ABSTRACTS

Dmitry Abanin (Geneva)

Ergodicity, entanglement, and many-body localization

Abstract: We are used to describing systems of many particles by statistical mechanics. However, recently it was realized that the basic postulate of statistical mechanics – ergodicity – breaks down in so-called many-body localized systems, where disorder prevents particle transport and thermalization. In this talk, I will describe a recent theory of the many-body localized (MBL) phase, based on new insights from quantum entanglement. I will argue that, in contrast to ergodic systems, MBL eigenstates are not highly entangled, but rather obey so-called area law, typical of ground states in gapped systems. I will use this fact to show that MBL phase is characterized by an infinite number of emergent local conservation laws, in terms of which the Hamiltonian acquires a universal form. Turning to the experimental implications, I will show that MBL systems exhibit a universal response to quantum quenches: surprisingly, entanglement shows logarithmic in time growth, reminiscent of glasses, while local observables exhibit power-law approach to equilibrium values. I will also discuss the transition between many-body localized and ergodic phases, as well as other recent developments in exploring ergodicty and its breaking in quantum many-body systems.

Serge Aubry (Saclay)

KAM tori in the 1D Random DNLS model and Absence of Diffusion of a Wave-packet?

Abstract Numerical investigations shows that a finite norm initially localized wave-packet in a system with linear Anderson localization and extra nonlinearity, may generate two kinds of trajectories which both are obtained with non vanishing probability. The first kind of wave-packets consists of almost periodic KAM trajectories which are recurrent and do not spread. The second kind consists of trajectories which look initially chaotic and often spread over long times. However it can be proven in several special models that complete spreading is impossible despite initial chaos. Thus, it is still questionable whether diffusion may persist forever and under which conditions. In case where complete diffusion is impossible, the nature of the limit state of initially chaotic trajectories is still unknown.
W. De Roeck (Leuven)

Many body nekoroshev estimates and (or versus) many-body localization

Abstract I will describe past and ongoing work together with Francois Huveneers and Alex Bols on ‘many-body Nekoroshev’ estimates in quantum and classical systems. These estimates were in the past proven in large generality for systems with a few degrees of freedom. Our project is to extend these to extended systems. A related topic, receiving a lot of attention in the recent condensed matter literature, is many-body localization. This describes the situation where a KAM theorem (stronger than Nekoroshev) applies for an extended system. We believe that this situation is very rare, possibly only occurring in 1dim strongly disordered quantum spin systems, and that most observed cases are in fact manifestations of Nekoroshev estimates (or ‘asymptotic localization’ as it has come to be called). My talk will survey both rigorous, heuristic, and numerical results.

L.H. Eliasson (Paris)

ALMOST REDUCIBILITY FOR THE QUASI-PERIODIC LINEAR WAVE EQUATION

Abstract We will consider the linear wave equation on a torus (= periodic boundary conditions) with a mass term and perturbed by a potential that depends quasi-periodically on time. The potential is analytic and the quasi-periodic frequencies are supposed to be Diophantine. We shall discuss the almost reducibility of this model. This is part of a joint project with B. Grebert and S. Kuksin to better understand the KAM-theory for the non-linear wave-equation.

Guido Gentile (Rome3)

Resonant tori of arbitrary codimension for quasi-periodically forced systems

Abstract Consider a system of rotators subject to a small quasi-periodic forcing which (1) is analytic, (2) satisfies a time-reversibility property, and (3) has a Bryuno frequency vector. Without imposing any non-degeneracy condition, we prove that there exists at least one quasi-periodic solution with the same frequency vector as the forcing. The result can be interpreted as a theorem of persistence of lower-dimensional tori of arbitrary codimension in degenerate cases.
A. Giuliani (Roma3)

Quantization of the Hall conductivity in interacting electron systems

Abstract: In this talk I discuss a recent proof of the quantization of the Hall conductivity for general weakly interacting gapped fermionic systems on two-dimensional periodic lattices. The result applies, among others, to the interacting Haldane and Hofstadter models. The proof is based on fermionic cluster expansion techniques combined with exact lattice Ward identities. Joint work with V. Mastropietro and M. Porta

E. Langmann (KTH)

Transport in the Luttinger model from a non-equilibrium approach

Abstract: I present exact results for transport properties of the Luttinger model based on a realistic non-equilibrium model. The latter describes the evolution and approach to steady state of certain local observables following a quench from a non-uniform initial state. The talk is based on common work with Joel Lebowitz, Vieri Mastropietro, and Per Moosavi [arXiv:1511.01884].

A. Majocchi

Classical perturbation theory for nonlinear chains in the thermodynamic limit

Abstract: In this talk we will discuss some classical perturbation theory results for nonlinear chains, which are valid in the thermodynamic limit. In particular, we will show how to construct adiabatic invariants both for a completely resonant model, as the discretized Phi4 model, and the Fermi Pasta Ulam system. In the first case, an exponential Nekhoroshev-type estimate for the stability times can be obtained, in the second one we got an averaging theorem estimate. We will stress the difficulties related to the presence of a large number small divisors, arising in the thermodynamic limit.

R. Montalto (Zurich)

Quasi-periodic standing wave solutions for gravity capillary water waves

Abstract: I will present a recent result (obtained with M. Berti) concerning the existence and the stability of small-amplitude quasi-periodic solutions for the water waves equations with surface tension. The core of the proof is the reduction of the linearized equation (at any approximate solutions) to constant coefficients. Such a reduction procedure is achieved by using Pseudo differential operators theory and a KAM reducibility scheme.
G. Panati (Rome 1)

On the localization of Wannier functions for periodic (magnetic) Schrödinger dynamics

Abstract: The localization of electrons in crystalline solids is often expressed in terms of the Wannier functions, which provide an orthonormal basis of $L^2(\mathbb{R}^d)$ canonically associated to a given periodic (magnetic) Schrödinger operator. The existence of exponentially localized (composite) Wannier functions might be, a priori, topologically obstructed, in view of the possible competition between regularity and periodicity of the corresponding (quasi-) Bloch functions. In a previous work (2007), we proved that the obstruction to the existence of exponentially localized Wannier functions is given, for $d \geq 3$, by the Hall conductance of the system, which is the physical counterpart of the Chern number of a vector bundle canonically associated to the given Schrödinger operator. On the other hand, for time-reversal (TR) symmetric systems such obstruction vanishes. Thus one may ask a finer question, and investigate the existence of frames of Bloch functions which are simultaneously smooth, periodic and TR-symmetric. The answer to this question depends on the fact that the TR operator is even or odd. In the latter case, an intriguing relation with the $\mathbb{Z}_2$-invariants of TR-symmetric topological insulators appears. As for magnetic systems, we recently proved that the corresponding magnetic Wannier functions are delocalized, in the sense that the variance of the position operator is always infinite, unless the Chern number of the magnetic Bloch bundle is zero. The talk is based on joint papers with D. Fiorenza, D. Monaco, A. Pisante and S. Teufel.

A. Scardicchio (ICTP)

Emergent local integrals of motion in the many-body localized phase

Abstract: We show, by means of an analog of Andersons locator expansion perturbation theory for operators, and in the same set of approximations used in Basko, Aleiner and Altshuler, that in the many-body localized phase of spin-less interacting fermions there is a complete set of local integrals of motion. We discuss the implications for transport properties and open problems.

B. Schlein (Zurich)

Hartree-Fock dynamics for weakly interacting fermions
Abstract: Fermions are quantum particles described by wave functions that are antisymmetric with respect to permutations. According to the fundamental laws of quantum mechanics the time evolution of fermionic systems is governed by the many body Schroedinger equation. We are interested, in particular, in the mean field regime, which is characterised by a very large number of weak collisions among the particles. We will show that, for initial data close to appropriate Slater determinants, the Schroedinger evolution can be approximated by the Hartree-Fock equation, providing explicit bounds on the rate of the convergence.

S. Warzel (Munich)

Decay of correlations and absence of superfluidity for 1D Bosons in disorder with hard-core repulsive interaction

Abstract: In view of the woefully short list of rigorous results on disordered systems with interaction, limiting or integrable model systems present a testing ground for numerical works, conjectures and ideas. In the bosonic case, the limiting case of hard-core repulsive interaction is such an example: in the lattice set-up this amounts to studying the XY-spin Hamiltonian with a random magnetic field, and in the continuum this is the Tonks-Girardeau model with a random potential. Both models can be related to non-interacting fermions in an external random potential. In this talk I will report on (exponential) bounds on the correlations of such systems. The difficulty in both cases lies in the non-local dependence of the physical (bosonic) correlation functions on the underlying fermionic correlations. At technical level, this is taken care of by means of bounds on determinants, which go beyond the trivial Hadamard inequality. (This is based on joint works with R. Sims and R. Seiringer.)

J.You (Nanjing)

Reducibility and its application to quasi-periodic Schrödinger operators

Abstract: I will talk about the reducibility of quasi-periodic linear systems and its applications in the spectral theory of quasi-periodic Schrödinger operators, including counter-examples to Kotani-Last conjecture, Dry Ten Martini problem and Aubry-Andre-Jitomirskaya conjecture. The talk is based on joint works with Xuanji Hou, Artur Avila and Qi Zhou.

Localization and Transport in One-Dimensional Discrete Schrödinger Equation
Consider the one-dimensional discrete Schrödinger equation (linear or nonlinear)

\[ \mathrm{i} \partial_t q_n = -(q_{n+1} + q_{n-1}) + V(\theta + n\omega)q_n(+)q_n|q_n|^2, \quad n \in \mathbb{Z}, \]

with \( \omega \) a rationally independent vector and \( V \) a real-analytic function on the torus. By describing different growths of the diffusion norm

\[ ||q(t)||_s := \left( \sum_n n^{2s} |q_n(t)|^2 \right)^{\frac{1}{2}}, \quad s \geq 1, \]

in different cases, we discuss localization and transport in this Hamiltonian, based on some spectral properties of Schrödinger operator. These works are applications of KAM theory for block-diagonalization of the infinite-dimensional matrix, and for almost-reducibility of Schrödinger co-cycle.