Abstracts of Invited Talks

Michael Aizenman Princeton University

Kac-Ward propagator and graph zeta functions

Roland Bauerschmidt University of Cambridge

Delocalized eigenvectors for random regular graphs of fixed degree

I will discuss results on the delocalization of eigenvectors and the spectral measure of random regular graphs with large but fixed degree. Our approach combines the almost deterministic tree-like structure of random regular graphs at small distances with random matrix like behaviour at large distances by resampling the boundaries of large balls in the graphs.
This is joint work with Jiaoyang Huang and Horng-Tzer Yau.

John Bechhoefer Simon Fraser University

Measurement of the functional form of Shannon entropy by partial erasure of a bit

We use a feedback trap to erase a fraction of a bit of information from a memory whose states are encoded in the two states of a double-well potential. The system consists of a colloidal particle in water in a "virtual" potential. We show experimentally that the minimum amount of work required is proportional to the Shannon entropy function, for arbitrary state probabilities. Joint work with Momčilo Gavrilov and Raphaël Chétrite.

Curtis Callan Princeton University

The importance of the element of surprise in immunology

The T cells in your body are, in first approximation, all different, each one with a different antigen recognition specifity. The probability that your body will have produced any specific T cell is very small, and the number of different T cells that can be produced is very large, with the result that any two individuals have almost completely non-overlapping sets of T cells. As a result, any shared T cells between individuals constitute a "surprise". Such surprises do happen, and evidence is accumulating that these surprising T cells often recognize pathogens. We have developed a statistical approach to modern high-throughput sequencing data on T cell sequence repertoires that allows us to quantify these probabilities and put numbers on the element of surprise. It begins to look as if the dice that are rolled to generate the players of the immune system are "loaded" in favor of useful outcomes, presumably as the result of an evolutionary process. I will try to convey the essential elements of this developing story.

Jennifer Chayes Microsoft Research

Graphons and Machine Learning

I review the theory of graphons, developed myself, Christian Borgs and other collaborators to describe limits of dense and sparse networks. I then show how graphons can be used to model real-world networks, and how we learn those models from data. Finally, I show how these models can be used in real-world applications, like recommendation systems on networks such as Netflix.

Ivan Corwin Columbia University

Integrability and Random Interface Growth

Much is known about the statistics describing random interface growth due to connections of certain example models with integrable systems. This talk will highlight some of the most recent developments in this direction.

Krzysztof Gawedzki Laboratory of Physics ENS of Lyon

Response theory for periodically driven 2d crystals

The simplest topological invariant of gapped 2d static crystals is the Chern number that represents the transverse conductivity. I shall discuss the electromagnetic response for periodically driven 2d crystals and its relation to topological invariants.

Shelly Goldstein Rutgers University

Quantum Mechanics a la Juerg

I shall discuss Juerg Frohlich's version or understanding of quantum mechanics. I will try to convey how this differs from orthodox quantum theory, and how it compares with alternatives.

Gian Michele Graf ETH Zurich

Topological insulators and scattering theory

Many views of bulk-edge duality for Quantum Hall systems and for other topological insulators have been given. Inspired by the seminal view given by Hatsugai, we shall reinterpret the duality in terms of Levinson's theorem of scattering theory and illustrate it pictorially in terms of the Great Wall of China.

Don Howard University of Notre Dame

Physics and Human Rights: Then and Now

David Huse Princeton University

The Many-body Localization Phase Transition

John Imbrie University of Virginia

Localization and Eigenvalue Statistics for Schroedinger Operators with Discrete Disorder

Convergent expansions for eigenvalues and eigenvectors lead to new insights into the way randomness localizes eigenfunctions, smooths out eigenvalue distributions, and produces eigenvalue separation.

Mehran Kardar Massachusetts Institute of Technology

Transient Casimir forces from quenches in thermal and active matter

We compute fluctuation-induced (Casimir) forces for classical systems after a temperature quench. Using a generic coarse-grained model for fluctuations of a conserved density, we find that transient forces arise even if the initial and final states are force-free. In setups reminiscent of Casimir (planar walls) and van der Waals (small inclusions) interactions, we find comparable universal forms for the force, with dynamical details scaling the time axis of transient force curves. We propose that such quenches can be achieved, for instance, in experiments on active matter, employing tunable activity or interaction protocols.

Joachim Krug University of Cologne

Genotypes, phenotypes, and Fisher's geometric model

Biological evolution can be conceptualized as a dynamical process in the space of gene sequences guided by the fitness landscape, a mapping that assigns a measure of reproductive value to each genotype. The relationship between genotype and fitness is generally complex,as it is mediated by the multidimensional organismic phenotype that interacts with the environment and thereby determines reproductive success. A simple mathematical framework for exploring this relationship is provided by Fisher's geometric model, which describes the phenotype as a vector in an n-dimensional Euclidean trait space with a unique optimum located at the origin. Genetic mutations are encoded as random phenotypic displacements, and complex fitness landscapes arise from the projection of the discrete network of genotypes onto the continuous trait space. The talk will discuss the properties of these fitness landscapes in the context of the statistical physics of disordered systems, where the problem can be viewed as a variant of the anti-ferromagnetic Hopfield model. The talk is based on joint work with Sungmin Hwang and Su-Chan Park.

Kunihiko Kaneko University of Tokyo

Macroscopic Theory of Phenotypic Adaptation and Evolution: Fluctuation-response, Genetic Assimilation, and Deep Linearity

Based on statistical physics and dynamical-systems theory, we present a macroscopic theory of fluctuation and responses in a biological system, to characterize its plasticity, robustness, and evolvability quantitatively. First, by assuming that cells undergo steady growth, protein expression of thousands of genes is shown to change along a one-dimensional manifold in the state space in response to the environmental stress. This leads to a macroscopic law for cellular-states, as is confirmed by adaptation experiments of bacteria under stress. Next, the theory is extended to phenotypic evolution, to demonstrate grand fluctuation-response relationship, i.e., proportionality between phenotypic responses against genetic evolution and by environmental adaptation as well as between phenotypic fluctuations due to genetic change and noise, as is confirmed both in experiments and simulations. This relationship is further formulated by sow-manifold hypothesis as a constraint for possible phenotypic changes. Possible extension of the theory to non-growing cellular states and to multi-level evolution for multicellularity will be briefly discussed.

Antti Kupiainen University of Helsinki

A Constructive Approach to the Liouville Conformal Field Theory

I will review a probabilistic approach to the Liouville Conformal Field Theory (LCFT) where the correlation functions are expressed in terms of the partition function of a thermal particle moving in a 2d Gaussian Free Field environment and bound by logarithmic potentials to the insertion points. This approch sheds light to puzzling properties of LCFT like the reflection relation and might pave the way to a proof of the celebrated Dorm-Otto-Zamolodchicov-Zamolodchicov formula for the three point function. This is joint work with F.David, R.Rhodes and V.Vargas.

Edo Kussell New York University

Correlated mutations and bacterial recombination

I will discuss how correlated mutations provide a signature of recombination in bacterial genome sequences, and how this signal can be used to infer the major population genetic parameters without relying on phylogenetics.

Edwin Langmann Royal Institute of Technology, AlbaNova University Center

Heat transport in quasi-free systems

I plan to discuss a non-equilibrium approach to heat transport in quasi-free boson and fermion systems where, starting from a non-equilibrium initial state with a position dependent temperature profile, the systems time evolves with a translation-invariant Hamiltonian. For suitable such initial state, one thus can obtain a non-equilibrium steady state (NESS) at large times carrying a constant heat current. Our approach leads to fully explicit formulas describing not only the NESS but even the full time evolution. Our results apply to many examples, including the Luttinger model and quasi-free models describing lattice fermions or phonons in arbitrary dimensions.

Elliott Lieb Princeton University

A `liquid-solid' phase transition in a simple model for swarming

We consider a non-local shape optimization problem, which is motivated by a simple model for swarming and other self-assembly/aggregation models, and prove the existence of different phases. (With Rupert Frank)

Vieri Mastropietro University of Milano

Coupled identical localized fermionic chains with quasi-random disorder

We analyze the ground state localization properties of an array of identical interacting spinless fermionic chains with quasi-random disorder, using non-perturbative Renormalization Group methods. In the single or two chains case localization persists while for a larger number of chains a different qualitative behavior is generically expected, unless the many body interaction is vanishing. This is due to number theoretical properties of the frequency, similar to the ones assumed in KAM theory, and cancellations due to Pauli principle which in the single or two chains case imply that all the effective interactions are irrelevant; in contrast for a larger number of chains relevant effective interactions are present. These theoretical results are in agreement with recent cold atoms experiments.

Steve Miller Rutgers University

Energy minimization in 8 dimensions

Given a potential function and a collection of points in space having fixed density, what configuration of those points has minimal energy? This is generally a nontrivial question even when the configuration is assumed to be a lattice. I'll describe recent work with Henry Cohn, Abhinav Kumar, Danylo Radchenko, and Maryna Viazovska which solves this problem for a class of potential functions in 8 dimensions, which share the E8 root lattice as their "universally optimal" minimizer.

Clement Mouhot University of Cambridge

De Giorgi-Nash-Moser regularity theory for kinetic equations

Adam Nahum Oxford University

Entanglement growth and classical statistical mechanics

Nikita Nekrasov Stony Brook University

The Magnificent Four

Stefano Olla Paris Dauphine University

Macroscopic temperature profiles in non-equilibrium stationary states

Systems that have more than one conserved quantity (i.e. energy plus momentum, density etc.) can exhibit quite interesting temperature profiles in non-equilibrium stationary states. I will present some numerical experiment and mathematical result.

Marcello Porta Institute for Mathematics, University of Zurich

Universality in the critical Haldane-Hubbard model

The Haldane-Hubbard model is a paradigmatic example of interacting two-dimensional topological insulator. The result I will present provides a rigorous construction of the interacting topological phase diagram of the system, and establishes the universality of conductivity at criticality. The proof is based on a combination of rigorous renormalization group methods and Ward identities. Joint work with A. Giuliani, I. Jauslin and V. Mastropietro.

Tatyana Shcherbina Princeton University

Transfer matrix approach to 1d random band matrices

Random band matrices (RBM) are natural intermediate models to study eigenvalue statistics and quantum propagation in disordered systems, since they interpolate between mean-field type Wigner matrices and random Schrodinger operators. In particular, RBM can be used to model the Anderson metal-insulator phase transition (crossover) even in 1d. In this talk we will discuss some recent progress in application of the supersymmetric method (SUSY) and transfer matrix approach to the analysis of local spectral characteristics of some specific types of RBM.

Sergio Simonella Technical University of Munich

Collisions plus long range interactions in a simple model system

I will discuss the instability arising when incorporating long-range effects into a collisional dynamics. For a tracer particle in a spatially random potential, a Boltzmann-Vlasov description can be derived rigorously.

Yakov Sinai Princeton University

Littlewood Conjecture

Sasha Sodin Queen Mary, University of London & Tel Aviv University

Non-Hermitian random Schroedinger operators

Non-Hermitian random Schroedinger operators were put forth in the mid 1990-s by Hatano and Nelson, and mathematically studied by Goldscheid and Khoruzhenko. We shall discuss some results obtained in a work in progress jointly with I. Goldsheid.

Avy Soffer Rutgers University

Large time behavior of some Quantum Kinetic equations

Nicolas Sourlas Ecole Normale Superieure

Recent Progress in the Random Field Ising Model

Thanks to intensive numerical simulations a lot of progress has been made recently in our understanding of the Random Field Ising model. I will review these recent developpents. Contrary to previous claims,random fields generated by different probability distributions and diluted antiferromagnets in a field, belong to the same universality class as predicted by the perturbative renormalization group (PRG). It is well known that dimensional reduction predicted by the PRG is not valid in three dimensions. It was shown recently that, as it was anticipated some time ago, this breaking of the PRG is a low dimensional phenomenon and that dimensional reduction is restored in five dimensions. I will argue that the validity of PRG at higher dimensions explains universality in three dimensions.

Daniel Ueltschi University of Warwick

Universal behavior of loop soup models in D>2

Some models of classical and quantum statistical physics can be represented by a gas of one-dimensional loops that live in the D-dimensional space. These include classical spin systems (Brydges-Froehlich-Spencer representation), and quantum spin systems (Toth and Aizenman-Nachtergaele representations).

All loop soup models share a universal behavior in dimensions 3 and higher: There is a phase where loops are macroscopic, and the joint distribution of their lengths can be described explicitly (Poisson-Dirichlet).

Paul Wiegmann University of Chicago

Hydrodynamics of Onsager vortex flow

Horng-Tzer Yau Harvard University

Two dimensional coulomb gas

Martin Zirnbauer Institute for Theoretical Physics, University of Cologne

Conformal field theory of the integer quantum Hall plateau transition

The scaling behavior near the transition between plateaus of the Integer Quantum Hall Effect has traditionally been interpreted on the basis of a two-parameter renormalization group flow conjectured from the non-linear sigma model of Pruisken. Yet, this scaling picture never led to any analytical understanding of the critical behavior. Here we propose a quantitative description of the critical point as a gauged Wess-Zumino-Witten model of level 4. This proposal explains the existing numerical data for the multifractal scaling exponents of critical wavefunctions.