Operator Algebras and Mathematical Physics

October 25 (Tue) - 28 (Fri), 2011

Kyoto, JapanKansai Seminar House

October 25

13:30-14:30 Robert Seiringer Bose Gases, Bose-Einstein Condensation, and the Bogoliubov Approximation

14:50-15:50 Vojkan Jakšić Entropic fluctuations in statistical mechanics

16:10-17:10 Benjamin Schlein Spectral Properties of Wigner Matrices

October 26

9:30-10:30 Igor Bjelaković Quantum Communications under Channel Uncertainty

10:50-11:50 Benoît Collins Applications of Random Matrix Theory to Quantum Information Theory.

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Robert Seiringer

Title: Bose Gases, Bose-Einstein Condensation, and the Bogoliubov Approximation

Abstract: We present an overview of mathematical results on the low temperature properties of dilute Bose gases, which have been obtained in the past few years. The presentation includes results on the ground state energy in the thermodynamic limit, and on Bose-Einstein condensation and the excitation spectrum in trapped gases. In particular, the validity of the Bogoliubov approximation will be investigated. We shall give a description of the mathematics involved in understanding the various phenomena, starting from the underlying many-body Schroedinger equation.

Vojkan Jakšic

Title: Entropic fluctuations in statistical mechanics

Abstract: In the first part of the mini-course I shall discuss how the entropy production observable can be defined for any classical or quantum dynamical system as a derivative of the Radon-Nikodym cocycle. For the so-called open systems, which describe the interaction of several thermal reservoirs, this definition coincides with the standard thermodynamical definition in terms of the fluxes (heat, charge, mass...) across the system. After reviewing some basic properties of the entropy production observable and non-equilibrium steady states, I shall describe the large deviation theory of the entropy production observable. The main topic will be certain symmetries (Evans-Searls and Gallavotti-Cohen) of the moment generating functionals which can be interpreted as an extension of the Green-Kubo linear response formula to far from equilibrium steady states.The emphasis of the course will be on the mathematical structure of the theory. One novelty of the exposition is that the classical and quantum case will be treated in parallel. The mini-course is based on some recent joint work with Claude-Alain Pillet, Yan Pautrat, Yoshiko Ogata and Luc Rey-Bellet.

Benjamin Schlein

Title: Spectral Properties of Wigner Matrices

Abstract: The entries of Wigner random matrices are, up to symmetry constraints, independent and identically distributed random variables. In this mini-course, I am going to discuss recent results concerning the spectrum of N by N Wigner matrices in the limit of large N. In 1955, Wigner showed that, in this limit, the density of states of Wigner matrices converges to the famous semicircle law. In the first lecture, I plan to explain an extension of Wigner's original result to prove the semicircle law also on very small "microscopic" intervals. In the second lecture, I will present some of the consequences of the refined convergence to the semicircle law. In particular, I will show the complete delocalization of the eigenvectors of Wigner matrices (every component of any eigenvector is typically of the same size) and I will show the phenomenon of eigenvalue repulsion. In the last lecture, I will discuss the universality of the local eigenvalue statistics. Universality refers to the fact that, in the limit of large N, the (local) eigenvalue correlation functions depend on the symmetry of the ensemble but are otherwise independent of the choice of the probability law of

the matrix entries.

Igor Bjelaković

Title: Quantum Communications under Channel Uncertainty

Abstract: In this series of talks we give an introduction to our recent work on quantum communication over unknown quantum channels. Starting from the quantum state merging (Horodecki, Oppenheim, and Winter 05), which is one among the fundamental protocols of Quantum Information Theory giving an operational explanation of the phenomenon of negative information we will derive optimal entanglement distillation rates and capacity results for quantum channels.

After explaining a universal merging result,not relying on the full knowledge of the quantum state being merged, we shall derive a multi letter formula for the entanglement transmission capacity for communication over partially known quantum channel.

This will lead us to capacity results for arbitrarily varying quantum channels which are obtained via a robustification technique. This model describes the situation where the sender and the receiver try to generate entanglement via a quantum channel which is selected by an adversary and can vary in an arbitrarily and unknown manner from one channel use to the next.

This is a joint work with R. Ahlswede, H. Boche, G. Janssen, and J. Noetzel

References: arXiv:1106.2850, arXiv:1010.0418, arXiv:0811.4588

Benoît Collins

Title: Applications of Random Matrix Theory to Quantum Information Theory.

Abstract: in this series of lectures, I will explain how techniques in Random Matrix Theory can give a new insight into important problems in Quantum Information Theory. The important problems that we are interested in, are the quantification of entanglement of typical subspaces in a tensor product, and the problem of additivity for the minimum output entropies of quantum channels. The techniques from random matrix theory are Weingarten calculus and recently obtained norm estimates. These techniques fit well in the conceptual framework of free probability theory. I will first spend some time on the techniques, and then on the applications.