

Frobenius Algebras And 2d Topological Quantum Fiel

Hisham Sati,Urs Schreiber

Frobenius Algebras and 2-D Topological Quantum Field Theories Joachim Kock,2004 This 2003 book describes a striking connection between topology and algebra, namely that 2D topological quantum field theories are equivalent to commutative Frobenius algebras. The precise formulation of the theorem and its proof is given in terms of monoidal categories, and the main purpose of the book is to develop these concepts from an elementary level, and more generally serve as an introduction to categorical viewpoints in mathematics. Rather than just proving the theorem, it is shown how the result fits into a more general pattern concerning universal monoidal categories for algebraic structures. Throughout, the emphasis is on the interplay between algebra and topology, with graphical interpretation of algebraic operations, and topological structures described algebraically in terms of generators and relations. The book will prove valuable to students or researchers entering this field who will learn a host of modern techniques that will prove useful for future work.

Frobenius Algebras and 2D Topological Quantum Field Theories Joachim Kock,2003 Proves striking results connecting topology and algebra and shows how the result fits into a more general pattern. The book will prove valuable to students or researchers entering this field who will learn a host of modern techniques. There are numerous exercises and examples making the book suitable for teaching.

Mathematical Foundations of Quantum Field Theory and Perturbative String Theory Hisham Sati,Urs Schreiber,2011-12-07 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.

Homotopy Quantum Field Theory Vladimir G. Turaev,2010 Homotopy Quantum Field Theory (HQFT) is a branch of

Topological Quantum Field Theory founded by E. Witten and M. Atiyah. It applies ideas from theoretical physics to study principal bundles over manifolds and, more generally, homotopy classes of maps from manifolds to a fixed target space. This book is the first systematic exposition of Homotopy Quantum Field Theory. It starts with a formal definition of an HQFT and provides examples of HQFTs in all dimensions. The main body of the text is focused on 2-dimensional and 3-dimensional HQFTs. A study of these HQFTs leads to new algebraic objects: crossed Frobenius group-algebras, crossed ribbon group-categories, and Hopf group-coalgebras. These notions and their connections with HQFTs are discussed in detail. The text ends with several appendices including an outline of recent developments and a list of open problems. Three appendices by M. Muger and A. Virelizier summarize their work in this area. The book is addressed to mathematicians, theoretical physicists, and graduate students interested in topological aspects of quantum field theory. The exposition is self-contained and well suited for a one-semester graduate course. Prerequisites include only basics of algebra and topology.

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 Quantum

Non-Semisimple Topological Quantum Field Theories for 3-Manifolds with Corners Thomas Kerler, Volodymyr V. Lyubashenko, 2003-07-01 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.

Lectures on Field Theory and Topology Daniel S. Freed, 2019-08-23 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.

Quantum Groups, Quantum Categories and Quantum Field Theory Jürg Fröhlich, Thomas Kerler, 2006-11-15 This book reviews recent results on low-dimensional quantum field theories and their connection with quantum group theory and the theory of braided, balanced tensor categories. It presents detailed, mathematically precise introductions to these subjects and then continues with new results. Among the main results are a detailed analysis of the representation theory of $U(\mathfrak{sl}_q)$, for q a primitive root of unity, and a semi-simple quotient thereof, a classification of braided tensor categories generated by an object of q -dimension less than two, and an application of these results to the theory of sectors in algebraic quantum field theory. This clarifies the notion of quantized symmetries in quantum field theory. The reader is expected to be familiar with basic notions and results in algebra. The book is intended for research mathematicians, mathematical physicists and graduate students.

Advances in Topological Quantum Field Theory John M. Bryden, 2005-03-02

Dirichlet Branes and Mirror Symmetry, 2009 Research in string theory has generated a rich interaction with algebraic geometry, with exciting work that includes the Strominger-Yau-Zaslow conjecture. This monograph builds on lectures at the 2002 Clay School on Geometry and String Theory that sought to bridge the gap between the languages of string theory and algebraic geometry.

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

Tensor Categories Pavel Etingof, Shlomo Gelaki, Dmitri Nikshych, Victor Ostrik, 2016-08-05 Is there a vector space whose dimension is the golden ratio? Of course not—the golden ratio is not an integer! But this can happen for generalizations of vector spaces—objects of a tensor category. The theory of tensor categories is a relatively new field of mathematics that generalizes the theory of group representations. It has deep connections with many other fields, including representation theory, Hopf algebras, operator algebras, low-dimensional topology (in particular, knot theory), homotopy theory, quantum mechanics and field theory, quantum computation, theory of motives, etc. This book gives a systematic introduction to this theory and a review of its applications. While giving a detailed overview of general tensor categories, it focuses especially on the theory of finite tensor categories and fusion categories (in particular, braided and modular ones), and discusses the main results about them with proofs. In particular, it shows how the main properties of finite-dimensional Hopf algebras may be derived from the theory of tensor categories. Many important results are presented as a sequence of exercises, which makes the book valuable for students and suitable for graduate courses. Many applications, connections to other areas, additional results, and references are discussed at the end of each chapter.

Complex Cobordism and Stable Homotopy Groups of Spheres Douglas C. Ravenel, 2023-02-09 Since the publication of its first edition, this book has served as one of the few available on the classical Adams spectral sequence, and is the best account on the Adams-Novikov spectral sequence. This new edition has been updated in many places, especially the final chapter, which has been completely rewritten with an eye toward future research in the field. It remains the definitive reference on the stable homotopy groups of spheres. The first three chapters introduce the homotopy groups of spheres and take the reader from the classical results in the field through the computational aspects of the classical Adams spectral sequence and its modifications, which are the main tools topologists have to investigate the homotopy groups of spheres. Nowadays, the most efficient tools are the Brown-Peterson theory, the Adams-Novikov spectral sequence, and the chromatic spectral sequence, a device for analyzing the global structure of the stable homotopy groups of spheres and relating them to the cohomology of the Morava stabilizer groups. These topics are described in detail in Chapters 4 to 6. The revamped Chapter 7 is the computational payoff of the book, yielding a lot of information about the stable homotopy group of spheres. Appendices follow, giving self-contained accounts of the theory of formal group laws and the homological algebra associated with Hopf algebras and Hopf algebroids. The book is intended for anyone wishing to study computational stable homotopy theory. It is accessible to graduate students with a knowledge of algebraic topology and recommended to anyone wishing to

venture into the frontiers of the subject.

Buchdruckerei Passavia ,1954

Geometric and Topological Methods for Quantum Field Theory Hernan Ocampo,Eddy Pariguan,Sylvie Paycha,2010-04-29 Aimed at graduate students in physics and mathematics, this book provides an introduction to recent developments in several active topics at the interface between algebra, geometry, topology and quantum field theory. The first part of the book begins with an account of important results in geometric topology. It investigates the differential equation aspects of quantum cohomology, before moving on to noncommutative geometry. This is followed by a further exploration of quantum field theory and gauge theory, describing AdS/CFT correspondence, and the functional renormalization group approach to quantum gravity. The second part covers a wide spectrum of topics on the borderline of mathematics and physics, ranging from orbifolds to quantum indistinguishability and involving a manifold of mathematical tools borrowed from geometry, algebra and analysis. Each chapter presents introductory material before moving on to more advanced results. The chapters are self-contained and can be read independently of the rest.

Noncommutative Geometry, Quantum Fields and Motives Alain Connes,Matilde Marcolli,2019-03-13 The unifying theme of this book is the interplay among noncommutative geometry, physics, and number theory. The two main objects of investigation are spaces where both the noncommutative and the motivic aspects come to play a role: space-time, where the guiding principle is the problem of developing a quantum theory of gravity, and the space of primes, where one can regard the Riemann Hypothesis as a long-standing problem motivating the development of new geometric tools. The book stresses the relevance of noncommutative geometry in dealing with these two spaces. The first part of the book deals with quantum field theory and the geometric structure of renormalization as a Riemann-Hilbert correspondence. It also presents a model of elementary particle physics based on noncommutative geometry. The main result is a complete derivation of the full Standard Model Lagrangian from a very simple mathematical input. Other topics covered in the first part of the book are a noncommutative geometry model of dimensional regularization and its role in anomaly computations, and a brief introduction to motives and their conjectural relation to quantum field theory. The second part of the book gives an interpretation of the Weil explicit formula as a trace formula and a spectral realization of the zeros of the Riemann zeta function. This is based on the noncommutative geometry of the adèle class space, which is also described as the space of commensurability classes of \mathbb{Q} -lattices, and is dual to a noncommutative motive (endomotive) whose cyclic homology provides a general setting for spectral realizations of zeros of L-functions. The quantum statistical mechanics of the space of \mathbb{Q} -lattices, in one and two dimensions, exhibits spontaneous symmetry breaking. In the low-temperature regime, the equilibrium states of the corresponding systems are related to points of classical moduli spaces and the symmetries to the class field theory of the field of rational numbers and of imaginary quadratic fields, as well as to the automorphisms of the field of modular functions.

The book ends with a set of analogies between the noncommutative geometries underlying the mathematical formulation of the Standard Model minimally coupled to gravity and the moduli spaces of Q-lattices used in the study of the zeta function.

Quantum Field Theory and Topology Albert S. Schwarz, 2013-04-09 In recent years topology has firmly established itself as an important part of the physicist's mathematical arsenal. It has many applications, first of all in quantum field theory, but increasingly also in other areas of physics. The main focus of this book is on the results of quantum field theory that are obtained by topological methods. Some aspects of the theory of condensed matter are also discussed. Part I is an introduction to quantum field theory: it discusses the basic Lagrangians used in the theory of elementary particles. Part II is devoted to the applications of topology to quantum field theory. Part III covers the necessary mathematical background in summary form. The book is aimed at physicists interested in applications of topology to physics and at mathematicians wishing to familiarize themselves with quantum field theory and the mathematical methods used in this field. It is accessible to graduate students in physics and mathematics.

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.

Dualizable Tensor Categories Christopher L. Douglas, Christopher Schommer-Pries, Noah Snyder, 2021-06-18 We investigate the relationship between the algebra of tensor categories and the topology of framed 3-manifolds. On the one hand, tensor categories with certain algebraic properties determine topological invariants. We prove that fusion categories of nonzero global dimension are 3-dualizable, and therefore provide 3-dimensional 3-framed local field theories. We also show that all finite tensor categories are 2-dualizable, and yield categorified 2-dimensional 3-framed local field theories. On the other hand, topological properties of 3-framed manifolds determine algebraic equations among functors of tensor categories. We show that the 1-dimensional loop bordism, which exhibits a single full rotation, acts as the double dual

autofunctor of a tensor category. We prove that the 2-dimensional belt-trick bordism, which unravels a double rotation, operates on any finite tensor category, and therefore supplies a trivialization of the quadruple dual. This approach produces a quadruple-dual theorem for suitably dualizable objects in any symmetric monoidal 3-category. There is furthermore a correspondence between algebraic structures on tensor categories and homotopy fixed point structures, which in turn provide structured field theories; we describe the expected connection between pivotal tensor categories and combed fixed point structures, and between spherical tensor categories and oriented fixed point structures.

Non-Semisimple Topological Quantum Field Theories for 3-Manifolds with Corners Thomas Kerler, Volodymyr V. Lyubashenko, 2014-09-01

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In a world defined by information and interconnectivity, the enchanting power of words has acquired unparalleled significance. Their power to kindle emotions, provoke contemplation, and ignite transformative change is really awe-inspiring. Enter the realm of "**Frobenius Algebras And 2d Topological Quantum Fiel**," a mesmerizing literary masterpiece penned with a distinguished author, guiding readers on a profound journey to unravel the secrets and potential hidden within every word. In this critique, we shall delve into the book's central themes, examine its distinctive writing style, and assess its profound impact on the souls of its readers.

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