Frontiers of Quantum and Mesoscopic Thermodynamics 2008 (FQMT'08)

Location: Prague, Czech Republic
Date: Monday July 28 – Saturday August 2, 2008

General Aim

To discuss foundations of quantum physics and non-equilibrium quantum statistical mechanics of mesoscopic (nanoscale) systems, in terms of both theory and experiment.

Topics

- Foundations of quantum physics
- Physics of quantum measurement
- Theory of quantum dissipation, dephasing and decoherence
- Quantum optics
- Physics of quantum computing and quantum information
- Non-equilibrium quantum statistical physics and quantum thermodynamics
- Macroscopic quantum behavior, e.g. Bose-Einstein condensates
- Mesoscopic and nano-electromechanical systems
- Spin systems and their dynamics
- Brownian motion, molecular motors and biological systems

Specific Aims

FQMT'08 is a follow-up to the previous, successful Prague conference "Frontiers of Quantum and Mesoscopic Thermodynamics 2004" (FQMT'04). As in FQMT'04, the aim of FQMT'08 is to create a bridge between the fields of modern condensed matter physics, quantum optics and statistical physics and the quickly developing field of foundations of quantum physics, as have been covered by a number of recent conferences and workshops (Hot topics in Quantum Statistical Physics: q–thermodynamics, q–decoherence and q-motors**,** Leiden 2003; Non-equilibrium Green's Functions I-III conferences, Rostock 1999, Dresden 2002, Kiel 2005; Conferences on the Second Law of Thermodynamics and Quantum Physics, San Diego 2002, 2006; Beyond the Quantum, Leiden 2006; and Vaxjo meetings on Quantum Theory: Reconsideration of Foundations, Vaxjo 2001, 2003, 2005, 2007), in which the organizers of the present meeting took an essential part in. It is an objective to gather important scientists from overlapping branches of physics who can mutually benefit from the exchange of different views, experiences with studies of many different systems and various theoretical and experimental approaches to the study of current problems in physics. The conference is intended to bring together a unique combination of scientists across a disciplinary spectrum ranging from

foundations of quantum physics to emerging statistical physics approaches to the study of non-equilibrium quantum systems (i.e., those who are studying various mesoscopic systems, either of artificial or biological origin, both from the theoretical and experimental point of view). 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 broader perspective of overlap with other fields. It is intended that this arrangement of the scientific programme 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 and the physics of nanoscale systems, and further will motivate new collaboration and intensive discussions between experts from different fields (i.e. physics, chemistry and biology).

The conference has attained the same status as FQMT'04, as it is confirmed as a satellite of the 22nd General Conference of the Condensed Matter Division European Physical Society (CMD22, Rome, August 25-29, 2008).

Scientific Programme Background

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 sizes. 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, prions and viruses.

There is thus a growing demand for an understanding of the laws which govern the behavior of these systems. To find these laws is an 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.

In general, the conference will address quantum physics and non-equilibrium quantum statistical physics. The systems considered will be mainly of nanoscale size. The main task of the conference is to contribute to the uncovering of possible phenomenological ("quantum thermodynamical") laws governing the behavior of nanoscale systems, providing a better understanding and insight into the problems and interpretations of quantum physics based upon the methods of condensed matter physics and quantum optics.

Objectives

FQMT'08 will focus on six main aspect and problem areas:

1. Time evolution of non-equilibrium quantum systems
2. The role of size and dimension on systems.

3. Many-body effects, disorder

4. Quantum noise and quantum decoherence

5. Molecular motors, nanoscale biological systems

6. Foundations of quantum mechanics and quantum field theory

These aspects and problems concern many physical situations studied by condensed matter physics (e.g., metals, semiconductors, superconductors, and their various combinations, in artificially created structures), plasma physics, nuclear physics, elementary particle physics, chemistry and biology.

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. The theory of non-equilibrium behavior of quantum systems is, however, 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 states, (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 above problems are related to questions of 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. The best systems to measure and investigate these problems and questions are mesoscopic systems which are nowadays prepared by technologies which provide artificial structures having well defined parameters. Various systems of nanoscale size are studied by methods of condensed matter physics and quantum optics, using suitable samples, 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, nonlocality and quantum measurement.

A better knowledge and insight into the foundations of quantum physics is the principle interest for proper formulation of the fundamental laws of physics in 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.

Time evolution of mesoscopic systems and accompanied decoherence processes are 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. An understanding of mesoscopic systems, however, is far from being complete. 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). These systems not only provide interesting data, they also bring other possibilities of how to measure and investigate other small systems of various origins.

The last, but not least, challenging problem is represented by 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. Particularly, spin fluctuations and related dynamics will be discussed. Experimental as well as theoretical studies of transport and optical properties, including full counting statistics of systems will be considered. The conference will also consider the physics of Brownian motion and molecular motors, of both artificial and biological systems.