University, or are extensions of the material presented in the talks at the workshop. These papers present new developments beyond rational conformal field theories and modular tensor categories and new applications in mathematics and physics. The topics covered include tensor categories from representation categories of Hopf algebras, applications of conformal field theories and tensor categories to topological phases and gapped systems, logarithmic conformal field theories and the corresponding non-semisimple tensor categories, and new developments in the representation theory of vertex operator algebras. Some of the papers contain detailed introductory material that is helpful for graduate students and researchers looking for an introduction to these research directions. The papers also discuss exciting recent developments in the area of conformal field theories, tensor categories and their applications and will be extremely useful for researchers working in these areas.

**Boundary Conformal Field Theory and the Worldsheet Approach to D-Branes**

Building on the foundations laid in his Introduction to Superstrings and M Theory, Professor Kaku discusses such topics as the classification of conformal string theories, knot theory, the Yang-Baxter relation, quantum groups, and the insights into 11-dimensional strings recently obtained from M-theory. New chapters discuss such topics as Seiberg-Witten theory, M theory and duality, and D-branes. Throughout, the author conveys the vitality of the current research and places readers at its forefront. Several chapters reviewing the fundamentals of string theory, making the presentation of the material self-contained while keeping overlap with the earlier book to a minimum.

**Geometric and Topological Methods for Quantum Field Theory**

This book contains papers presented by speakers at the AMS-IMS-SIAM Joint Summer Research Conference on Conformal Field Theory, Topological Field Theory and Quantum Groups, held at Mount Holyoke College in June 1992. One group of papers deals with one aspect of conformal field theory, namely, vertex operator algebras or superalgebras and their representations. Another group deals with various aspects of quantum groups. Other topics covered include the theory of knots in three-manifolds, symplectic geometry, and tensor products. This book provides an excellent view of some of the latest developments in this growing field of research.

**Quantum Field Theory, Statistical Mechanics, Quantum Groups And Topology - Proceedings Of The Nato Advanced Research Workshop**

Following on the foundations laid in his earlier book "Introduction to Superstrings", Professor Kaku discusses such topics as the classification of conformal string theories, the non-polynomial closed string field theory, matrix models, and topological field theory. The presentation of the material is self-contained, and several chapters review material expounded in the earlier book. This book provides students with an understanding of the main areas of current progress in string theory, placing the reader at the forefront of current research.

**Geometric and Topological Methods for Quantum Field Theory**

Exploring topics from classical and quantum mechanics and field theory, this book is based on lectures presented in the Graduate Summer School at the Regional Geometry Institute in Park City, Utah, in 1991. The chapter by Bryant treats Lie groups and symplectic geometry, examining not only the connection with mechanics but also the application to differential equations and the recent work of the Gromov school. Rabin's discussion of quantum mechanics and field theory is specifically aimed at mathematicians. Alvarez describes the application of supersymmetry to prove the Atiyah-Singer index theorem, touching on ideas that also underlie more complicated applications of supersymmetry. Quinn's account of the topological quantum field theory captures the formal aspects of the path integral and shows how these ideas can influence branches of mathematics which at first glance may not seem connected. Presenting material at a level between that of textbooks and research papers, much of the book would provide excellent material for graduate courses. The book provides an entree into a field that promises to remain exciting and important for years to come.
A Mathematical Introduction to Conformal Field Theory

From the unique perspective of partial differential equations (PDE), this self-contained book presents a systematic, advanced introduction to the Black-Scholes-Merton's option pricing theory. A unified approach is used to model various types of option pricing as PDE problems, to derive pricing formulas as their solutions, and to design efficient algorithms from the numerical calculation of PDEs. In particular, the qualitative and quantitative analysis of American option pricing is treated based on free boundary problems, and the implied volatility as an inverse problem is solved in the optimal control framework of parabolic equations.

Constructive Quantum Field Theory II

"Recently it was shown that modular functors can be constructed from conformal field theory, giving an interesting relationship between algebraic geometry and topological quantum field theory. This book provides a timely introduction to an intensively studied topic of conformal field theory with gauge symmetry by a leading algebraic geometer, and includes all the necessary techniques and results that are used to construct the modular functor."--BOOK JACKET.

Conformal Field Theory

Compiled to illustrate the recent history of Quantum Field Theory and its trends, this collection of selected reprints by Jürg Fröhlich, a leading theoretician in the field, is a comprehensive guide of the more mathematical aspects of the subject. Results and methods of the past fifteen years are reviewed. The analytical methods employed are non-perturbative and, for the larger part, mathematically rigorous. Most articles are review articles surveying certain important developments in quantum field theory and guiding the reader towards the original literature. The volume begins with a comprehensive introduction by Jürg Fröhlich. The theory of phase transitions and continuous symmetry breaking is reviewed in the first section. The second section discusses the non-perturbative quantization of topological solitons. The third section is devoted to the study of gauge fields. A paper on the triviality of $\lambda\phi^4$ — theory in four and more dimensions is found in the fourth section, while the fifth contains two articles on “random geometry”. The sixth and final part addresses topics in low-dimensional quantum field theory, including braid statistics, two-dimensional conformal field theory and an application to condensed matter theory.

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