

V. RIVASSEAU

# From Perturbative to Constructive Renormalization



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# From Perturbative To Constructive Renormalization

**Vincent Rivasseau**



## **From Perturbative To Constructive Renormalization:**

*From Perturbative to Constructive Renormalization* Vincent Rivasseau, 2014-07-14 The last decade has seen striking progress in the subject of renormalization in quantum field theory The old subject of perturbative renormalization has been revived by the use of powerful methods such as multiscale decompositions precise estimates have been added to the initial theorems on finiteness of renormalized perturbation theory with new results on its large order asymptotics Furthermore constructive field theory has reached one of its major goals the mathematically rigorous construction of some renormalizable quantum field theories For these models one can in particular investigate rigorously the phenomenon of asymptotic freedom which plays a key role in our current understanding of the interaction among elementary particles However until this book there has been no pedagogical synthesis of these new developments Vincent Rivasseau who has been actively involved in them now describes them for a wider audience There are in fact common concepts at the heart of the progress on perturbative and constructive techniques Exploiting these similarities the author uses perturbative renormalization which is the more widely known and conceptually simpler of the two cases to explain the less familiar but more mathematically meaningful constructive renormalization Originally published in 1991 The Princeton Legacy Library uses the latest print on demand technology to again make available previously out of print books from the distinguished backlist of Princeton University Press These editions preserve the original texts of these important books while presenting them in durable paperback and hardcover editions The goal of the Princeton Legacy Library is to vastly increase access to the rich scholarly heritage found in the thousands of books published by Princeton University Press since its founding in 1905 **From**

**Perturbative to Constructive Renormalization** Vincent Rivasseau, 1991 Wavelets And Renormalization Guy Battle, 1999-03-03 WAVELETS AND RENORMALIZATION describes the role played by wavelets in Euclidean field theory and classical statistical mechanics The author begins with a stream lined introduction to quantum field theory from a rather basic point of view Functional integrals for imaginary time ordered expectations are introduced early and naturally while the connection with the statistical mechanics of classical spin systems is introduced in a later chapter A vastly simplified wavelet version of the celebrated Glimm Jaffe construction of the 43 quantum field theory is presented It is due to Battle and Federbush and it bases an inductively defined cluster expansion on a wavelet decomposition of the Euclidean quantum field The presentation is reserved for the last chapter while the more basic aspects of cluster expansions are reviewed in the chapter on classical spin systems Wavelets themselves are studied from two different points of view arising from two disciplines The mathematical point of view covers the basic properties of wavelets and methods for constructing well known wavelets such as Meyer wavelets Daubechies wavelets etc The physical point of view covers the renormalization group formalism where there is a close connection between wavelets and Gaussian fixed points The book is heavily mathematical but avoids the theorem proof theorem proof format in the interests of preserving the flow of the discussion i e it is written in

the style of an old fashioned theoretical physics book but the major claims are rigorously proven The minor themes of the book are reflection positivity the combinatorics of cluster expansions and the issue of phase transitions themes which have nothing to do with wavelets but which provide necessary cultural background for the physical context

*Renormalization and Galois Theories* Frédéric Fauvet, Jean-Pierre Ramis, 2009 This volume is the outcome of a CIRM Workshop on Renormalization and Galois Theories held in Luminy France in March 2006 The subject of this workshop was the interaction and relationship between four currently very active areas renormalization in quantum field theory QFT differential Galois theory noncommutative geometry motives and Galois theory The last decade has seen a burst of new techniques to cope with the various mathematical questions involved in QFT with notably the development of a Hopf algebraic approach and insights into the classes of numbers and special functions that systematically appear in the calculations of perturbative QFT pQFT The analysis of the ambiguities of resummation of the divergent series of pQFT an old problem has been renewed using recent results on Gevrey asymptotics generalized Borel summation Stokes phenomenon and resurgent functions The purpose of the present book is to highlight in the context of renormalization the convergence of these various themes orchestrated by diverse Galois theories It contains three lecture courses together with five research articles and will be useful to both researchers and graduate students in mathematics and physics

Renormalization Manfred Salmhofer, 2013-03-14 Why another book on the renormalization of field theory This book aims to contribute to the bridging of the gap between the treatments of renormalization in physics courses and the mathematically rigorous approach It provides a simple but rigorous introduction to perturbative renormalization and in doing so also equips the reader with some basic techniques which are a prerequisite for studying renormalization nonperturbatively Beside these technical issues it also contains a proof of renormalizability of  $\phi^4$  theory in  $d = 4$  dimensions and a discussion of renormalization for systems with a Fermi surface which are realistic models for electrons in metals Like the two courses on which it is based the book is intended to be easily accessible to mathematics and physics students from the third year on and after going through it one should be able to start reading the current literature on the subject in particular on nonperturbative renormalization Chapter 1 provides a brief motivation for studying quantum theory by functional integrals as well as the setup In Chap 2 the techniques of Gaussian integration and Feynman graph expansions are introduced I then give simple proofs of basic results such as the theorem that the logarithm of the generating functional is a sum of values of connected Feynman graphs In Chap 3 the Wilson renormalization flow is defined and perturbative renormalizability of  $\phi^4$  theory in  $d = 4$  dimensions is proven using a renormalization group differential equation The Feynman graph expansion of Chap 3

**Principles Of Phase Structures In Particle Physics** Hildegard Meyer-ortmanns, Thomas Reisz, 2006-12-06 The phase structure of particle physics shows up in matter at extremely high densities and or temperatures as they were reached in the early universe shortly after the big bang or in heavy ion collisions as they are performed nowadays in laboratory experiments In contrast to phase transitions of condensed

matter physics the underlying fundamental theories are better known than their macroscopic manifestations in phase transitions These theories are quantum chromodynamics for the strong interaction part and the electroweak part of the Standard Model for the electroweak interaction It is their non Abelian gauge structure that makes it a big challenge to predict the type of phase conversion between phases of different symmetries and different particle contents The book is about a variety of analytical and numerical tools that are needed to study the phase structure of particle physics To these belong convergent and asymptotic expansions in strong and weak couplings dimensional reduction renormalization group studies gap equations Monte Carlo simulations with and without fermions finite size and finite mass scaling analyses and the approach of effective actions as supplement to first principle calculations

**CPT Invariance and the Spin-Statistics Connection** Jonathan Bain, 2016-04-08 This book seeks to answer the question What explains CPT invariance and the spin statistics connection These properties play foundational roles in relativistic quantum field theories RQFTs are supported by high precision experiments and figure into explanations of a wide range of phenomena from antimatter to the periodic table of the elements to superconductors and superfluids They can be derived in RQFTs by means of the famous CPT and Spin Statistics theorems but the author argues these theorems cannot be said to explain these properties at least under standard philosophical accounts of scientific explanation This is because there are multiple in some cases incompatible ways of deriving these theorems and secondly because the theorems fail for the types of theories that underwrite the empirical evidence non relativistic quantum theories and realistic interacting RQFTs The goal of this book is to work towards an understanding of CPT invariance and the spin statistics connection by first providing an analysis of the necessary and sufficient conditions for these properties and second by advocating a particular account of explanation appropriate for this context

Introduction to Algebraic and Constructive Quantum Field Theory John C. Baez, Irving E. Segal, Zhengfang Zhou, 2014-07-14 The authors present a rigorous treatment of the first principles of the algebraic and analytic core of quantum field theory Their aim is to correlate modern mathematical theory with the explanation of the observed process of particle production and of particle wave duality that heuristic quantum field theory provides Many topics are treated here in book form for the first time from the origins of complex structures to the quantization of tachyons and domains of dependence for quantized wave equations This work begins with a comprehensive analysis in a universal format of the structure and characterization of free fields which is illustrated by applications to specific fields Nonlinear local functions of both free fields or Wick products and interacting fields are established mathematically in a way that is consistent with the basic physical constraints and practice Among other topics discussed are functional integration Fourier transforms in Hilbert space and implementability of canonical transformations The authors address readers interested in fundamental mathematical physics and who have at least the training of an entering graduate student A series of lexicons connects the mathematical development with the underlying physical motivation or interpretation The examples and problems illustrate

the theory and relate it to the scientific literature Originally published in 1992 The Princeton Legacy Library uses the latest print on demand technology to again make available previously out of print books from the distinguished backlist of Princeton University Press These editions preserve the original texts of these important books while presenting them in durable paperback and hardcover editions The goal of the Princeton Legacy Library is to vastly increase access to the rich scholarly heritage found in the thousands of books published by Princeton University Press since its founding in 1905

*Pascos '94 - Proceedings Of The Fourth International Symposium On Particles, Strings And Cosmology* Kameshwar C Wali, 1995-03-31 This proceedings volume is sixth in the series of international conferences covering the fission quasi fission fusion fission phenomena and synthesis of superheavy nuclei mainly at low or near barrier energies Both experimental and theoretical issues are covered The topics are discussed by a group of participants and an overview of the current activities in the field is given

**Seventh Marcel Grossmann Meeting, The: On Recent Developments In Theoretical And Experimental General Relativity, Gravitation, And Relativistic Field Theories - Proceedings Of The 7th Marcel Grossmann Meeting (In 2 Parts)** Remo Ruffini, George Mac Keiser, Robert T Jantzen, 1997-03-19 Since 1975 the triennial Marcel Grossmann Meetings have been organized in order to provide opportunities for discussing recent advances in gravitation general relativity and relativistic field theories emphasizing mathematical foundations physical predictions and experimental tests The proceedings of the Seventh Marcel Grossmann Meeting include the invited papers given at the plenary sessions the summaries of the parallel sessions the contributed papers presented at the parallel sessions and the evening public lectures The authors of these papers discuss many of the recent theoretical observational and experimental developments that have significant implications for the fields of physics cosmology and relativistic astrophysics

**Combinatorial Physics** Adrian Tanasa, 2021 The goal of the book is to use combinatorial techniques to solve fundamental physics problems and vice versa to use theoretical physics techniques to solve combinatorial problems

**Symmetries and Groups in Contemporary Physics** Chengming Bai, 2013 This volume focuses on developments in the field of group theory in its broadest sense and is of interest to theoretical and experimental physicists mathematicians and scientists in related disciplines who are interested in the latest methods and applications In an increasingly ultra specialized world this volume will demonstrate the interchange of ideas and methods in theoretical and mathematical physics

**Prospects in Mathematics** Hugo Rossi, In celebration of Princeton University's 250th anniversary the mathematics department held a conference entitled Prospects in Mathematics The purpose of the conference was to speculate on future directions of research in mathematics This collection of articles provides a rich panorama of current mathematical activity in many research areas From Gromov's lecture on quantitative differential topology to Witten's discussion of string theory new ideas and techniques transfixed the audience of international mathematicians The volume contains 11 articles by leading mathematicians including historical presentations by J Milnor and D Spencer It provides a guide to some of the most

significant mathematical work of the past decade

**Renormalization Group** Giuseppe Benfatto, Giovanni

Gallavotti, 2020-11-10 Scaling and self similarity ideas and methods in theoretical physics have in the last twenty five years coalesced into renormalization group methods This book analyzes from a single perspective some of the most important applications the critical point theory in classical statistical mechanics the scalar quantum field theories in two and three space time dimensions and Tomonaga's theory of the ground state of one dimensional Fermi systems The dimension dependence is discussed together with the related existence of anomalies in Tomonaga's theory and in 4 e dimensions for the critical point The theory of Bose condensation at zero temperature in three space dimensions is also considered Attention is focused on results that can in principle be formally established from a mathematical point of view The 4 e dimensions theory Bose condensation as well as a few other statements are exceptions to this rule because no complete treatment is yet available However the truly mathematical details are intentionally omitted and only referred to This is done with the purpose of stressing the unifying conceptual structure rather than the technical differences or subtleties

**Tensorial Methods and Renormalization in Group Field Theories** Sylvain Carrozza, 2014-04-12 The main focus of this thesis is the mathematical structure of Group Field Theories GFTs from the point of view of renormalization theory Such quantum field theories are found in approaches to quantum gravity related on the one hand to Loop Quantum Gravity LQG and on the other to matrix and tensor models Background material on these topics including conceptual and technical aspects are introduced in the first chapters The work then goes on to explain how the standard tools of Quantum Field Theory can be generalized to GFTs and exploited to study the large cut off behaviour and renormalization group transformations of the latter Among the new results derived in this context are a proof of renormalizability of a three dimensional GFT with gauge group  $SU(2)$  which opens the way to applications of the formalism to quantum gravity

**Mathematical Methods of Many-Body Quantum Field**

**Theory** Detlef Lehmann, 2004-08-30 Mathematical Methods of Many Body Quantum Field Theory offers a comprehensive mathematically rigorous treatment of many body physics It develops the mathematical tools for describing quantum many body systems and applies them to the many electron system These tools include the formalism of second quantization field theoretical perturbation theory functional integral methods bosonic and fermionic and estimation and summation techniques for Feynman diagrams Among the physical effects discussed in this context are BCS superconductivity s wave and higher l wave and the fractional quantum Hall effect While the presentation is mathematically rigorous the author does not focus solely on precise definitions and proofs but also shows how to actually perform the computations Presenting many recent advances and clarifying difficult concepts this book provides the background results and detail needed to further explore the issue of when the standard approximation schemes in this field actually work and when they break down At the same time its clear explanations and methodical step by step calculations shed welcome light on the established physics literature

*Quantum Theory from Small to Large Scales* Jürg Frohlich, Manfred Salmhofer, Vieri Mastropietro, Wojciech De

Roeck, Leticia F. Cugliandolo, 2012-05-24 This book collects lecture courses and seminars given at the Les Houches Summer School 2010 on Quantum Theory From Small to Large Scales Fundamental quantum phenomena appear on all scales from microscopic to macroscopic Some of the pertinent questions include the onset of decoherence the dynamics of collective modes the influence of external randomness and the emergence of dissipative behaviour Our understanding of such phenomena has been advanced by the study of model systems and by the derivation and analysis of effective dynamics for large systems and over long times In this field research in mathematical physics has regularly contributed results that were recognized as essential in the physics community During the last few years the key questions have been sharpened and progress on answering them has been particularly strong This book reviews the state of the art developments in this field and provides the necessary background for future studies All chapters are written from a pedagogical perspective making the book accessible to master and PhD students and researchers willing to enter this field

**Quantum Field Theory I: Basics in Mathematics and Physics** Eberhard Zeidler, 2007-04-18 This is the first volume of a modern introduction to quantum field theory which addresses both mathematicians and physicists at levels ranging from advanced undergraduate students to professional scientists The book bridges the acknowledged gap between the different languages used by mathematicians and physicists For students of mathematics the author shows that detailed knowledge of the physical background helps to motivate the mathematical subjects and to discover interesting interrelationships between quite different mathematical topics For students of physics fairly advanced mathematics is presented which goes beyond the usual curriculum in physics

*Mathematical Reviews*, 2002 [The Millennium Prize Problems](#) James Carlson, Arthur Jaffe, Andrew Wiles, 2023-09-14 On August 8 1900 at the second International Congress of Mathematicians in Paris David Hilbert delivered his famous lecture in which he described twenty three problems that were to play an influential role in mathematical research A century later on May 24 2000 at a meeting at the Collège de France the Clay Mathematics Institute CMI announced the creation of a US 7 million prize fund for the solution of seven important classic problems which have resisted solution The prize fund is divided equally among the seven problems There is no time limit for their solution The Millennium Prize Problems were selected by the founding Scientific Advisory Board of CMI Alain Connes Arthur Jaffe Andrew Wiles and Edward Witten after consulting with other leading mathematicians Their aim was somewhat different than that of Hilbert not to define new challenges but to record some of the most difficult issues with which mathematicians were struggling at the turn of the second millennium to recognize achievement in mathematics of historical dimension to elevate in the consciousness of the general public the fact that in mathematics the frontier is still open and abounds in important unsolved problems and to emphasize the importance of working towards a solution of the deepest most difficult problems The present volume sets forth the official description of each of the seven problems and the rules governing the prizes It also contains an essay by Jeremy Gray on the history of prize problems in mathematics



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