MECHANICS: CLASSICAL, STATISTICAL AND QUANTUM
A conference in honor of the 70th birthday of Giovanni Gallavotti
Roma, July 2 – 5, 2012   Università di Roma Sapienza

ABSTRACTS

Michael Aizenman *Does the 2D Random Field Ising Model exhibit a phase transition in the disorder parameter?*

Abstract: In low dimensional models of statistical mechanics, including the Random Field Ising Model (RFIM) as well as a general class of classical and quantum systems, first order phase transitions are unstable with respect to the addition of arbitrarily weak disorder in the field conjugate to the order parameter. The general argument (made rigorous with J. Wehr) and its quantum extension (recent joint work with R. Greenblatt and J. Lebowitz) do not address the nature of the possible singularities which may be left when the first order transitions are rounded. The talk will focus on the question posed in the title. A pointer to the answer may be found in a renormalization group perspective, which however does not yet yield a proof. (Joint work with L. Geisinger and J. Hanson.)

Giancarlo Benettin *The Fermi-Pasta-Ulam problem: old ideas, recent results*

Abstract: The aim of the talk is to revisit, in the light of some recent numerical results (still in progress), some old ideas concerning the FPU problem, namely (i) The presence, in the so called "alpha-model" (dominant cubic nonlinearity), of at least two well separated time scales: a short one, where only a few normal modes share energy, and a long one, where energy equipartition among all normal modes occurs. (ii) The fact that in the short time scale the dynamics of FPU, in spite of the partial energy sharing, is essentially integrable and practically coincides with the dynamics of the Toda model, while in the long time scale nonintegrability becomes manifest. The role of the constants of motion of the Toda model in the FPU dynamics will be also discussed.

Giuseppe Benfatto *The rigorous construction of the Hubbard model by RG techniques*

Abstract: In the last twenty years, many people in Rome have studied various types of Fermion models, by applying rigorous RG techniques. This line of research was open at the end of the 80's by Giovanni Gallavotti, who published on JSP in 1990, in collaboration with myself, a paper on the weakly interacting Fermi gas in one and three dimensions. In this talk I will give, without too many technical details, a review of the results that have been obtained in the case of the one dimensional extended Hubbard model (a gas of fermions of spin 1/2 on the one dimensional lattice) at weak coupling and generic repulsive short range interaction. These results concern the existence of the zero temperature limit of the Grand Canonical Ensemble, the Borel summability of perturbation theory and some universal relations satisfied by some critical indices and certain thermodynamical quantities (all depending on the coupling and all other details of the model). These universal relations were conjectured many years ago in the physical literature, but were checked only in some special solvable spinless fermion models.

Massimiliano Berti *Quasi-periodic solutions of PDEs*

Abstract: I will present recent existence results about quasi-periodic solutions of Hamiltonian PDE like nonlinear wave and Schrödinger (NLS) in any space dimensions and the 1-d-derivative wave equation. The proofs rely of Nash-Moser implicit function techniques and reducible KAM theory for PDEs.

Federico Bonetto *Nonequilibrium steady state for a simple model of electric conduction*

Abstract: A very simple model for electric conduction consists of N particles moving in a periodic array of scatterers under the influence of an electric field and of a Gaussian thermostat that keeps their energy fixed. I will present analytic result for the behaviour of the steady state of the system at small electric field, where the velocity distribution becomes independent of the geometry of the scatterers, and at large N, where the system can be described by a linear Boltzmann type equation.

David Brydges *The Ising model and the theory of heaps*

Abstract: I will explain some recent work by Tyler Helmuth who has found a simple derivation of the solution of the Ising model in two dimensions along the lines of Kac and Ward (1952) and recent work by Cimasoni. His derivation uses the combinatorial theory of heaps, which I will explain, to write certain correlations as sums over non-backtracking walks with complex weights.

E.G.D. Cohen *Einstein and Boltzmann: Deterministic versus Probabilistic*

Abstract: Einstein repeatedly objected to Boltzmann's $S = k \ln W$, because he argued that Boltzmann's W was not a real probability and that moreover a dynamical theory should be given.
In my talk I will do that for the virial expansions of the thermodynamic and other properties of systems in thermal equilibrium, based on Bogolubov's theory of nonequilibrium systems.

Margherita Disertori *Nematic phase in a system of long hard rods*

Abstract: We consider a two-dimensional lattice model for liquid crystals consisting of long rods interacting via purely hard core interactions, with two allowed orientations defined by the underlying lattice. For this model, we rigorously prove the existence of a nematic phase, i.e., we show that at intermediate densities the system exhibits orientational order, either horizontal or vertical, but no positional order. This is joint work with A. Giuliani.

Pierluigi Falco *Critical exponents for two-dimensional statistical models*

Abstract: One of the most interesting and challenging objectives of Statistical Mechanics is the study of the critical exponents of probabilistic models. In this talk I will discuss conjectures, results and open problems about the critical exponents of two kinds of systems: a) two-dimensional lattice spin models, such as the Ashkin-Teller and the Eight-Vertex models ; b) the two-dimensional Coulomb Gas. Emphasis will not be on the techniques used in the proofs (which are mostly rigorous versions of the Renormalization Group), but rather on the physicists' unifying vision that resulted in several predictions for very many two dimensional systems.

Jean-Pierre Françoise *Analytic prolongation of normal forms*

Abstract: We consider the problem of the analytic prolongation of Birkhoff normal forms for classical integrable Hamiltonians. We discuss the relation with the existence of global action-angle coordinates. The case of Hamiltonian systems with one degree of freedom (and some cases with higher degree of freedom) can be reduced to relative cohomology techniques. We discuss the link with stationary phase integrals, in particular in relation with the Jacobian identity associated with real hyperplane arrangements discovered by Aomoto-Forrester.

Jürg Fröhlich *Gauge theory of states of matter*

Abstract: A general scheme for the analysis and classification of states of (NR) matter is described. It can be viewed to represent a generalization of Landau Theory. The starting point is to search for "all" fundamental and accidental global symmetries of a system of matter and, subsequently, to promote them to local (gauge) symmetries. One then studies the response of the system to coupling the matter degrees of freedom to small, slowly varying external gauge fields corresponding to those symmetries. Assuming only very general properties of the system, e.g., the presence of a mobility gap in the bulk of the system, and exploiting gauge invariance, one is able to determine the general form of the effective action or effective free energy in the (long-distance, small-frequency) scaling limit. The form of the effective action (or free energy) enables one to infer important properties of the system, including ones pertaining to the nature of surface degrees of freedom. Our approach (which goes back to the early 90's) is exemplified on quantum Hall fluids, topological insulators and the primordial plasma in the universe.

Pedro Garrido *Observing rare events out of equilibrium*

Abstract: Fluctuations encode fundamental aspects of the physics of any system. Rare fluctuations, in particular, may play an essential role in some situations. Furthermore, understanding the statistics of fluctuations out of equilibrium, both rare and typical, is opening an unexplored route towards a general theory of nonequilibrium phenomena. These rare fluctuations, usually unobservable in experiments or computer simulations, can nowadays be measured in detail using advanced Monte Carlo techniques, and this possibility is revealing a plethora of new and interesting phenomena. Using these novel methods, we study current fluctuations in an isolated diffusive system in one and two dimensions. While small fluctuations result from weakly-correlated, incoherent local events, for currents above a critical threshold the system self-organizes into a coherent traveling wave which facilitates the current deviation by gathering energy in a localized packet, thus breaking translation invariance. This results in Gaussian statistics for small fluctuations but non-Gaussian tails above the critical current. Our observations, which agree with predictions derived from hydrodynamic fluctuation theory, and other recent results strongly suggest that rare events are generically associated with coherent, self-organized patterns which enhance their probability. (Joint work with P.I. Hurtado and C. Perez-Espigares).

Krzysztof Gawędzki *Finite-time stochastic thermodynamics*

Abstract: Stochastic modelization of mesoscopic systems in interaction with thermal environment permits to revisit links between statistical and thermodynamical concepts in simple out of equilibrium situations. I shall discuss in such a setup a finite-time refinement, related to the Monge-Kantorovich optimal mass transport, of the Second Law of Thermodynamics.

Giovanni Jona-Lasinio *Thermodynamic transformations of nonequilibrium states*

Abstract: We consider transformations driving a thermodynamic system from s stationary state to another one. We study the energy balance within the macroscopic fluctuation theory developed in the last ten years in collaboration with Bertini, De Sole, Gabrielli and Landim. We discuss in particular how the large deviation functional is related to the work involved in the transformations and show that it represents the relative entropy of the initial state with respect to the final state.

Sergei Kuksin *Effective equations for damped and driven Hamiltonian PDE*

Abstract: In my talk I will review the recent progress in the study of long time behaviour of solutions for damped and driven Hamiltonian PDE, in particular using the method of effective equations. The latter applies if the corresponding Hamiltonian PDE is a linear or an integrable equation.

Antti Kupiainen *From random measures to random curves*

Abstract: I will discuss random measures on the line and the plane whose density is given by the exponential of the Gaussian Free Field. The associated random energy models exhibit a spin glass transition in the variance of the field. I will discuss the nature of the transition and a construction of random curves on the plane obtained by glueing two discs with metrics on their boundaries given by two independent copies of these measures in the high temperature phase. The curves should be loop versions of SLE.

Joel Lebowitz *Microscopic and macroscopic evolutions of multiparticle systems*

Abstract: Assume that some deterministic equation,such as the diffusion or Boltzmann equation, "adequately" describes the time evolution of the macrostate of an isolated system with Hamiltonian (or unitary) microscopic dynamics. Then, as is well known, the Boltzmann entropy, which is the large deviation function (LDF) for macrostates in the micro-canonical ensemble, which is stationary for the microscopic dynamics, serves as a Lyapunov function for the macroscopic equation. This connection between the micro and macro dynamics can be readily extended to systems in contact with a single heat bath: the stationary measure for the (stochastic) microscopic dynamics is now the canonical or grand-canonical ensemble. Extension to systems in contact with several heat baths is only possible at present for some special cases, which I shall discuss. I will then discuss the nonequilibrium stationary states of a system with N particles with thermostatted, deterministic or stochastic, dynamics. There are exact, old and new, results for the case when $N = 1$, and a surprising universality for $N > 1$. This part will serve as an introduction to the talk of Bonetto.

Elliott Lieb *Topics in quantum entropy and entanglement*

Abstract: Several recent results on quantum entropy and the uncertainty principle will be discussed. This is partly joint work with Eric Carlen on lower bounds for entanglement, which has no classical analog, in terms of the negative of the conditional entropy, $S_1 - S_{12}$, whose negativity, when it occurs, also has no classical analog.

It is also partly joint work with Rupert Frank on the uncertainty principle for quantum entropy which compares the quantum von Neumann entropy with the classical entropies with respect to two different bases. We prove an extension to the product of two and three spaces, which has applications in quantum information theory.

Vieri Mastropietro *Universality in many-body theory*

Abstract: I will discuss some universality results for interacting many-body models, including the universal conductivity in graphene and the Kadanoff-Haldane relations for (non solvable) spin 1/2 chains. Universality is due in the above cases to certain emerging relativistic symmetries, and the exact cancellations of all the possible non-universal corrections is obtained by combining Ward Identities with the multiscale analysis in terms of Gallavotti trees.

Salvador Miracle-Solé *Interface model interacting with a wall*

Abstract: We consider a solid-on-solid interface model above a horizontal wall, in the three dimensional space, with an attractive interaction when the interface is in contact with the wall, and study its behaviour, layering and wetting transitions, at low temperatures. We extend, in part, this study to the case of a semi-infinite Ising model.

Stefano Olla *Macroscopic transport and diffusion of energy*

Abstract: I will review some results about energy transport in chains of oscillators and other hamiltonian dynamics slightly perturbed by energy conserving noise. Existence and properties of thermal conductivity coefficient can be proven with little conditions on the stochastic perturbation, while obtaining heat equation is a much more challenging problem that can be obtained with stronger noise. I will explain connection with non-equilibrium stationary states with Langevin heat bath at the boundaries, and some numerical results for a system of rotors 'very far from equilibrium'.

Giorgio Parisi *Off equilibrium dynamics and metastable states.*
Markov chains in parameter space and the replica approach

Abstract: In presence of many metastable states (as it happens in mean field models of glassy systems) the dynamics becomes rather complex and hysterical effects may be present. In this talk this problem will be studied by considering a chain of identical glassy systems in a constrained equilibrium where each bond of the chain is forced to remain at a preassigned distance to the previous one. I will apply this description to Mean Field Glassy systems in the limit of long chain where each bond is close to the previous one. I will show show that in specific conditions this pseudo-dynamic process can formally describe real relaxational dynamics the long time. In particular, in mean field spin glass models we can recover in this way the equations of Langevin dynamics in the long time limit at the dynamical transition temperature and below. I will interpret the formal identity as an evidence that in these situations the configuration space is explored in a quasi-equilibrium fashion. This general formalism, that relates dynamics to equilibrium puts slow dynamics in a new perspective and opens the way to the computation of new dynamical quantities in glassy systems.

Michela Procesi *Normal forms for the nonlinear Schrödinger equation*

Abstract: We discuss a result on existence and stability of quasi-periodic solutions for the completely resonant nonlinear Schrödinger equation on a torus.

Vincent Rivasseau *Tensor field theories*

Abstract: We present an approach to emergent space-time and quantum gravity which is based on recent progress on the analysis of large random tensors. We review the first step, namely the construction of renormalizable tensor field theories.

David Ruelle *Are real numbers the same for physicists and mathematicians?*

Abstract: Mathematics is the language used by physicists to describe the universe. The mathematics used by physicists is in some sense the same as that used by mathematicians: there can be no contradiction between the two. There are however definite differences of intuition and technical tools considered appropriate. Here we will discuss the fact that the real numbers used by physicists are not quite the same as those used by mathematicians.

Robert Seiringer *How much energy does it cost to make a hole in the Fermi sea?*

Abstract: The change in energy of an ideal Fermi gas when a local one-body potential is inserted into the system, or when the density is changed locally, are important quantities in condensed matter physics. We show that they can be rigorously bounded from below by a universal constant times the value given by the semiclassical approximation. In more technical terms, we extend the well-known Lieb-Thirring inequalities, which give a bound on the negative eigenvalues of a Schrödinger operator, to analogous inequalities for perturbations of the continuous spectrum of the Laplacian by local potentials. (This is joint work with R. Frank, M. Lewin and E. Lieb.)

Thomas Spencer *An approach to localization for disordered quantum spin systems*

Abstract: I shall report on preliminary work with John Imbrie on a KAM like approach to understanding the structure eigenstates for a strongly disordered quantum spin systems. The goal is to prove that eigenstates can be approximately expressed as a tensor product of local states. We apply a sequence of local unitary transformations so that the renormalized interaction becomes small.

Herbert Spohn *Stochastic integrability and the Kardar-Parisi-Zhang equation*

Abstract: My focus will be on integrable systems with many degrees of freedom. Classical and quantum integrable systems have a long tradition. In recent years, other models, like the KPZ equation, have been studied which are best classified as being stochastic integrable. I will explore this notion and point out (dis)similarities to quantum integrability

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Fabio Lucio Toninelli *Discrete interfaces, random tilings and stochastic dynamics*

Abstract: Consider a finite portion A of the plane and all the possible tilings of A, for instance with dominos (2×1 rectangles) or with lozenges. To each tiling is associated a discrete two-dimensional height function (or interface). We study a stochastic dynamics on the tilings, which converges in the long-time limit to the uniform measure on all the possible tilings. In the case of lozenge tilings, this corresponds to the zero-temperature dynamics of the 3D nearest-neighbor Ising model. For a natural class of boundary conditions (i.e. of domain shapes A) we provide almost-optimal bounds on the equilibration time of the dynamics, when A is large. Our technique uses on one side the gaussian-free field like behavior of height fluctuations of uniform tilings, and on the other the intuition that the interface should evolve by mean curvature. Based on collaboration with P. Caputo, F. Martinelli, F. Simenhaus and B. Laslier.

Jakob Yngvason *Quantum Hall phases of rotating bosons in anharmonic traps*

Abstract: Rotating cold Bose gases in harmonic traps have strongly correlated many-body ground states in the lowest Landau level if the rotational speed is close to the trapping frequency and the coupling constant is large. In joint work with Nicolas Rougerie we have studied the effect of adding an anharmonic term to the trapping potential. A new strongly correlated phase with a 'hole' in the density around the center may arise if the rotational speed exceeds the harmonic trapping frequency. The particle density is asymptotically determined by a mean field limit of a classical 2D Coulomb gas.

Francesco Zamponi *A transition path sampling to compute escape rates in many-body discrete systems: application to the 2D Ising model*

Abstract: I will discuss a new Monte Carlo method for efficient sampling of trajectories with fixed initial and final conditions in a system with discrete degrees of freedom. The method can be applied to any stochastic process with local interactions, including systems that are out of equilibrium. Combining the proposed path-sampling algorithm with a suitable thermodynamic integration, one can compute transition rates between metastable states. To demonstrate the performances of the method and compare with other algorithms, I will discuss the well studied 2D Ising model with periodic boundary conditions.
