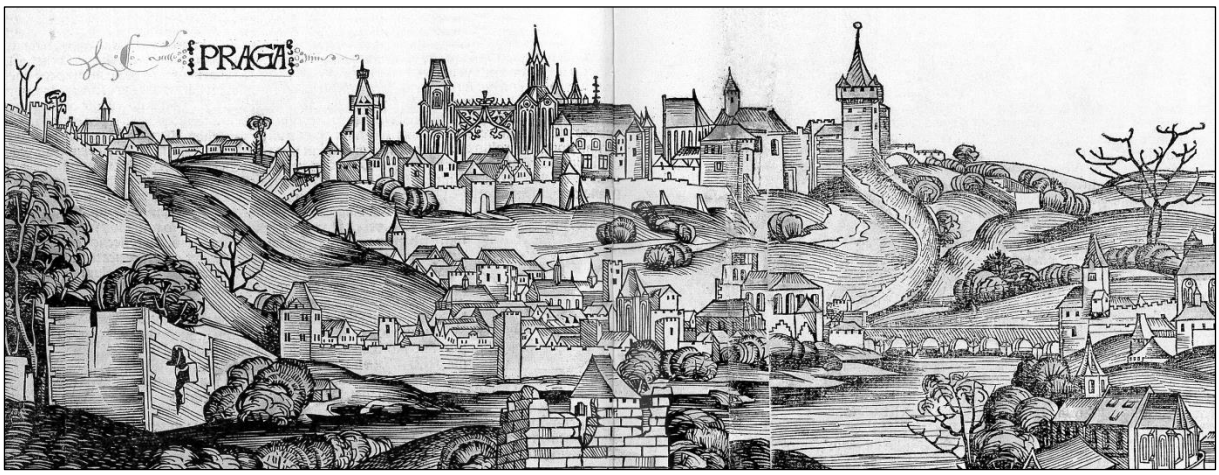
International multidisciplinary conference

Frontiers of Quantum and Mesoscopic Thermodynamics 2022

(FQMT'22)

Zero Announcement



The conference is focused on

Non-equilibrium phenomena
mainly in mesoscopic and biological systems,
cold atoms and molecules

Quantum statistical physics
Foundations of quantum physics
Quantum optics

31 July – 6 August 2022, Prague

https://fqmt.fzu.cz/22/

FQMT Conference Series Overview

FQMT conferences form a series of successful conferences (FQMT'04, FQMT'08, FQMT'11, FQMT'13, FQMT'15, FQMT'17, FQMT'19, and FQMT' 21 - online) which are traditionally held in Prague. Follow-up to the eight previous conferences will be FQMT'22 to be held in July-August 2022. For the details of the conference programs and the history of the FQMT conferences see the www pages: https://fqmt.fzu.cz/. The title of the conference is traditional and reflects main topics of early FQMT conferences. The contributions from the previous conferences have been published in Physica E (vol. 29, issues 1-2, 2005, and vol. 43, issue 3, 2010), Physica Scripta (vol. T151, 2012, and vol. T165, 2015), Fortschritte der Physik (Progress of Physics), vol. 65, 2017, and the European Physical Journal Special Topics (vol. 227, issues 15-16, 2019 and vol. 230, issue 4, 2021).

Public Lectures at the FQMT Conferences - Overview

The previous public lectures were presented by the following speakers:

FQMT'04		
	Anthony Leggett:	Does the everyday world really obey quantum mechanics?
FQMT'08		
	Georgy Shlyapnikov:	Novel physics with ultracold fermions
	Marlan Scully:	The demon and the quantum: From thermodynamics to quantum mechanics and beyond
	Raymond Chiao:	The Big Bang and the Cosmic Gravitational-wave Background (CGB): Using quantum mechanics to detect the first rumors in the Universe
FQMT'11		
	Martin Rees:	From Big Bang to Biospheres
	Claude Cohen-Tannoudji:	Laser manipulation of atoms
FQMT'13		
	Serge Haroche:	Juggling with photons in a box to explore the quantum world
	Pavel Kroupa:	How astronomers define our world view
FQMT'15		
	Gerard 't Hooft:	The quantum deep down
	Marlan Scully:	The photon sheds light on the quantum
FQMT'17		
	John Pendry:	Metamaterials and the science of invisibility
	Anton Zeilinger:	From quantum puzzles to quantum information technology
FQMT'19		
	William Phillips:	Time, Einstein and the coolest stuff in the universe
	Rainer Weiss:	The beginnings of gravitational wave astronomy
	Wolfgang Ketterle:	Cooling close to absolute zero temperature: A recipe for discoveries

FQMT'21

The conference was held online only and no public lectures were included.

Conference overview

Frontiers of Quantum and Mesoscopic Thermodynamics (FQMT'22)

31 July (Sunday) – 6 August (Saturday) 2022, Prague, Czech Republic

https://fqmt.fzu.cz/22/

Scope of the FQMT'22 conference

The main goal of the conference is to contribute to a better understanding of the behavior of quantum systems out of equilibrium. To reach this aim we also need to improve our knowledge of systems in equilibrium and steady state situations. The conference will thus address foundations of quantum physics, quantum many body physics, statistical physics, and thermodynamics relying on the theoretical and experimental methods of condensed matter physics and quantum optics. The systems considered will be mainly on the order of mesoscopic (nanoscale) size, and include those of both natural and artificial origin. Special attention will be given to non-equilibrium quantum systems, physics of quantum information and manifestation of quantum effects in biological systems. Subjects from astrophysics, gravitation or cosmology related to the above scope will also be included

Topics

- Non-equilibrium quantum phenomena
- Dissipation, dephasing and noise,
- Quantum statistical physics and thermodynamics
- Foundations of quantum physics
- Quantum measurement, entanglement and coherence
- Many body physics, quantum field theory
- Light matter interactions, quantum optics
- Physics of quantum information and computing
- Topological states of quantum matter, quantum phase transitions
- Macroscopic quantum behavior
- Atomic physics, cold atoms and molecules
- Mesoscopic, nano-electromechanical and nano-optical systems
- Molecular motors, quantum heat engines
- Biological systems
- Cosmology, gravitation and astrophysics

Multidisciplinary Character of the Conferences

The aim of FQMT'22 conference is to create a bridge between the fields of non-equilibrium statistical physics, quantum many body physics, foundations of quantum physics, quantum thermodynamics, quantum optics, physics of quantum information, astrophysics, condensed matter physics, physics of mesoscopic systems, chemical physics and biophysics.

Following the tradition of the FQMT conferences, FQMT'22 will again bring together a unique combination of both young and experienced scientists across a disciplinary spectrum covering the above mentioned topics. The interdisciplinary character of the conference will be supported by the choice of key speakers who, apart from their specializations, are not only able to report specific results within their fields, but are also able to discuss the state of the art of their fields from the standpoint of a broader perspective of overlap with other fields. It is an objective to gather important scientists from overlapping branches of physics who can mutually benefit from the exchange of different views and ideas, experiences from studies of many different systems and various theoretical and experimental approaches to the study of current problems in physics. It is intended that this arrangement of the scientific program of the conference will again significantly contribute to the formulation of challenging questions and problems, as well as their related answers that are nowadays essential to improve the understanding of the foundations of quantum physics, many body physics, quantum statistical physics of systems far from equilibrium, the physics of nanoscale and biological systems, and further, will motivate new collaboration and intensive discussions between experts from differing fields of physics, chemistry, and biology.

Public Lectures

Following the tradition of FQMT conferences, the FQMT'22 program will include several public lectures which will present interesting topics in the form attractive for both the conference participants and general audience. The following lecturer is, at present, expected (others are anticipated):

- Harrison H. Schmitt (Apollo 17 geologist/astronaut)

The lectures will be held at special venues and accompanied by concerts.

Musical, Art and Social Programs

An encompassing social program includes a number of social events and tours enabling participants to enjoy not only physics but also Prague during the conference, in a way hardly available to common visitors of Prague. Hence for accompanying persons, this is an opportunity for a very rare quality to visit to this city.

Participants of FQMT'22 conference will have an exceptional opportunity to spend some time in the Wallenstein Palace. Participants and their partners will enjoy the large baroque Garden

of the Wallenstein Palace with its beautiful Sala Terrena for discussions during the evening welcome party. A guided tour will be organized through the huge baroque complex of the Wallenstein Palace. This will be a unique experience by itself, since it is difficult to see all these places under ordinary circumstances.

In keeping with the multidisciplinary character of the scientific program, the cultural richness of the city of Prague and the tradition of the previous FQMT conferences, the FQMT'22 program will feature concerts performed by world-class musicians, held at outstanding venues of the city. The list of these places will likely include e.g. Dvořák's Hall of the Rudolfinum (the seat of the Czech Philharmonic Orchestra and famous by concerts of Prague Spring Festival), the Gothic Cathedral of St. Vitus at Prague Castle (one of the symbols of the Czech Lands), and the Baroque St. Margaret Church at the Břevnov Monastery.

The scientific, the fine arts, and the musical programs are intended as a complement to one another, where scientists, historians of the arts and musicians are encouraged to mingle and share their knowledge and experience. The encompassing social programs include tours and a number of very special events unavailable to the general tourist.

FQMT'22 Organizing Committee

Conference chair: Václav Špička (*Institute of Physics, Czech Academy of Sciences, Prague*)
Jiří Bok (*Charles University, Prague*)
Howard Brubaker (*Detroit*)
Pavla Bušová (*Prague*)
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Josef Kšica (*Prague*)
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Theo M. Nieuwenhuizen (*University of Amsterdam*)
Claudia Pombo (*Amsterdam*)
Marie Svobodová (*Tacca Agency, Prague*)
Jarmila Šidáková (*Prague*)

FQMT'22 Scientific Committee

(not yet complete)

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Franco Nori (*RIKEN, Wako-shi, and University of Michigan, Ann Arbor*)
Henri Orland (*CEA-Saclay*)
Giorgio Parisi (*Università di Roma I. La sapienza*)
Christophe Salomon (*Laboratoire Kastler Brossel, Paris*)

Marlan Scully (*Texas A&M University, Baylor University and Princeton University*)
Georgy Shlyapnikov (*Université Paris Sud*)
Wolfgang Schleich (*University of Ulm*)
Ady Stern (*Weizmann Institute, Rehovot*)
Michael Thorwart (*University of Hamburg*)
Jan van Ruitenbeek (*Leiden University, Kamerlingh Onnes Laboratory*)
Anton Zeilinger (*University of Vienna*)
Peter Zoller (*Institute for Quantum Optics and Quantum Information, Innsbruck*)

The conference is organized by

Institute of Physics of the Czech Academy of Sciences
Committee on Education, Science, Culture, Human Rights and Petitions of the Senate of the Parliament of the Czech Republic

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Institute of Physics of the Czech Academy of Sciences
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Institute of Physics of the Czech Academy of Sciences
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Department of Physics, Texas A&M University, USA
Institut de Physique Théorique, CEA/CNRS Saclay, France

FQMT'22 Scientific Background

Recent advances in technologies have led to enormous improvements of measurement, imaging and observation techniques at microscopic, mesoscopic and macroscopic scales. At the same time, various methods allow us to investigate not only equilibrium features of complex many body systems, but also time evolution of these systems (which are in general far from equilibrium) at different time scales. This increasing ability to study subtle details of

the dynamics of systems yields new versions of old questions and creates new challenges in many fields of physics.

The FQMT'22 program will be thus focused on conceptual and experimental challenges of non-equilibrium statistical physics, quantum many body physics, quantum thermodynamics, foundations of quantum mechanics, and quantum field theory. Further development of all these fields is needed to deal with an increasing requirement for more detailed understanding and use of such phenomena as quantum correlations, entanglement and their dynamics; decoherence and dissipation; light−matter interactions; behavior of closed and open quantum systems far from equilibrium; equilibration and thermalization of systems; roles of initial and boundary conditions; influences of environment, reservoirs and external fields on the time evolution of systems; quantum to classical transitions; dynamics of quantum phase transitions; and topological states of systems.

A good understanding of the time evolution of both classical and quantum systems is essential for an explanation of many observations and experiments of contemporary physics. Observed systems must be often treated as non-equilibrium, open systems in which their behavior is influenced not only by their inner parameters, but also by properties of their environment and time dependent external fields. The theory of non-equilibrium behavior of quantum many-body systems is, however, far from complete. Important problems include such questions as irreversible behavior of real systems in comparison with reversible microscopic laws, emergence of classical macroscopic behavior from microscopic quantum behavior, charge (electron), spin and heat transport, limits to "phenomenological" thermodynamic descriptions, and the problem of how to describe properly open quantum systems far from equilibrium, especially in the case of strong interaction between a small system and reservoirs. Thus, further experimental as well as theoretical studies of short to long time dynamics (via transport as well as optical properties) and the influence of initial and boundary conditions are needed.

Non-equilibrium processes and the system's environment also play a decisive role in living organisms and there are many questions to be answered before we fully understand the laws which govern the performance of the nanometer structures which are essential for life. In this regard, it appears one of the necessary conditions for the proper performance of cells is that their dynamics be based on far from equilibrium states and related nonlinear, non-equilibrium transport. There are also questions about the role of quantum physics in the behavior of various systems which are essential for living organisms, i.e., under which circumstances quantum effects, coherence, fluctuations and noise can influence a cell's functions.

Mesoscopic systems are of special importance for these studies. Various systems, of natural and artificial origin, can exhibit mesoscopic features depending on inherent inner parameters and interactions with their environment. Typical mesoscopic systems are of nanometer size, enabling fast developing nanoscale technologies for the preparation of structures with well-defined inner parameters, providing an enormous diversity of systems subject to interaction with the external environment. Nanoscale structures include not only very small artificially prepared structures, but also structures occurring in living cells, as for example complex molecules, proteins and molecular motors. Such systems are on the borderline between different disciplines where the dynamic behavior of these systems and corresponding various

methods of their description (individual and statistical, microscopic and macroscopic, classical and quantum) meet. These (often open) systems are commonly dominated by quantum effects, by topology of their structures and states, and by strong interactions with their environment. Due to their position between the macro and micro world, these systems exhibit many surprising phenomena which can lead to a better understanding of quantum mechanics, many-body physics, and the relation between classical and quantum behaviors by sensitive choice of parameters. The development of theoretical concepts for their description and reliable experimental methods is of great importance for investigating these systems, testing theories and designing new nanostructures with well defined, desired behavior. They can be studied by methods of condensed matter physics and quantum optics in such detail that affords a deeper understanding of quantum physics, as represented by quantum interferences, entanglement, the uncertainty principle and quantum measurement processes.

Another challenging problem is stochastic behavior of such systems caused either by innate features of the systems or by noise related to the studied systems being open. Studies of quantum and temperature fluctuations, as well as quantum noise, dephasing and dissipation are of key importance, since these phenomena are closely related to the performance and the reliability of both artificially created nano-devices and "nano-engines" as well as natural "engines", as are for example molecular motors and processes in cells in general.

Behavior of molecular motors is associated with more general considerations related to thermodynamics and the use of various mesoscopic structures. Among the central themes of classical thermodynamics are the concepts of "temperature", "system", "reservoir", and "engine". Due to quantum features of mesoscopic systems, it is necessary to deal with quantum thermodynamics to discuss possible quantum pumps, heat engines or refrigerators based on features of mesoscopic (molecular) systems. The task of quantum thermodynamics is to provide a good "phenomenological" frame for the "macroscopic" description of open mesoscopic systems coming from more detailed studies of non-equilibrium quantum statistical physics of open systems and the foundations of quantum mechanics.

In general, the above problems arise in dissipation, dephasing and decoherence processes, and, on a very basic level, the foundations of quantum mechanics and related theories of quantum measurement. A better knowledge and insight into the foundations of quantum physics is essential for a proper formulation of the fundamental laws of physics. It is also essential for developing a suitable description of small quantum systems and their applications. This applies particularly to studies of light-matter interactions, cold atoms and molecules, quantum optics and physics of quantum information and computing, where questions of quantum interference, entanglement and decoherence processes, together with knowledge of time scales governing the dynamics of the studied systems, are essential and mutually beneficial. Various quantum (two states) systems are nowadays intensively studied in a hope that their parameters and related dynamics will be suitable for quantum computers.

Many of the above mentioned problems are also important for cosmology, gravitation and astrophysics, for the reason that these areas of investigation are strongly related to non-equilibrium statistical physics, many body physics, foundations of quantum physics, physics of quantum measurement, macroscopic quantum phenomena and also, mainly due to

measurement methods used for observation and detection, to quantum optics, condensed matter physics, and physics of mesoscopic systems.

Both theoretical and experimental experiences from such seemingly different, but in fact strongly correlated, fields as condensed matter physics, quantum optics, plasma physics, nuclear physics, physics of quantum information and computing, chemistry, biophysics and astrophysics, will be discussed during the conference program.