

**Temperley-Lieb Recoupling Theory  
and Invariants of 3-Manifolds**

BY

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# Temperley Lieb Recoupling Theory And Invariants Of 3 Manifolds

**Louis H. Kauffman, Sostenes Lins**



## **Temperley Lieb Recoupling Theory And Invariants Of 3 Manifolds:**

**Temperley-Lieb Recoupling Theory and Invariants of 3-Manifolds (AM-134), Volume 134** Louis H.

Kauffman, Sostenes Lins, 2016-03-02 This book offers a self contained account of the 3 manifold invariants arising from the original Jones polynomial These are the Witten Reshetikhin Turaev and the Turaev Viro invariants Starting from the Kauffman bracket model for the Jones polynomial and the diagrammatic Temperley Lieb algebra higher order polynomial invariants of links are constructed and combined to form the 3 manifold invariants The methods in this book are based on a recoupling theory for the Temperley Lieb algebra This recoupling theory is a  $q$  deformation of the  $SU(2)$  spin networks of Roger Penrose The recoupling theory is developed in a purely combinatorial and elementary manner Calculations are based on a reformulation of the Kirillov Reshetikhin shadow world leading to expressions for all the invariants in terms of state summations on 2 cell complexes Extensive tables of the invariants are included Manifolds in these tables are recognized by surgery presentations and by means of 3 gems graph encoded 3 manifolds in an approach pioneered by Sostenes Lins The appendices include information about gems examples of distinct manifolds with the same invariants and applications to the Turaev Viro invariant and to the Crane Yetter invariant of 4 manifolds **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: A Study Of Knots, 3-manifolds, And Their Sets Tomotada

Ohtsuki, 2001-12-21 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 Simons field theory and the Wess Zumino Witten model are described as the physical background of the invariants

**Algorithmic Topology and Classification of 3-Manifolds** Sergei Matveev, 2013-04-17 The book is devoted to algorithmic low dimensional topology This branch of mathematics has recently been undergoing an intense development On the one hand the exponential advancement of computer technologies has made it possible to conduct sophisticated computer experiments and to implement algorithmic solutions which have in turn provided a motivation to search for new and better algorithms On the other hand low dimensional topology has received an additional boost because of the discovery of numerous connections with theoretical physics There is also another deep reason why algorithmic topology has received a lot of attention It is that a search for algorithmic solutions generally proves to be a rich source of well stated mathematical problems Speaking out of my experience it seems that an orientation towards how to rather than just how is serves as a probing stone for choosing among possible directions of research much like problems in mechanics led once to the development of calculus

**Knots and Physics** Louis H. Kauffman, 2001 This invaluable book is an introduction to knot and link invariants as generalised amplitudes for a quasi physical process The demands of knot theory coupled with a quantum statistical framework create a context that naturally and powerfully includes a extraordinary range of interrelated topics in topology and mathematical physics The author takes a primarily combinatorial stance toward knot theory and its relations with these subjects This stance has the advantage of providing direct access to the algebra and to the combinatorial topology as well as physical ideas The book is divided into two parts Part I is a systematic course on knots and physics starting from the ground up and Part II is a set of lectures on various topics related to Part I Part II includes topics such as frictional properties of knots relations with combinatorics and knots in dynamical systems In this third edition a paper by the author entitled Functional Integration and Vassiliev invariants has been added This paper shows how the Kontsevich integral approach to the Vassiliev invariants is directly related to the perturbative expansion of Witten's functional integral While the book supplies the background this paper can be read independently as an introduction to quantum field theory and knot invariants and their relation to quantum gravity As in the second edition there is a selection of papers by the author at the end of the book Numerous clarifying remarks have been added to the text

**Knots And Physics (Second Edition)** Louis H Kauffman, 1994-01-15 In this second edition the following recent papers have been added Gauss Codes Quantum Groups and Ribbon Hopf Algebras Spin Networks Topology and Discrete Physics Link Polynomials and a Graphical Calculus and Knots Tangles and Electrical Networks An appendix with a discussion on invariants of embedded

graphs and Vassiliev invariants has also been included This book is an introduction to knot and link invariants as generalized amplitudes vacuum vacuum amplitudes for a quasi physical process The demands of knot theory coupled with a quantum statistical framework create a context that naturally and powerfully includes an extraordinary range of interrelated topics in topology and mathematical physics The author takes a primarily combinatorial stance toward knot theory and its relations with these subjects This has the advantage of providing very direct access to the algebra and to the combinatorial topology as well as the physical ideas This book is divided into 2 parts Part I of the book is a systematic course in knots and physics starting from the ground up Part II is a set of lectures on various topics related to and sometimes based on Part I Part II also explores some side topics such as frictional properties of knots relations with combinatorics and knots in dynamical systems

Functorial Knot Theory: Categories Of Tangles, Coherence, Categorical Deformations And Topological Invariants David N Yetter,2001-04-16 Almost since the advent of skein theoretic invariants of knots and links the Jones HOMFLY and Kauffman polynomials the important role of categories of tangles in the connection between low dimensional topology and quantum group theory has been recognized The rich categorical structures naturally arising from the considerations of cobordisms have suggested functorial views of topological field theory This book begins with a detailed exposition of the key ideas in the discovery of monoidal categories of tangles as central objects of study in low dimensional topology The focus then turns to the deformation theory of monoidal categories and the related deformation theory of monoidal functors which is a proper generalization of Gerstenhaber s deformation theory of associative algebras These serve as the building blocks for a deformation theory of braided monoidal categories which gives rise to sequences of Vassiliev invariants of framed links and clarify their interrelations

*Geometry and Quantum Physics* H. Gausterer,H. Grosse,L. Pittner,2008-01-11 In modern mathematical physics classical together with quantum geometrical and functional analytic methods are used simultaneously Non commutative geometry in particular is becoming a useful tool in quantum field theories This book aimed at advanced students and researchers provides an introduction to these ideas Researchers will benefit particularly from the extensive survey articles on models relating to quantum gravity string theory and non commutative geometry as well as Connes approach to the standard model

*Geometry and Physics* H. Pedersen,J. Andersen,J. Dupont,Andrew Swann,1996-10-11 Based on the proceedings of the Special Session on Geometry and Physics held over a six month period at the University of Aarhus Denmark and on articles from the Summer school held at Odense University Denmark Offers new contributions on a host of topics that involve physics geometry and topology Written by more than 50 leading international experts

**Quantum Geometry** Jan Ambjørn,Bergfinnur Durhuus,Þórður Jónsson,1997-06-19 Describes random geometry and applications to strings quantum gravity topological field theory and membrane physics **Low Dimensional Topology and Number Theory** Masanori Morishita,Hiroaki Nakamura,Jun Ueki,2025-03-02 This book is the result of research initiatives formed during the workshop Low Dimensional Topology and Number Theory XIII at Kyushu University in 2022 It is also

dedicated to the memory of Professor Toshie Takata who has been a main figure of the session chairs for the series of annual workshops since 2009. The activity was aimed at understanding and deepening recent developments of lively and fruitful interactions between low dimensional topology and number theory over the past decades. In this volume of proceedings the reader will find research papers as well as survey articles including open problems at the interface between classical and quantum topology and algebraic and analytic number theory written by leading experts and active researchers in the respective fields. Topics include among others the strong slope conjecture, Kashiwara-Vergne Lie algebra, braids and fibered double branched covers of 3-manifolds, Temperley-Lieb Jones category and conformal blocks, WRT invariants and false theta functions, the colored Jones polynomial of the figure eight knot, potential functions and  $A$ -polynomials,  $l$ -adic Galois polylogarithms, Dijkgraaf-Witten invariants in Bloch groups, analogies between knots and primes in arithmetic topology, normalized Jones polynomials for rational links, Iwasawa main conjecture, Weber's class number problem. The book provides a valuable resource for researchers and graduate students interested in topics related to both low dimensional topology and number theory.

Global Surgery Formula for the Casson-Walker Invariant Christine Lescop, 1996-01-11. This book presents a new result in 3-dimensional topology. It is well known that any closed oriented 3-manifold can be obtained by surgery on a framed link in  $S^3$ . In *Global Surgery Formula for the Casson-Walker Invariant* a function  $F$  of framed links in  $S^3$  is described and it is proven that  $F$  consistently defines an invariant  $\lambda$  of closed oriented 3-manifolds.  $\lambda$  is then expressed in terms of previously known invariants of 3-manifolds. For integral homology spheres  $\lambda$  is the invariant introduced by Casson in 1985 which allowed him to solve old and famous questions in 3-dimensional topology.  $\lambda$  becomes simpler as the first Betti number increases. As an explicit function of Alexander polynomials and surgery coefficients of framed links, the function  $F$  extends in a natural way to framed links in rational homology spheres. It is proven that  $F$  describes the variation of  $\lambda$  under any surgery starting from a rational homology sphere. Thus  $F$  yields a global surgery formula for the Casson invariant.

*Morse Theory* John Willard Milnor, 1963. One of the most cited books in mathematics, John Milnor's exposition of Morse theory has been the most important book on the subject for more than forty years. Morse theory was developed in the 1920s by mathematician Marston Morse. Morse was on the faculty of the Institute for Advanced Study and Princeton published his *Topological Methods in the Theory of Functions of a Complex Variable* in the *Annals of Mathematics Studies* series in 1947. One classical application of Morse theory includes the attempt to understand with only limited information the large scale structure of an object. This kind of problem occurs in mathematical physics, dynamic systems and mechanical engineering. Morse theory has received much attention in the last two decades as a result of a famous paper in which theoretical physicist Edward Witten relates Morse theory to quantum field theory. Milnor was awarded the Fields Medal, the mathematical equivalent of a Nobel Prize, in 1962 for his work in differential topology. He has since received the National Medal of Science in 1967 and the Steele Prize from the American Mathematical Society twice in 1982 and 2004 in recognition of his explanations of mathematical

concepts across a wide range of scientific disciplines The citation reads The phrase sublime elegance is rarely associated with mathematical exposition but it applies to all of Milnor's writings Reading his books one is struck with the ease with which the subject is unfolding and it only becomes apparent after reflection that this ease is the mark of a master Milnor has published five books with Princeton University Press      **Knots And Physics (Fourth Edition)** Louis H Kauffman,2012-11-09 This invaluable book is an introduction to knot and link invariants as generalized amplitudes for a quasi physical process The demands of knot theory coupled with a quantum statistical framework create a context that naturally and powerfully includes an extraordinary range of interrelated topics in topology and mathematical physics The author takes a primarily combinatorial stance toward knot theory and its relations with these subjects This stance has the advantage of providing direct access to the algebra and to the combinatorial topology as well as physical ideas The book is divided into two parts Part I is a systematic course on knots and physics starting from the ground up and Part II is a set of lectures on various topics related to Part I Part II includes topics such as frictional properties of knots relations with combinatorics and knots in dynamical systems In this new edition an article on Virtual Knot Theory and Khovanov Homology has been added

**Representations of Algebras and Related Topics** Ragnar-Olaf Buchweitz,Helmut Lenzing,2005 Twelve year old Molly and her ten year old brother Michael have never liked their younger stepsister Heather Ever since their parents got married she's made Molly and Michael's life miserable Now their parents have moved them all to the country to live in a house that used to be a church with a cemetery in the backyard If that's not bad enough Heather starts talking to a ghost named Helen and warning Molly and Michael that Helen is coming for them Molly feels certain Heather is in some kind of danger but every time she tries to help Heather twists things around to get her into trouble It seems as if things can't get any worse But they do when Helen comes Genuinely scary complete with dark secrets from the past unsettled graves and a very real ghost The Bulletin of the Center for Children's Books An unusually scary well crafted ghost fantasy Kirkus Reviews      **The Action Principle and Partial Differential Equations** Demetrios Christodoulou,2000-01-17 This book introduces new methods in the theory of partial differential equations derivable from a Lagrangian These methods constitute in part an extension to partial differential equations of the methods of symplectic geometry and Hamilton Jacobi theory for Lagrangian systems of ordinary differential equations A distinguishing characteristic of this approach is that one considers at once entire families of solutions of the Euler Lagrange equations rather than restricting attention to single solutions at a time The second part of the book develops a general theory of integral identities the theory of compatible currents which extends the work of E Noether Finally the third part introduces a new general definition of hyperbolicity based on a quadratic form associated with the Lagrangian which overcomes the obstacles arising from singularities of the characteristic variety that were encountered in previous approaches On the basis of the new definition the domain of dependence theorem and stability properties of solutions are derived Applications to continuum mechanics are discussed throughout the book The last chapter is devoted to

the electrodynamics of nonlinear continuous media      *Euler Systems* Karl Rubin, 2000-05-21 One of the most exciting new subjects in Algebraic Number Theory and Arithmetic Algebraic Geometry is the theory of Euler systems Euler systems are special collections of cohomology classes attached to  $p$ -adic Galois representations Introduced by Victor Kolyvagin in the late 1980s in order to bound Selmer groups attached to  $p$ -adic representations Euler systems have since been used to solve several key problems These include certain cases of the Birch and Swinnerton Dyer Conjecture and the Main Conjecture of Iwasawa Theory Because Selmer groups play a central role in Arithmetic Algebraic Geometry Euler systems should be a powerful tool in the future development of the field Here in the first book to appear on the subject Karl Rubin presents a self contained development of the theory of Euler systems Rubin first reviews and develops the necessary facts from Galois cohomology He then introduces Euler systems states the main theorems and develops examples and applications The remainder of the book is devoted to the proofs of the main theorems as well as some further speculations The book assumes a solid background in algebraic Number Theory and is suitable as an advanced graduate text As a research monograph it will also prove useful to number theorists and researchers in Arithmetic Algebraic Geometry      **The Interface of Knots and Physics** Louis H. Kauffman, 1996 This text is the result of an AMS Short Course on Knots and Physics that was held in San Francisco in January 1994 The authors use ideas and methods of mathematical physics to extract topological information about knots and manifolds The book features a basic introduction to knot polynomials in relation to statistical link invariants as well as concise introductions to topological quantum field theories and to the role of knot theory in quantum gravity

**Introduction to Toric Varieties** William Fulton, 1993 Toric varieties are algebraic varieties arising from elementary geometric and combinatorial objects such as convex polytopes in Euclidean space with vertices on lattice points Since many algebraic geometry notions such as singularities birational maps cycles homology intersection theory and Riemann Roch translate into simple facts about polytopes toric varieties provide a marvelous source of examples in algebraic geometry In the other direction general facts from algebraic geometry have implications for such polytopes such as to the problem of the number of lattice points they contain In spite of the fact that toric varieties are very special in the spectrum of all algebraic varieties they provide a remarkably useful testing ground for general theories The aim of this mini course is to develop the foundations of the study of toric varieties with examples and describe some of these relations and applications The text concludes with Stanley's theorem characterizing the numbers of simplices in each dimension in a convex simplicial polytope Although some general theorems are quoted without proof the concrete interpretations via simplicial geometry should make the text accessible to beginners in algebraic geometry      Gauss Sums, Kloosterman Sums, and Monodromy Groups Nicholas M. Katz, 1988 The study of exponential sums over finite fields begun by Gauss nearly two centuries ago has been completely transformed in recent years by advances in algebraic geometry culminating in Deligne's work on the Weil Conjectures It now appears as a very attractive mixture of algebraic geometry representation theory and the sheaf theoretic incarnations of such



standard constructions of classical analysis as convolution and Fourier transform The book is simultaneously an account of some of these ideas techniques and results and an account of their application to concrete equidistribution questions concerning Kloosterman sums and Gauss sums

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