

Quantum Theory of Open Systems

Thesis at ETH Zuerich

Manuel Lorenzo Sentís

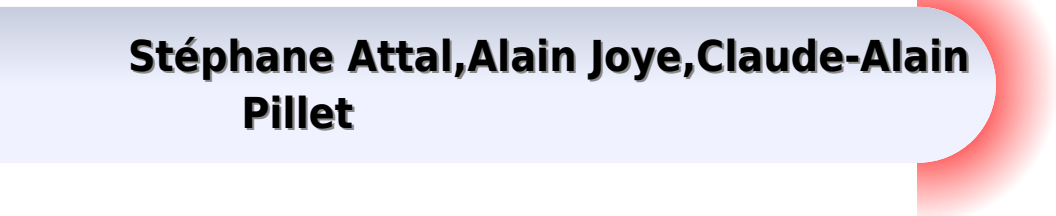
Supervision: Prof. Dr. Jürg Fröhlich and Dr. Marco Merkli

August 15, 2002



The Theory Of Open Quantum Systems

**Stéphane Attal, Alain Joye, Claude-Alain
Pillet**



The Theory Of Open Quantum Systems:

The Theory of Open Quantum Systems Heinz-Peter Breuer, Francesco Petruccione, 2002 This book treats the central physical concepts and mathematical techniques used to investigate the dynamics of open quantum systems To provide a self contained presentation the text begins with a survey of classical probability theory and with an introduction into the foundations of quantum mechanics with particular emphasis on its statistical interpretation The fundamentals of density matrix theory quantum Markov processes and dynamical semigroups are developed The most important master equations used in quantum optics and in the theory of quantum Brownian motion are applied to the study of many examples Special attention is paid to the theory of environment induced decoherence its role in the dynamical description of the measurement process and to the experimental observation of decohering Schrodinger cat states The book includes the modern formulation of open quantum systems in terms of stochastic processes in Hilbert space Stochastic wave function methods and Monte Carlo algorithms are designed and applied to important examples from quantum optics and atomic physics such as Levy statistics in the laser cooling of atoms and the damped Jaynes Cummings model The basic features of the non Markovian quantum behaviour of open systems are examined on the basis of projection operator techniques In addition the book expounds the relativistic theory of quantum measurements and discusses several examples from a unified perspective e g non local measurements and quantum teleportation Influence functional and super operator techniques are employed to study the density matrix theory in quantum electrodynamics and applications to the destruction of quantum coherence are presented The text addresses graduate students and lecturers in physics and applied mathematics as well as researchers with interests in fundamental questions in quantum mechanics and its applications Many analytical methods and computer simulation techniques are developed and illustrated with the help of numerous specific examples Only a basic understanding of quantum mechanics and of elementary concepts of probability theory is assumed Quantum Theory of Open Systems Edward Brian Davies, 1976 *The Theory of Open Quantum Systems* Heinz-Peter Breuer, 2002 This text provides an introduction to the dynamics of open quantum systems To provide a self contained presentation the book begins with a survey of the classical theory of probability and stochastic processes and an introduction into the foundations of quantum mechanics **Open Quantum Systems** Subhashish Banerjee, 2018-11-01 This book discusses the elementary ideas and tools needed for open quantum systems in a comprehensive manner The emphasis is given to both the traditional master equation as well as the functional path integral approaches It discusses the basic paradigm of open systems the harmonic oscillator and the two level system in detail The traditional topics of dissipation and tunneling as well as the modern field of quantum information find a prominent place in the book Assuming a basic background of quantum and statistical mechanics this book will help readers familiarize with the basic tools of open quantum systems Open quantum systems is the study of quantum dynamics of the system of interest taking into account the effects of the ambient environment It is ubiquitous in the sense that any system

could be envisaged to be surrounded by its environment which could naturally exert its influence on it. Open quantum systems allow for a systematic understanding of irreversible processes such as decoherence and dissipation of the essence in order to have a correct understanding of realistic quantum dynamics and also for possible implementations. This would be essential for a possible development of quantum technologies.

Theory of Open Quantum Systems Heinz-Peter Breuer, Francesco Petruccione, 2006

Open Quantum Systems Bassano Vacchini, 2024-12-30 The proposed book is a bridge between the foundations of quantum mechanics and the theory of open quantum systems. The treatment of open quantum systems is a rapidly growing subject of interest to an ever increasing number of scientists. The main focus is on overcoming the idealization of perfect isolation of a quantum system so as to allow for a more realistic treatment and to provide the relevant background for the development of quantum technologies. The book is addressed to students and researchers in the field of open quantum systems and more generally quantum mechanics, a wide community of physicists, mathematicians and chemists. It is devised both to enter the field and to prepare a series of lectures or a one semester course on the topic.

Open Quantum Systems I Stéphane Attal, Alain Joye, Claude-Alain Pillet, 2006-08-18 Understanding dissipative dynamics of open quantum systems remains a challenge in mathematical physics. This problem is relevant in various areas of fundamental and applied physics. Significant progress in the understanding of such systems has been made recently. These books present the mathematical theories involved in the modeling of such phenomena. They describe physically relevant models, develop their mathematical analysis and derive their physical implications.

Open Quantum Systems Ángel Rivas, Susana F. Huelga, 2011-10-01 In this volume the fundamental theory of open quantum systems is revised in the light of modern developments in the field. A unified approach to the quantum evolution of open systems is presented by merging concepts and methods traditionally employed by different communities such as quantum optics, condensed matter, chemical physics and mathematical physics. The mathematical structure and the general properties of the dynamical maps underlying open system dynamics are explained in detail. The microscopic derivation of dynamical equations including both Markovian and non Markovian evolutions is also discussed. Because of the step by step explanations, this work is a useful reference to novices in this field. However, experienced researchers can also benefit from the presentation of recent results.

Open Quantum Systems III Stéphane Attal, Alain Joye, Claude-Alain Pillet, 2006-08-18 This volume is the third and last of a series devoted to the lecture notes of the Grenoble Summer School on Open Quantum Systems which took place at the Institut Fourier from June 16 to July 4, 2003. The contributions presented in this volume correspond to an expanded version of the lecture notes provided by the authors to the students of the Summer School. The corresponding lectures were scheduled in the last part of the School devoted to recent developments in the study of Open Quantum Systems. Whereas the first two volumes were dedicated to a detailed exposition of the mathematical techniques and physical concepts relevant in the study of Open Systems with no a priori pre-requisites, the contributions presented in this volume request from the reader some

familiarity with these aspects Indeed the material presented here aims at leading the reader already acquainted with the basics in quantum statistical mechanics spectral theory of linear operators C dynamical systems and quantum stochastic differential equations to the front of the current research done on various aspects of Open Quantum Systems Nevertheless pedagogical efforts have been made by the various authors of these notes so that this volume should be essentially self contained for a reader with minimal previous posure to the themes listed above In any case the reader in need of complements can always turn to these rst two volumes The topics covered in these lectures notes start with an introduction to n equilibrium quantum statistical mechanics

Open Quantum Systems II Stéphane Attal, 2006-06-07 Understanding dissipative dynamics of open quantum systems remains a challenge in mathematical physics This problem is relevant in various areas of fundamental and applied physics Significant progress in the understanding of such systems has been made recently These books present the mathematical theories involved in the modeling of such phenomena They describe physically relevant models develop their mathematical analysis and derive their physical implications

Thermodynamics and Control of Open Quantum Systems Gershon Kurizki, Abraham G. Kofman, 2022-01-13 The theory of open quantum systems is developed from first principles and a detailed discussion of real quantum devices is also covered This unique and self contained book is accessible to graduate students and researchers working in atomic physics quantum information condensed matter physics and quantum chemistry

Applications of the Theory of Open Quantum Systems - from Born-Markov Approximation to Hierarchical Equations of Motion, 2022 *Open Quantum Physics and Environmental Heat Conversion into Usable Energy* Eliade Stefanescu, 2014-12-18

A Quantum system can be viewed as a larger closed system comprising of two components an open quantum system and its surrounding environment These two components interact with each other and in the realm of theoretical physics this interaction cannot be neglected This eBook explains mathematical and statistical concepts essential for describing a realistic quantum system by presenting recent contributions in this field The book commences by explaining of the basics of quantum mechanics statistical physics and physics of open quantum systems Detailed methods of deriving theoretical equations with explicit analytical coefficients with respect to open quantum systems are also explained The book concludes with the study of a quantum heat converter in the framework of an all microscopic theory involving fermions photons and phonons Readers of this book will gain a better understanding on the following topics Quantum mechanics including the Boson and Fermion states Fermi Dirac and Bose Einstein statistics spin statistics relation many body systems of Bosons and Fermions the Fermi Dirac integrals of the Fermion state densities and transport phenomena in semiconductors Dissipative dynamics and quantum systems such as friction diffusion friction diffusion relation mobility occupation probability dynamics damping spectral width correlation and autocorrelation memory stability bifurcation self organization and chaos Lindblad s theory of open quantum systems through the work of Alicki and Lendi Quantum tunneling as an interaction with a system Optical bistability including the fundamental contributions of

Carmichael McCall and Bonifacio Master equations based on the microscopic theory of Ford Lewis and O Connell Field propagation in a semiconductor structure Coherent light propagation in the framework of a microscopic model including the refractive index and the Raman frequency shift Heat conversion in the framework of an all microscopic model of open quantum systems Entropy dynamics in a matter field system *Advances in Open Systems and Fundamental Tests of Quantum Mechanics* Bassano Vacchini, Heinz-Peter Breuer, Angelo Bassi, 2019-11-01 Quantum mechanics has shown unprecedented success as a physical theory but it has forced a new view on the description of physical reality In recent years important progress has been achieved both in the theory of open quantum systems and in the experimental realization and control of such systems A great deal of the new results is concerned with the characterization and quantification of quantum memory effects From this perspective the 684 WE Heraeus Seminar has brought together scientists from different communities both theoretical and experimental sharing expertise on open quantum systems as well as the commitment to the understanding of quantum mechanics This book consists of many contributions addressing the diversified physics community interested in foundations of quantum mechanics and its applications and it reports about recent results in open quantum systems and their connection with the most advanced experiments testing quantum mechanics *Towards an Effective Theory of Open Quantum Systems Through Open Qubit Systems* Sean Prudhoe, 2024 We explore procedures to approximate the reduced dynamics of open qubit systems to understand the construction of effective open theories in more general systems We provide constructions both for infinitesimal time evolution i e master equations and for discrete time evolution through random ensembles of quantum channels An argument is made that the ensemble approach is a much better suited method to tackle the open dynamics experienced in more novel open systems such as those with time dependent boundaries that are found in quantum cosmology We also explore the idea that quantum subsystems may appear through a process of spontaneous symmetry breaking which serves as the prequel to the appearance of an open quantum system

Control of Quantum Systems Shuang Cong, 2014-02-27 Advanced research reference examining the closed and open quantum systems Control of Quantum Systems Theory and Methods provides an insight into the modern approaches to control of quantum systems evolution with a focus on both closed and open dissipative quantum systems The topic is timely covering the newest research in the field and presents and summarizes practical methods and addresses the more theoretical aspects of control which are of high current interest but which are not covered at this level in other text books The quantum control theory and methods written in the book are the results of combination of macro control theory and microscopic quantum system features As the development of the nanotechnology progresses the quantum control theory and methods proposed today are expected to be useful in real quantum systems within five years The progress of the quantum control theory and methods will promote the progress and development of quantum information quantum computing and quantum communication Equips readers with the potential theories and advanced methods to solve existing problems in quantum optics information computing mesoscopic

systems spin systems superconducting devices nano mechanical devices precision metrology Ideal for researchers academics and engineers in quantum engineering quantum computing quantum information quantum communication quantum physics and quantum chemistry whose research interests are quantum systems control **Mathematics Of Open Quantum**

Systems, The: Dissipative And Non-unitary Representations And Quantum Measurements Konstantin A

Makarov, Eduard R Tsekanovskii, 2021-12-24 This book presents new developments in the open quantum systems theory with emphasis on applications to the frequent measurement theory In the first part of the book the uniqueness theorems for the solutions to the restricted Weyl commutation relations braiding unitary groups and semi groups of contractions are discussed The major theme involves an intrinsic characterization of the simplest symmetric operator solutions to the Heisenberg uncertainty relations the problem posed by J rgensen and Muhly followed by the proof of the uniqueness theorems for the simplest solutions to the restricted Weyl commutation relations The detailed study of unitary invariants of the corresponding dissipative and symmetric operators opens up a look at the classical Stone von Neumann uniqueness theorem from a new angle and provides an extended version of the uniqueness result relating various realizations of a differentiation operator on the corresponding metric graphs The second part of the book is devoted to mathematical problems of the quantum measurements under continuous monitoring Among the topics discussed are the complementarity of the Quantum Zeno effect and Exponential Decay scenario in frequent quantum measurements and a rigorous treatment within continuous monitoring paradigm of the celebrated double slit experiment where the renowned exclusive and interference measurement alternatives approach in quantum theory is presented in a way that is accessible for mathematicians One of the striking applications of the generalized 1 stable central limit theorem is the mathematical evidence of exponential decay of unstable states of the quantum pendulum under continuous monitoring Bohmian Mechanics, Open Quantum Systems and Continuous Measurements

Antonio B. Nassar, Salvador Miret-Artés, 2017-03-14 This book shows how Bohmian mechanics overcomes the need for a measurement postulate involving wave function collapse The measuring process plays a very important role in quantum mechanics It has been widely analyzed within the Copenhagen approach through the Born and von Neumann postulates with later extension due to L ders In contrast much less effort has been invested in the measurement theory within the Bohmian mechanics framework The continuous measurement sharp and fuzzy or strong and weak problem is considered here in this framework The authors begin by generalizing the so called Mensky approach which is based on restricted path integral through quantum corridors The measuring system is then considered to be an open quantum system following a stochastic Schr dinger equation Quantum stochastic trajectories in the Bohmian sense and their role in basic quantum processes are discussed in detail The decoherence process is thereby described in terms of classical trajectories issuing from the violation of the noncrossing rule of quantum trajectories *Open Quantum Systems and Feynman Integrals* Pavel Exner, 1984-11-30 Every part of physics offers examples of non stability phenomena but probably

nowhere are they so plentiful and worthy of study as in the realm of quantum theory The present volume is devoted to this problem we shall be concerned with open quantum systems i e those that cannot be regarded as isolated from the rest of the physical universe It is a natural framework in which non stationary processes can be investigated There are two main approaches to the treatment of open systems in quantum theory In both the system under consideration is viewed as part of a larger system assumed to be isolated in a reasonable approximation They are differentiated mainly by the way in which the state Hilbert space of the open system is related to that of the isolated system either by orthogonal sum or by tensor product Though often applicable simultaneously to the same physical situation these approaches are complementary in a sense and are adapted to different purposes Here we shall be concerned with the first approach which is suitable primarily for a description of decay processes absorption etc The second approach is used mostly for the treatment of various relaxation phenomena It is comparably better examined at present in particular the reader may consult a monograph by E B Davies

Open Quantum Systems Dorothea Bahns, Anke Pohl, Ingo Witt, 2019-06-28 This book presents four survey articles on various aspects of open quantum systems specifically addressing quantum Markovian processes Feller semigroups and nonequilibrium dynamics The contributions are based on lectures given by distinguished experts at a summer school in Gttingen Germany Starting from basic notions the authors of these lecture notes accompany the reader on a journey up to the latest research highlighting new challenges and addressing unsolved problems at the interface between mathematics and physics Though the book is primarily addressed to graduate students it will also be of interest to researchers

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Table of Contents The Theory Of Open Quantum Systems

1. Understanding the eBook The Theory Of Open Quantum Systems
 - The Rise of Digital Reading The Theory Of Open Quantum Systems
 - Advantages of eBooks Over Traditional Books
2. Identifying The Theory Of Open Quantum Systems
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an The Theory Of Open Quantum Systems
 - User-Friendly Interface
4. Exploring eBook Recommendations from The Theory Of Open Quantum Systems

- Personalized Recommendations
- The Theory Of Open Quantum Systems User Reviews and Ratings
- The Theory Of Open Quantum Systems and Bestseller Lists
- 5. Accessing The Theory Of Open Quantum Systems Free and Paid eBooks
 - The Theory Of Open Quantum Systems Public Domain eBooks
 - The Theory Of Open Quantum Systems eBook Subscription Services
 - The Theory Of Open Quantum Systems Budget-Friendly Options
- 6. Navigating The Theory Of Open Quantum Systems eBook Formats
 - ePub, PDF, MOBI, and More
 - The Theory Of Open Quantum Systems Compatibility with Devices
 - The Theory Of Open Quantum Systems Enhanced eBook Features
- 7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of The Theory Of Open Quantum Systems
 - Highlighting and Note-Taking The Theory Of Open Quantum Systems
 - Interactive Elements The Theory Of Open Quantum Systems
- 8. Staying Engaged with The Theory Of Open Quantum Systems
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers The Theory Of Open Quantum Systems
- 9. Balancing eBooks and Physical Books The Theory Of Open Quantum Systems
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection The Theory Of Open Quantum Systems
- 10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
- 11. Cultivating a Reading Routine The Theory Of Open Quantum Systems
 - Setting Reading Goals The Theory Of Open Quantum Systems
 - Carving Out Dedicated Reading Time
- 12. Sourcing Reliable Information of The Theory Of Open Quantum Systems

- Fact-Checking eBook Content of The Theory Of Open Quantum Systems
 - Distinguishing Credible Sources
13. Promoting Lifelong Learning
- Utilizing eBooks for Skill Development
 - Exploring Educational eBooks
14. Embracing eBook Trends
- Integration of Multimedia Elements
 - Interactive and Gamified eBooks

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