Conformal Field Theory Philippe Francesco

Part I gives a detailed, self-contained and mathematically rigorous exposition of classical conformal symmetry in n dimensions and its quantization in two dimensions. The conformal groups are determined and the appearence of the Virasoro algebra in the context of the quantization of two-dimensional conformal symmetry is explained via the classification of central extensions of Lie algebras and groups. Part II surveys more advanced topics of conformal field theory such as the representation theory of the Virasoro algebra, conformal symmetry within string theory, an axiomatic approach to Euclidean conformally covariant quantum field theory and a mathematical interpretation of the Verlinde formula in the context of moduli spaces of holomorphic vector bundles on a Riemann surface.

Volume 2: Superstring Theory and Beyond, begins with an introduction to supersymmetric string theories and goes on to a broad presentation of the important advances of recent years. The book first introduces the type I, type II, and heterotic superstring theories and their interactions. It then goes on to present important recent discoveries about strongly coupled strings, beginning with a detailed treatment of D-branes and their dynamics, and covering string duality, M-theory, and black hole entropy, and discusses many classic results in conformal field theory. The final four chapters are concerned with four-dimensional string theories, and

have two goals: to show how some of the simplest string models connect with previous ideas for unifying the Standard Model; and to collect many important and beautiful general results on world-sheet and spacetime symmetries.

This textbook covers the basic principles of statistical physics and thermodynamics. The text is pitched at the level equivalent to first-year graduate studies or advanced undergraduate studies. It presents the subject in a straightforward and lively manner. After reviewing the basic probability theory of classical thermodynamics, the author addresses the standard topics of statistical physics. The text demonstrates their relevance in other scientific fields using clear and explicit examples. Later chapters introduce phase transitions, critical phenomena and non-equilibrium phenomena.

Twenty-fifth anniversary edition featuring a new Preface, invaluable for graduate students and researchers in high energy physics and astrophysics.

This book describes a relativistic quantum theory developed by the author starting from the E.C.G. Stueckelberg approach proposed in the early 40s. In this framework a universal invariant evolution parameter (corresponding to the time originally postulated by Newton) is introduced to describe dynamical evolution. This theory is able to provide solutions for some of the fundamental problems encountered in early attempts to construct a relativistic quantum theory. A relativistically covariant construction is given for which particle spins and angular momenta can be combined through the usual rotation group Clebsch-Gordan coefficients.

Solutions are defined for both the classical and quantum two body bound state and scattering problems. The recently developed quantum Lax-Phillips theory of semi group evolution of resonant states is described. The experiment of Lindner and coworkers on interference in time is discussed showing how the property of coherence in time provides a simple understanding of the results. The full gauge invariance of the Stueckelberg-Schroedinger equation results in a 5D generalization of the usual gauge theories. A description of this structure and some of its consequences for both Abelian and non-Abelian fields are discussed. A review of the basic foundations of relativistic classical and quantum statistical mechanics is also given. The Bekenstein-Sanders construction for imbedding Milgrom's theory of modified spacetime structure into general relativity as an alternative to dark matter is also studied.

Ever since 1911, the Solvay Conferences have shaped modern physics. The 23rd edition, chaired by 2004 Nobel Laureate David Gross, did not break with that tradition. It gathered most of the leading figures working on the central problem of reconciling Einstein's theory of gravity with quantum mechanics.These proceedings give a broad overview with unique insight into the most fundamental issues raised by this challenge for 21st century physics, by distinguished renowned scientists. The contributions cover: the status of quantum mechanics, spacetime singularities and breakdown of classical space and time, mathematical structures underlying the most promising attempts under current development, spacetime as an emergent concept, as

well as cosmology and the cosmological constant puzzle. A historical overview of the Solvay conferences by historian of sciences Peter Galison opens the volume.In the Solvay tradition, the volume also includes the discussions among the participants ? many of which were quite lively and illustrate dramatically divergent points of view ? carefully edited and reproduced in full.
Providing a new perspective on quantum field theory, this book gives a pedagogical and up-to-date exposition of non-perturbative methods in relativistic quantum field theory and introduces the reader to modern research work in theoretical physics. It describes in detail non-perturbative methods in quantum field theory, and explores two- dimensional and four- dimensional gauge dynamics using those methods. The book concludes with a summary emphasizing the interplay between two- and four- dimensional gauge theories. Aimed at graduate students and researchers, this book covers topics from two-dimensional conformal symmetry, affine Lie algebras, solitons, integrable models, bosonization, and 't Hooft model, to four-dimensional conformal invariance, integrability, large N expansion, Skyrme model, monopoles and instantons. Applications, first to simple field theories and gauge dynamics in two dimensions, and then to gauge theories in four dimensions and quantum chromodynamics (QCD) in particular, are thoroughly described.
New and striking results obtained in recent years from an intensive study of asymptotic combinatorics have led to a new, higher level of understanding of related problems: the theory of integrable systems, the Riemann-Hilbert

problem, asymptotic representation theory, spectra of random matrices, combinatorics of Young diagrams and permutations, and even some aspects of quantum field theory.

Critical phenomena arise in a wide variety of physical systems. Classi cal examples are the liquid-vapour critical point or the paramagnetic ferromagnetic transition. Further examples include multicomponent fluids and alloys, superfluids, superconductors, polymers and fully developed tur bulence and may even extend to the quark-gluon plasma and the early uni verse as a whole. Early theoretical investigators tried to reduce the problem to a very small number of degrees of freedom, such as the van der Waals equation and mean field approximations, culminating in Landau's general theory of critical phenomena. Nowadays, it is understood that the common ground for all these phenomena lies in the presence of strong fluctuations of infinitely many coupled variables. This was made explicit first through the exact solution of the two-dimensional Ising model by Onsager. Systematic subsequent developments have been leading to the scaling theories of critical phenomena and the renormalization group which allow a precise description of the close neighborhood of the critical point, often in good agreement with experiments. In contrast to the general understanding a century ago, the presence of fluctuations on all length scales at a critical point is emphasized today. This can be briefly summarized by saying that at a critical point a system is scale invariant. In addition, conformal invaTiance permits also a non-uniform, local rescal ing, provided only that angles remain unchanged.

The aim of this book is to provide the reader with an introduction to conformal field theory and its applications to topology. The author starts with a description of geometric

aspects of conformal field theory based on loop groups. By means of the holonomy of conformal field theory he defines topological invariants for knots and 3-manifolds. He also gives a brief treatment of Chern-Simons perturbation theory.
The Cargese Workshop "Quantum Field Theory and String Theory" was held from May 10 to May 21, 1993. The broad spectrum of the work presented at the Workshop was the reflec tion of a time of intensive search for new ways of solving some of the most fun damental problems in string theory, quantum gravity and non-perturbative field theory. A number of talks indicated the emergence of new promising domains of investigation. It is this very diversity of topics which, in our opinion, represents one of the most attractive features of the present volume which we hope will provide a good orientation in the abundant flow of ideas and publications in modern quantum field theory. Many contributions to the present proceedings are concerned with two di mensional quantum field theory. The continuous advances in the domain of two dimensional integrable theories on the lattice as well as in the continuum, including conformal field theories, Liouville field theory and matrix models of two dimensional quantum gravity are very well represented. Other papers address physically realistic (and therefore very complicated) problems like de veloped turbulence, the Hofstadter problem, higher dimensional gravity and phenomenological strings. A new elegant class of topological field theories is presented. New ideas in the string representation of multicolor quantum chromo dynamics were widely discussed at the Workshop, more particularly the example of the exactly solvable two dimensional case.
Supergravity, together with string theory, is one of the most significant developments in theoretical physics. Written by two of the most respected workers in the field, this is the first-ever authoritative and systematic account of supergravity. The

book starts by reviewing aspects of relativistic field theory in Minkowski spacetime. After introducing the relevant ingredients of differential geometry and gravity, some basic supergravity theories (D=4 and D=11) and the main gauge theory tools are explained. In the second half of the book, complex geometry and N=1 and N=2 supergravity theories are covered. Classical solutions and a chapter on AdS/CFT complete the book. Numerous exercises and examples make it ideal for Ph.D. students, and with applications to model building, cosmology and solutions of supergravity theories, it is also invaluable to researchers. A website hosted by the authors, featuring solutions to some exercises and additional reading material, can be found at www.cambridge.org/supergravity.

Conformal Field TheorySpringer Science & Business Media

This primer develops Conformal Field Theory (CFT) from scratch, whereby CFT is viewed as any conformally-invariant theory that describes a fixed point of a renormalization group flow in quantum field theory. The book is divided into four lectures: Lecture 1 addresses the physical foundations of conformal invariance, while Lecture 2 examines the constraints imposed by conformal symmetry on the correlation functions of local operators, presented using the so-called projective null cone – a procedure also known as the embedding formalism. In turn, Lecture 3 focuses on the radial quantization and the operator product expansion, while Lecture 4 offers a very brief introduction to the conformal bootstrap. Derived from course-based notes, these lectures are intended as a first point of entry to this topic for Master and PhD students alike.

Notes after each chapter.

Based on class-tested notes, this text offers an introduction to Conformal Field Theory with a special emphasis on computational techniques of relevance for String Theory. It

introduces Conformal Field Theory at a basic level, Kac-Moody algebras, one-loop partition functions, Superconformal Field Theories, Gepner Models and Boundary Conformal Field Theory. Eventually, the concept of orientifold constructions is explained in detail for the example of the bosonic string. In providing many detailed CFT calculations, this book is ideal for students and scientists intending to become acquainted with CFT techniques relevant for string theory but also for students and non-specialists from related fields.

This self-contained text describes the modern mean field theory of simple structural glasses using a quantum statistical mechanical approach. Describing the theory in clear and simple terms, this is a valuable resource for graduate students and researchers working in condensed matter physics and statistical mechanics.

This second volume of Featured Reviews makes available special detailed reviews of some of the most important mathematical articles and books published from 1997 through 1999. Also included are excellent reviews of several classic books and articles published prior to 1970. Among those reviews, for example, are the following: Homological Algebra by Henri Cartan and Samuel Eilenberg, reviewed by G. Hochschild; Faisceaux algebriques coherents by Jean-Pierre Serre, reviewed by C. Chevalley; and On the Theory of General Partial Differential Operators by Lars Hormander, reviewed by J. L. Lions. In particular, those seeking

information on current developments outside their own area of expertise will find the volume very useful. By identifying some of the best publications, papers, and books that have had or are expected to have a significant impact in applied and pure mathematics, this volume will serve as a comprehensive guide to important new research across all fields covered by MR.

This volume contains Introductory Notes and major reprints on conformal field theory and its applications to 2-dimensional statistical mechanics of critical phenomena. The subject relates to many different areas in contemporary physics and mathematics, including string theory, integrable systems, representations of infinite Lie algebras and automorphic functions. Contents:General Principles:Infinite Conformal Symmetry in Two-dimensional Quantum Field Theory (A A Belavin et al.)Conformal Invariance and Surface Critical Behaviour (J Cardy)Mathematical Background:Contravariant Form for Infinite-dimensional Lie Algebras and Superalgebras (V Kac)Verma Modules over the Virasoro Algebra (B Feigin & D Fuks)Unitary Representations of the Virasoro and Super-Virasoro Algebras (P Goddard et al.)Critical Models and Computation of Correlations:Conformal Algebra and Multipoint Correlation Functions in 2D Statistical Models (Vl Dotsenko & V Fateev)On the Identification of Finite

Operator Algebras in Two-dimensional Conformally Invariant Field Theories (P Christe & R Flume)Finite Size Scaling:Conformal Invariance, the Central Charge and Universal Finite Size Amplitudes at Criticality (H Blöte et al.)Universal Term in the Free Energy at a Critical Point and the Conformal Anomaly (I Affleck)Exact Surface and Wedge Exponents for Polymers in Two Dimensions (B Duplantier & H Saleur)Modular Invariance:Modular Invariant Partition Functions in Two Dimensions (A Cappelli et al.)Modular Invariant Partition Functions for Parafermionic Field Theories (D Gepner & Z Qiu)Discrete Symmetries of Conformal Theories (J-B Zuber)Connections With Integrable Systems:Exact Exponents for Infinitely many New Multicritical Points (D Huse)Automorphic Properties of Local Height Probabilities for Integrable Solid-on-solid Models (E Date et al.)Models with c = 1:Correlation Functions on the Critical Lines of the Baxter and Ashkin-Teller Models (L Kadanoff & A Brown)Supersymmetric Critical Phenomena and the Two Dimensional Gaussian Model (D Friedan & S Shenker)Curiosities at c=1 (P Ginsparg)Coulomb Gas Picture:Lattice Derivation of Modular Invariant Partition Functions on the Torus (V Pasquier)Vicinity of the Critical Point:Integrals of Motion in Scaling 3-state Potts Model Field Theory (A Zamolodchikov)Correlation Functions and Higher Topology:The Conformal Field Theory of Orbifolds (L Dixon et al.)Conformal and

Current Algebras on a General Riemann Surface (T Eguchi & H Ooguri)and other papers Readership: Theoretical physicists in particle and statistical physics and mathematicians.

The problem of enumerating maps (a map is a set of polygonal "countries" on a world of a certain topology, not necessarily the plane or the sphere) is an important problem in mathematics and physics, and it has many applications ranging from statistical physics, geometry, particle physics, telecommunications, biology, ... etc. This problem has been studied by many communities of researchers, mostly combinatorists, probabilists, and physicists. Since 1978, physicists have invented a method called "matrix models" to address that problem, and many results have been obtained. Besides, another important problem in mathematics and physics (in particular string theory), is to count Riemann surfaces. Riemann surfaces of a given topology are parametrized by a finite number of real parameters (called moduli), and the moduli space is a finite dimensional compact manifold or orbifold of complicated topology. The number of Riemann surfaces is the volume of that moduli space. Mor e generally, an important problem in algebraic geometry is to characterize the moduli spaces, by computing not only their volumes, but also other characteristic numbers called intersection numbers. Witten's conjecture (which was first proved by

Kontsevich), was the assertion that Riemann surfaces can be obtained as limits of polygonal surfaces (maps), made of a very large number of very small polygons. In other words, the number of maps in a certain limit, should give the intersection numbers of moduli spaces. In this book, we show how that limit takes place. The goal of this book is to explain the "matrix model" method, to show the main results obtained with it, and to compare it with methods used in combinatorics (bijective proofs, Tutte's equations), or algebraic geometry (Mirzakhani's recursions). The book intends to be self-contained and accessible to graduate students, and provides comprehensive proofs, several examples, and give s the general formula for the enumeration of maps on surfaces of any topology. In the end, the link with more general topics such as algebraic geometry, string theory, is discussed, and in particular a proof of the Witten-Kontsevich conjecture is provided.

Presenting the physics of the most challenging problems in condensed matter using the conceptual framework of quantum field theory, this book is of great interest to physicists in condensed matter and high energy and string theorists, as well as mathematicians. Revised and updated, this second edition features new chapters on the renormalization group, the Luttinger liquid, gauge theory, topological fluids, topological insulators and quantum

entanglement. The book begins with the basic concepts and tools, developing them gradually to bring readers to the issues currently faced at the frontiers of research, such as topological phases of matter, quantum and classical critical phenomena, quantum Hall effects and superconductors. Other topics covered include one-dimensional strongly correlated systems, quantum ordered and disordered phases, topological structures in condensed matter and in field theory and fractional statistics.

As recent developments have shown, supersymmetric quantum field theory and string theory are intimately related, with advances in one area often shedding light on the other. The organising ideas of most of these advances are the notion of duality and the physics of higher dimensional objects or p-branes. The topics covered in the present volume include duality in field theory, in particular in supersymmetric field theory and supergravity, and in string theory. The Seiberg-Witten theory and its recent developments are also covered in detail. A large fraction of the volume is devoted to the current state of the art in M-theory, in particular its underlying superalgebra as well as its connection with superstring and N = 2 strings. The physics of D-branes and its essential role in the beautiful computation of the black hole entropy is also carefully covered. Finally, the last two sets of

lectures are devoted to the exciting matrix approach to non-perturbative string theory.

Filling an important gap in the literature, this comprehensive text develops conformal field theory from first principles. The treatment is self-contained, pedagogical, and exhaustive, and includes a great deal of background material on quantum field theory, statistical mechanics, Lie algebras and affine Lie algebras. The many exercises, with a wide spectrum of difficulty and subjects, complement and in many cases extend the text. The text is thus not only an excellent tool for classroom teaching but also for individual study. Intended primarily for graduate students and researchers in theoretical high-energy physics, mathematical physics, condensed matter theory, statistical physics, the book will also be of interest in other areas of theoretical physics and mathematics. It will prepare the reader for original research in this very active field of theoretical and mathematical physics.

The purpose of this book is to thoroughly prepare the reader for research in string theory at an intermediate level. As such it is not a compendium of results but intended as textbook in the sense that most of the material is organized in a pedagogical and self-contained fashion. Beyond the basics, a number of more advanced topics are introduced, such as conformal field theory, superstrings and string dualities - the text does not cover applications

to black hole physics and cosmology, nor strings theory at finite temperatures. End-of-chapter references have been added to guide the reader wishing to pursue further studies or to start research in well-defined topics covered by this book.

Lie!algebras - Topological!groups - Lie!groups - Representations - Special!functions - Induced!representations.

' The monograph summarizes recent achievements in the calculation of matrix elements of local operators (form factors) for completely integrable models. Particularly, it deals with sine-Gordon, chiral Gross-Neven and O(3) nonlinear s models. General requirements on form factors are formulated and explicit formulas for form factors of most fundamental local operators are presented for the above mentioned models. Contents:Completely Integrable Models of Quantum Field TheoryThe Space of Physical StatesThe Necessary Properties of Form FactorsThe Local Commutativity TheoremSoliton Form Factors in SG ModelThe Main Properties of the Soliton Form FactorsBreathers Form Factors in SG ModelProperties of the Operators j?, T??, exp(± i?u/2) in SG ModelForm Factors in SU(2)-Invariant Thirring ModelForm Factors in O(3)-Nonlinear ?-modelAsymptotics of Form FactorsCurrent AlgebrasForm Factors in SU(N) — Invariant Thirring Model (SU(N) Chiral Gross-Neveu Model)Phenomenological Reasonings Readership: Mathematical physicists. Keywords:Integrable;Quantum Field Theory in Two Dimensions;S-Matrix;Existence of Completely Integrable Models;Scattering Operator;Many-Particle Scattering;Yang-Baxter Triangle Equation;Soluable Lattice Models of Classical Statistical Mechanics;Form Factors;Zamolodchikov-Faddeev Approach;SU(2)-Invariant Thirring Model;Kinks;O(3)-Invariant

?-Model “It will be of great help to those who look for a reliable source of the numerous detailed calculations that have been performed over the years by many experts.” Mathematics Abstracts '

Ever since 1911, the Solvay Conferences have shaped modern physics. The 24th edition chaired by Bertrand Halperin did not break the tradition. Held in October 2008, it gathered in Brussels most of the leading figures working on the ?quantum theory of condensed matter?, addressing some of the most profound open problems in the field. The proceedings contain the ?rapporteur talks? giving a broad overview with unique insights by distinguished renowned scientists. These lectures cover the five sessions treating: mesoscopic and disordered systems; exotic phases and quantum phase transitions in model systems; experimentally realized correlated-electron materials; quantum Hall systems, and one-dimensional systems; systems of ultra-cold atoms, and advanced computational methods. In the Solvay tradition, the proceedings include also the prepared comments to the rapporteur talks. The discussions among the participants ? some of which are quite lively and involving dramatically divergent points of view ? have been carefully edited and reproduced in full.

W-symmetry is an extension of conformal symmetry in two dimensions. Since its introduction in 1985, W-symmetry has become one of the central notions in the study of two-dimensional conformal field theory. The mathematical structures that underlie W-symmetry are so-called W-algebras, which are higher-spin extensions of the Virasoro algebra. This book contains a collection of papers on W-symmetry, covering the period from 1985 through 1993. Its main focus is the construction of W-algebras and their representation theory. A recurrent theme is the intimate connection between W-algebras and affine Lie algebras.

Some of the applications, in particular W-gravity, are also covered.The significance of this reprint volume is that there are no textbooks entirely devoted to the subject.

This book gives an exposition of the relations among the following three topics: monoidal tensor categories (such as a category of representations of a quantum group), 3-dimensional topological quantum field theory, and 2-dimensional modular functors (which naturally arise in 2-dimensional conformal field theory). The following examples are discussed in detail: the category of representations of a quantum group at a root of unity and the Wess-Zumino-Witten modular functor. The idea that these topics are related first appeared in the physics literature in the study of quantum field theory. Pioneering works of Witten and Moore-Seiberg triggered an avalanche of papers, both physical and mathematical, exploring various aspects of these relations. Upon preparing to lecture on the topic at MIT, however, the authors discovered that the existing literature was difficult and that there were gaps to fill. The text is wholly expository and finely succinct. It gathers results, fills existing gaps, and simplifies some proofs. The book makes an important addition to the existing literature on the topic. It would be suitable as a course text at the advanced-graduate level.

A pioneering treatise presenting how the mathematical techniques of holographic duality can unify the fundamental theories of physics.

This research monograph offers an introduction to advanced quantum field theoretical techniques for many-particle systems beyond perturbation theory. Several schemes for resummation of the Feynman diagrams are described. The resulting approximations are especially well suited for strongly correlated fermion and boson systems. Also considered is the crossover from BCS superconductivity to Bose--Einstein condensation in fermion systems with strong attractive

interaction. In particular, a field theoretic formulation of "bosonization" is presented; it is published here for the first time. This method is applied to the fractional quantum Hall effect, to the Coulomb plasma, and to several exactly solvable models.

This volume is a collection of lecture notes for six of the ten courses given in Buzios, Brazil by prominent probabilists at the 2010 Clay Mathematics Institute Summer School, ``Probability and Statistical Physics in Two and More Dimensions'' and at the XIV Brazilian School of Probability. In the past ten to fifteen years, various areas of probability theory related to statistical physics, disordered systems and combinatorics have undergone intensive development. A number of these developments deal with two-dimensional random structures at their critical points, and provide new tools and ways of coping with at least some of the limitations of Conformal Field Theory that had been so successfully developed in the theoretical physics community to understand phase transitions of two-dimensional systems. Included in this selection are detailed accounts of all three foundational courses presented at the Clay school--Schramm-Loewner Evolution and other Conformally Invariant Objects, Noise Sensitivity and Percolation, Scaling Limits of Random Trees and Planar Maps--together with contributions on Fractal and Multifractal properties of SLE and Conformal Invariance of Lattice Models. Finally, the volume concludes with extended articles based on the courses on Random Polymers and Self-Avoiding Walks given at the Brazilian School of Probability during the final week of the school. Together, these notes provide a panoramic, state-of-the-art view of probability theory areas related to statistical physics, disordered systems and combinatorics. Like the lectures themselves, they are oriented towards advanced students and postdocs, but experts should also find much of interest.

A comprehensible introduction to the most fascinating research in theoretical physics: advanced quantum gravity. Ideal for researchers and graduate students.

This modern text combines fundamental principles with advanced topics and recent techniques in a rigorous and self-contained treatment of quantum field theory.Beginning with a review of basic principles, starting with quantum mechanics and special relativity, students can refresh their knowledge of elementary aspects of quantum field theory and perturbative calculations in the Standard Model. Results and tools relevant to many applications are covered, including canonical quantization, path integrals, non-Abelian gauge theories, and the renormalization group. Advanced topics are explored, with detail given on effective field theories, quantum anomalies, stable extended field configurations, lattice field theory, and field theory at a finite temperature or in the strong field regime. Two chapters are dedicated to new methods for calculating scattering amplitudes (spinor-helicity, on-shell recursion, and generalized unitarity), equipping students with practical skills for research. Accessibly written, with numerous worked examples and end-of-chapter problems, this is an essential text for graduate students. The breadth of coverage makes it an equally excellent reference for researchers.

Integrable Sys Quantum Field Theory

This vividly illustrated history of the International Congress of Mathematicians — a meeting of mathematicians from around the world held roughly every four years — acts as a visual history of the 25 congresses held between 1897 and 2006, as well as a story of changes in the culture of mathematics over the past century. Because the congress is an international meeting, looking at its history allows us a glimpse into the effect of wars and strained relations between nations on the scientific community.

The physics of non-equilibrium many-body systems is one of the most rapidly expanding areas of theoretical physics. Traditionally used in the study of laser physics and superconducting kinetics, these techniques have more recently found applications in the study of dynamics of cold atomic gases, mesoscopic and nano-mechanical systems. The book gives a self-contained presentation of the modern functional approach to non-equilibrium field-theoretical methods. They are applied to examples ranging from biophysics to the kinetics of superfluids and superconductors. Its step-by-step treatment gives particular emphasis to the pedagogical aspects, making it ideal as a reference for advanced graduate students and researchers in condensed matter physics.

A short, graduate-level synthesis of recent

developments in theoretical physics, from a pioneer in the fieldshort, graduate-level synthesis of recent developments in theoretical physics, from a pioneer in the field Lectures on the Infrared Structure of Gravity and Gauge Theory presents an accessible, graduate-level synthesis of a frontier research area in theoretical physics. Based on a popular Harvard University course taught by the author, this book gives a concise introduction to recent discoveries concerning the structure of gravity and gauge theory at very long distances. These discoveries unite three disparate but well-developed subjects in physics. The first subject is the soft theorems, which were found by particle physicists in the 1950s to control the behavior of low-energy photons and are essential for all collider predictions. The second subject is asymptotic symmetries, found by general relativists in the 1960s to provide a surprising, infinite number of exact relations between distinct physical phenomena. The third subject is the memory effect, the measurement of which is sought in upcoming gravitational wave observations. An exploration of the physical and mathematical equivalence of these three subjects has provided a powerful new perspective on old results and led to a plethora of new results, involving symmetries of QED, gluon scattering amplitudes, flat-space holography in quantum gravity, black hole information, and beyond. Uniquely connective and cutting-edge, Lectures on

the Infrared Structure of Gravity and Gauge Theory takes students and scholars to the forefront of new developments in the discipline. Materials are presented in a "lecture notes" style with problem sets included Concise and accessible pedagogical approach Topics include soft theorems, the memory effect, asymptotic symmetries with applications to QED, Yang-Mills theory, quantum gravity, and black holes