# 2 Physics Chapterwise Notes Tortillassuprema

Designing molecules and materials with desired properties is an important prerequisite for advancing technology in our modern societies. This requires both the ability to calculate accurate microscopic properties, such as energies, forces and electrostatic multipoles of specific configurations, as well as efficient sampling of potential energy surfaces to obtain corresponding macroscopic properties. Tools that can provide this are accurate first-principles calculations rooted in quantum mechanics, and statistical mechanics, respectively. Unfortunately, they come at a high computational cost that prohibits calculations for large systems and long time-scales, thus presenting a severe bottleneck both for searching the vast chemical compound space and the stupendously many dynamical configurations that a molecule can assume. To overcome this challenge, recently there have been increased efforts to accelerate quantum simulations with machine learning (ML). This emerging interdisciplinary community encompasses chemists, material scientists, physicists, mathematicians and computer scientists, joining forces to contribute to the exciting hot topic of progressing machine learning and AI for molecules and materials. The book that has emerged from a series of workshops provides a snapshot of this rapidly developing field. It contains tutorial material explaining the relevant foundations needed in chemistry, physics as well as machine learning to give an easy starting point for interested readers. In addition, a number of research papers defining the current state-of-the-art are included. The book has five parts (Fundamentals, Incorporating Prior Knowledge, Deep Learning of Atomistic Representations, Atomistic Simulations and Discovery and Design), each prefaced by editorial commentary that puts the respective parts into a broader scientific context.

This course-based monograph introduces the reader to the theory of continuous measurements in quantum mechanics and provides some benchmark applications. The approach chosen, quantum trajectory theory, is based on the stochastic Schrödinger and master equations, which determine the evolution of the a-posteriori state of a continuously observed quantum system and give the distribution of the measurement output. The present introduction is restricted to finite-dimensional quantum systems and diffusive outputs. Two appendices introduce the tools of probability theory and quantum measurement theory which are needed for the theoretical developments in the first part of the book. First, the basic equations of quantum trajectory theory are introduced, with all their mathematical properties, starting from the existence and uniqueness of their solutions. This makes the text also suitable for other applications of the same stochastic differential equations in different fields such as simulations of master equations or dynamical reduction theories. In the next step the equivalence between the stochastic approach and the theory of continuous measurements is demonstrated. To conclude the theoretical exposition, the properties of the output of the continuous measurement are analyzed in detail. This is a stochastic process with its own distribution, and the reader will learn how to compute physical quantities such as its moments and its spectrum. In particular this last concept is introduced with clear and explicit reference to the measurement process. The two-level atom is used as the basic prototype to illustrate the theory in a concrete application. Quantum phenomena appearing in the spectrum of the fluorescence light, such as Mollow’s triplet structure, squeezing of the fluorescence light, and the linewidth narrowing, are presented. Last but not least, the theory of quantum continuous measurements is the natural starting point to develop a feedback control theory in continuous time for quantum systems. The two-level atom is again used to introduce and study an example of feedback based on the observed output.

The aim of this book is to introduce a graduate student to selected concepts in condensed matter physics for which the language of field theory is ideally suited. The examples considered in this book are those of superfluidity for weakly interacting bosons, collinear magnetism, and superconductivity. Quantum phase transitions are also treated in the context of quantum dissipative junctions and interacting fermions constrained to one-dimensional position space. The style of presentation is sufficiently detailed and comprehensive that it only presumes familiarity with undergraduate physics.

Networks can provide a useful model and graphic image useful for the description of a wide variety of web-like structures in the physical and man-made realms, e.g. protein networks, food webs and the Internet. The contributions gathered in the present volume provide both an introduction to, and an overview of, the multifaceted phenomenology of complex networks. Statistical Mechanics of Complex Networks also provides a state-of-the-art picture of current theoretical methods and approaches.

Bridging the Scales from Quarks to Neutron Stars

Statistical Mechanics of Complex Networks

Physics Lesson 2: Velocity

Brandeis University Summer institute in theoretical physics 1959. Lecture notes. vol. 1-2

Field-theoretical Approach and Applications

*Superfluidity – and closely related to it, superconductivity – are very general phenomena that can occur on vastly different energy scales. Their underlying theoretical mechanism of spontaneous symmetry breaking is even more general and applies to a multitude of physical systems. In these lecture notes, a pedagogical introduction to the field-theory approach to superfluidity is presented. The connection to more traditional approaches, often formulated in a different language, is carefully explained in order to provide a consistent picture that is useful for students and researchers in all fields of physics. After introducing the basic concepts, such as the two-fluid model and the Goldstone mode, selected topics of current research are addressed, such as the BCS-BEC crossover and Cooper pairing with mismatched Fermi momenta.*

*The present treatise is concerned with the quantum mechanical theory of measurement. Since the development of quantum theory in the 1920s the measuring process has been considered a very important problem. A large number of articles have accordingly been devoted to this subject. In this way the quantum mechanical measurement problem has been a source of inspiration for physical, mathematical and philo sophical investigations into the foundations of quantum theory, which has had an impact on a great variety of research fields, ranging from the physics of macroscopic systems to probability theory and algebra. Moreover, while many steps forward have been made and much insight has been gained on the road towards a solution of the measurement problem, left open nonetheless are important questions, which have in duced several interesting developments. Hence even today it cannot be said that the measurement process has lost its topicality and excite ment. Moreover, research in this field has made contact with current advances in high technology, which provide new possibilities for per* *forming former Gedanken experiments. For these reasons we felt that the time had come to develop a systematic exposition of the quantum theory of measurement which might serve as a basis and reference for future research into the foundations of quantum mechanics. But there are other sources of motivation which led us to make this effort. First of all, in spite of the many contributions to measurement theory there is still no generally accepted approach.*

*This author provides an easily accessible introduction to quantum field theory via Feynman rules and calculations in particle physics. His aim is to make clear what the physical foundations of present-day field theory are, to clarify the physical content of Feynman rules. The book begins with a brief review of some aspects of Einstein's theory of relativity that are of particular importance for field theory, before going on to consider the relativistic quantum mechanics of free particles, interacting fields, and particles with spin. The techniques learnt in the chapters are then demonstrated in examples that might be encountered in real accelerator physics. Further chapters contain discussions of renormalization, massive and massless vector fields and unitarity. A final chapter presents concluding arguments concerning quantum electrodynamics. The book includes valuable appendices that review some essential mathematics, including complex spaces, matrices, the CBH equation, traces and dimensional regularization. An appendix containing a comprehensive summary of the rules and conventions used is followed by an appendix specifying the full Lagrangian of the Standard Model and the corresponding Feynman rules. To make the book useful for a wide audience a final appendix provides a discussion of the metric used, and an easy-to-use dictionary connecting equations written with different metrics. Written as a textbook, many diagrams, exercises and examples are included. This book will be used by beginning graduate students taking courses in particle physics or quantum field theory, as well as by researchers as a source and reference book on Feynman diagrams and rules.*

*Casimir effects serve as primary examples of directly observable manifestations of the nontrivial properties of quantum fields, and as such are attracting increasing interest from quantum field theorists, particle physicists, and cosmologists. Furthermore, though very weak except at short distances, Casimir forces are universal in the sense that all material objects are subject to them. They are thus also an increasingly important part of the physics of atom-surface interactions, while in nanotechnology they are being investigated not only as contributors to ‘stiction’ but also as potential mechanisms for actuating micro-electromechanical devices. While the field of Casimir physics is expanding rapidly, it has reached a level of maturity in some important respects: on the experimental side, where most sources of imprecision in force measurements have been identified as well as on the theoretical side, where, for example, semi-analytical and numerical methods for the computation of Casimir forces between bodies of arbitrary shape have been successfully developed. This book is, then, a timely and comprehensive guide to the essence of Casimir (and Casimir-Polder) physics that will have lasting value, serving the dual purpose of an introduction and reference to the field. While this volume is not intended to be a unified textbook, but rather a collection of largely independent chapters written by prominent experts in the field, the detailed and carefully written articles adopt a style that should appeal to non-specialist researchers in the field as well as to a broader audience of graduate students.*

*Machine Learning Meets Quantum Physics*

*The Path to Feynman Diagrams*

*Lecture Notes in Applied Differential Equations of Mathematical Physics*

*Lessons from Modern Concepts*

*Chiral Quark Dynamics*

*An Advanced Course in Computational Nuclear Physics*

*This book focuses on the phenomena of inertia and gravitation, one objective being to shed some new light on the basic laws of gravitational interaction and the fundamental nature and structures of spacetime. Chapter 1 is devoted to an extensive, partly new analysis of the law of inertia. The underlying mathematical and geometrical structure of Newtonian spacetime is presented from a four-dimensional point of view, and some historical difficulties and controversies - in particular the concepts of free particles and straight lines - are critically analyzed, while connections to projective geometry are also explored. The relativistic extensions of the law of gravitation and its intriguing consequences are studied in Chapter 2. This is achieved, following the works of Weyl, Ehlers, Pirani and Schild, by adopting a point of view of the combined conformal and projective structure of spacetime. Specifically, Mach’s fundamental critique of Newton’s concepts of ‘absolute space’ and ‘absolute time’ was a decisive motivation for Einstein’s development of general relativity, and his equivalence principle provided a new perspective on inertia. In Chapter 3 the very special mathematical structure of Einstein’s field equations is analyzed, and some of their remarkable physical predictions are presented. By analyzing different types of dragging phenomena, Chapter 4 reviews to what extent the equivalence principle is realized in general relativity - a question intimately connected to the ‘new force’ of gravitomagnetism, which was theoretically predicted by Einstein and Thirring but which was only recently experimentally confirmed and is thus of current interest.*

*Covering the theory of computation, information and communications, the physical aspects of* *computation, and the physical limits of computers, this text is based on the notes taken by one of its editors, Tony Hey, on a lecture course on computation given b*

*The treatment of time in quantum mechanics is still an important and challenging open question in the foundation of the quantum theory. This multi-authored book, written as an introductory guide for newcomers to the subject, as well as a useful source of information for the expert, covers many of the open questions. The book describes the problems, and the attempts and achievements in defining, formalizing and measuring different time quantities in quantum theory.*

*Stochastic Energetics by now commonly designates the emerging field that bridges the gap between stochastic dynamical processes and thermodynamics. Triggered by the vast improvements in spatio-temporal resolution in nanotechnology, stochastic energetics develops a framework for quantifying individual realizations of a stochastic process on the mesoscopic scale of thermal fluctuations. This is needed to answer such novel questions as: Can one cool a drop of water by agitating an immersed nano-particle? How does heat flow if a Brownian particle pulls a polymer chain? Can one measure the free-energy of a system through a single realization of the associated stochastic process? This book will take the reader gradually from the basics to the applications: Part I provides the necessary background from stochastic dynamics (Langevin, master equation), Part II introduces how stochastic energetics describes such basic notions as heat and work on the mesoscopic scale, Part III details several applications, such as control and detection processes, as well as free-energy transducers. It aims in particular at researchers and graduate students working in the fields of nanoscience and technology.*

*Inertia and Gravitation*

*Lecture Notes on Newtonian Mechanics*

*Solar Energetic Particles*

*New Frontiers In Nuclear Physics - Lecture Notes Of Jsps-ins International Spring School*

*Lie Algebras and Applications*

*The Kolmogorov Legacy in Physics*

***These Lecture Notes are based partly on a lecture given by one of us (H. R. ) at Tiibingen University in Spring 1991 and partly on a lecture given at the f Egyptian-German Spring School "Particle and Nuclear Phyic I' in Cairo in April 1992. They are addressed to graduate students and young esearch workers in theoretical physics. Some knowledge ofquantum field theory, especially on func tional integral techniques, are required. These Notes are intended to give a ped agogical introduction into the description of hadrons, Le. , mesons and baryons, within a quark model based on a chirally invariant quantum field theory. A more detailed description of of the subject in Chap. 4, the chiral soliton of the Nambu-Jona-Lasinio model, is given in a recent review [AHW95]. In these Notes we have used results from recent research papers. It is a pleasureto thank our coauthors for their fruitful collaboration. We are especially indebted to Dr. Herbert Weigel who carried the main load in the investigations concerning the NJL soliton. We thank also Albrecht Buck and Udo Ziickert for their valuable contributions. Furthermore we also acknowledge discussions with Kurt Langfeld, Lorenz von Smekal, Christian Weiss, Roman Friedrich, Axel Bender, Gerhard Hellstern, and Jiirgen Schlienz. Tiibingen, January 1995 R. Alkofer H. Reinhardt Contents 1 Introduction 1 2 Reduction of Low-Energy QCD to QFD 5 2. 1 Effective Low-Energy Quark Interaction 5 2. 2 Invariance Properties of QCD and QFD 10 2. 3 Fierz-Transformation ofthe Effective Quark Interaction .***

***This volume presents the state-of-the-art in selected topics across modern nuclear physics, covering fields of central importance to research and illustrating their connection to many different areas of physics. It describes recent progress in the study of superheavy and exotic nuclei, which is pushing our knowledge to ever heavier elements and neutron-richer isotopes. Extending nuclear physics to systems that are many times denser than even the core of an atomic nucleus, one enters the realm of the physics of neutron stars and possibly quark stars, a topic that is intensively investigated with many ground-based and outer-space research missions as well as numerous theoretical works. By colliding two nuclei at very high ultra-relativistic energies one can create a fireball of extremely hot matter, reminiscent of the universe very shortly after the big bang, leading to a phase of melted hadrons and free quarks and gluons, the so-called quark-gluon plasma. These studies tie up with effects of crucial importance in other fields. During the collision of heavy ions, electric fields of extreme strength are produced, potentially destabilizing the vacuum of the atomic physics system, subsequently leading to the decay of the vacuum state and the emission of positrons. In neutron stars the ultra-dense matter might support extremely high magnetic fields, far beyond anything that can be produced in the laboratory, significantly affecting the stellar properties. At very high densities general relativity predicts the stellar collapse to a black hole. However, a number of current theoretical activities, modifying Einstein's theory, point to possible alternative scenarios, where this collapse might be avoided. These and related topics are addressed in this book in a series of highly readable chapters. In addition, the book includes fundamental analyses of the practicalities involved in transiting to an electricity supply mainly based on renewable energies, investigating this scenario less from an engineering and more from a physics point of view. While the topics comprise a large scope of activities, the contributions also show an extensive overlap in the methodology and in the analytical and numerical tools involved in tackling these diverse research fields that are the forefront of modern science.***

***The 3rd edition is thoroughly revised, applications are substantially enriched, it includes a new account of the early history of the subject (from 1800 to 1957) and a new chapter recounting the recent solution of open problems of long standing in classical aerodynamics. The bibliography comprises now over fifteen hundred titles. From the reviews: "The author is known as one of the leading experts in the field. His masterly written book is, surely, the most complete exposition in the subject of conservations laws." --Zentralblatt MATH***

***Although used with increasing frequency in many branches of physics, random matrix ensembles are not always sufficiently specific to account for important features of the physical system at hand. One refinement which retains the basic stochastic***

*approach but allows for such features consists in the use of embedded ensembles. The present text is an exhaustive introduction to and survey of this important field. Starting with an easy-to-read introduction to general random matrix theory, the text then develops the necessary concepts from the beginning, accompanying the reader to the frontiers of present-day research. With some notable exceptions, to date these ensembles have primarily been applied in nuclear spectroscopy. A characteristic example is the use of a random two-body interaction in the framework of the nuclear shell model. Yet, topics in atomic physics, mesoscopic physics, quantum information science and statistical mechanics of isolated finite quantum systems can also be addressed using these ensembles. This book addresses graduate students and researchers with an interest in applications of random matrix theory to the modeling of more complex physical systems and interactions, with applications such as statistical spectroscopy in mind.*

*Lecture Notes from SERC Schools*

*Lecture Notes on Field Theory in Condensed Matter Physics*

*Surveys in Theoretical High Energy Physics-2*

*Diagrammatica*

*Introduction to Superfluidity*

*Surveys in Theoretical High Energy Physics - 2*

This book describes the basic concepts of various physical phenomena in semiconductors and their modulated structures under l magnetic fields. The topics cover magneto-transport phenomena, cyclotron resonance, far-infrared spectroscopy, magneto-optica spectroscopy, diluted magnetic semiconductors in high magnetic fields, as well as the recent advances in the experimental techn needed for high field experiments. Starting from the introductory part describing the basic theoretical background, each chapter introduces typical experimental data which were actually obtained in very high magnetic fields mostly in the pulsed field range up several megagauss (20-100T). The book has both the character of a textbook and a monograph. For researchers and students w interest in semiconductor physics or in high magnetic fields, it will serve as a useful guide.

One could make the claim that all branches of physics are basically generalizations of classical mechanics. It is also often the firs course which is taught to physics students. The approach of this book is to construct an intermediate discipline between general courses of physics and analytical mechanics, using more sophisticated mathematical tools. The aim of this book is to prepare a s consistent and compact text that is very useful for teachers as well as for independent study.

This book pays tribute to 25 Singaporean South Asians who pioneered and excelled in their respective fields from 1950 to 2015. meant to be a 'quick take' on 25 Singaporean South Asian personalities, across a broad spectrum of professions and activities, w believed in the value and virtue of service to the community and gave the best of themselves.They had a sense of mission in thei professions, dedicated to what they were doing and fostered a sense of community and nation. Many of them laid foundations tha triggered the transformation of the island, including sportspeople whose records have stood the test of time. They were a people their time whose work many may not know but which we hope will inspire others. This book is timely, for those who want to get a snapshot appreciation of the contributions of Singaporean South Asians.

Density functional theory (DFT) is by now a well-established method for tackling the quantum mechanics of many-body systems. Originally applied to compute properties of atoms and simple molecules, DFT has quickly become a work horse for more comple applications in the chemical and materials sciences. The present set of lectures, spanning the whole range from basic principles t relativistic and time-dependent extensions of the theory, is the ideal introduction for graduate students or nonspecialist researche wishing to familiarize themselves with both the basic and most advanced techniques in this field.

Lectures On Computation

Physics Lecture Notes, Study Guides, and Lesson Plans

The Diffusive Case

Annual Catalogue

Stochastic Energetics

Nonlinear Optics and Optical Physics

This book, designed for advanced graduate students and post-graduate researchers, introduces Lie algebras and some of their applications to the spectroscopy of molecules, atoms, nuclei and hadrons. The book contains many examples that help to elucidate the abstract algebraic definitions. It provides a summary of many formulas of practical interest, such as the eigenvalues of Casimir operators and the dimensions of the representations of all classical Lie algebras.

A timely presentation of new results, challenges, and opportunities in the quickly developing field of nuclear cluster physics, presented by an international group of eminent theoretical and experimental scientists active in the field. Their work reveals how correlations of nucleons can appear spontaneously, propagate, and survive in nuclear matter at both low and high densities. Characteristic nuclear substructures, beyond those predicted by mean-field or collective scenarios, appear on microscopic and cosmic length scales. They can influence the dynamics of fusion of light nuclei and the decay of heavy, fissioning nuclei or of systems produced transiently in heavy-ion reactions. A must-read for young scientists entering the field and a valuable resource for more seasoned nuclear researchers!

We read in order to know we are not alone, I once heard, and perhaps it could also be suggested that we write in order not to be alone, to endorse, to promote continuity. The idea for this book took about 10 years to materialize, and it is the author's hope that its content will constitute the beginning of further explorations beyond current horizons. More speci cally, this book appeals to the reader to engage upon and persevere with a journey, moving through the less well explored territories in the evolution of the very early universe, and pushing towards new landscapes. P- haps, during or after consulting this book, this attitude and this willingness will be embraced by someone, somewhere, and this person will go on to enrich our quantum cosmological description of the early universe, by means of a clearer supersymm- ric perspective. It is to these creative and inquisitive 'young minds' that the book is addressed. The reader will not therefore nd in this book all the answers to all the problems regarding a supersymmetric and quantum description of the early universe, and this remark is substantiated in the book by a list of unresolved and challenging problems, itself incomplete.

This graduate-level text collects and synthesizes a series of ten lectures on the nuclear quantum many-body problem. Starting from our current understanding of the underlying forces, it presents recent advances within the field of lattice quantum chromodynamics before going on to discuss effective field theories, central many-body methods like Monte Carlo methods, coupled cluster theories, the similarity renormalization group approach, Green's function methods and large-scale diagonalization approaches. Algorithmic and computational advances show particular promise for breakthroughs in predictive power, including proper error estimates, a better understanding of the underlying effective degrees of freedom and of the respective forces at play. Enabled by recent improvements in theoretical, experimental and numerical techniques, the state-of-the art applications considered in this volume span the entire range, from our smallest components – quarks and gluons as the mediators of the strong force – to the computation of the equation of state for neutron star matter. The lectures presented provide an in-depth exposition of the underlying theoretical and algorithmic approaches as well details of the numerical implementation of the methods discussed. Several also include links to numerical software and benchmark calculations, which readers can use to develop their own programs for tackling challenging nuclear many-body problems.

Quantum Trajectories and Measurements in Continuous Time

Hyperbolic Conservation Laws in Continuum Physics

New Horizons in Fundamental Physics

Nuclear Particle Correlations And Cluster Physics

LECTURE NOTES- FINNISH SUMMER SCHOOL IN NUCLEAR PHYSICS- 2 PARTS.

Time in Quantum Mechanics

**The Ultimate Guide to Learning or Teaching Physics! This book contains the real lecture notes and slide of a highly effective high school and college Physics teacher. This series covers all of the topics in general physics and is perfect to help you prepare for AP Physics, A Level Physics, or any general Physics course! Teachers: Never plan another lesson again! Students: Ace your upcoming exam! This series covers all of the topics of General Physics: Vectors, Velocity, Acceleration, Projectiles, Forces, Work, Energy, Power, Momentum, Rotation, Torque, Hooke's Law, Pendulums, Waves, Sound, Light, Electricity, Circuits, Resistance, Magnetism, Thermodynamics, and Fluid Dynamics.**

**Casimir PhysicsSpringer Science & Business Media**

**This concise primer introduces the non-specialist reader to the physics of solar energetic particles (SEP) and systematically reviews the evidence for the two main mechanisms which lead to the so-called impulsive and gradual SEP events. More specifically, the timing of the onsets, the longitude distributions, the high-energy spectral shapes, the correlations with other solar phenomena (e.g. coronal mass ejections), as well as the all-important elemental and isotopic abundances of SEPs are investigated. Impulsive SEP events are related to magnetic reconnection in solar flares and jets. The concept of shock acceleration by scattering on self-amplified Alfvén waves is introduced, as is the evidence of reacceleration of impulsive-SEP material in the seed population accessed by the shocks in gradual events. The text then develops processes of transport of ions out to an observer. Finally, a new technique to determine the source plasma temperature in both impulsive and gradual events is demonstrated. Last but not least the role of SEP events as a radiation hazard in space is mentioned and a short discussion of the nature of the main particle telescope designs that have contributed to most of the SEP measurements is given.**

**- Up-to-date account of the principles and practice of inelastic and spectroscopic methods available at neutron and synchrotron sources - Multi-technique approach set around a central theme, rather than a monograph on one technique - Emphasis on the complementarity of neutron spectroscopy and X-ray spectroscopy which are usually treated in separate books**

**Lecture Notes In Topics In Path Integrals And String Representations**

**N=2 Supersymmetric Dynamics for Pedestrians**

**Fluid Physics - Lecture Notes Of Summer Schools**

**The Quantum Theory of Measurement**

**Quantum Cosmology - The Supersymmetric Perspective - Vol. 2**

**Physics of Semiconductors in High Magnetic Fields**

*Functional Integrals is a well-established method in mathematical physics, especially those mathematical methods used in modern non-perturbative quantum field theory and string theory. This book presents a unique, original and modern treatment of strings representations on Bosonic Quantum Chromodynamics and Bosonization theory on 2d Gauge Field Models, besides of rigorous mathematical studies on the analytical regularization scheme on Euclidean quantum field path integrals and stochastic quantum field theory. It follows an analytic approach based on Loop space techniques, functional determinant exact evaluations and exactly solubility of four dimensional QCD loop wave equations through Elfin Botelho fermionic extrinsic self avoiding string path integrals.*

*The present volume, published at the occasion of his 100th birthday anniversary, is a collection of articles that reviews the impact of Kolomogorov's work in the physical sciences and provides an introduction to the modern developments that have been triggered in this way to encompass recent applications in biology, chemistry, information sciences and finance.*

*The book presents pedagogical reviews of important topics on high energy physics to the students and researchers in particle physics. The book also discusses topics on the Quark–Gluon plasma, thermal field theory, perturbative quantum chromodynamics, anomalies and cosmology. Students of particle physics need to be well-equipped with basic understanding of many concepts underlying the standard models of* *particle physics and cosmology. This is particularly true today when experimental results from colliders, such as large hadron collider (LHC) and relativistic heavy ion collider (RHIC), as well as inferences from cosmological observations, are expected to further expand our understanding of particle physics at high energies. This volume is the second in the Surveys in Theoretical High Energy Physics Series (SThEP). Topics covered in this book are based on lectures delivered at the SERC Schools in Theoretical High Energy Physics at the Physical Research Laboratory, Ahmedabad, and the University of Hyderabad. Understanding the dynamics of gauge theories is crucial, given the fact that all known interactions are based on the principle of local gauge symmetry. Beyond the perturbative regime, however, this is a notoriously difficult problem. Requiring invariance under supersymmetry turns out to be a suitable tool for analyzing supersymmetric gauge theories over a larger region of the space of parameters. Supersymmetric quantum field theories in four dimensions with extended N=2 supersymmetry are further constrained and have therefore been a fertile field of research in theoretical physics for quite some time. Moreover, there are far-reaching mathematical ramifications that have led to a successful dialogue with differential and algebraic geometry. These lecture notes aim to introduce students of modern theoretical physics to the fascinating developments in the understanding of N=2 supersymmetric gauge theories in a coherent fashion. Starting with a gentle introduction to electric-magnetic duality, the author guides readers through the key milestones in the field, which include the work of Seiberg and Witten, Nekrasov, Gaiotto and many others. As an advanced graduate level text, it assumes that readers have a working knowledge of supersymmetry including the formalism of superfields, as well as of quantum field theory techniques such as regularization, renormalization and anomalies. After his graduation from the University of Tokyo, Yuji Tachikawa worked at the Institute for Advanced Study, Princeton and the Kavli Institute for Physics and Mathematics of the Universe. Presently at the Department of Physics, University of Tokyo, Tachikawa is the author of several important papers in supersymmetric quantum field theories and string theory.*

*Embedded Random Matrix Ensembles in Quantum Physics*
*Neutron and X-ray Spectroscopy*
*CRM Proceedings & Lecture Notes*
*A Modern Primer on Understanding Sources, Acceleration and Propagation*
*Advanced Topic*
*Casimir Physics*