LIST OF INVITED SPEAKERS AND THEIR TALK INFORMATION
107th STATISTICAL MECHANICS CONFERENCE

- **Natan Andrei, Rutgers University**
  Title: Quench Dynamics of Interacting Bosons
  Abstract: TBA

- **Mark Bowick, Syracuse University**
  Title: Facets of Order
  Abstract: I will discuss the interplay between shape and order in block copolymer vesicles with internal liquid crystalline order including the realization of faceted liquid crystalline shells.

- **Yana Bromberg, Rutgers University**
  Title: Differentiating SNP-mediated function disruption from disease
  Abstract: A major current effort in the scientific community focuses on evaluating individual predispositions to specific phenotypic traits/diseases given their genetic backgrounds. While the majority of disease causing mutants affect molecular function, the reverse is not necessarily true; i.e. functionally disruptive mutants do not always cause disease. The importance of a variant-affected site to specific molecular function or proper folding of the protein differentiates disease-causing variants from those with less severe phenotypes. Here we present a computational method for identification of protein functional sites via analysis of variant effects. We further relate the natural occurrence of mutations in these functional sites to the development of disease.

- **Eric Carlen, Rutgers University**
  Title: Bounds for entanglement via an extension of strong subadditivity of entropy
  Abstract: We prove sharp lower bounds for the entanglement of formation and the squashed entanglement for bipartite states in terms of the conditional entropy,and give a new class of states for which both measures of entanglement can be exactly computed. We also derive upper bounds. This is joint work with Elliott Lieb.

- **Premi Chandra, Rutgers University**
  Title: An Emergent Critical Phase in a 2D Frustrated Heisenberg Model
  Abstract: TBA

- **Michael Chertkov, Los Alamos National Laboratory**
  Title: Statistical Physics for Smart (Power) Grids
  Abstract: We are asking modern power grids to serve under conditions for which they were not originally designed. We also expect the grids to be smart, in how they function, how they withstand contingencies, how they respond to fluctuations in generation and load, and how the grids are controlled. To meet these ever-increasing expectations requires extending power grid models beyond the scope of traditional power engineering. In this talk aimed at applied mathematicians and physicists I first review basics of power flows, and then outline a number of new problems in modeling power grids. In particular, I describe new approaches to study (a) voltage stability/collapse in distribution (low voltage) system; and if time permits, (b) probabilistic distance to failure in transmission (high voltage) system.

- **Philippe Choquard, ITP, EPF Lausanne CH**
  Title: The 2D. Euler-Coriolis fluid: Theory and Illustration
  Abstract: We start with a canonical Hamiltonian, Clebsch like, formulation of inviscid, compressible and rotational,charged or neutral fluids, and their ensuing equations of motion including Euler equations for the velocity fields. We consider next the simplest example of a 2D perfect fluid in a rotating frame of reference, called the Euler-Coriolis fluid.Then,we take up the problem of describing the dynamics of a single cylindrical vortex immersed in an infinite compressible medium by means of the method of characteristics. An extension of the Hopf-Lax-Bellman variational principle is evoked to qualify the nature of the solutions, weak in general. Results of numerical analysis are lastly presented.

- **Sergio Ciliberto, CNRS**
  Title: Experimental verification of Landauer's principle linking information and thermodynamics

  Abstract: TBA

- **James P. Crutchfield, University of California, Davis**
  Title: The Past and the Future in the Present
  Abstract: We show why the amount of information communicated between the past and future---the excess entropy---is not in general the amount of information stored in the present---the statistical complexity. This is a puzzle, and a long-standing one, since the former describes observed behavior, while optimal prediction requires the latter. We present a closed-form expression for the excess entropy in terms of optimal causal predictors and retrodictors---both epsilon-machines of computational mechanics. This leads us to two new system properties: causal irreversibility---the temporal asymmetry between causal representations---and crypticity---the degree to which a process hides its state information. Joint work with Chris Ellison, Ryan James, and John Mahoney.

- **Freeman Dyson, Institute for Advanced Study**
  Title: Partitions and the Grand Canonical Ensemble

Abstract: Two disconnected remarks about partitions. First, a pedagogical remark connecting pure mathematics with statistical physics. The grand canonical ensemble of statistical mechanics is applied to the counting of partitions. This picture borrowed from physics gives a simple approximation to the exact calculation of the partition function by Hardy and Ramanujan.

- **Yves Elskens, CNRS/Aix-Marseilles University**
  Title: Propagation of chaos in wave-particle interaction
  Abstract: The validity of quasilinear (QL) theory describing the paradigmatic weak warm beam instability has been controversial for decades. We prove that the velocities of N passive particles in a single one-dimensional wave field converge in law to a diffusion process, in the limit of a dense wave spectrum with independent amplitudes and random phases, when the power spectrum is uniform. The proof provides a full probabilistic foundation to the QL approximation and to the ensemble picture for a single realization of the stochastic environment. For the self-consistent Vlasov?wave dynamics, we prove analytically and nume- rically that in the strongly nonlinear regime where the particle distribution function has formed a plateau and wave intensities have settled, QL predictions remain valid thanks to the absence of mode coupling, and particles evolve in a quenched random wave field. We confirm numerically that the wave power spectrum at saturation agrees statistically with the prediction from the conservation law resulting from the locality in velocity of the wave-particle interaction. We also observe a nonlinear, non-QL stage in the development of the instability, before its saturation.
  1. Y. Elskens and E. Pardoux, Diffusion limit for many particles in a periodic stochastic acceleration field, Ann. Appl. Prob. 20 (2010) 2022-2039.
  2. N. Besse, Y. Elskens, D.F. Escande and P. Bertrand, Validity of quasilinear theory : refutations and new numerical confirmation, Plasma Phys. Control. Fusion 53 (2011) 025012.

- **Laszlo Erdoes, Universitat Muenchen**
  Title: Localization length in random band matrices
  Abstract: TBA

- **Santo Fortunato, Aalto University**
  Title: Characterizing and modeling citation dynamics
  Abstract: Citation distributions are crucial for the analysis and modeling of the activity of scientists. We investigated bibliometric data of papers published in journals of the American Physical Society, searching for the type of function which best describes the observed citation distributions. We used the goodness of fit with Kolmogorov-Smirnov statistics for three classes of functions: log-normal, simple power law and shifted power law. The shifted power law turns out to be the most reliable hypothesis for all citation networks we derived, which correspond to different time spans. We find that citation dynamics is characterized by bursts, usually occurring within a few years since publication of a paper, and the burst size spans several orders of magnitude. We also investigated the microscopic mechanisms for the evolution of citation networks, by proposing a linear preferential attachment with time dependent initial attractiveness. The model successfully reproduces the empirical citation distributions and accounts for the presence of citation bursts as well.

- **Carl Franck, Cornell University**
  Title: Experimentally Exploring the Limits and Consequences of Chemical Communication Between Cells
  Abstract: Statistical physicists have long enjoyed investigating the collective states that arise via interactions between molecules. Turning to unicellular microbes, we now contemplate the ``purposeful" cooperative behavior that results from the exchange of chemical messages in living matter. To begin, we will explain how our recent measurements of the sensitivity of the amoeba Dictyostelium discoideum (Dicty) to chemical gradients challenge contemporary theory based on intrinsic noise in chemical message detection. In the second part of the talk, we

  will argue that a familiar but unsolved problem for cell biologists, that a nutritious medium fails to ignite cell proliferation below a critical density of cells, present physicists with the chance to explore a transition to multicellular life. We will be especially focused on the experimental confirmation of the transition in dilute Dicty suspensions in the midst of biological variability.

- **Jochen Gemmer, Universitat Osnabruk**
  Title: Emergence of Thermodynamcical Behavior in Closed Quantum Systems: A Small Spin System as an Example
  Abstract: "Thermodynamical behavior" implies a number of properties: Describability in terms of a few variables, approach of these variables to universal equilibrium values (relaxation), possibly an exponential form of the above relaxation, etc. Most of these properties appear to be absent in standard quantum mechanics. In order to cure this many approaches resort to some sort of bath. We deliberately try to avoid the standard notion of a bath here and look for the above properties in an isolated spin system. The considered observable is the spatial distribution of the magnetization. Key words are typicality, eigenstate thermalization hypothesis (ETH), Langevin-dynamics, etc.

- **Vojkan Jaksic, McGill University**
  Title: Quantum entropic functionals, fluctuations symmetries, and Araki-Lieb-Thirring inequality
  Abstract: TBA

- **Konstantin Khanin, University of Toronto**
  Title: Intermediate disorder for directed polymers
  Abstract: We discuss the scaling properties of directed polymers in the situation when inverse temperature is scaled with the size of the polymer. It turns out that in the critical case one can observe a new universal disorder regime.

- **Roberto Livi, INFN**
  Title: Transport properties of the Discrete Nonlinear Schrodinger equation
  Abstract: We discuss how negative temperature metastable states may emerge in the DNLSE as a product of the spontaneous formation of nonlinear excitations (breathers). This phenomenon determines anomalous transport features that can be detected experimentally in BEC on optical lattices as well as in arrays of coupled optical fibers.

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- **Natalia Komarova, University of California, Irvine**
  Title: Cooperation as an engine of evolution
  Abstract: Cancer comes about by a sequence of mutations that change the cells' fitness and create advantageous phenotypes. These phenotypes displace other cells and spread, thus winning the evolutionary competition. It is possible that in order to create those advantageous mutants, several different mutations have to be accumulated in a cell, such that each individual mutation is disadvantageous, and together they comprise a fitness advantage. In the literature, this is often called "crossing a fitness valley". In this talk I will present a novel mechanism by which such fitness valleys can be crossed. It envolves the notion of cooperation among the cells, where shared benefits are received through "division of labor". I will show how in such context, cooperation can speed up the evolutionary process. Moreover, the emergence of cheaters that destroy cooperation dynamics can "unite" all mutations within one individual on a fast time scale. Paradoxically, the presence of such cheaters happens to accelerate evolution even more.

- **Mariano Lopez, University of Mexico**
  Coauthors: A. Santos [1],S. B. Yuste[1] and M. Lopez de Haro*[2]
  Title: Structural properties of fluids interacting via piece-wise constant potentials with a hard core
  Abstract: The structural properties of fluids whose molecules interact via potentials with a hard-core plus n piece-wise constant sections of different widths and heights are derived by using a (semi-analytical) rational-function approximation method. The results are illustrated for the cases of a square-shoulder plus square-well potential and a shifted square-well and compared both with simulation data and with those that follow from the (numerical) solutions of the Percus-Yevick integral equation.
  [1] Departamento de Fisica, Universidad de Extremadura, Badajoz 06071, Spain
  [2] Centro de Investigacion en Energia, Universidad Nacional Autonoma de Mexico, Temixco, Mor. 62580, Mexico.

- **Juan Maldacena, Institute for Advanced Study**
  Title: Solving a four dimensional gauge theory using integrability
  Abstract: We will review progress on exact solutions for the planar limit of the most supersymmetric version of four dimensional quantum chromodynamics. In the large N limit, this theory contains some strings. One can solve the theory on these strings by the ideas of integrability. This uses methods that have been developed to solve integrable spin chains in condensed matter, with some suitable modifications. These exact solutions smoothly interpolate between almost free gluons in four dimensions at weak coupling and strings in ten dimensions at strong coupling.

- **Robert McCann, University of Toronto**
  Title: Higher-order time asymptotics of fast diffusion in Euclidean space: a dynamical systems approach
  Abstract: With Jochen Denzler (UT Knoxville) and Herbert Koch (Bonn), we quantify the speed of convergence and higher asymptotics of fast diffusion dynamics on Euclidean space to the Barenblatt (self similar) profile. The degeneracy in the parabolicity of the equation is cured by re-expressing the dynamics on a manifold with a cylindrical end, called the cigar. The nonlinear evolution semigroup becomes differentiable with respect to Hoelder initial data on the cigar. The linearization of the dynamics is given by Laplace-Beltrami operator plus a drift term (which can be suppressed by the introduction of appropriate weights into the function space norm), plus a finite-depth potential well with a universal profile. In the limiting case of the (linear) heat equation, the depth diverges, the number of eigenstates increases without bound, and the continuous spectrum recedes to infinity. We provide a detailed study of the linear and nonlinear problems in Hoelder spaces on the cigar, including a sharp boundedness estimate for the semigroup, and use this as a tool to obtain sharp convergence results toward the Barenblatt solution. In finer convergence results (after modding out symmetries of the problem), a subtle interplay between convergence rates and tail behavior is revealed. The difficulties involved in choosing the right functional analytic spaces in which to carry out the analysis can be interpreted as genuine features of the equation rather than mere annoying technicalities.

- **Clement Mouhot, University of Cambridge**
  Title: A new approach to the hydrodynamic limit of interacting particle systems: the zero range process
  Abstract: TBA

- **Bruno Nachtergaele, University of California, Davis**
  Title: Five generalizations of the AKLT model
  Abstract: The spin-1 antiferromagnetic quantum spin chain introduced by Affleck, Kennedy, Lieb, and Tasaki in 1987 (now known as the AKLT model) was the starting point of and continues to be the inspiration for a great number of significant advances in our understanding of quantum spin models. In this talk I will give an overview of some of these developments guided by five generalizations of the AKLT model.

- **Zohar Nussinov, Washington University in St. Louis**
  Title: The detection of hidden spatial and spatio-temporal structures in complex physical systems by multi-scale clustering and some of their properties
  Abstract: TBA

- **David Pine, New York University**
  Title: Colloidal lock and keys - towards self-replication
  Abstract: TBA

- **Raul Rechtman, University of Mexico**
  Title: Motion of a cylinder attached to a spring subject to a flow
  Abstract: We present numerical solutions of the flow around a circular cylinder between parallel plates attached to a linear spring using the lattice Boltzmann equation. The problem was solved for a wide range of Reynolds numbers and different spring constants. We present results of the dynamics of the cylinder due to the spring and the drag force and its relation with the observed vortex shedding behind the cylinder.

- **Sriram Shastry, University of California, Santa Cruz**
  Title: Quantum integrable models in finite dimensional Hilbert spaces
  Abstract: TBA

- **Robert Seiringer, McGill University**
  Title: The Excitation Spectrum for Weakly Interacting Bosons
  Abstract: We investigate the low energy excitation spectrum of a Bose gas with weak, long range repulsive interactions. In particular, we prove that the Bogoliubov spectrum of elementary excitations with linear dispersion relation for small momentum becomes exact in the mean-field limit.

- **Anneke Levelt-Sengers, NIST**
  Title:Science and Technology for Development: An Initiative of the Network of Science Academies in the Americas

- **Jan Sengers, University of Maryland, College Park**
  Title: Light scattering and shadowgraphy measurements of thermal nonequilibrium fluctuations in fluids
  Abstract: In the abstract of a paper, entitled Light scattering from fluids not in thermal equilibrium, published in Kinam 3A, 39 (1981), E.G.D.

  Cohen made the following prediction: "In a fluid not in thermal equilibrium, long-range correlations between fluctuations exist, due to mode-coupling effects, that are absent in fluids in equilibrium. Light scattering can reveal these correlations." This presentation will review the experimental evidence for the presence of these long-range fluctuations, including some very recent results demonstrating the effects of gravity and confinement on thermal nonequilibrium fluctuations.

- **Israel Michael Sigal, University of Toronto**
  Title: Long distance behaviour of van der Waals forces
  Abstract: In this talk I will describe a recent work with my former student, Ioannis Anapolitanos, in which we derive long-range behaviour of van der Waals forces for an arbitrary system of neutral atoms. Discussions with Elliott Lieb played an important role in the scope of this work.

- **Avraham Soffer, Rutgers University**
  Title: A model of quantum friction rigorous results
  Abstract: TBA

- **Shivaji Sondhi, Princeton University**
  Title: The Statistical Mechanics of Quantum Satisfiability
  Abstract: The class QMA generalizes the idea of the class NP to quantum computers. A problem in the class QMA has a solution that is easily checked by a quantum computer and "complete" problems in this class are believed to be hard even for quantum computers. I will describe results on a random ensemble of a QMA complete problem that allow a first cut of a natural phase diagram for it as well as a striking "geometrization theorem" that suggests that almost all instances might even be a classical graph theoretic problem in disguise.

- **Eitan Tadmor, University of Maryland, College Park**
  Title: Consensus and flocking in heterophily self-alignment dynamics
  Abstract: We discuss particle-based models for self-organized dynamics, with a focus on a prototype model driven by non-symmetric self-alignment. We explain the emergence of consensus and unconditional flocking when the interactions decay is sufficiently slow. When the self-alignment is compactly supported, then there are open questions regarding clustering and the emerging consensus in heterophily dynamics. These questions are linked to the connectivity of the underlying graph. The methodology carries over from particle to kinetic and hydrodynamic descriptions.

- **Giuseppe Toscani, Universita di Pavia**
  Title: Fast diffusion asymptotics and Sobolev inequalities
  Abstract: Functional inequalities are often related to nonlinear evolution equations. Here we outline the relationship between Sobolev's inequality and fast diffusion equations. It is known that the di fference of the two terms in Sobolev's inequality (with optimal constant) measures a distance to the manifold of the optimal functions. We give an explicit estimate of the remainder term and establish an improved inequality, with explicit norms and fully detailed constants. Our approach is based on nonlinear evolution equations and improved entropy - entropy production estimates along the associated flow. Optimizing a relative entropy functional with respect to a scaling parameter, or handling properly second moment estimates, turns out to be the central technical issue. This is a new method in the theory of nonlinear evolution equations, which also applies to other interpolation inequalities of Gagliardo-Nirenberg-Sobolev type.

- **Jane Wang, Cornell University**
  Title: How do Insects Fly and Turn
  Abstract: Insect's aerial acrobatics results from the concerted efforts of its brain, flight muscles, and flapping wings. To understand its flight, we started from the outer scale, analyzing the unsteady aerodynamics of flapping flight, and are gradually working toward the inner scale, deducing the control algorithms. We are particularly interested in seeking mechanistic explanations for their flight dynamics.
  In this talk, I will first describe the aerodynamics tricks that dragonfly employs to hover and fly efficiently. I will then describe how fruit flies recover from aerial stumbles, and how they make subtle wing movements to induce sharp turns in 40-80ms, or tens of wing beats. These work involves direction numerical simulations, reduced order models for unsteady fluid forces, and analyses of experimental data of insects in free flight.

- **Ned Wingreen, Princeton University**
  Title: The role of enzyme clustering in metabolic regulation
  Abstract: Metabolism is the set of enzymatic reactions that cells use to generate energy and biomass. Interestingly, recent studies suggest

Abstract: Metabolism is the set of enzymatic reactions that cells use to generate energy and biomass. Interestingly, recent studies suggest that many metabolic enzymes assemble into higher-order structures, often in response to environmental conditions. Theoretically, we find that large-scale enzyme clusters, with no internal spatial ordering of enzymes, offer many of the same advantages as direct substrate channeling: accelerating intermediate processing, protecting intermediates from degradation/cross-reactions, and protecting the cell from toxic intermediates. I will discuss the requirements to realize these potential benefits of enzyme clustering, e.g. what are the necessary sizes, shapes, internal organizations, and external arrangements of functional enzyme clusters?

- **Horng-Tzer Yau, Harvard University**
  Title: Random matrices and Dyson Brownian motion
  Abstract: TBA

- **Alexander Zamolodchikov, Rutgers University**
  Title: On high energy scattering in Ising field theory
  Abstract: TBA

- **Robert Ziff, University of Michigan**
  Title: Percolation on regular and hyperbolic lattices
  Abstract: Percolation figures in a wide variety of problems in statistical physics, including the problem of deterministic diffusion in a random environment studied by Eddie Cohen. We will discuss that work, along with several recent advances that have been made: determination of exact thresholds for large classes of lattices, finding retention in an invasion percolation problem, and studying correlations and crossing problems. Finally, recent work using the crossing idea to study percolation on hyperbolic lattices will be presented.