

## Quantum Machines Measurement Control Of Engineered Quantum Systems Lecture Notes Of The Les Houches Summer School Volume 96 July 2011

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A quantum machine is a human-made device whose collective motion follows the laws of quantum mechanics. The idea that macroscopic objects may follow the laws of quantum mechanics dates back to the advent of quantum mechanics in the early 20th century. However, as highlighted by the Schrödinger's cat thought experiment, quantum effects are not readily observable in large-scale objects. Consequently, quantum states of motion have only been observed in special circumstances at extremely low ...

## Quantum machine - Wikipedia

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The beginning of the 20th century saw a revolution in Physics with the discovery that the fundamental constituents of matter and radiation do not obey Newtonian laws, but those of an entirely new theory of motion and its measurement: quantum mechanics. After a century of experimentation in the world of photons, atoms, molecules, and other microscopic particles, the application of quantum laws is presently being extended to the world of macroscopic, engineered systems, whose complexity is such that an exhaustive, bottom-up description is both impossible and fruitless. In these so-called quantum machines, the very level of control signals that govern the evolution of the system operates quantum-mechanically. Quantum machines are based on artificial structures like superconducting tunnel junction circuits or semiconductor quantum dots, and this book provides the conceptual tools to build and utilize them.

This book gathers the lecture notes of courses given at the 2011 summer school in theoretical physics in Les Houches, France, Session XCVI. What is a quantum machine? Can we say that lasers and transistors are quantum machines? After all, physicists advertise these devices as the two main spin-offs of the understanding of quantum mechanical phenomena. However, while quantum mechanics must be used to predict the wavelength of a laser and the operation voltage of a transistor, it does not intervene at the level of the signals processed by these systems. Signals involve macroscopic collective variables like voltages and currents in a circuit or the amplitude of the oscillating electric field in an electromagnetic cavity resonator. In a true quantum machine, the signal collective variables, which both inform the outside on the state of the machine and receive controlling instructions, must themselves be treated as quantum operators, just as the position of the electron in a hydrogen atom. Quantum superconducting circuits, quantum dots, and quantum nanomechanical resonators satisfy the definition of quantum machines. These mesoscopic systems exhibit a few collective dynamical variables, whose fluctuations are well in the quantum regime and whose measurement is essentially limited in precision by the Heisenberg uncertainty principle. Other engineered quantum systems based on natural, rather than artificial degrees of freedom can also qualify as quantum machines: trapped ions, single Rydberg atoms in superconducting cavities, and lattices of ultracold atoms. This book provides the basic knowledge needed to understand and investigate the physics of these novel systems.

First-ever comprehensive introduction to the major new subject of quantum computing and quantum information.

Over the last decade new experimental tools and theoretical concepts are providing new insights into collective nonequilibrium behavior of quantum systems. The exquisite control provided by laser trapping and cooling techniques allows us to observe the behavior of condensed Bose and degenerate Fermi gases under nonequilibrium drive or after 'quenches' in which a Hamiltonian parameter is suddenly or slowly changed. On the solid state front, high intensity short-time pulses and fast (femtosecond) probes allow solids to be put into highly excited states and probed before relaxation and dissipation occur. Experimental developments are matched by progress in theoretical techniques ranging from exact solutions of strongly interacting nonequilibrium models to new approaches to nonequilibrium numerics. The summer school 'Strongly interacting quantum systems out of equilibrium' held at the Les Houches School of Physics as its XCIX session was designed to summarize this progress, lay out the

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Open questions and define directions for future work. This book collects the lecture notes of the main courses given in this summer school.

The Les Houches Summer School in August 2015 covered the emerging fields of cavity optomechanics and quantum nanomechanics. Optomechanics is flourishing and its concepts and techniques are now applied to a wide range of topics. Modern quantum optomechanics was born in the late 1970s in the framework of gravitational wave interferometry, with an initial focus on the quantum limits of displacement measurements. Carlton Caves, Vladimir Braginsky, and others realized that the sensitivity of the anticipated large-scale gravitational-wave interferometers (GWI) was fundamentally limited by the quantum fluctuations of the measurement laser beam. After tremendous experimental progress, the sensitivity of the upcoming next generation of GWI will effectively be limited by quantum noise. In this way, quantum-optomechanical effects will directly affect the operation of what is arguably the world's most impressive precision experiment. However, optomechanics has also gained a life of its own with a focus on the quantum aspects of moving mirrors. Laser light can be used to cool mechanical resonators well below the temperature of its environment. After proof-of-principle demonstrations of this cooling in 2006, a number of systems were used as the field gradually merged with its condensed matter cousin (nanomechanical systems) to try to reach the mechanical quantum ground state, eventually demonstrated in 2010 by pure cryogenic techniques and just one year later by a combination of cryogenic and radiation-pressure cooling. The book covers all aspects -- historical, theoretical, experimental -- of the field, with its applications to quantum measurement, foundations of quantum mechanics and quantum information. It is an essential read for any new researcher in the field.

Quantum Optics and Nanophotonics consists of the lecture notes of the Les Houches Summer School 101 held in August 2013. Some of the most eminent experts in this flourishing area of research have contributed chapters lying at the intersection of basic quantum science and advanced nanotechnology. The book is part of the renowned series of tutorial books that contain the lecture notes of all the Les Houches Summer Schools since the 1950's and cover the latest developments in physics and related fields.

Introduction to the Theory of Quantum Information Processing provides the material for a one-semester graduate level course on quantum information theory and quantum computing for students who have had a one-year graduate course in quantum mechanics. Many standard subjects are treated, such as density matrices, entanglement, quantum maps, quantum cryptography, and quantum codes. Also included are discussions of quantum machines and quantum walks. In addition, the book provides detailed treatments of several underlying fundamental principles of quantum theory, such as quantum measurements, the no-cloning and no-signaling theorems, and their consequences. Problems of various levels of difficulty supplement the text, with the most challenging problems bringing the reader to the forefront of active research. This book provides a compact introduction to the fascinating and rapidly evolving interdisciplinary field of quantum information theory, and it prepares the reader for doing active research in this area.

The authors provide an introduction to quantum computing. Aimed at advanced undergraduate and beginning graduate students in these disciplines, this text is illustrated with diagrams and exercises.

This volume, number 109 of the Les Houches Summer School series, presents the lectures held in August 2017 on the subject of turbulent flows in climate dynamics. Leading scientists in

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the fields of climate dynamics, atmosphere and ocean dynamics, geophysical fluid dynamics, physics and non-linear sciences present their views on this fast growing and interdisciplinary field of research, by venturing upon fundamental problems of atmospheric convection, clouds, large scale circulation, and predictability. Climate is controlled by turbulent flows. Turbulent motions are responsible for the bulk of the transport of energy, momentum, and water vapor in the atmosphere, which determine the distribution of temperature, winds, and precipitation on Earth. The aim of this book is to survey what is known about how turbulent flows control climate, what role they may play in climate change, and to outline where progress in this important area can be expected, given today's computational and observational capabilities. This book reviews the state-of-the-art developments in this field and provides an essential background to future studies. All chapters are written from a pedagogical perspective, making the book accessible to masters and PhD students and all researchers wishing to enter this field.

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