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Wandering with Curiosity in Complex Landscapes
A scientific conference in honor of Giorgio Parisi
for his 60th birthday
Rome, September 8-10 2008
La Sapienza University and Accademia dei Lincei

TITLES AND ABSTRACTS

***************** Michael Aizenman *****************************

A dynamical perspective on the success of Parisi's hierarchical ansatz

Michael Aizenman

Princeton University, USA

***************** Guido Altarelli *****************************

Progress on QCD Evolution Equations

Guido Altarelli

Universita' di Roma 3

Stimulated by the data collected at HERA and in view of the start of the LHC programme, the theoretical study of splitting functions has been much improved in recent years. I will summarize the recent achievements in this domain and discuss in some detail the problem of the behavior of singlet splitting functions at small Bjorken x.

***************** Kurt Binder *********************************

Unconventional First Order Phase Transitions: are "Dogmas" of Statistical Mechanics Violated?

Kurt Binder

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At conventional first order phase transitions a jump of an extensive thermodynamic variable is encountered, when an intensive variable is changed. Unconventional first order phase transitions may show the opposite behavior: e.g. when a polymer chain (of chain length N tending to infinity) is dragged into a tube of finite diameter, using the distance of the chain end from the tube entrance as the control variable, it is the force acting at the chain which exhibits a jump when the part of the chain outside of the tube finally jumps in. Although this system is quasi-one-dimensional, and the interactions are strictly short-range, in the thermodynamic limit a sharp transition occurs. The "escape transition" of compressed polymer mushrooms is a further example, where an intensive variable jumps, and different ensembles of statistical mechanics yield inequivalent results near the transition.

The final example that will be discussed is the "droplet evaporation/condensation" transition of a fluid system slightly inside

the vapor-liquid coexistence curve:there the chemical potential jumps from a larger value (a supersaturated gas without a large droplet) to a smaller value (less supersaturated gas surrounding a large droplet).

It is pointed out that the unifying feature of all these transitions is that phase coexistence between the states involved in the transition is not possible.
Models of evolution and spin glasses

***************** Edouard Brezin ******************************

Critical Interface

Edouard Brezin

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A mean field comparison of twisted boundary conditions for a pure system and a spin glass, at Tc, as a function of the size of the system.

***************** Bernard Derrida ******************************

Mean Field Spin Glasses and Models of Evolution

Bernard Derrida

Ecole Normale Superieure, Paris, France

This talk will try to show the analogies which exist between mean field spin glasses and models of evolution [1]. In presence of selection [2,3], models of evolution can be related to a problem of directed polymers in a random medium [4], and the genealogies have the same statistical properties as the trees of pure states as in the Parisi theory of spin glasses. The problem can also be studied as the effect of noise on traveling waves.

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[2] E. Brunet, B. Derrida, A. H. Mueller, S. Munier, Noisy traveling waves: Effect of selection on genealogies Europhys. Lett. 76, 1-7 (2006)

[3] E. Brunet, B. Derrida, A. H. Mueller, S. Munier, Effect of selection on ancestry: an exactly soluble case and its phenomenological generalization Phys. Rev. E 76, 041104 (2007)

[4] E. Brunet, B. Derrida, D. Simon, Universal tree structures in directed polymers and models of evolving populations Phys. Rev. E. 2008 in press cond-mat/0806.1603

***************** Uriel Frisch *********************************

Bottlenecks: an Interplay of Equilibrium Statistical Mechanics and Turbulence

Uriel Frisch

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It is shown that the use of a high power alpha of the Laplacian in the dissipative term of hydrodynamical equations leads asymptotically to truncated inviscid conservative dynamics with a finite range of spatial Fourier modes. Those at large wave-numbers thermalize, whereas modes at small wave-numbers obey ordinary viscous dynamics [C.~Cichowlas et al., Phys. Rev. Lett. 95, 264502 (2005)]. The energy bottleneck observed for finite alpha may be interpreted as incomplete thermalization. Artifacts arising from models with alpha > 1 are discussed.

Based on a paper with S. Kurien, R. Pandit, W. Pauls, S. Ray, A. Wirth and J. Z. Zhu.

***************** Giovanni Gallavotti ******************************

Thermostats, Entropy Production and SRB Distributions.

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The microscopic interpretation of entropy production and its relation with the Green-Kubo formulae and the SRB distribution will be discussed.

***************** Francesco Guerra *********************************

A Poisson Diluted Mean Field Spin Model Interpolating between Ferromagnetic, Spin Glass and Anti-Ferromagnetic Physical Behavior.

Francesco Guerra

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***************** Yoseph Imry *********************************

A Mean-Field Model for the Electron Glass Dynamics

Yoseph Imry

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We study a microscopic mean-field model for the dynamics of the electron glass, near a local equilibrium state. The space dependent mean site energy, E_j, depends on the mean occupations of other sites Coulomb-interacting with site j. Phonon-induced tunneling processes are responsible for generating transitions between localized electronic sites, which eventually lead to the thermalization of the system.

We find that the decay of an excited state to a locally stable state is far from being exponential in time, and does not have a characteristic time scale. Working in a mean-field approximation, we write rate equations for the average occupation numbers n_i, and describe the return to the locally stable state using the eigenvalues of a rate matrix, A, describing the linearized time-evolution of the occupation numbers.

Analyzing the probability distribution P(lambda) of the eigenvalues of A we find that, under certain physically reasonable assumptions, it takes the form P(lambda) \simeq 1/lambda, leading naturally to logarithmic decays of the site occupations and other physical objects in time. While our derivation of the matrix A is specific for the chosen model, we expect that other glassy systems, with different microscopic characteristics, will be described by random rate matrices belonging to the same universality class of A. Namely, the rate matrix has elements with a very broad distribution, as in the case of exponentials of a variable with nearly uniform distribution. The model is able to capture the Coulomb gap and its temperature dependence as well as both the Mott and the interaction dominated variable range hopping, as well as their crossover.

Based on a paper by Ariel Amir, Yuval Oreg and Yoseph Imry

***************** Joel Lebowitz *********************************

Local and Global Structure of Stationary States of Macroscopic Systems

Joel L. Lebowitz

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The microscopic structure of a macroscopic system in a steady state is described locally, i.e. at a suitably scaled macroscopic point x,by a time invariant measure mu_x(Â•) of the corresponding infinite system with translation invariant dynamics. This measure mu_x may be extremal, with good decay of correlations, or a superposition of extremal measures, with weights depending on x (and possibly even on the way one scales). In the latter case a possible scenario would be to have

mu_x = \int k(x;rho) nu^{(rho)} drho,

with nu^{(rho)} a translation invariant extremal measure of the infinite system with density rho.

We expect that the microscopic configuration in the vicinity of x will fluctuate, over sufficiently long times, between configurations typical for the different nu^{(rho) entering the decomposition of mu_x. One expects (and proves in some cases) that there are equations, deterministic or stochastic, describing the evolution, on the appropriate hydrodynamic scale, of the macroscopic state of the system. As the parameters of the dynamics are changed or the globally conserved densities are varied, the system may undergo phase transitions which are reflected in the k(x;rho).

I will illustrate the above by some exact results for 1D lattice systems with two types of particles (plus holes) evolving according to variants of the simple asymmetric exclusion process, in open or closed systems. Somewhat surprisingly, the spatially asymmetric local dynamics satisfy (in some cases) detailed balance with respect to a global Gibbs measure with long range pair interactions.

***************** Marc Mezard   *********************************

The Cavity Method

Marc Mezard

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The cavity method, invented more than twenty years ago in order to solve the SK model, has now turned into an efficient and versatile tool for disordered systems. The talk will explain its evolution and point out some recent successes.

***************** Remi Monasson *****************************

Inverse Statistical Methods to Infer Neural Couplings, and their Application to the Retina

Remi Monasson

ENS, Paris, France

Multi-electrode recordings make available the simultaneous spiking activity of tens of neurons for hours. An open issue in computational neurobiology is to infer the interactions between cells from those recordings. I will present two inverse statistical approaches to tackle this problem, and discuss their applications to the analysis of the activity of ganglion cells in the salamander retina.

***************** Giorgio Parisi ******************************

Spin Glasses, Where Do We Stand?

Giorgio Parisi

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***************** David Sherrington *********************************

Reflections on Replica Symmetry Breaking and Spin Glasses

David Sherrington

University of Oxford

Replica Symmetry Breaking and the conceptual, mathematical and physical challenges it raised have been a rich and fruitful source from which new knowledge and application have flowed profusely since it was invented 30 years ago by Giorgio Parisi and show no sign of abating. In this talk I shall reflect on some of the history and some of the recent investigations.

***************** Gerard 't Hooft ************************

Crystalline Gravity

Gerard 't Hooft

Utrecht University, The Netherlands

***************** Raffaele Tripiccione ************************

Easy, Maybe Even Possible: Giorgio and Computing.

Raffaele Tripiccione

Universita’ di Ferrara

***************** Akira Ukawa ********************************

Progress in Lattice QCD -- Physics, Algorithms, Machines --

Akira Ukawa

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There has been tremendous progress in lattice QCD since 1980 when Giorgio first computed the mass of nucleon with a VAX computer. The advances over the last several years have been particularly exciting in that the combination of the understanding of dynamics, the application of efficient algorithms which take advantage of this understanding, and increasingly powerful computers have made it possible to simulate lattice QCD including the full vacuum polarization effects of light quarks, i.e., up, down and strange, at their physical quark masses. We review the progress in the triad of physics, algorithms and machines which brought about this advance, and discuss future perspectives.

***************** Eric Vincent ********************************

Real Spin Glasses Slowly Relax in the Shade of Hierarchical Trees

Eric Vincent

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The theorist’s spin glass is a set of randomly interacting objects with frozen disorder, a problem whose conceptual simplicity sharply contrasts with the sophistication of the mathematical methods that have been necessary to solve its mean-field approximation. There is no obvious reason for a mean-field description to be relevant for the "real" spin glass, which lives in 3 dimensions, is site-diluted, and in which the magnetic interactions are of limited range, even in metallic compounds. However, we will discuss here a few experimental situations on which the mean-field results have significantly shed light, even from very far away, providing the experimentalists with remarkably rich guidelines of reflection.

Magnetic noise measurements are a very difficult challenge. M. Ocio and D. Herisson succeeded in measuring the fluctuation-dissipation ratio and its crossover behaviour between equilibrium and non-equilibrium time regimes [1]. This measurable quantity is indeed reflecting, in the mean-field approximation, the shape of the order parameter distribution P(q). There is still further work to be done in this matter, but the results of Ocio et al already show clearly that the spin glass does not behave like a disguised ferromagnet, and presents a degree of complexity which pertains to "replica symmetry breaking" glasses.

Detailed experiments on the effect of temperature variations on aging effects have revealed astonishing "rejuvenation and memory" phenomena [2], for which a hierarchical organization of the metastable states with temperature has come out as a formidable key to the description of the results. The nature of a possible link with the hierarchical

tree of the pure states in the mean-field spin glass has nothing obvious [3]. However, this empirical hierarchical scheme has turned out to be also applicable in the real space of spins, after it became possible to measure the slow growth of a "dynamical correlation length" during aging [4]. The rejuvenation and memory effects are now understood in terms of a hierarchy of embedded length scales, which define the scale at which "spin glass order" can be established during the experiment at a given temperature [5].

The recent results show that spin-glass order indeed grows very slowly [6]. Numerical simulations, on the other hand, are limited to a still shorter range than experiments, which hinders a direct comparison. New experiments on the glassy behaviour of the giant "superspins" formed by magnetic nanoparticles [7] might help to bridge this gap between experimental and numerical spin glasses in the near future.

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[7] E. Wandersman, V. Dupuis, E. Dubois, R. Perzynski, S. Nakamae, E. Vincent, http://arxiv.org/abs/0806.0564

***************** Johan Wastlund *******************************

Combinatorial optimization and the mean field model

Johan Wastlund
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It was discovered by Giorgio Parisi and other physicists in the 1980’s that the replica and cavity methods can be applied in the study of random instances of optimization problems such as the traveling salesman problem. The so-called mean field model of distance is very simple, there are N points, and the pairwise distances are taken as independent random variables. Several striking results on optimization problems in this model were obtained by Marc Mezard, Parisi and others. Although mathematically non-rigorous, the predictions were extremely precise and inspired many mathematicians to study this type of problem. Twenty years later we are slowly beginning to catch up, and several of the conjectures have now been established rigorously.

***************** Anthony Zee **********************************

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Topological Aspects of RNA Folding

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