Open Systems: Non-Equilibrium Phenomena - Dissipation, Decoherence, Transport

June 8 - 12, 2009
Auditorium HG F3, ETH Zentrum,

	Monday, June 8, 2009
9.00 – 9.40	**J. Avron, Technion Haifa** **Quantum swimming** Swimming in a one-dimensional Fermi sea at zero temperature is topological: The swimming distance covered in one stroke is quantized in half integer multiples of the Fermi wave length. In particular, the swimming distance is independent of the time-parametrization of the stroke and insensitive to small deformations of the swimming style. The talk is based on joint work with Boris Gutkin and David Oaknin (PRL 2006).
9.50 – 10.30	**J.-P. Eckmann, Université de Genève** **A model of heat conduction** In this talk I will describe a classical, one-dimensional model of particles and scatterers in which one can study heat conduction. This is work with P. Collet and C. Mejjia-Monasterio.
10.30 – 11.00	**Coffee Break**
11.00 – 11.40	**W. Abou Salem, University of Toronto** **Long-time dynamics of solitons in random potentials** I discuss progress in rigorously understanding the effective dynamics of solitons for the generalized nonlinear Schroedinger equation in a random and time-dependent potential. If the random potential is almost surely space-adiabatic, the the long-time dynamics of the soliton is described by Hamilton's equations for a classical particle in the random potential. Furthermore, one has sufficient control over the dynamics in order to study its limiting behavior in the weak-coupling/space-adiabatic limit. Under certain mixing hypotheses for the potential, the momentum of the center of mass of the soliton converges in law to a diffusion process on a sphere of constant energy in two dimensions. In three and higher dimensions, the soliton undergoes spatial diffusion.
14.00 – 14.40	**D. Ruelle, IHES, Bures-sur-Yvette** **Linear Response for General Smooth Dynamical Systems** A natural model for nonequilibrium statistical mechanics is given by a general smooth dynamical system on a compact manifold. Nonequilibriumsteady states correspond to SRB measures, entropy creation to volume contraction, etc. Of course, this misses some important physical features related to the thermodynamic limit. Nevertheless, it is instructive to study linear response in this setting. For uniformly hyperbolic dynamical systems the SRB measure depends differentiably on parameters, and linear response can be interpreted in terms of a susceptibility function with the expected analyticity properties. For systems that are not uniformly hyperbolic, however, nondifferentiable response arises, and also 'acausal' singularities of the susceptibility, for which we shall give a physical interpretation in terms of 'energy nonconservation'.
14.50 – 15.30	**G. Gallavotti, Università di Roma** **Thermodynamic limits in nonequilibrium statistical mechanics** The question of thermodynamic limit existence and equivalence of different thermostatting mechanicsms (frictionless versus dissipative) will be discussed in space dimensions d=1,2,3.
15.30 – 16.00	**Coffee Break**

16.00 – 16.40	**D. Dürr, Ludwig-Maximilians-Universität München** **On the role of decoherence in Bohmian Mechanics** Bohmian Mechanics is a theory explaining non relativistic quantum phenomena and the classical world. It does away with all mysteries, paradoxa and inconsistencies of quantum orthodoxy. I shall explain what role decoherence plays in the analysis of Bohmian mechanics. The explanation may be helpful also to those who do not know Bohmian mechanics to understand the role of decoherence in our quantum world.
16.50 – 17.10	**V. Bach, Johnannes Gutenberg-Universität Mainz** **Rigorous Foundation of the Brockett-Wegner Flow** The Brockett-Wegner flow was found independently by Brockett and Wegner in the early 1990ies to diagonalize self-adjoint matrices by a time-dependent Schroedinger equation. The lecture will discuss the mathematical foundation of this flow.
17.10 – 17.30	**S. Bachmann, ETH Zürich** **Time ordering and counting statistics** Time-ordered current correlators in mesoscopic systems have been computed using asymptotic in/out currents or the generating function for the statistics of transferred charge. First, I shall discuss the relation between the generating function and the time ordering of correlators. It turns out that the correct time ordering differs from the conventional one by contact terms living on the time coincidences. Second, I will present a model of energy independent scattering where that difference matters.

	Tuesday, June 9, 2009
9.00 – 9.40	**C.-A. Pillet, Université de Toulon-Var** **Spectral analysis of a CP map and thermal relaxation of a QED cavity** I will present the results of a recent joint work with L. Bruneau (Cergy) concerning the thermal relaxation of a QED cavity under repeated interactions with atoms (a so called one-atom maser). The main points of this work are: (i) to study return to equilibrium for some open system with infinite dimensional Hilbert space(results in this direction are scarce); (ii) to show that, using an appropriate version of Perron-Froebenius theory(due to Schrader), one can obtain interesting information on the spectrum of completely positive (CP) maps which can be turned into ergodic properties of the semigroup generated by this map.
9.50 – 10.30	**M. Pulvirenti, Università di Roma** **Does regularity imply global validity for the Boltzmann equation?** In this talk I present a possible strategy for proving the validity of the Boltzmann equation, globally in time, assuming smoothness of the solutions.
10.30 – 11.00	**Coffee Break**
11.00 – 11.40	**H.C. Oettinger, ETH Zurich** **Lessons from nonequilibrium thermodynamics: flow-driven glasses** Nonlinear frameworks of nonequilibrium thermodynamics are usually formulated for isolated systems. However, the postulated existence of a powerful underlying structure has implications also for open nonequilibrium systems. I first discuss the role of the Poisson (bracket) structure for reversible dynamics, and I then elaborate some concrete implications for structural glasses driven by external flow. Poisson brackets are fully determined by static properties. By postulating the existence of an underlying Poisson bracket we are led to a static signature for the glass transition. This static signature goes beyond what one could rationalize in terms of the more familiar thermodynamic concepts of energy and entropy. References: [1] H.C. Öttinger, Nonequilibrium Thermodynamics of Glasses, Phys. Rev. E 74 (2006) 011113. [2] E. Del Gado, P. Ilg, M. Kröger and H.C. Öttinger, Nonaffine Deformation of Inherent Structure as a Static Signature of Cooperativity in Supercooled Liquids, Phys. Rev. Lett. 101 (2008) 095501.
14.00 – 14.40	**T. Spencer, IAS, Princeton** **A SUSY model for quantum transport in a random environment** We describe a SUSY hyperbolic sigma model which is expected to qualitatively reflect Anderson localization. In 3D we prove that this model has a "diffusive" phase. Correlations of this model are equivalent to random walk in a correlated random environment. This is joint work with M. Disertori and M. Zirnbauer.
14.50 – 15.30	**J. Schenker, Michigan State University** **Diffusion of Wave Packets in a Markov Random Potential** Solutions to the tight binding Schroedinger equation with a time dependent random potential will be considered. If the potential evolves according to a stationary Markov process, we will see that the square amplitude of the wave packet converges, after diffusive rescaling, to a solution of a heat equation.
15.30 – 16.00	**Coffee Break**

16.00 – 16.40	**G.B. Lesovik (a), M.V. Suslov (b) and G. Blatter (c)** **(a) L.D. Landau Institute for Theoretical Physics RAS, Moscow** **(b) Moscow Institute of Physics and Technology** **(c) ETH Zürich** **Quantum divisibility test and its application in mesoscopic physics** We present a quantum algorithm to transform the cardinality of a set of charged particles flowing along a quantum wire into a binary number. The setup performing this task (for at most N particles) involves log2 N quantum bits serving as counters and a sequential read out. Applications include a divisibility check to experimentally test the size of a finite train of particles in a quantum wire with a one-shot measurement and a scheme allowing to entangle multi-particle wave functions and generating Bell states, Greenberger-Horne-Zeilinger states, or Dicke states in a Mach-Zehnder interferometer.
16.50 – 17.10	**G. Hagedorn, Virginia Polytechnic Institute and State University** **Non-Adiabatic Transitions in a Simple Born-Oppenheimer Scattering System** We describe mathematical results, obtained in collaboration with Alain Joye, that concern non–adiabatic transitions in a simple molecular dynamics model. We study scattering theory for the time–dependent molecular Schrödinger equation $$i\,\epsilon^2\,\frac{\partial\psi}{\partial t}\;=\;-\,\frac{\epsilon^4}{2}\,\frac{\partial^2\psi}{\partial x^2}\;+\;h(x)\,\psi$$ in the small ϵ (Born–Oppenheimer) limit. We assume the electron Hamiltonian $h(x)$ has finitely many levels and consider the propagation of coherent nuclear states with sufficiently high total energy. We further assume two of the electronic levels are isolated from the rest of the electron Hamiltonian's spectrum and have an avoided crossing with a small ϵ–independent gap. We compute the leading order behavior for the nuclear wave function associated with the non–adiabatic transition that is generated as the nuclei move through the avoided crossing. This component is of order $\exp\left(-\,C/\epsilon^2\right)$. It propagates asymptotically as a free Gaussian in the nuclear variables, and its momentum is shifted. The total transition probability for this transition and the momentum shift are both larger than what one would expect from a naive approximation and energy conservation.

	Wednesday, June 10, 2009
9.00 – 9.40	**A. Kupiainen, University of Helsinki** **Diffusion in Coupled Map Lattices** We consider a dynamical system consisting of subsystems indexed by a lattice. Each subsystem has one conserved degree of freedom ("energy") the rest being uniformly hyperbolic. The subsystems are weakly coupled together so that the sum of the subsystem energies remains conserved. We prove that the subsystem energies satisfy diffusion equation in a suitable scaling limit.
9.50 – 10.30	**C. Maes, KU Leuven** **Trying for a fluctuation-dissipation theorem out-of-equilibrium** A new fluctuation-response relation is found for thermal systems driven out of equilibrium. Its derivation is independent of many details of the dynamics, which is only required to be first-order. The result gives a correction to the equilibrium fluctuation-dissipation theorem, in terms of the correlation between observable and the excess in dynamical activity caused by the perturbation. Previous approaches to this problem are recovered and extended in a unifying scheme. (Joint work with Marco Baiesi and Bram Wynants, arXiv:0902.3955)
10.30 - 11.00	**Coffee Break**
11.00 - 11.40	**A. Teta, Università Degli Studi – L'Aquila** **Classical trajectories in a cloud chamber** We consider a simple model of a cloud chamber consisting of a test particle (the α-particle) interacting with two other particles (the atoms of the vapour) subject to attractive potentials centered in $a_1, a_2 \in \mathbb{R}^3$. At time zero the α-particle is described by a diverging spherical wave centered in the origin and the atoms are in their ground state. We show that, under suitable assumptions on the physical parameters of the system and up to second order in perturbation theory, the probability that both atoms are ionized is negligible unless a_2 lies on the line joining the origin with a_1. The work (in collaboration with G. Dell'Antonio and R. Figari) is a fully time-dependent version of the original analysis proposed by Mott in 1929.
14.00 – 14.40	**I.M. Sigal, University of Toronto** **On Renormalization Group and Resonances in Non-relativistic QED** In this talk I present recent results on existence and properties of resonances in non-relativistic QED . I will also outline main steps in the proof of existence which uses the renormalization group (RG). The main new ingredients here are a generalized Pauli-Fierz transform and momentum-anisotropic Banach spaces, which transform the RG-marginal problem into an RG-irrelevant one.
14.50 – 15.30	**B. Schlein, University of Cambridge** **Universality of sine kernel for Wigner matrices with small Gaussian perturbations** We consider ensembles of N by N hermitian Wigner matrices with independent and identically distributed entries having a Gaussian component with variance larger than N^{-3/4} (that is, we consider matrices of the form (1-t^2) H + t G, where H is a general Wigner matrix, G is from the Gaussian Unitary Ensemble, and the parameter t is at least N^{-3/8}). We prove that, in the limit of large N, the local eigenvalue statistics is described by Dyson's sine kernel.
15.30 – 16.00	**Coffee Break**

16.00 – 16.40	**C. Landim, IMPA, Rio de Janeiro** **Action functional and quasi-potential for the Burgers equation in a bounded interval** Consider the viscous Burgers equation on the interval $[0,1]$ with Dirichlet boundary conditions at the endpoints namely, $$\begin{cases} u_t + f(u)_x = \varepsilon u_{xx} \\ u(t,0) = \rho_0\,, \quad u(t,1) = \rho_1\,, \end{cases}$$ where the flux f is the function $f(u) = u(1-u)$, $\varepsilon > 0$ is the viscosity, and the boundary data satisfy $0 < \rho_0 < \rho_1 < 1$. Consider the action functional $$I_T^\varepsilon(u) := \sup_H \Big\{ \ell_u^\varepsilon(H) - \varepsilon \int_0^T dt \int_0^1 \sigma(u)\, H_x^2\, dx \Big\}\,,$$ where $T > 0$, $\sigma(u) := u(1-u)$ stands for the mobility of the system, the supremum is carried over all smooth functions $H : (-T,0) \times [0,1] \to R$ vanishing at the boundary $x = 0$, 1, and ℓ_u is the linear functional $$\ell_u^\varepsilon(H) \;:=\; \int_0^T dt \int_0^1 \Big\{ u\, H_t + f(u)\, H_x \;-\varepsilon u_x\, H_x \Big\} dx\,.$$ We examine in this talk properties of the quasi-potential associated to this action functional and characterize the optimal paths. In contrast with previous models, for ε small enough, the unstable manifold of the Hamiltonian dynamics is not a graph.
17.00	**Aperitif in the Alumni Pavillon (GEP Pavillon), ETH Zentrum**

	Thursday, June 11, 2009
9.00 – 9.40	**A. Carati and L. Galgani, Università degli Studi di Milano** **On the role of dynamics for the foundations of statistical thermodynamics** The point we make is that, sometimes, the role of dynamics for the foundations of statistical thermodynamics is not sufficiently stressed. Such a role is well manifested in connection with the fluctuation–dissipation theorem, for example of the case of specific heat. There, it is made clear that the main role is played by the time–autocorrelation of the energy of the considered system, while the Gibbs ensemble is just used in weighting the initial data entering the definition of the correlation itself. On the other hand, the statement of the theorem shows that the Gibbs ensemble can be used also in estimating the specific heat, but only after a time at which the time–autocorrelation of energy did essentially decay to zero. Instead, if the dynamics is such that the time–autocorrelation decays to some nonvanishing value, the system turns out to obey some statistical thermodynamics which differs from the standard canonical one. The fact that a statistical thermodyamics different from that of Gibbs may be compatible with a Gibbs ensemble for the initial data was apparently first pointed out in an old paper of W. Nernst of the year 1916. Some recent results by one of us are then mentioned, which provide the prescriptions for the formulation of statistical thermodynamics in the general case. From such works it is made clear that the use of the Gibbs ensemble for statistical thermodynamics is allowed only for sufficiently chaotic dynamical ssystems, in which the wandering in phase space is a process of Poisson type, while other forms of statistical thermodynamics are obtained for less choatic systems presenting some kind of correlations, or typical orbits of a fractal type.
9.50 – 10.30	**A. Gerschenfeld, ENS, Paris** **Invariance and large deviations of the current for exclusion processes on Z** The distribution of the flow of particles or energy between two systems put in contact for a duration t can be analytically calculated in some cases, such as those of an exclusion process on the infinite line whose sites are initially occupied with density ρ_a on one side of the origin and ρ_b on the other. There the law of the flow of particles Q_t across the origin exhibits a non-Gaussian decay in $e^{-Q_t^3/t}$ [1]. Moreover, a striking invariance allows one to deduce the general case from the study of $\rho_a = 1$, $\rho_b = 0$: this invariance can be derived either from the microscopic dynamics or from its hydrodynamic limit. [1] B. Derrida, A. Gerschenfeld, *Current Fluctuations of the One Dimensional Symmetric Exclusion Process with Step Initial Condition* arXiv:0902.2364 (2009)
10.30 – 11.00	**Coffee Break**
11.00 – 11.40	**G. Jona-Lasinio, Università di Roma** **The large deviation approach to nonequilibrium diffusive systems: recent developments and an assessment** The approach in the title is based on the study of fluctuations of macroscopic variables in systems where diffusion is the main physical mechanism of evolution. The central mathematical object is a functional, new in the context of fluid dynamics, in terms of which various variational principles can be established according to the problem under study. The guiding thread is provided by stochastic microscopic models (lattice gases) which are unified at the macroscopic level by a simple selfcontained description which can be used as a phenomenological theory. Equations for correlations of any order of thermodynamic variables are simply derived. Macroscopic long range correlations are typical of nonequilibrium states and have been observed experimentally. Current fluctuations have also been intensely studied by several people with very interesting results.

14.00 – 14.40	**A. Joye, Universite de Grenoble** **Leaky repeated Interacting Quantum Systems** We consider a small reference system S interacting with two large quantum systems of a different nature. On the one hand the system S interacts for a fixed duration with the successive elements E of an infinite chain C of identical independent quantum subsystems E. And, on the other hand, it interacts continuously with a heat reservoir R at a some inverse temperature given by an infinitely extended Fermi gas. The reservoir and the chain are not coupled. Our goal is to describe the large time behaviour of the fully coupled system S+R+C, i.e. the asymptotic state of this system and the exchanges between the chain and the reservoir in the large times limit. This is joint work with Laurent Bruneau and Marco Merkli.
14.50 – 15.30	**T. Sasamoto, Technische Universität München** **An analysis of the lattice Kardar-Parisi-Zhang equation** We consider a discretized version of the Kardar-Parisi-Zhang(KPZ) equation. We formulate the model in terms of bosons and discuss some of its properties. In particular we apply the method of resolvent hierarchy to study the large time behaviors of the current-current correlations (Joint work with H. Spohn).
15.30 – 16.00	**Coffee Break**
16.00 – 16.40	**J. Derezinski, Warsaw University** **Infimum of the excitation spectrum of the Bose gas and rigorous criteria for superfluidity** It is well known that Bose gas at very low temperatures exhibits supefluid behavior. According to the (appropriately interpreted) physics literature this is related to a special form of the joint energy momentum spectrum of the homogeneous Bose gas. This suggests some interesting conjectures about spectral properties of ist Hamiltonian, unfortunately very difficult to prove rigorously.
16.50 – 17.10	**R. Schrader, Freie Universität Berlin** **Causal free quantum fields on metric graphs** Based on the analysis of Laplace operators on metric graphs by Kostrykin and the author, we introduce free quantum fields on such graphs satisfying the Klein-Gordon equation and causal commutation relations. As a by product finite propagation speed for classical solutions of the Klein-Gordon and the wave equation equation are established.
17.10 – 17.30	**Marco Merkli, Memorial University of Newfoundland** **Dynamics of Disentanglement** We study the temporal evolution of the entanglement (concurrence) of two spins coupled to collective and local reservoirs. We show that generally, if the reservoir temperature is not too low, the reduced state of the spins will become disentangled after a finite time. We apply a dynamical theory of quantum resonances to estimate the disentanglement time.

	Friday, June 12, 2009
9.00 – 9.40	**I. Klich, University of Virginia** **Quantum quenches: current survival and other problems** A quantum quench is a rapid change of a quantum system from one phase to another at zero temperature. Such quenches have been the subject of growing interest in recent years due to possible realization in cold atom systems. In the talk I will describe some of the questions raised in this subject. I will study in detail the survival of super-currents in a system of impenetrable bosons subject to a quantum quench from critical superfluid phase to an insulating phase. I will describe the evolution of the current and it's oscillations when the quench follows a Rosen-Zener profile, which is exactly solvable.
9.50 – 10.30	**H. Spohn, Technische Universität München** **Kinetic limit for the Hubbard model** I report on joint work with Jani Lukkarinen, Helsinki. For the weakly coupled Hubbard model one expects the one-particle Wigner function to be governed by the Nordheim-Boltzmann equation. While a proof remains elusive, we establish a corresponding result for the <a(t)*a(0)> correlation in equilibrium. We use the Duhamel expansion together the Erdoes-Yau techniques, see J. Lukkarinen, H. Spohn, arXiv:math-ph/0807.5072, arXiv:math-ph/0901.3283.
10.30 – 11.00	**Coffee Break**
11.00 – 11.40	**Wojciech De Roeck, ETH Zürich** **Irreversibility in particle-field systems: diffusion, dehocerence, Cerenkov radiation, friction, and universal conductance fluctuations** We report on progress towards deriving the phenomena in the title from Hamiltonian quantum dynamics. sThe setup is that of a quantum particle in contact with a reservoir at positive temperature (diffusion) and zero temperature (Cerenkov radiation, friction). Time permitting, we also describe the phenomenon of universal conductance fluctuations. This is the fact that, in a quasi 1-dimensional disordered quantum wire, the second cumulant of the conductance depends only on the symmetry class of the system as long as the wire is shorter than its localization length. All of these phenomena have the common property that they can be modelled by a Markov approximation which assumes some degrees of freedom to be instantly randomized.
14.00 – 14.40	**S. De Bièvre, USTL, Villeneuve d'Ascq** **Stochastic acceleration applies ballistic motion** We study the long time behaviour of fast particles moving through space and time homogeneous, time-dependent random force fields with rapidly decaying spatial correlations. We show the existence of a large degree of universality in the behaviour of the particles' averaged kinetic energy $\langle p^2(t)\rangle$ and mean square displacement $\langle q^2(t)\rangle$, which only depend on whether the force is a gradient vector field or not. In the former case we show that asymptotically $\langle p^2(t)\rangle \sim t^{2/5}$, independently of the details of the potential and of the space dimension. As a result, in one dimension the motion is superballistic with $\langle q^2(t)\rangle \sim t^{12/5}$, whereas in higher dimensions it is ballistic: $\langle q^2(t)\rangle \sim t^2$. We support these results with numerical data. For force fields not obtained from a potential, the power laws are different: $\langle p^2(t)\rangle \sim t^{2/3}$ and $\langle q^2(t)\rangle \sim t^{8/3}$ in all dimensions $d \geq 1$.