DISORDERED SYSTEMS AND RANDOM MATRIX THEORY

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ABSTRACTS

Gernot Akemann *Products of Random Matrices - From QCD to Telecommunication*

Abstract: Random matrices continue to enjoy a lot of new developments and applications, despite many years of research in this area. After giving a short overview on standard invariant ensembles and their solution using orthogonal polynomials I will present some new results on products of random matrices which can be solve within the same framework. The applications range from the complex spectrum of the QCD Dirac operator with chemical potential to multiple-channel scattering in telecommunication.

Lara Benfatto *Superconductor-insulator transition at strong disorder: unconventional superfluid response and glassy physics*

Abstract: In the last few years there has been a resurgence of interest in the superconductor-insulator transition (SIT) induced by strong disorder in conventional superconductors [1]. Indeed, the improvement of the experimental tecniques, as e.g. scanning tunneling microscopy, offered a new perspective on the characteristics of the superconducting state near the SIT, which can even share similarities with the behavior of unconventional high-temperature superconductors. A typical example is provided by the spontaneous emergence of spatial inhomogeneity of the local density-of-state on nanometer scales, with a persistence of gap-like features even above the critical temperature (the so-called pseudogap). These finding stimulated a new theoretical investigation on some long-standing issues, as e.g. the validity of the “bosonic” vs “fermionic” picture of the SIT, and on new ones, as the emergence of a “glassy”-like behavior of the system. In this talk I will try to make a short overview of the experimental and theoretical state-of-the art in this field, and I will briefly discuss some recent results we obtained for the unconventional superfluid response [2] and the spatial order-parameter distribution [3] at strong disorder.

[1] M. V. Feigel’man *et al.*, Annals of Physics **325**, 1368 (2010) and references therein.
[2] G. Seibold, L. Benfatto, C. Castellani and J. Lorenzana, Phys Rev. Lett. 108, 207004 (2012).
[3] G. Lemarie, A. Kamlapure, D. Bucheli, L. Benfatto, J. Lorenzana, G. Seibold, S. C. Ganguli, P. Raychaudhuri and C. Castellani, arXiv:1208.3336.

Claudio Conti *Nonlinear effects in disorder induced wave localization in optics*

Abstract: We will review some of the recent results concerning the observation of disorder induced localized states in light propagation, in laser emission, and in Bose-Einstein condensation. We will discuss the role of nonlinear effects, and some theoretical results concerning modelling localizations in random optical systems, with reference to the nonlinear Schroedinger equation.

Margherita Disertori *Non linear sigma models and history dependent stochastic processes.*

Abstract: I will give an example of a non-linear sigma model inspired by a quantum mechanical problem that suprisingly turned out to be the mixing measure for a history dependent stochastic process. Using techniques from theoretical physics (Ward identities, fermionic integrals, multi-scale analysis) it is then possible to study recurrence/transience properties for the stochastic process.

Francesco Guerra *Spontaneous replica symmetry breaking as a real physical phenomenon*

Abstract: In the frame of the replica trick, can be considered as a real physical phenomenon. In appropriate conditions, a small coupling among replicas, removed after that the infinite volume limit is taken, leads to a change of state. The consequences on the general structure of statistical mechanics of complex systems are pointed out. Nonequilibrium steady state for a simple model of electric conduction

Enzo Marinari *A Scalable Algorithm to Explore the Gibbs Energy Landscape of Genome-Scale Metabolic Networks*

Abstract: The integration of various types of genomic data into predictive models of biological networks is one of the main challenges currently faced by computational biology. Constraint-based models in particular play a key role in the attempt to obtain a quantitative understanding of cellular metabolism at genome scale. In essence, their goal is to frame the metabolic capabilities of an organism based on minimal assumptions that describe the steady states of the underlying reaction network via suitable stoichiometric constraints, specifically mass balance and energy balance (i.e. thermodynamic feasibility). The implementation of these requirements to generate viable configurations of reaction fluxes and/or to test given flux profiles for thermodynamic feasibility can however prove to be computationally intensive. We propose here a fast and scalable stoichiometry-based method to explore the Gibbs energy landscape of a biochemical network at steady state. The method is applied to the problem of reconstructing the Gibbs energy landscape underlying metabolic activity in the human red blood cell, and to that of identifying and removing thermodynamically infeasible reaction cycles in the Escherichia coli metabolic network (iAF1260). In the former case, we produce consistent predictions for chemical potentials (or log-concentrations) of intracellular metabolites; in the latter, we identify a restricted set of loops (23 in total) in the periplasmic and cytoplasmic core as the origin of thermodynamic infeasibility in a large sample of flux configurations generated randomly and compatibly with the prior information available on reaction reversibility.

Fabio Martinelli *Scaling limit and cube-root fluctuations in SOS surfaces above a wall*

Abstract: We give a full description for the shape of the classical $(2+1)$-d Solid-On-Solid model above a wall, introduced by Temperley (1952). On an $L \times L$ box at a large inverse-temperature the height of most sites concentrates on a single level H proportional to $\log(L)$ for most values of L. For a sequence of diverging boxes the ensemble of level lines of heights $(H, H-1, \ldots)$ has a scaling limit in Hausdorff distance iff the fractional parts of $1/4\beta x \log(L_n)$ converge to a noncritical value. The scaling limit is explicitly given by nested distinct loops formed via translates of Wulff shapes. Finally, the H-level lines feature $L^{1/3} + o(1)$ fluctuations from the side boundaries.

Vieri Mastropietro *Exact Renormalization Group for disordered 2D Dirac fermions*

Abstract: Disordered 2D Dirac fermions, arising as an effective model for Ising models, graphene and several other systems, have been deeply investigated but their properties are still somewhat controversial, the reason of this being their sensitivity to regularizations and approximations. It is therefore interesting to analyze them by Exact Renomalization Group methods, which are free of approximations and can take into account lattice effects. We show, in the case of vector disorder, the presence, at all orders of the renormalized expansion, of a line of fixed points and of anomalous exponents. Some universality emerges in the averaged current-curent correlation at zero energy, as consequence of an exact cancellation of the anomalies following by the Adler-Bardeen non renormalization property. These results are valid in presence of a momentum cut-off to be removed at the end; the effects of other cut-offs, like a square or honeycomb lattice, will be also briefly discussed.

Andrea Pelissetto *Diagramma di fase e transizioni nel modello di Ising bimodale*

Abstract: I will discuss the phase diagram of the bimodal Ising model as a function of temperature and of the probability of the ferromagnetic bonds. In particular I will present results for the para-ferro, para-glassy and glassy-ferro transitions.

Florin Radulescu *Random matrices and Operator Algebras*

Abstract: We will review some of constructions introduced by Dan Voiculescu and review their use in the theory of von Neumann Algebras associated with free groups-in particular we will describe the concept of a fractional number of generators

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