First Announcement (April 21, 2010)

Frontiers of Quantum and Mesoscopic Thermodynamics (FQMT'11)

25 July (Monday) – 30 July (Saturday) 2011, Prague, Czech Republic

http://conferences.fzu.cz/fqmt/11/

Scope of the Conference

The conference will address the foundations of quantum physics and non-equilibrium quantum statistical physics. The systems considered will be mainly on the order of mesoscopic (nanoscale) size, and include those of both natural and artificial origin. The main goal of the conference is to contribute to the uncovering of possible phenomenological ("quantum thermodynamic") laws governing the behavior of mesoscopic systems, and to provide better understanding and insight into the recent problems of the foundations, relying on the theoretical and experimental methods of condensed matter physics and quantum optics. Special attention will be given to the dynamics of mesoscopic open systems and their relevance to problems of measurement of non-equilibrium quantum systems, thermal and quantum fluctuations, dissipation, noise, physics of quantum information and biological systems, in terms of both theory and experiment. Additional subjects will include biophysics, gravitation and cosmology.

Topics

- Foundations of quantum physics
- Non-equilibrium quantum statistical physics
- Quantum thermodynamics
- Quantum measurement, entanglement and coherence
- Dissipation, dephasing, noise and decoherence
- Quantum optics
- Macroscopic quantum behavior, e.g. cold atoms, Bose-Einstein condensates
- Physics of quantum computing and quantum information
- Mesoscopic, nano-electromechanical and nano-optical systems
- Spin systems and their dynamics
- Biological systems, molecular motors
- Cosmology, gravitation and astrophysics

Scientific Committee

Chair: Theo Nieuwenhuizen (University of Amsterdam)
Co-Chair: Václav Špička (Institute of Physics, Prague)
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Reinhard Lipowsky (Max Planck Institute, Potsdam)
Daniel Loss (University of Basel)
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Marlan Scully (Texas and Princeton Universities)
Francesco Sylos Labini (La Sapienza, Rome)
Dale Van Harlingen (University of Illinois at Urbana Champaign)*
Vlatko Vedral (University of Oxford)
Anton Zeilinger (Institute for Quantum Optics and Quantum Information, Vienna)
Peter Zoller (Institute for Quantum Optics and Quantum Information, Innsbruck)

*participation in the Committee has not been confirmed yet

Organizing Committee

Conference chair: Václav Špička (Institute of Physics, Acad. Sci. CR, Prague)
Peter D. Keefe (University of Detroit Mercy)
Theo M. Nieuwenhuzien (University of Amsterdam)
Jiří Bok (Charles University, Prague)
Howard J. Brubaker (Detroit)
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Jiří J. Mareš (Institute of Physics, Acad. Sci. CR, Prague)
Jarmila Šidáková (Institute of Physics, Acad. Sci. CR, Prague)

History of the Conference

FQMT'11 is a follow-up to the two previous, successful Prague conferences "Frontiers of Quantum and Mesoscopic Thermodynamics 2004" (FQMT'04), and "Frontiers of Quantum and Mesoscopic Thermodynamics 2008" (FQMT'08). For the details of their programs see their www pages: http://conferences.fzu.cz/fqmt/04/ and http://conferences.fzu.cz/fqmt/08/. The contributions from these conferences were published in Physica E (vol. 29, issues 1-2, 2005, and vol. 43, issue 3, 2010, respectively).

Many aspects of the FQMT topics have been covered by a number of recent, more specialized, conferences and workshops which the organizers of the FQMT conferences have taken an essential part in, namely: Hot topics in Quantum Statistical Physics: q-thermodynamics, q-decoherence and q-motors**,** Leiden 2003; Non-equilibrium Green's Functions I-IV conferences, Rostock 1999, Dresden 2002, Kiel 2005, and Glasgow 2009; Conferences on the Second Law of Thermodynamics and Quantum Physics, San Diego 2002, and 2006; Beyond the Quantum, Leiden 2006; and the Vaxjö meetings on Quantum Theory: Reconsideration of Foundations, Vaxjö 2001, 2003, 2005, 2007, and 2009.

Multidisciplinary Character of the Conference

The aim of FQMT’11 is to create a bridge between the fields of modern condensed matter physics, quantum optics, statistical physics, biophysics, and the quickly developing field of foundations of quantum physics.

The conference will bring together a unique combination of young and experienced scientists across a disciplinary spectrum ranging from foundations of quantum physics to emerging statistical physics approaches to the study of non-equilibrium quantum systems. As in FQMT’04 and FQMT’08, the interdisciplinary character of the conference will be supported by 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, 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 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, quantum statistical physics of finite systems far from equilibrium and the physics of nanoscale systems, and further, will motivate new collaboration and intensive discussions between experts from differing fields (i.e., physics, chemistry, biology and cosmology).

Musical and Social Programs

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’11 program will feature concerts of classical and jazz music performed by world-class musicians, held at outstanding venues of the city. Both the scientific program and the musical program are intended as a complement to one another, where scientists and musicians are encouraged to mingle and share their knowledge and experience.

An encompassing social program is planned which will include tours and a number of very special events unavailable to the general tourist.

Preliminary program

Core of the conference program will consist of:

1. Lectures invited only by the scientific committee. No contributed talks are assumed.
2. Contributed papers discussed during poster session(s).

Preliminary program will include (subject to change):

I. **Invited lectures:**
   Non-parallel lectures of 30 minutes length (discussion included). Special or evening lecture longer. Possibility of 20 minutes talks and/or parallel sessions.

II. Two or three Evening lectures open to public

III. Round table: probably on Saturday after special longer introductory lecture(s)

IV. Poster session for submitted contributions

V. Time for discussion/networking

VI. Tour through Prague

VII. Concerts

VIII. Conference dinner: Friday

Detailed Scientific Background and Comments

Recent progress in nanoscale technologies enables the preparation of well defined artificial structures composed of atoms (molecules) in the number range of between several and hundreds and to measure many characteristics of such systems of nanoscale size. At the same time, advances of measurement techniques open the possibility to investigate not only these artificial structures, but also structures of similar nanoscale size occurring in nature, as for example complex molecules, molecular motors in living cells, proteins and viruses.

There is thus a growing demand for an understanding of the laws which govern the behavior of these systems. The development of theoretical concepts for their description and reliable experimental methods is of great importance for investigating these systems and designing new nanostructures with well defined, desired behavior.

Depending on conditions, nanoscale (i.e., nanoscopic or microscopic) systems can demonstrate characteristics of mesoscopic systems. As the name suggests, mesoscopic systems are, by their observed properties, on the borderline between the macro and micro world: contrary to macroscopic systems, fluctuations around average values can play an essential role in their behavior, but similarly to macroscopic systems, which are governed by the laws of classical mechanics, the behavior of mesoscopic systems is generally determined by large numbers of particles, wherein individuality of particles does not play an important role. Mesoscopic systems have, however, one common characteristic with microscopic systems: their behavior demonstrates quantum mechanical features and their description does not lie within classical physics. Due to their position between the macro and micro world, mesoscopic systems exhibit many surprising phenomena which can lead not only to novel devices, but also to a better understanding of quantum mechanics and the relation between the classical and quantum behavior by sensitive choice of parameters of the studied mesoscopic systems.

An understanding of mesoscopic systems, however, is far from being complete. To find laws governing these systems is a challenging task, due to the complexity of these systems, their diversity, and the fact that these systems are on the borderline between different disciplines (i.e., physics, chemistry, and biology) where the diverse dynamic behavior of these systems and corresponding various methods of their description (individual and statistical, microscopic and macroscopic, classical and quantum) meet.

A good understanding of the time evolution of quantum systems, both on the short and long time scale, is essential for an explanation of many experiments pertaining to mesoscopic systems. They 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 (e.g., electric and magnetic) time dependent external fields. The theory of non-equilibrium behavior of quantum systems is, however, also far from being complete. There are lasting and extremely important problems related to modern technologies, including questions of irreversible behavior of real systems in comparison with reversible microscopic laws, emergence of classical macroscopic behavior from microscopic quantum behavior and macroscopic quantum systems (such as Bose-Einstein condensates), limits to “phenomenological” thermodynamic descriptions, and the problem of how to describe properly open quantum systems far from equilibrium (as for example a system under the influence of strong time dependent laser pulses), especially in the case of strong interaction between a small system and reservoirs (contact baths). The conference program will consider experimental as well as theoretical studies of transport and optical properties, including both short time (transient) as well as long time dynamics and steady state transport. Due to possible abrupt changes of system dynamics caused either by sudden changes of external fields or by quick switches ("quantum quenches"), it is also important to discuss the influence of the initial conditions on the dynamics of non-equilibrium quantum systems, especially where it is desired to measure and explain short time (transient) behavior.

Time evolution of mesoscopic systems and accompanied decoherence processes are also strongly related to the many body interactions in systems. The strong correlations in systems are, however, far from being understood even in equilibrium. Apart from the properties determined by (electron) charges, spin dynamics of nanoscale systems are also interesting to study, both in terms of basic research and possible applications. The conference program will include discussions of the latest development in the competitive, and at the same time complementary, approaches used for the description of many body systems out of equilibrium, as represented by various density matrix methods (including use of renormalization group), non-equilibrium Green's function (NGF) methods, and time dependent density functional (TDDFT) or dynamical mean field theory (DMFT).

Another challenging problem related to the conference program is stochastic behavior of quantum systems caused either by innate features of the systems or by noise related to the fact that the studied systems are open. Quantum and temperature fluctuations, as well as quantum noise in mesoscopic systems, will create an essential part of the conference contributions. Recently, various versions of non-equilibrium fluctuation-dissipation theorems for quantum systems have been discussed. The conference aims at supporting investigations in this direction in order to improve our understanding of these theorems, their use and relations between their various versions for classical and quantum systems. Additional important themes of the conference program include: full counting statistics methods based on density matrix as well as non-equilibrium Green's function approaches and especially their use for fluctuations of electron current, systems with strong electron-phonon coupling, spin fluctuations and related dynamics. These studies are of key importance since the fluctuations and noise (in general in a state out of equilibrium) are closely related to the performance and the reliability of both artificially created nano-devices as well as natural "engines", as are for example molecular motors in cells.

Stochastic behavior of small systems is also related to Brownian motion and the physics of molecular motors. This theme brings us to the vast field of biophysics: various versions of molecular motors play an important role in the cells and tissues of living organisms. Again, non-equilibrium processes and the system's environment, together with related dissipation, play a decisive role in the behavior of small (nanoscopic) structures of living organisms and there are many important questions to be answered before we fully understand the laws which govern the performance of the nanoscopic 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 extensive discussions about the role of quantum physics in the behavior of various nanoscopic systems which are essential for living organisms. For example, there are studies about the role of quantum coherence in photosynthesis. Another phenomenon which can play an important role in living organism is the so-called stochastic resonance, which, perhaps, helps to improve the performance of certain parts of living cells. This opens the question under which circumstances fluctuations and noise, quantum effects, and coherence have positive or negative influence on a cell's performance. All the above questions are important not only for an understanding of living organisms, but also for studies of artificially prepared structures which are motivated by nanobiology, and in this regard biomimetics is a quickly developing area of research. Moreover, recently there have been a number of studies related to the possible use of biological molecules and systems for various purposes. Well known are, for example, the recent investigations of various properties of the DNA molecule in relation to data processing and storage.

Performance of molecular motors and the field of biomimetics are 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 engines 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. The central question which will also be discussed during the conference is under which conditions the thermodynamic behavior (such as well defined temperature) still manifests in various mesoscopic (open) systems.

In general, the above problems are related to questions of the description of dissipation, dephasing and decoherence processes, and, on a very basic level, to the foundations of quantum mechanics and related theories of quantum measurement. As already indicated, the "best" systems to measure and investigate these problems and questions are mesoscopic systems. Nowadays, various systems of nanoscale size are studied by methods of condensed matter physics and quantum optics, using suitable samples with well defined parameters, to observe the behavior of quantum systems in order to obtain a deeper understanding of quantum physics, as represented by quantum interference phenomena, decoherence processes, entanglement, the uncertainty principle, non-locality and 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 with regard to Bell inequalities and quantum gravity. It is also essential for developing a suitable description of small quantum systems and their applications. This applies particularly to quantum optics investigations and physics of quantum 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. This can be well documented by various examples from the physics of quantum computing, information and metrology and the physics of cold atoms, together with a vast number of studies dealing with Bose-Einstein condensation in various systems. An important part of the conference program will be devoted to discussions of the physics of all the above mentioned systems.

Another promising contribution to advance the understanding of mesoscopic systems, and at the same time the foundation of quantum physics, comes from a combination of electron transport and mechanical degrees of freedom in so-called nano-electro-mechanical systems (NEMS), and a combination with light in the case of opto-mechanical systems. These systems not only provide interesting data, they also introduce possibilities of how to measure and investigate other small systems of various origins. Recent progress in technologies and methods of cooling now even allow for investigations which measure directly the transition between classical and quantum behavior of small mechanical oscillators.

Further included in the conference program are the fields of cosmology, gravitation and astro-particle physics, for the reason that these areas of investigation are strongly related to the foundations of quantum physics, physics of quantum measurement, macroscopic quantum phenomena (e.g., magnetization) and also, mainly due to measurement methods used for observation and detection, to quantum optics, condensed matter physics, and physics of mesoscopic systems.

To summarize, the conference will deal mainly with mesoscopic systems and phenomena which are observed in various structures and materials. such as carbon allotropes (e.g., graphene and carbon nanotubes), quantum wires and dots, microcavities, single molecule nanomagnets, various structures in living cells, as well as specific arrangements featuring cold atoms which can exhibit various macroscopic quantum effects, such as Bose-Einstein condensation. These finite size open systems are commonly dominated by quantum effects and by strong interactions with their environment. They are often experimentally investigated via, or their performance is based upon, quantum phenomena, including for example decoherence, tunneling or entanglement, optical, transient and transport phenomena. Therefore, an understanding of the foundations of quantum physics and development of a reliable non-equilibrium fully quantum statistical theory are needed for their description. The purpose of the conference is to discuss all the above aspects of mesoscopic systems and to address related fundamental problems which are encountered on the way to understanding the physics of these systems.