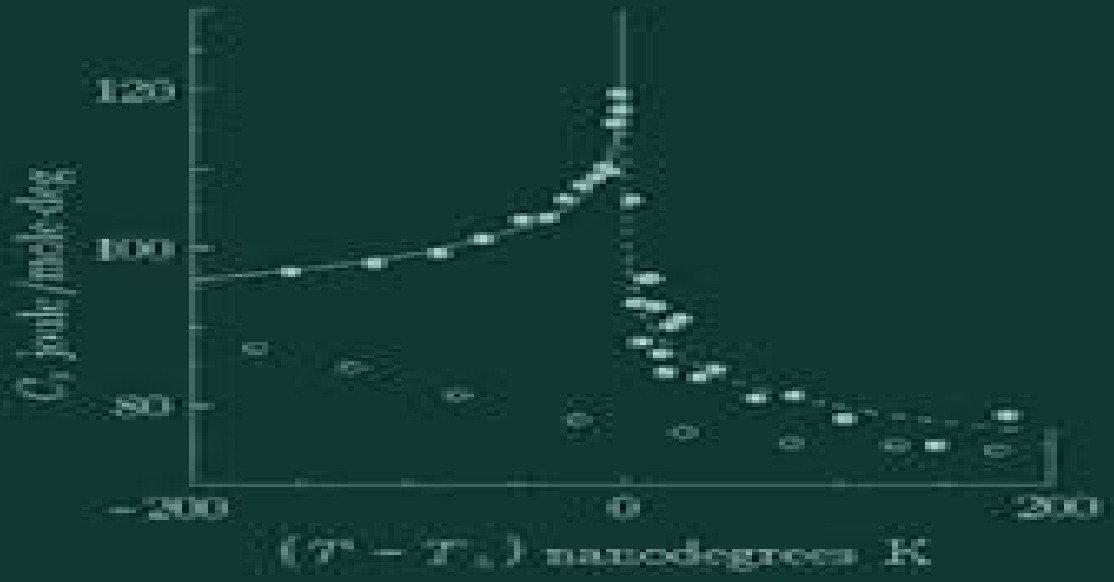
Critical Properties of ϕ^4 - Theories

Hagen Kleinert
Verena Schulte-Frohlinde



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Critical Properties Of O4 Theories:

Critical Properties of [Greek Letter Phi]4-theories Hagen Kleinert,Verena Schulte-Frohlinde,2001 This book explains in detail how to perform perturbation expansions in quantum field theory to high orders and how to extract the critical properties of the theory from the resulting divergent power series These properties are calculated for various second order phase transitions of three dimensional systems with high accuracy in particular the critical exponents observable in experiments close to the phase transition Beginning with an introduction to critical phenomena this book develops the functional integral description of quantum field theories their perturbation expansions and a method for finding recursively all Feynman diagrams to any order in the coupling strength Algebraic computer programs are supplied on accompanying World Wide Web pages The diagrams correspond to integrals in momentum space They are evaluated in 4 dimensions where they possess pole terms in 1 The pole terms are collected into renormalization constants The theory of the renormalization group is used to find the critical scaling laws They contain critical exponents which are obtained from the renormalization constants in the form of power series These are divergent due to factorially growing expansion coefficients The evaluation requires resummation procedures which are performed in two ways 1 using traditional methods based on Pad and Borel transformations combined with analytic mappings 2 using modern variational perturbation theory where the results follow from a simple strong coupling formula As a crucial test of the accuracy of the methods the critical exponent governing the divergence of the specific heat of superfluid helium is shown to agree very well with the extremely precise experimental number found in the space shuttle orbiting the earth whose data are displayed on the cover of the book The phi4 theories investigated in this book contain any number N of fields in an O N symmetric interaction or in an interaction in which O N symmetry is broken by a term of a cubic symmetry The crossover behavior between the different symmetries is investigated In addition alternative ways of obtaining critical exponents of phi4 theories are sketched such as variational perturbation expansions in three rather than 4 dimensions and improved ratio tests in high temperature expansions of lattice models

Critical Properties Of Phi4- Theories Hagen Kleinert,Verena Schulte-frohlinde,2001-07-30 This book explains in detail how to perform perturbation expansions in quantum field theory to high orders and how to extract the critical properties of the theory from the resulting divergent power series These properties are calculated for various second order phase transitions of three dimensional systems with high accuracy in particular the critical exponents observable in experiments close to the phase transition Beginning with an introduction to critical phenomena this book develops the functional integral description of quantum field theories their perturbation expansions and a method for finding recursively all Feynman diagrams to any order in the coupling strength Algebraic computer programs are supplied on accompanying World Wide Web pages The diagrams correspond to integrals in momentum space They are evaluated in 4 dimensions where they possess pole terms in 1 The pole terms are collected into renormalization constants The theory of the renormalization group is used to find

the critical scaling laws They contain critical exponents which are obtained from the renormalization constants in the form of power series These are divergent due to factorially growing expansion coefficients The evaluation requires resummation procedures which are performed in two ways 1 using traditional methods based on Pad and Borel transformations combined with analytic mappings 2 using modern variational perturbation theory where the results follow from a simple strong coupling formula As a crucial test of the accuracy of the methods the critical exponent governing the divergence of the specific heat of superfluid helium is shown to agree very well with the extremely precise experimental number found in the space shuttle orbiting the earth whose data are displayed on the cover of the book The phi4 theories investigated in this book contain any number N of fields in an O N symmetric interaction or in an interaction in which O N symmetry is broken by a term of a cubic symmetry The crossover behavior between the different symmetries is investigated In addition alternative ways of obtaining critical exponents of phi4 theories are sketched such as variational perturbation expansions in three rather than 4 dimensions and improved ratio tests in high temperature expansions of lattice models *A Modern Approach to Critical Phenomena* Igor Herbut,2007-01-04 Critical phenomena is one of the most exciting areas of modern physics This 2007 book provides a thorough but economic introduction into the principles and techniques of the theory of critical phenomena and the renormalization group from the perspective of modern condensed matter physics Assuming basic knowledge of quantum and statistical mechanics the book discusses phase transitions in magnets superfluids superconductors and gauge field theories Particular attention is given to topics such as gauge field fluctuations in superconductors the Kosterlitz Thouless transition duality transformations and quantum phase transitions all of which are at the forefront of physics research This book contains numerous problems of varying degrees of difficulty with solutions These problems provide readers with a wealth of material to test their understanding of the subject It is ideal for graduate students and more experienced researchers in the fields of condensed matter physics statistical physics and many body physics

Order, Disorder And Criticality: Advanced Problems Of Phase Transition Theory - Volume 2 Yurij Holovatch,2007-07-05 This book is the second volume of review papers on advanced problems of phase transitions and critical phenomena following the success of the first volume in 2004 Broadly the volume aims to demonstrate that the phase transition theory which experienced its golden age during the 70s and 80s is far from over and there is still a good deal of work to be done both at the fundamental level and in respect of applications The topics presented in this volume include critical behavior as explained by the non perturbative renormalization group critical dynamics a spacetime approach to phase transitions self organized criticality and exactly solvable models of phase transitions in strongly correlated systems As the first volume this book is based on the review lectures that were given in Lviv Ukraine at the Ising lectures a traditional annual workshop on phase transitions and critical phenomena which brings together scientists working in the field with university students and those who are interested in the subject **The Critical Point** C Domb,1996-02-20 The relationship

between liquids and gases engaged the attention of a number of distinguished scientists in the mid 19th Century In a definitive paper published in 1869 Thomas Andrews described experiments he performed on carbon dioxide and from which he concluded that a critical temperature exists below which liquids and gases are distinct phase Line Defects in Conformal Field Theory Julien Barrat,2025-01-02 This book investigates conformal line defects in both the weak and strong coupling regimes Conformal field theory finds applications across diverse fields from statistical systems at criticality to quantum gravity through the AdS CFT correspondence These theories are subject to strong constraints enabling a systematic non perturbative analysis Conformal defects provide a controlled means of breaking the symmetry introducing new physical phenomena while preserving crucial benefits of the underlying conformal symmetry Two distinct classes of models are studied First we focus on the supersymmetric Wilson line in N 4 Super Yang Mills which serves as an ideal testing ground for the development of innovative techniques such as the analytic conformal bootstrap The second class consists of magnetic lines in Yukawa models which have fascinating applications in 3d condensed matter systems These systems have the potential to emulate phenomena observed in the Standard Model in a low energy setting A Philosophical Approach to Quantum Field Theory Hans Christian Öttinger,2018-01-11 This text presents an intuitive and robust mathematical image of fundamental particle physics based on a novel approach to quantum field theory which is guided by four carefully motivated metaphysical postulates In particular the book explores a dissipative approach to quantum field theory which is illustrated for scalar field theory and quantum electrodynamics and proposes an attractive explanation of the Planck scale in quantum gravity Offering a radically new perspective on this topic the book focuses on the conceptual foundations of quantum field theory and ontological questions It also suggests a new stochastic simulation technique in quantum field theory which is complementary to existing ones Encouraging rigor in a field containing many mathematical subtleties and pitfalls this text is a helpful companion for students of physics and philosophers interested in quantum field theory and it allows readers to gain an intuitive rather than a formal understanding The Large N Expansion in Quantum Field Theory and Statistical Physics E. Br□zin,Spenta R. Wadia,1993 This book contains an edited comprehensive collection of reprints on the subject of the large N limit as applied to a wide spectrum of problems in quantum field theory and statistical mechanics The topics include 1 Spin Systems 2 Large N Limit of Gauge Theories 3 Two Dimensional QCD 4 Exact Results on Planar Perturbation Series and the Nature of the 1 N Series 5 Schwinger Dyson Equations Approach 6 QCD Phenomenological Lagrangians and the Large N Limit 7 Other Approaches to Large N Eguchi Kawai Model Collective Fields and Numerical Methods 8 Matrix Models 9 Two Dimensional Gravity and String Theory **Path Integrals in Quantum Mechanics, Statistics, Polymer Physics, and Financial Markets** Hagen Kleinert,2004-03-05 This is the third significantly expanded edition of the comprehensive textbook published in 1990 on the theory and applications of path integrals It is the first book to explicitly solve path integrals of a wide variety of nontrivial quantum mechanical systems in particular the hydrogen atom The solutions have

become possible by two major advances The first is a new euclidean path integral formula which increases the restricted range of applicability of Feynman s famous formula to include singular attractive 1 r and 1 r2 potentials The second is a simple quantum equivalence principle governing the transformation of euclidean path integrals to spaces with curvature and torsion which leads to time sliced path integrals that are manifestly invariant under coordinate transformations In addition to the time sliced definition the author gives a perturbative definition of path integrals which makes them invariant under coordinate transformations A consistent implementation of this property leads to an extension of the theory of generalized functions by defining uniquely integrals over products of distributions The powerful Feynman Kleinert variational approach is explained and developed systematically into a variational perturbation theory which in contrast to ordinary perturbation theory produces convergent expansions The convergence is uniform from weak to strong couplings opening a way to precise approximate evaluations of analytically unsolvable path integrals Tunneling processes are treated in detail The results are used to determine the lifetime of supercurrents the stability of metastable thermodynamic phases and the large order behavior of perturbation expansions A new variational treatment extends the range of validity of previous tunneling theories from large to small barriers A corresponding extension of large order perturbation theory also applies now to small orders Special attention is devoted to path integrals with topological restrictions These are relevant to the understanding of the statistical properties of elementary particles and the entanglement phenomena in polymer physics and biophysics The Chern Simons theory of particles with fractional statistics anyons is introduced and applied to explain the fractional quantum Hall effect The relevance of path integrals to financial markets is discussed and improvements of the famous Black Scholes formula for option prices are given which account for the fact that large market fluctuations occur much more frequently than in the commonly used Gaussian distributions The author s other book on Critical Properties of 4 Theories gives a thorough introduction to the field of critical phenomena and develops new powerful resummation techniques for the extraction of physical results from the divergent perturbation expansions Request Inspection Copy **Lectures Of Sidney Coleman On Quantum Field Theory: Foreword By David Kaiser** Bryan Gin-ge Chen,David Derbes,David Griffiths,Brian Hill,Richard Sohn,Yuan-sen Ting,2018-11-08 Sidney Coleman was the master teacher of quantum field theory All of us who knew him became his students and disciples Sidney s legendary course remains fresh and bracing because he chose his topics with a sure feel for the essential and treated them with elegant economy Frank WilczekNobel Laureate in Physics 2004Sidney Coleman was a physicist s physicist He is largely unknown outside of the theoretical physics community and known only by reputation to the younger generation He was an unusually effective teacher famed for his wit his insight and his encyclopedic knowledge of the field to which he made many important contributions There are many first rate quantum field theory books the venerable Bjorken and Drell the more modern Itzykson and Zuber the now standard Peskin and Schroeder and the recent Zee but the immediacy of Prof Coleman s approach and his ability to present an argument simply

without sacrificing rigor makes his book easy to read and ideal for the student Part of the motivation in producing this book is to pass on the work of this outstanding physicist to later generations a record of his teaching that he was too busy to leave himself **Critical Phenomena in Loop Models** Adam Nahum,2014-10-01 When close to a continuous phase transition many physical systems can usefully be mapped to ensembles of fluctuating loops which might represent for example polymer rings or line defects in a lattice magnet or worldlines of quantum particles Loop models provide a unifying geometric language for problems of this kind This thesis aims to extend this language in two directions The first part of the thesis tackles ensembles of loops in three dimensions and relates them to the statistical properties of line defects in disordered media and to critical phenomena in two dimensional quantum magnets The second part concerns two dimensional loop models that lie outside the standard paradigms new types of critical point are found and new results given for the universal properties of polymer collapse transitions in two dimensions All of these problems are shown to be related to sigma models on complex or real projective space CP n 1 or RP n 1 in some cases in a replica limit and this thesis is also an in depth investigation of critical behaviour in these field theories **Introduction To The Theory Of Critical Phenomena: Mean Field, Fluctuations And Renormalization (2nd Edition)** Dimo I Uzunov,2010-08-31 This book provides a comprehensive introduction to the theory of phase transitions and critical phenomena The content covers a period of more than 100 years of theoretical research of condensed matter phases and phase transitions providing a clear interrelationship with experimental problems It starts from certain basic University knowledge of thermodynamics statistical physics and quantum mechanics The text is illustrated with classic examples of phase transitions Various types of phase transition and multi critical points are introduced and explained The classic aspects of the theory are naturally related with the modern developments This interrelationship and the field theoretical renormalization group method are presented in details The main applications of the renormalization group methods are presented Special attention is paid to the description of quantum phase transitions This edition contains a more detailed presentation of the renormalization group method and its applications to particular systems Critical Phenomena Melville S. Green,J. V. Sengers,1966 Critical Phenomena CEAUSESCU,COSTACHE,GEORGESCU,2013-11-21 **Path Integrals In Quantum Mechanics, Statistics, Polymer Physics, And Financial Markets (5th Edition)** Hagen Kleinert,2009-05-18 This is the fifth expanded edition of the comprehensive textbook published in 1990 on the theory and applications of path integrals It is the first book to explicitly solve path integrals of a wide variety of nontrivial quantum mechanical systems in particular the hydrogen atom The solutions have been made possible by two major advances The first is a new euclidean path integral formula which increases the restricted range of applicability of Feynman s time sliced formula to include singular attractive 1 r and 1 r2 potentials The second is a new nonholonomic mapping principle carrying physical laws in flat spacetime to spacetimes with curvature and torsion which leads to time sliced path integrals that are manifestly invariant under coordinate transformations In

addition to the time sliced definition the author gives a perturbative coordinate independent definition of path integrals which makes them invariant under coordinate transformations A consistent implementation of this property leads to an extension of the theory of generalized functions by defining uniquely products of distributions The powerful Feynman Kleinert variational approach is explained and developed systematically into a variational perturbation theory which in contrast to ordinary perturbation theory produces convergent results The convergence is uniform from weak to strong couplings opening a way to precise evaluations of analytically unsolvable path integrals in the strong coupling regime where they describe critical phenomena Tunneling processes are treated in detail with applications to the lifetimes of supercurrents the stability of metastable thermodynamic phases and the large order behavior of perturbation expansions A variational treatment extends the range of validity to small barriers A corresponding extension of the large order perturbation theory now also applies to small orders Special attention is devoted to path integrals with topological restrictions needed to understand the statistical properties of elementary particles and the entanglement phenomena in polymer physics and biophysics The Chern Simons theory of particles with fractional statistics anyons is introduced and applied to explain the fractional quantum Hall effect The relevance of path integrals to financial markets is discussed and improvements of the famous Black Scholes formula for option prices are developed which account for the fact recently experienced in the world markets that large fluctuations occur much more frequently than in Gaussian distributions Statistics of Linear Polymers in Disordered Media Bikas K. Chakrabarti,2005-06-09 With the mapping of the partition function graphs of the n vector magnetic model in the n to 0 limit as the self avoiding walks the conformational statistics of linear polymers was clearly understood in early seventies Various models of disordered solids percolation model in particular were also established by late seventies Subsequently investigations on thestatistics of linear polymers or of self avoiding walks in say porous medium or disordered lattices were started in early eighties Inspite of the brilliant ideas forwarded and extensive studies made for the next two decades the problem is not yet completely solved in its generality This intriguing and important problem has remained since a topic of vigorous and active research This book intends to offer the readers a first hand and extensive review of the various aspects of the problem written by the experts in the respective fields We hope the contents of the book will provide a valuable guide for researchers in statistical physics of polymers and will surely induce further research and advances towards a complete understanding of the problem First book on statistics of polymers in random media Contents straight away from research labs Chapters written by foremost experts in the respective fields Theories experiments and computer simulations extensively discussed Includes latest developments in understanding related important topics like DNA unzipping Travelling salesman problem etc Comprehensive index for quick search for keywords *Critical Point Theory and Hamiltonian Systems* Jean Mawhin,2013-04-17 FACHGEB The last decade has seen a tremendous development in critical point theory in infinite dimensional spaces and its application to nonlinear boundary value problems In particular striking

results were obtained in the classical problem of periodic solutions of Hamiltonian systems This book provides a systematic presentation of the most basic tools of critical point theory minimization convex functions and Fenchel transform dual least action principle Ekeland variational principle minimax methods Lusternik Schirelmann theory for Z2 and S1 symmetries Morse theory for possibly degenerate critical points and non degenerate critical manifolds Each technique is illustrated by applications to the discussion of the existence multiplicity and bifurcation of the periodic solutions of Hamiltonian systems Among the treated questions are the periodic solutions with fixed period or fixed energy of autonomous systems the existence of subharmonics in the non autonomous case the asymptotically linear Hamiltonian systems free and forced superlinear problems Application of those results to the equations of mechanical pendulum to Josephson systems of solid state physics and to questions from celestial mechanics are given The aim of the book is to introduce a reader familiar to more classical techniques of ordinary differential equations to the powerful approach of modern critical point theory The style of the exposition has been adapted to this goal The new topological tools are introduced in a progressive but detailed way and immediately applied to differential equation problems The abstract tools can also be applied to partial differential equations and the reader will also find the basic references in this direction in the bibliography of more than 500 items which concludes the book ERSCHEIN Modern Theoretical and Observational Cosmology Manolis Plionis,Spiros Cotsakis,2012-12-06 Proceedings of the second Hellenic Cosmology Meeting held in the National Observatory of Athens Penteli 19 20 April 2001 **Path Integrals In Quantum Mechanics, Statistics, Polymer Physics, And Financial Markets (4th Edition)** Hagen Kleinert,2006-07-19 This is the fourth expanded edition of the comprehensive textbook published in 1990 on the theory and applications of path integrals It is the first book to explicitly solve path integrals of a wide variety of nontrivial quantum mechanical systems in particular the hydrogen atom The solutions have become possible by two major advances The first is a new euclidean path integral formula which increases the restricted range of applicability of Feynman s famous formula to include singular attractive 1 r and 1 r2 potentials The second is a simple quantum equivalence principle governing the transformation of euclidean path integrals to spaces with curvature and torsion which leads to time sliced path integrals that are manifestly invariant under coordinate transformations In addition to the time sliced definition the author gives a perturbative definition of path integrals which makes them invariant under coordinate transformations A consistent implementation of this property leads to an extension of the theory of generalized functions by defining uniquely integrals over products of distributions The powerful Feynman Kleinert variational approach is explained and developed systematically into a variational perturbation theory which in contrast to ordinary perturbation theory produces convergent expansions The convergence is uniform from weak to strong couplings opening a way to precise approximate evaluations of analytically unsolvable path integrals Tunneling processes are treated in detail The results are used to determine the lifetime of supercurrents the stability of metastable thermodynamic phases and the large order

behavior of perturbation expansions A new variational treatment extends the range of validity of previous tunneling theories from large to small barriers A corresponding extension of large order perturbation theory also applies now to small orders Special attention is devoted to path integrals with topological restrictions These are relevant to the understanding of the statistical properties of elementary particles and the entanglement phenomena in polymer physics and biophysics The Chern Simons theory of particles with fractional statistics anyons is introduced and applied to explain the fractional quantum Hall effect The relevance of path integrals to financial markets is discussed and improvements of the famous Black Scholes formula for option prices are given which account for the fact that large market fluctuations occur much more frequently than in the commonly used Gaussian distributions The author s other book on Critical Properties of 4 Theories gives a thorough introduction to the field of critical phenomena and develops new powerful resummation techniques for the extraction of physical results from the divergent perturbation expansions *50 Years Of The Renormalization Group: Dedicated To The Memory Of Michael E Fisher* Amnon Aharony,Ora Entin-wohlman,David A Huse,Leo Radzihovsky,2024-07-26 The contributions in the book are devoted to the memory of Michael E Fisher and hence include many personal memories from people whose work was influenced by him Also the book is a collection of articles from leaders in the field of phase transitions and critical phenomena to celebrate 50 years of the renormalization group and the 1972 paper by Wilson and Fisher Many of the articles review in tutorial form the progress in the fields of phase transitions and the renormalization group

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