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Vladimir G. Turaev

QUANTUM INVARIANTS OF KNOTS AND 3-MANIFOLDS

3RD EDITION

STUDIES IN MATHEMATICS 18



Quantum Invariants Of Knots And 3manifolds De Gruyter Studies In Mathematics

Louis H. Kauffman



Quantum Invariants Of Knots And 3-manifolds De Gruyter Studies In Mathematics:

Quantum Invariants of Knots and 3-manifolds Vladimir Turaev, 1994 **Quantum Invariants of Knots and 3-Manifolds** Vladimir G. Turaev, 2016-07-11 Due to the strong appeal and wide use of this monograph it is now available in its third revised edition The monograph gives a systematic treatment of 3 dimensional topological quantum field theories TQFTs based on the work of the author with N Reshetikhin and O Viro This subject was inspired by the discovery of the Jones polynomial of knots and the Witten Chern Simons field theory On the algebraic side the study of 3 dimensional TQFTs has been influenced by the theory of braided categories and the theory of quantum groups The book is divided into three parts Part I presents a construction of 3 dimensional TQFTs and 2 dimensional modular functors from so called modular categories This gives a vast class of knot invariants and 3 manifold invariants as well as a class of linear representations of the mapping class groups of surfaces In Part II the technique of $6j$ symbols is used to define state sum invariants of 3 manifolds Their relation to the TQFTs constructed in Part I is established via the theory of shadows Part III provides constructions of modular categories based on quantum groups and skein modules of tangles in the 3 space This fundamental contribution to topological quantum field theory is accessible to graduate students in mathematics and physics with knowledge of basic algebra and topology It is an indispensable source for everyone who wishes to enter the forefront of this fascinating area at the borderline of mathematics and physics Contents Invariants of graphs in Euclidean 3 space and of closed 3 manifolds Foundations of topological quantum field theory Three dimensional topological quantum field theory Two dimensional modular functors $6j$ symbols Simplicial state sums on 3 manifolds Shadows of manifolds and state sums on shadows Constructions of modular categories **Quantum Invariants of Knots and 3-Manifolds** Vladimir G. Turaev, 2020-03-23 This monograph provides a systematic treatment of topological quantum field theories TQFT s in three dimensions inspired by the discovery of the Jones polynomial of knots the Witten Chern Simons field theory and the theory of quantum groups The author one of the leading experts in the subject gives a rigorous and self contained exposition of new fundamental algebraic and topological concepts that emerged in this theory The book is divided into three parts Part I presents a construction of 3 dimensional TQFT s and 2 dimensional modular functors from so called modular categories This gives new knot and 3 manifold invariants as well as linear representations of the mapping class groups of surfaces In Part II the machinery of $6j$ symbols is used to define state sum invariants of 3 manifolds Their relation to the TQFT s constructed in Part I is established via the theory of shadows Part III provides constructions of modular categories based on quantum groups and Kauffman s skein modules This book is accessible to graduate students in mathematics and physics with a knowledge of basic algebra and topology It will be an indispensable source for everyone who wishes to enter the forefront of this rapidly growing and fascinating area at the borderline of mathematics and physics Most of the results and techniques presented here appear in book form for the first time **Quantum Invariants** Tomotada Ohtsuki, 2002 This book provides an extensive and self

contained presentation of quantum and related invariants of knots and 3 manifolds Polynomial invariants of knots such as the Jones and Alexander polynomials are constructed as quantum invariants i.e invariants derived from representations of quantum groups and from the monodromy of solutions to the Knizhnik Zamolodchikov equation With the introduction of the Kontsevich invariant and the theory of Vassiliev invariants the quantum invariants become well organized Quantum and perturbative invariants the LMO invariant and finite type invariants of 3 manifolds are discussed The Chern-OC-Simons field theory and the Wess-OC-Zumino-OC-Witten model are described as the physical background of the invariants Contents Knots and Polynomial Invariants Braids and Representations of the Braid Groups Operator Invariants of Tangles via Sliced Diagrams Ribbon Hopf Algebras and Invariants of Links Monodromy Representations of the Braid Groups Derived from the Knizhnik-OC-Zamolodchikov Equation The Kontsevich Invariant Vassiliev Invariants Quantum Invariants of 3 Manifolds Perturbative Invariants of Knots and 3 Manifolds The LMO Invariant Finite Type Invariants of Integral Homology 3 Spheres Readership Researchers lecturers and graduate students in geometry topology and mathematical physics **Quantum**

Field Theory and Manifold Invariants Daniel S. Freed, Sergei Gukov, Ciprian Manolescu, Constantin Teleman, Ulrike Tillmann, 2021-12-02 This volume contains lectures from the Graduate Summer School Quantum Field Theory and Manifold Invariants held at Park City Mathematics Institute 2019 The lectures span topics in topology global analysis and physics and they range from introductory to cutting edge Topics treated include mathematical gauge theory anti self dual equations Seiberg Witten equations Higgs bundles classical and categorified knot invariants Khovanov homology Heegaard Floer homology instanton Floer homology invertible topological field theory BPS states and spectral networks This collection presents a rich blend of geometry and topology with some theoretical physics thrown in as well and so provides a snapshot of a vibrant and fast moving field Graduate students with basic preparation in topology and geometry can use this volume to learn advanced background material before being brought to the frontiers of current developments Seasoned researchers will also benefit from the systematic presentation of exciting new advances by leaders in their fields **Introductory**

Lectures on Knot Theory Louis H. Kauffman, 2012 More recently Khovanov introduced link homology as a generalization of the Jones polynomial to homology of chain complexes and Ozsvath and Szabo developed Heegaard Floer homology that lifts the Alexander polynomial These two significantly different theories are closely related and the dependencies are the object of intensive study These ideas mark the beginning of a new era in knot theory that includes relationships with four dimensional problems and the creation of new forms of algebraic topology relevant to knot theory The theory of skein modules is an older development also having its roots in Jones discovery Another significant and related development is the theory of virtual knots originated independently by Kauffman and by Goussarov Polyak and Viro in the 90s All these topics and their relationships are the subject of the survey papers in this book *Mathematical Aspects of Quantum Computing* 2007 Mikio Nakahara, Robabeh Rahimi, Akira Sai Toh, 2008 This book provides a comprehensive overview of the mathematical aspects of

quantum computing It will be useful for graduate students and researchers interested in quantum computing from different areas of physics mathematics informatics and computer science The lecture notes in this volume are written in a self contained style and hence are accessible for graduate students and researchers with even less background in the topics

Linknot: Knot Theory By Computer Slavik Vlado Jablan,Radmila Sazdanovic,2007-11-16 LinKnot Knot Theory by Computer provides a unique view of selected topics in knot theory suitable for students research mathematicians and readers with backgrounds in other exact sciences including chemistry molecular biology and physics The book covers basic notions in knot theory as well as new methods for handling open problems such as unknotting number braid family representatives invertibility amphicheirality undetectability non algebraic tangles polyhedral links and 2 2 moves Hands on computations using Mathematica or the webMathematica package LinKnot and beautiful illustrations facilitate better learning and understanding LinKnot is also a powerful research tool for experimental mathematics implementation of Caudron s ideas The use of Conway notation enables experimenting with large families of knots and links Conjectures discussed in the book are explained at length The beauty universality and diversity of knot theory is illuminated through various non standard applications mirror curves fullerenes self referential systems and KL automata *Topology And Physics - Proceedings Of The Nankai International Conference In Memory Of Xiao-song Lin* Zhenghan Wang,Weiping Zhang,Kelvin Lin,2008-08-11 This unique volume resulting from a conference at the Chern Institute of Mathematics dedicated to the memory of Xiao Song Lin presents a broad connection between topology and physics as exemplified by the relationship between low dimensional topology and quantum field theory The volume includes works on picture 2 1 TQFTs and their applications to quantum computing Berry phase and Yang Baxterization of the braid relation finite type invariant of knots categorification and Khovanov homology Gromov Witten type invariants twisted Alexander polynomials Faddeev knots generalized Ricci flow Calabi Yau problems for CR manifolds Milnor s conjecture on volume of simplexes Heegaard genera of 3 manifolds and the A B slice problem It also includes five unpublished papers of Xiao Song Lin and various speeches related to the memorial conference **Topology and Physics** Zhenghan Wang,2008 This unique volume resulting from a conference at the Chern Institute of Mathematics dedicated to the memory of Xiao Song Lin presents a broad connection between topology and physics as exemplified by the relationship between low dimensional topology and quantum field theory The volume includes works on picture 2 1 TQFTs and their applications to quantum computing Berry phase and Yang Baxterization of the braid relation finite type invariant of knots categorification and Khovanov homology Gromov Witten type invariants twisted Alexander polynomials Faddeev knots generalized Ricci flow Calabi Yau problems for CR manifolds Milnor s conjecture on volume of simplexes Heegaard genera of 3 manifolds and the A B slice problem It also includes five unpublished papers of Xiao Song Lin and various speeches related to the memorial conference **Topological Quantum Computation** Zhenghan Wang,2010 Topological quantum computation is a computational paradigm based on topological

phases of matter which are governed by topological quantum field theories In this approach information is stored in the lowest energy states of many anyon systems and processed by braiding non abelian anyons The computational answer is accessed by bringing anyons together and observing the result Besides its theoretical esthetic appeal the practical merit of the topological approach lies in its error minimizing hypothetical hardware topological phases of matter are fault avoiding or deaf to most local noises and unitary gates are implemented with exponential accuracy Experimental realizations are pursued in systems such as fractional quantum Hall liquids and topological insulators This book expands on the author's CBMS lectures on knots and topological quantum computing and is intended as a primer for mathematically inclined graduate students With an emphasis on introducing basic notions and current research this book gives the first coherent account of the field covering a wide range of topics Temperley Lieb Jones theory the quantum circuit model ribbon fusion category theory topological quantum field theory anyon theory additive approximation of the Jones polynomial anyonic quantum computing models and mathematical models of topological phases of matter

Lectures on Differential Topology

Riccardo Benedetti, 2021-10-27 This book gives a comprehensive introduction to the theory of smooth manifolds maps and fundamental associated structures with an emphasis on bare hands approaches combining differential topological cut and paste procedures and applications of transversality In particular the smooth cobordism cup product is defined from scratch and used as the main tool in a variety of settings After establishing the fundamentals the book proceeds to a broad range of more advanced topics in differential topology including degree theory the Poincaré Hopf index theorem bordism characteristic numbers and the Pontryagin-Thom construction Cobordism intersection forms are used to classify compact surfaces their quadratic enhancements are developed and applied to studying the homotopy groups of spheres the bordism group of immersed surfaces in a 3-manifold and congruences mod 16 for the signature of intersection forms of 4-manifolds Other topics include the high dimensional h -cobordism theorem stressing the role of the Whitney trick a determination of the singleton bordism modules in low dimensions and proofs of parallelizability of orientable 3-manifolds and the Lickorish-Wallace theorem Nash manifolds and Nash's questions on the existence of real algebraic models are also discussed This book will be useful as a textbook for beginning masters and doctoral students interested in differential topology who have finished a standard undergraduate mathematics curriculum It emphasizes an active learning approach and exercises are included within the text as part of the flow of ideas Experienced readers may use this book as a source of alternative constructive approaches to results commonly presented in more advanced contexts with specialized techniques

Quantum Groups, Hopf Algebras, and Applications Susan Montgomery, Siu-Hung Ng, 2025-03-13 This volume contains the proceedings of the AMS Special Session on Quantum Groups Hopf Algebras and Applications in memory of Professor Earl J Taft which was held from October 22-23, 2022 at the University of Utah Salt Lake City Utah Hopf algebras play a crucial role in many areas of mathematics from finite groups to tensor categories and allows researchers to make many connections between these

subjects Applications of Hopf algebras to low dimensional topology topological quantum field theory and condensed matter physics provide further motivation for the study of representations of Hopf algebras and their generalizations In memory of Earl Jay Taft a pioneer of the theory of Hopf algebras this volume collects research articles on Hopf algebras quantum groups and tensor categories contributed by prominent researchers The articles in this volume manifest the diversity and richness of the subject and contain exciting new results which will certainly have applications to different areas of mathematics and physics

The interface of knots and physics Louis H. Kauffman, 1995-12-01 This book is the result of an AMS Short Course on Knots and Physics that was held in San Francisco January 1994 The range of the course went beyond knots to the study of invariants of low dimensional manifolds and extensions of this work to four manifolds and to higher dimensions The authors use ideas and methods of mathematical physics to extract topological information about knots and manifolds Features A basic introduction to knot polynomials in relation to statistical link invariants Concise introductions to topological quantum field theories and to the role of knot theory in quantum gravity Knots and Physics would be an excellent supplement to a course on algebraic topology or a physics course on field theory

Moduli Spaces of Curves, Mapping Class Groups and Field Theory Xavier Buff, 2003 It concludes with a study of the canonical Galois action on the fundamental groupoids computed using Grothendieck Teichmüller theory Finally Chapter 3 studies strict ribbon categories which are closely related to braided tensor categories here they are used to construct invariants of 3 manifolds which in turn give rise to quantum field theories

BOOK JACKET *Theta Functions and Knots* Razvan Gelca, 2014 This book presents the relationship between classical theta functions and knots It is based on a novel idea of Razvan Gelca and Alejandro Uribe which converts Weil's representation of the Heisenberg group on theta functions to a knot theoretical framework by giving a topological interpretation to a certain induced representation It also explains how the discrete Fourier transform can be related to 3 and 4 dimensional topology Theta Functions and Knots can be read in two perspectives People with an interest in theta functions or knot theory can learn how the two are related Those interested in Chern-OCoSimons theory find here an introduction using the simplest case that of abelian Chern-OCoSimons theory Moreover the construction of abelian Chern-OCoSimons theory is based entirely on quantum mechanics and not on quantum field theory as it is usually done Both the theory of theta functions and low dimensional topology are presented in detail in order to underline how deep the connection between these two fundamental mathematical subjects is Hence the book is a self contained unified presentation It is suitable for an advanced graduate course as well as for self study Contents Some Historical Facts A Quantum Mechanical Prototype Surfaces and Curves The Theta Functions Associated to a Riemann Surface From Theta Functions to Knots Some Results About 3 and 4 Dimensional Manifolds The Discrete Fourier Transform and Topological Quantum Field Theory Theta Functions and Quantum Groups An Epilogue OCoAbelian Chern-OCoSimons Theory Readership Graduate students and young researchers with an interest in complex analysis mathematical physics algebra geometry and low dimensional topology

When Form Becomes Substance Luciano

Boi, Carlos Lobo, 2022-11-30 This interdisciplinary volume collects contributions from experts in their respective fields with as common theme diagrams. Diagrams play a fundamental role in the mathematical visualization and philosophical analysis of forms in space. Some of the most interesting and profound recent developments in contemporary sciences whether in topology, geometry, dynamic systems, theory, quantum field theory or string theory have been made possible by the introduction of new types of diagrams which in addition to their essential role in the discovery of new classes of spaces and phenomena have contributed to enriching and clarifying the meaning of the operations, structures and properties that are at the heart of these spaces and phenomena. The volume gives a closer look at the scope and the nature of diagrams as constituents of mathematical and physical thought, their function in contemporary artistic work and appraise in particular the actual importance of the diagrams of knots of braids of fields of interaction of strings in topology and geometry in quantum physics and in cosmology but also in theory of perception in plastic arts and in philosophy. The editors carefully curated this volume to be an inspiration to students and researchers in philosophy, phenomenology, mathematics and the sciences as well as artists, musicians and the general interested audience.

Solitons, Geometry, and Topology: On the Crossroad V. M. Buchstaber, Sergei Petrovich Novikov, 1997

Mathematical Physics in Mathematics and Physics Roberto Longo, 2001

The beauty and the mystery surrounding the interplay between mathematics and physics is captured by E. Wigner's famous expression: "The unreasonable effectiveness of mathematics." We don't know why but physical laws are described by mathematics and good mathematics sooner or later finds applications in physics often in a surprising way. In this sense mathematical physics is a very old subject as Egyptian, Phoenician or Greek history tells us. But mathematical physics is a very modern subject as any working mathematician or physicist can witness. It is a challenging discipline that has to provide results of interest for both mathematics and physics. Ideas and motivations from both these sciences give it a vitality and freshness that is difficult to find anywhere else. One of the big physical revolutions in the twentieth century, quantum physics, opened a new magnificent era for this interplay. With the appearance of noncommutative analysis, the role of classical calculus has been taken by commutation relations, a subject still growing in an astonishing way. A good example where mathematical physics showed its power, beauty and interdisciplinary character is the Doplicher-Haag-Roberts analysis of superselection sectors in the late 1960s. Not only did this theory explain the origin of statistics and classify it but year after year new connections have merged for example with Tomita-Takesaki modular theory, Jones theory of subfactors and Doplicher-Roberts abstract duality for compact groups. This volume contains the proceedings of the conference "Mathematical Physics in Mathematics and Physics" dedicated to Sergio Doplicher and John E. Roberts held in Siena, Italy. The articles offer current research in various fields of mathematical physics primarily concerning quantum aspects of operator algebras.

Topological Quantum Field Theories from Subfactors Vijay Kodiyalam, 2019-05-20 Pure mathematicians have only recently begun a rigorous study of topological quantum field theories (TQFTs). Ocneanu in particular showed that subfactors

yield TQFTs that complement the Turaev Viro construction. Until now, however, it has been difficult to find an account of this work that is both detailed and accessible. *Topological Quant*

Quantum Invariants Of Knots And 3manifolds De Gruyter Studies In Mathematics Book Review: Unveiling the Power of Words

In a global driven by information and connectivity, the energy of words has be much more evident than ever. They have the ability to inspire, provoke, and ignite change. Such could be the essence of the book **Quantum Invariants Of Knots And 3manifolds De Gruyter Studies In Mathematics**, a literary masterpiece that delves deep to the significance of words and their impact on our lives. Compiled by a renowned author, this captivating work takes readers on a transformative journey, unraveling the secrets and potential behind every word. In this review, we will explore the book is key themes, examine its writing style, and analyze its overall impact on readers.

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