

Workshop on Analytical Aspects of Mathematical Physics

May 27 - 31, 2013

ETH Hönggerberg, HIT Building, Room E 51

	Monday, May 27, 2013
9.00	Registration
9:30	Simone Warzel, Technische Universität München The first-order transition of the ground-state in the quantum random energy model <p>The quantum random energy model or, as it is also known, the Anderson model on the hypercube, features in various contexts: from mathematical biology to quantum information theory as well as for an effective description of the localization-delocalization transition in many-particle models in condensed matter physics. Among its interesting properties is a first-order phase transition of the ground state depending on the strength of the disorder. In this talk, we will describe a proof of this phase transition.</p>
10:15	Coffee Break
11:15	Mathieu Lewin, Université de Cergy-Pointoise Derivation of Hartree and Bogoliubov theories for generic mean-field Bose gases <p>We consider the limit of a large number N of bosons described by the many-body Schrödinger equation. We work in the mean-field regime, which means that the interaction is of order $1/N$. Under some general assumptions, we prove that the eigenvalues of the Schrödinger Hamiltonian are given to first order by the nonlinear Hartree theory, and to second order by Bogoliubov's theory. This is a review of recent works with Phan Thanh Nam (Cergy), Nicolas Rougerie (Grenoble), Sylvia Serfaty (Paris) and Jan Philip Solovej (Copenhagen).</p>
12:00	Alessandro Giuliani, Università di Roma Tre Interacting dimers, height function and bosonization <p>We consider a simple non-integrable model for interacting dimers on the two-dimensional square lattice at close packing density. The interaction, e.g., can be assumed to be proportional to the number of plaquettes occupied by two parallel dimers. It is well known that for close packed dimers one can define a non local function of the dimer configurations, the height $h(x)$, which is defined on the dual lattice up to an overall constant. For non-interacting dimers R. Kenyon proved in 2000 that the height fluctuations converge, in the scaling limit, to the Gaussian Free Field (GFF). No analogue of this claim was known insofar for non-solvable versions of the model. In this talk I will present the first rigorous result in this direction: if the interaction strength is sufficiently small, all the moments of the height difference $h(x)-h(y)$ converge to those of the GFF, asymptotically as $x-y \rightarrow \infty$; the dependence of our error bounds in $x-y$ is optimal. The proof is based on three key steps: (1) mapping of the model into interacting fermions in 1+1 dimensions; (2) rigorous Renormalization Group (RG) analysis of the interacting fermionic theory, including the use of asymptotic Ward Identities; (3) use of the discrete holomorphicity properties of the height function within the RG scheme. This is one of the very few rigorous results concerning bosonization in non-solvable critical two-dimensional models. The role of bosonization in the understanding of the conformal scaling limit of 2D statistical theories, and the relation of our result with the related conjectures will be briefly discussed. Joint work with V. Mastropietro, B. Laslier and F. Toninelli.</p>
13:00	Lunch
15:00	Wojciech DeRoeck, Universität Heidelberg Many-body Nekoroshev estimates <p>Understanding transport in Hamiltonian systems like anharmonic oscillator chains has been an ongoing project in mathematical physics. For weak anharmonicity, we believe that kinetic theory provides a good description, even though this is at present far from rigorous. In the opposite regime of very strong anharmonicity, one might wonder whether KAM-like phenomena could inhibit transport and lead to many-body localization, even in the absence of disorder (alternatively: replacing disorder with thermal fluctuations). We present some rigorous results suggesting that in certain regimes, transport is very slow (for example, vanishing faster than any polynomial in the temperature) and we discuss some conjectures (joint work with F. Huveneers, Ceremade, Paris).</p>
15.45	Coffee Break
16:15	Roy Kerr, University of Canterbury, Christchurch Title: tba

	Tuesday, May 28, 2013
9:30	Jon Dimock, State University of New York, Buffalo The renormalization group according to Balaban Over the years Balaban has developed a powerful renormalization group technique that is applicable to many problems in quantum field theory and statistical mechanics. In this expository talk we first review his results for various gauge theories and the linear sigma model. Then we describe in some detail how the method can be applied to a simpler case, namely to the ultraviolet problem for the φ_3^4 model. The treatment deals with the basic renormalization problem in a somewhat novel way which fits naturally with Balaban's scheme. This is a discrete dynamical systems method that makes no reference to perturbation theory.
10:45	Coffee Break
11:15	Antti Knowles, New York University Random band matrices and the extended states conjecture Random matrices were introduced in the 80s to model disordered quantum systems on large graphs (typically lattices). They provide a means of interpolating between random Schrodinger operators and mean-field models such as Wigner matrices. On the one-dimensional lattice it is conjectured that as one increases the band width a sharp transition occurs from the localized to the delocalized regime. In parallel, the local spectral statistics undergo a transition from Poisson to random matrix statistics. I give an overview of recent progress in understanding the eigenvector and eigenvalue distribution of random band matrices. I outline the derivation of delocalization bounds on the eigenvectors, as well as a proof of the Altshuler-Shklovskii formulas for eigenvalue correlations. The proofs are based on two different approaches: perturbative renormalization and the averaging of fluctuations among strongly correlated resolvent entries.
12:00	Ivo Kälén, ETH Zürich On the Mechanics of Crystalline Solids with a Continuous Distribution of Dislocations We formulate the laws governing the dynamics of a crystalline solid in which a continuous distribution of dislocations is present. Our formulation is based on new differential geometric concepts, which in particular relate to Lie groups. We then consider the static case, which describes crystalline bodies in equilibrium in free space. The mathematical problem in this case is the free minimization of an energy integral, and the associated Euler-Lagrange equations constitute a nonlinear elliptic system of partial differential equations. We solve the problem in the simplest cases of interest.
13:00	Lunch
15:00	Hugo Duminil-Copin, Université de Genève Parafermionic observables in planar Potts models and Self-Avoiding Walks In this talk, we will discuss the role of parafermionic observables in the study of several planar statistical physics models. These objects have been introduced recently in order to prove conformal invariance of the Ising model. We will explain how they can be combined with combinatorial and probabilistic arguments to compute the connective constant for self-avoiding walks (the $n=0$ loop $O(n)$ -model) on the hexagonal lattice, and to provide information on the critical phase of the Fortuin-Kasteleyn percolation (the graphical representation of Potts models). As an application of their use for FK percolation, we will show the absence of spontaneous magnetization for the critical planar Potts models with 2, 3 and 4 colors, thus proving part of the conjecture asserting that the planar Potts models undergo a discontinuous phase transition if and only if the number of colors is greater than 4.
15.45	Coffee Break
16:15	Ivan Corwin, MIT, Cambridge Integrable probability and Macdonald processes A large class of one dimensional particle systems are predicted to share the same universal long-time/large-scale behaviors. By studying certain integrable models within this (Kardar-Parisi-Zhang) universality class we access what should be universal statistics and phenomena. The purpose of today's talk is to explain how representation theory (in the form of symmetric function theory) is the source of integrability within this class. We develop the theory of Macdonald processes (generalizing Okounkov and Reshetikhin's Schur processes) which unites integrability in various areas of probability including directed polymers, particle systems, growth processes and random matrix theory. We likewise develop the many body system approach to integrable (stochastic) particle systems.
19:00	Concert / Apéro Semperaula, ETH Zentrum, HG G 60

	Wednesday, May 29, 2013
9:00	Detlev Buchholz, Universität Göttingen Resolvent Algebras: An Alternative Approach to Canonical Quantum Systems <p>The standard C^*-algebraic version of the Heisenberg algebra of canonical commutation relations, the Weyl algebra often causes difficulties since it does not admit physically interesting dynamical laws as automorphism groups. In this talk a C^*-algebra of the canonical commutation relations is presented which circumvents such problems. It is based on the resolvents of the canonical operators and their algebraic relations. The resulting C^*-algebra, the resolvent algebra, has many desirable analytic properties. In fact, it is of type I (postliminal) for finite quantum systems and nuclear in the infinite case. Its properties entail the existence of an abundance of one-parameter automorphism groups corresponding to physically relevant dynamics. They are also useful in the discussion of supersymmetry and systems with constraints. Moreover, the resolvent algebra has a rich and interesting ideal structure which encodes specific information about the dimension of the underlying physical system. It thus provides an excellent framework for the rigorous analysis of finite and infinite quantum systems. (Joint work with Hendrik Grundling)</p>
9:45	Hong-Tzer Yau, Harvard University Gap and Edge Universality of Beta Ensemble <p>In this lecture we will sketch the proof of the universality of Coulomb gases both in the bulk and at the edges of the spectrum. For both cases we will link the universality problem to the decay of correlation functions of Coulomb gases. We will show that such a decay follows from a Holder regularity of a discrete parabolic equation with random coefficients. The parabolic regularity will be established partly using the recent argument of Caffarelli-Chan-Vasseur, which is a De Giorgi-Nash-Moser type method. The singularities in random coefficients pose major challenges; we will use optimal level repulsion estimates in random matrices to control them.</p>
10:30	Coffee Break
11:15	Vieri Mastropietro, Università degli Studi di Milano Universality results in statistical physics <p>There is a group of phenomena in classical or quantum statistical physics showing remarkable universality properties, in the sense that they are largely independent from microscopic details. The combination of Ward Identities with bounds on the large distance decay of correlations, obtained by the methods of Constructive Quantum Field Theory, allows a rigorous understanding of universality in several cases. I will discuss recent results obtained for non integrable quantum spin chains, graphene systems (interacting fermions on the honeycomb lattice) or perturbed Ising models. A common feature of such phenomena is the role of the irrelevant terms, which cannot be neglected in order to ensure the correct lattice symmetries.</p>
12:00	group photo
12:15	Lunch
14:00	Gian Michele Graf on Walter Hunziker Arthur Jaffe, Rudolf Haag on Arthur Strong Wightman
14:30	Thomas Willwacher, ETH Zürich Title: tba
15:15	Coffee Break
16:00	Stanislav Smirnov, Université de Genève CFT and SLE and 2D statistical physics <p>Developed over two decades ago, Conformal Field Theory led to spectacular predictions for 2D lattice models of critical phenomena, suggesting exact values of many dimensions and exponents: e.g., critical percolation cluster a.s. has dimension $91/48$. More recently, a geometric approach involving random SLE curves was proposed by Oded Schramm, and developed by him, Greg Lawler, Wendelin Werner, Steffen Rohde and many others. Not only this approach is completely rigorous, it also constructs new objects of physical interest and gives results inaccessible by CFT means. We will give an expository talk comparing the two approaches.</p>

	Thursday, May 30, 2013
9:30	Thomas Spencer, IAS, Princeton The role of Symmetry in Statistical Mechanics and Random Matrices This talk will review some results and conjectures about statistical mechanics models inspired by random band matrices. Among these models are the classical Heisenberg model, the SUSY hyperbolic sigma model, and the edge reinforced jump process. Universality of mean field theory is conjectured and illustrated for spin systems with continuous symmetry breaking.
10.45	Coffee Break
11:15	Sven Bachmann, UC Davis The excess spin and edge representations of symmetries in ground state phases In this talk, I will discuss the appearance of spin representations at the edge of quantum chains that differ from the bulk. An 'excess spin' observable can be constructed explicitly in specific models. Moreover, its magnitude is believed to be an invariant within a gapped ground state phase, a statement that can be proven in broad generality.
12:00	Christian Jäkel, Cardiff School of Mathematics On the Construction of Two-dimensional Models in Local Quantum Physics We present a purely operator-algebraic construction of interacting quantum theories satisfying the Haag-Kastler axioms, both on de Sitter and Minkowski space. No field, neither classical nor quantum, appears at any stage of our construction; nor do we endeavor in any type of quantization. Instead, we rely on \mathfrak{sl}_2 the concept of modular localisation and Wigner's classification of positive energy representations of the Poincaré group; and \mathfrak{su}_2 non-commutative L^p -spaces, \mathfrak{sl}_2 relative modular operators, Connes cocycles and non-commutative Radon-Nikodym derivatives. Among the models constructed are the famous φ_2 models, and several other well-known models, but also many new, previously unknown models. This is joint work with Joao Barata and Jens Mund.
13:00	Lunch
15:00	John Imbrie, University of Virginia Newton's Method and Localization I will show how a scheme based on Newton's method can be used to diagonalize a random Hamiltonian. This leads to results on localization at strong disorder for Anderson tight-binding models and for many-body Hamiltonians.
15.45	Coffee Break
16:15	Joachim Krieger, EPF Lausanne On soliton stability/instability phenomena for nonlinear wave equations I will discuss recent developments in the stability/instability analysis of large static solutions for various nonlinear wave equations. This includes in particular threshold type dynamics for various problems, such as the critical nonlinear wave equation, but apparently also much more general ones, such as certain quasilinear problems.
19:00	Dinner

	Friday, May 31, 2013
9:30	Bertrand Duplantier, Institute for Theoretical Physics, Saclay Multifractality of Whole-Plane SLE <p>We revisit the Bieberbach conjecture in the framework of the SLE process. The study of its unbounded whole-plane version leads to a discrete series of explicit results for the expectations of coefficients and their variances, and for the derivative moments. These results are generalized to the associated m-fold conformal maps. We study the average integral means spectra of unbounded whole-plane SLE curves to prove the existence of a phase transition at a certain moment order, at which one goes from the bulk SLE multifractal spectrum to a new spectrum. The latter is related to radial SLE derivative exponents, and to non-standard, local tip exponents obtained from quantum gravity. Joint work with Chi Nguyen, Nga Nguyen and Michel Zinsmeister</p>
10.15	Coffee Break
11:15	Jakob Yngvason, Universität Wien Quantum Hall phases and plasma analogy in rotating Bose gases <p>In joint work with Nicolas Rougerie and Sylvia Serfaty we study strongly correlated states in a model of interacting bosons in the lowest Landau level in a rotating trap. The confining potential is a sum of a quadratic and a quartic term. As the rotational speed increases sufficiently beyond the frequency of the quadratic term, rigorous angular momentum estimates and trial state arguments indicate a transition from a pure Laughlin state to a state containing in addition a giant vortex at the center of the trap. There are also indications of a second transition where the density changes from a flat profile in a disc or an annulus to a radial Gaussian confined to a thin annulus. An important ingredient of our analysis is the interpretation of the densities of quantum Hall trial states as Gibbs measures of classical 2D Coulomb gases (plasma analogy).</p>
12:00	Michael Reiterer, ETH Zürich Choptuik's critical spacetime exists <p>About twenty years ago, Choptuik studied numerically the gravitational collapse (Einstein field equations) of a massless scalar field in spherical symmetry, and found strong evidence for a universal, self-similar solution at the threshold of black hole formation. We give a rigorous, computer assisted proof of the existence of Choptuik's spacetime, and show that it is real analytic. This is joint work with E. Trubowitz.</p>
13:00	Lunch
15:00	Benjamin Schlein, Universität Bonn Mean field dynamics of fermionic systems <p>For fermionic systems, the mean field regime is naturally coupled with a semiclassical limit. Asymptotically, the many body evolution can be described by the Vlasov equation. A better approximation to the Schroedinger dynamics can be obtained using the Hartree-Fock (or the Hartree) equation. In this talk, we will show precise bounds on the difference between the Schroedinger and the Hartree-Fock dynamics, for initial data close to Slater determinants with the correct semiclassical structure. This is a joint work with Niels Benedikter and Marcello Porta.</p>
15.45	Coffee Break