Mathematical physics and quantum mechanics

13.-17. October 2014

Venue: HIT E 41, ETH Hönggerberg

Program Structure: STS = Short talks session

	Monday	Tuesday	Wednesday	Thursday	Friday
9:30	M. Fraas	H. Siedentop	O. Kenneth	S. Bachmann	D. Lundholm
10:30	Coffee break				
11:00	P. Pickl	M. Salmhofer	G. Panati	F. Huveneers	D. Ueltschi
12:00	Lunch break				
14:30	A. Pizzo	W. de Roeck	A. Joye	P. Müller	
15:30	Coffee break				
16:00	S. Warzel	STS	J. Schmid	JP. Solovej	
17:00	JP. Eckmann	STS	Y. Avron		

Conference dinner: Wednesday 19:00, Restaurant Die Waid, Waidbadstrasse 45, Zürich

Titles and Abstracts

Monday

Martin Fraas: Adiabatic theory for quantum stochastic equations

In last two years there has been a growing interest of the mathematical physics community in the topic of non-demolition measurements, a theory of which has been developed for last 30 years in quantum optics and quantum control communities. I will review two main motivations to study this theory: Emergence of tracks, and closed loop control of quantum systems. In the continuous time limit, non-demolition measurements are described by quantum stochastic equations and I will also report on recent developments in the adiabatic theory of these equations.

Peter Pickl: Meanfield limits for gases of large volume

In recent years there has been a lot of progress in the understanding of quantum mechanical mean field limits. Usually one either considers the case of a gas of fixed volume while the coupling constant scales like the inverse density, or one considers dilute gases. In this talk I will present new results where the mean field description holds for gases of high volume and high density. Both, the Bosonic and the Fermionic case shall be presented and the physical relevance of the system discussed.

Alessandro Pizzo: Recent progress in foundations of two-electron scattering

The last two decades have witnessed substantial progress in the mathematical understanding of scattering of light and matter in the framework of non-relativistic QED. However, the case of Coulomb scattering, i.e., collisions of two electrons in the presence of photons, has remained outside of the scope of these investigations. In this talk, I will report on recent results in collaboration with W. Dybalski (TU-Munich). In particular, I will show how to construct two-electron scattering states and verify their tensor product structure in the infrared-regular massless Nelson model. The proof follows the lines of Haag-Ruelle scattering theory: Scattering state approximants are defined with the help of two time-dependent renormalized creation operators of the electrons acting on the vacuum. They depend on the ground state wave functions of the (single-electron) fiber Hamiltonians with infrared cut-off. The convergence of these approximants as $t \to \infty$ is shown with the help of Cooks method combined with a non-stationary phase argument. The removal of the infrared cut-off in the limit $t \to \infty$ requires sharp estimates on the derivatives of these ground state wave functions w.r.t. electron and photon momenta, with mild dependence on the infrared cut-off. These key estimates, which carry information about the localization of electrons in space, are obtained with the help of iterative analytic perturbation theory. Our results hold in the weak coupling regime.

Simone Warzel: TBA

Jean-Pierre Eckmann: Martin Hairer and KPZ the Fields Medal from a physicist's point of view

Tuesday

Heinz Siedentop: Dipoles in Graphene have Infinitely Many Bound States

In 3d dipoles have only finitely many bound states. In 2d – recently of interest in the context of graphene – it was argued by de Martino et al (2014) that there should exist infinitely many bound states. We prove this claim and show that the corresponding energies cluster at the edges of the spectral gap. – The talk is based on joined work with Jean-Claude Cuenin.

Manfred Salmhofer: Fermi systems at Van Hove points

Wojcieh de Roeck: TBA

Short talks session:

- Andrea Agazzi: The colors of graphene: the colored hofstadter butterfly for the honeycomb lattice
- Noé Cuneo: Non-equilibrium steady states for classical chains of 3 and 4 rotators
- Ori Hirschberg: Approach to equilibrium of diffusion in a logarithmic potential: some unexpected surprises

Wednesday

Oded Kenneth: TBA

Gianluca Panati: A geometric characterization of the $\mathbb{Z}_2$ invariants of topological insulators

Different topological phases of mesoscopic quantum matter can be labeled by integer- or $\mathbb{Z}_2$-valued indices, according to the fundamental symmetries of the physical system, as summarized in the celebrated Kitaev's periodic table.

A paradigmatic example is provided by Chern insulators, including Quantum Hall systems, associated to $\mathbb{Z}$-valued indices. In the 2-dimensional case, the index corresponds to the value of the transverse (Hall) conductance, measured in natural units, and has a natural geometrical interpretation as the Cher number of a vector bundle associated to the occupied states. More recently, time-reversal-symmetric topological insulators, associated instead to $\mathbb{Z}_2$-valued indices, have been first predicted and then experimentally realized.

Aiming to a geometric characterization of such $\mathbb{Z}_2$-indices, we consider a gapped periodic quantum system with a time-reversal symmetry of fermionic type (i. e. the time-reversal operator squares to -1), and we investigate the existence of periodic and time-reversal symmetric Bloch frames in dimensions 2 and 3.

In 2d, the obstruction to the existence of such a frame is shown to be encoded in a $\mathbb{Z}_2$-valued topological invariant, which can be computed by a simple algorithm. We prove that the latter agrees with the Fu-Kane index. In 3d, instead, four $\mathbb{Z}_2$ invariants emerge from the construction, again related to the Fu-Kane-Mele indices. When no topological obstruction is present, we provide a constructive algorithm yielding explicitly a periodic and time-reversal invariant Bloch frame. The result is formulated in an abstract setting, so that it applies both to discrete models and to continuous ones.

The talk is based on a recent work with D. Fiorenza and D. Monaco.

Alain Joye: Spectral Properties of Non-Unitary Band Matrices

We consider families of random non-unitary contraction operators defined as deformations of CMV matrices which appear naturally in the study of random quantum walks on trees or lattices. We establish several results about the location and nature of the spectrum of such non-normal operators as a function of their parameters. We relate these results to the analysis of certain random quantum walks, the dynamics of which can be studied by means of iterates of such random non-unitary contraction operators. This is joint work with Eman Hamza.

Jochen Schmid: Well-posedness of non-autonomous linear evolution equations for operators whose commutators are scalar

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Yosi Avron: The Index interpretation of the Quantum Hall effect: A tutorial

Thursday

Sven Bachmann: Scattering theory for gapped quantum spin systems

Quantum spin systems with reasonably local interactions have the property that the dynamics is characterized by a finite velocity of propagation a 'sound cone'. For translation invariant models, this can be used to generate space-time translations with properties similar to those of relativistic quantum field theories. Guided by this analogy, we construct a scattering theory for quantum spin systems with an isolated mass shell such as the Ising model in a strong magnetic field.

Francois Huveneers: A scenario for transport in many-body systems

In the last decade, many-body systems failing to thermalize due to quantum interference effects have been investigated intensively, a phenomenon now dubbed as many-body localization. The existence of a truly localized phase is however only firmly established in a few limited cases. In this talk I will introduce examples where at least asymptotic localization effects are expected in some regime, and I will discuss a possible mechanism for delocalization (thermal transport) by rare events. From joint work with W. De Roeck, M. Mueller, M. Schiulaz.

Peter Müller: Andersons orthogonality catastrophe

We quantify the asymptotic vanishing of the ground-state overlap of two non-interacting Fermi gases in d-dimensional Euclidean space in the thermodynamic limit. Given two one-particle Schrödinger operators in finite volume which differ by a compactly supported bounded potential, we prove a power-law upper bound on the ground-state overlap of the corresponding non-interacting N-particle systems. We express the decay exponent in terms of the transition matrix from scattering theory. This exponent reduces to the one predicted by Anderson [Phys. Rev. 164, 352–359 (1967)] for the exact asymptotics in the special case of a point-like perturbation. We therefore expect our upper bound to coincide with the exact asymptotics of the overlap. This is joint work with M. Gebert, H. Küttler and P. Otte.

Jan Philip Solovej: Travelling waves for Maxwell-Schrodinger and Maxwell-Pauli

I will discuss the existence of travelling waves for the coupled Maxwell-Schrodinger and Maxwell-Pauli system, i.e., for a charged particle moving with its self-generated (classical) electromagnetic field. For the Schrodinger system there exist travelling waves with all velocities up to the speed of light. For the Pauli system where the spin interaction with the magnetic field is included we can only prove existence up to a critical velocity less than the speed of light. I will also discuss the energy of these travelling waves and the implication for the effective mass of the charged particle.

Friday

Douglas Lundholm: Lieb-Thirring bounds for interacting Bose gases

The Lieb-Thirring inequality bounds the kinetic energy of a fermionic many-particle wave function in terms of its local particle density. Such a bound was recently extended to identical particles whose exchange statistics can be modeled using bosons with a local repulsive interaction, such as anyons in two dimensions, where Pauli repulsion is replaced by a local exclusion principle. Here we consider the generalization and application of similar energy bounds to a large family of pairwise interacting Bose gases, such as the hard-sphere gas in 3D, the hard-disk gas in 2D, as well as a general class of homogeneous potentials. This is joint work with F. Portmann and J. P. Solovej.

Daniel Ueltschi: Graphical representations of quantum spin systems

The graphical or probabilistic representations of quantum spin systems offer a different perspective, that helps to understand certain aspects better. They help to characterise the pure states and the nature of symmetry breaking. With Jakob Bjornberg, we recently used them to prove the exponential decay of the two-point correlation function in the presence of a transverse external field.