110th Statistical Mechanics Conference
Invited Speakers, Titles & Abstracts

Ethan Akin, City College of New York
"Solving the Iterated Prisoner's Dilemma"
Abstract: Recent work by Press and Dyson on the Iterated Prisoner's has led to a characterization of strategies which effectively lead to the cooperative payoff for both players. We describe some of these and compare them with the coercive strategies discussed by them.

Eric Akkermann, Technion – Israel Institute of Technology
"Universal Current Fluctuations and Large Deviations in the Symmetric Simple Exclusion Process on an Arbitrary Graph"
Abstract: We show that the statistics of the current of the symmetric simple exclusion process (SSEP) connected to two reservoirs are the same on an arbitrary graph or domain in d-dimensions as in the one-dimensional case. To prove this result supported by numerics, we use two different approaches. The first one, based on the macroscopic fluctuation theory of Bertini, De Sole, Gabrielli, Jona-Lasinio and Landim, consists of a direct calculation which bears a close analogy with electrostatics. The second approach makes use of energy forms and some of their useful properties.

Pavel Bleher, Indiana University – Purdue "Calculation of the Constant Factor in the Six-Vertex Model"
Abstract: We calculate explicitly the constant factor C in the large N asymptotic behavior of the partition function of the six-vertex model with domain wall boundary conditions on the critical line between the disordered and ferroelectric phases. This is a joint work with Thomas Bothner.

Jean-Philippe Bouchaud, Ecole Polytechnique
"Anomalous Price Impact and the Critical Nature of Liquidity in Financial Markets"
Abstract: TBA

Piers Coleman, Rutgers University
"Anderson like transition for a SUSY model in 3D"
Abstract: TBA

Wojciech De Roeck, Universität Heidelberg
"Rigorous Theory of Open Quantum Systems: Thermalization and Diffusion"
Abstract: TBA

Charles Epstein, University of Pennsylvania
"The Life History of PDE's and Computational Electromagnetics"
Abstract: TBA

Paul Falkowski, Rutgers University
"Photons as measure of life on Earth"
Abstract: This talk is about how the molecular mechanisms of solar induced fluorescence can be used to infer life on Earth. We live in a world where photons are converted to chemical bond energy. That reaction is inevitably inefficient, and leads to an optical signal, fluorescence. The fluorescence lifetimes are related to Boltzmann functions. However, the statistical fluctuations of molecules of water in the oceans lead to a

complex solution to why the ocean is blue, which is also a Boltzmann distribution, but not well resolved. But, when we have photosynthetic organisms in the ocean, red photons are emitted as a consequence of solar induced radiation on a blue background. The quantum yield of the photosynthetically derived spectra are a measure of life on Earth. I will discuss the statistical mechanics of a reaction that allows us to exist, and the non-equilibirium mechanics we need to understand that led to our very existence.

Daniel Fisher, Stanford University
"Rapid Spatial Spread of Biology"
Abstract: TBA

Michael Fisher, University of Maryland
"Effects of Proximity and Connectivity: Superfluid Helium Boxes and Layered Ising Models" Abstract: TBA
Abstract: TBA

Alice Guionnet, Massachusetts Institute of Technology
"About Topological Expansions"
Abstract: TBA

Duncan Haldane, Princeton University
"P. W. Anderson: his influential works"
Abstract: TBA

Bertrand Halperin, Harvard University
"Fractional quantized Hall effect and phase transitions in the lowest Landau level of single-layer grapheme"
Abstract: TBA

Pierre Hohenberg, New York University
"Microscopic and Macroscopic Formulations of Quantum Mechanics"
Abstract: The histories approach to quantum mechanics leads to a coherent microscopic formulation, in which only contextual probabilities (c-probabilities) and contextual truth (c-truth) are attached to quantum properties. Different c-probability functions belong to different frameworks, that are mutually incompatible. Physical probabilities and physical truth are emergent features, that only appear in the macroscopic limit, where the microscopic framework symmetry can be broken, and a physical framework can be selected. The full histories formulation of quantum mechanics (which goes under the names of Consistent or Decoherent Histories, or Compatible Quantum Theory) is a combination of the microscopic and macroscopic theories. The Copenhagen approach can be thought of as a simple phenomenological theory that partially incorporates the above ideas.

David Huse, Princeton University
"Many-Body Anderson Localization"
Abstract: The physical system that was considered in Phil Anderson's original 1958 localization paper was spins doped in to an insulator, with the spin-spin interactions included, but the spin-phonon interactions neglected. He considered this interacting many-body system at nonzero (even high) temperatures and argued that it could fail to be a thermal reservoir that thermalizes its constituent spins. Thus this many-body problem is the "original" definition of localization. In the same paper, Phil also considered single-particle localization, and that simpler problem has distracted most of the community since then. But a growing group of us are now revisiting the question of many-body localization, and I will say a little about some of this more recent work.

Ido Kanter, Bar Ilan University
"An Experimental Evidence-Based Computational Paradigm for New Logic-Gates in Nervous Activity"
Abstract: In 1943 McCulloch and Pitts suggested that the brain is composed of interconnected Boolean entities - the neurons -which function as threshold units that can produce highly complex patterns. These simplified neurons constitute pure and reliable logic-gates similar to the logic at the core of today's

computers. This framework was extremely influential in the development of artificial neural networks but had very limited impact on neuroscience, since neurons exhibit richer dynamics and can differ in their functionality and reliability. Seven decades later, there is still no comprehensive alternative description of the computational abilities of the nervous system. Here we propose a new experimentally corroborated paradigm in which the logical operations of the brain differ from the logic of conventional computers. Unlike a burned gate on a designed chip that consistently follows the same truth-table (e.g. AND, OR), here the functionality of the brain's logic-gates depends on the history of their activity, the stimulation frequencies of their input neurons, as well as the activity of their interconnections. Our results are based on an experimental procedure where conditioned stimulations were enforced on circuits of neurons embedded within a large-scale network of cortical cells in-vitro. We demonstrate that the underlying biological mechanism is the unavoidable increase of neuronal response latency to ongoing stimulations, which imposes a non-uniform gradual stretching of delays associated with the neuronal circuit. We anticipate our results to be a starting point for larger scale in-vitro experiments and structured recurrent neuronal circuits, which will lead to better understanding of the suitability of this computational paradigm to account for the brain's functionalities. In addition, this paradigm will require the development of new systematic methods and practical tools beyond the methods developed for traditional Boolean algebra.

Anthony Leggett, University of Illinois - Urbana-Champaign
"The TTLS Model of the Low-Temperature Properties of Glasses: Successes, Problems and Prospects"
Abstract: For more than 40 years the reigning paradigm for the thermal, ultrasonic and dielectric properties of amorphous materials below 1K has been the "tunneling two-level systems" model originated by Phil Anderson and others in 1970. This talk attempts to briefly survey the successful predictions of the model, the questions it raises and the prospects for a "smoking-gun" test of its essential aspects.

Dov Levine, Technion– Israel Institute of Technology
"Exotic Ordered States"
Abstract: TBA

Arnie Levine, Institute for Advanced Study
"Measuring the Clinal Evolution of Cancers and the Mutation Rates of Cancer Cells"
Abstract: TBA

Elliott Lieb, Princeton University
"Freeman Dyson"
Abstract: TBA

Cristopher Moore, University of New Mexico
"Analyzing Networks with the Cavity Method"
Abstract: A popular pastime in the field of networks is to identify communities: sets of nodes that connect strongly to each other, or (more generally) connect to the rest of the network in similar ways. The stochastic block model is one way to do this; it corresponds roughly to a generalized Potts model on a sparse random graph. I will describe how belief propagation, known as the cavity method in physics, gives us both a practical algorithm for fitting this model to large graphs, and insight into phase transitions into the detectability of these communities.

Luca Peliti, Università di Napoli
"Thermodynamics of information handling in some cellular processes
Abstract: TBA

Luciano Pietronero, ISC-CNR & Uni Sapienza
"New Metrics for Economic Complexity: Measuring the Intangible Growth Potential of Countries"
ABSTRACT: Economic Complexity refers to a new line of research which portrays economic growth as a process of evolution of ecosystems of technologies and industrial capabilities. Complex systems analysis,

simulation, systems science methods, and big data capabilities offer new opportunities to empirically map technology and capability ecosystems of countries and industrial sectors, analyse their structure, understand their dynamics and measure economic complexity. This approach provides a new vision of a data driven fundamental economics in a strongly connected, globalised world.

In particular here we discuss the COMTRADE dataset which provides the matrix of countries and their exported products. According to the standard economic theory the specialization of countries towards certain specific products should be optimal. The observed data show that this is not the case and that diversification is actually more important. Specialization may be the leading effect in a static situation but the strongly dynamical globalized world market suggests instead that flexibility and adaptability are essential elements of competitiveness as in bio-systems. The situation is different for individual companies or sectors which seem instead to specialize only on few products.

The crucial challenge is then how to turn these qualitative observations into quantitative variables. We have introduced a new metrics for the Fitness of countries and the Complexity of products which corresponds to the fixed point of the iteration of two nonlinear coupled equations. The nonlinearity is crucial because it represents the fact that the upper bound on the Complexity of a product is given by the less developed country that can produce it. The information provided by the new metrics can be used in various ways. The direct comparison of the Fitness with the country GDP gives an assessment of the non-expressed potential of the country. This can be used as a predictor of GDP evolution or stock index and sectors perfomances. The global dynamics shows, however, a large degree of heterogeneity which implies that countries which are in a certain zone of the parameter space evolve in a predictable way while others show a chaotic behaviour. This heterogeneous dynamics is also outside the usual economic concepts. When dealing with heterogeneous systems, in fact, the usual tools of linear regressions become of inappropriate. Making reliable predictions of growth in the context of economic complexity will then require a paradigm shift in order to catch the information contained in the complex dynamic patterns observed. Other possible applications of these concepts are in the risk analysis and industrial planning.

References
[1] A. Tacchella, M. Cristelli, G. Caldarelli, A. Gabrielli and L. Pietronero: A New Metrics for Countries' Fitness and Products' Complexity, Nature: Scientific Reports, 2-723 (2012) [2] M. Cristelli, A. Gabrielli, A. Tacchella, G. Caldarelli and L. Pietronero: Measuring the Intangibles: A Metrics for the Economic Complexity of Countries and Products, PLOS One Vol. 8, e70726 (2013)

Joshua Plotkin, University of Pennsylvania
"Evolution of Generosity in the Prisoner's Dilemma"
Abstract: TBA

Karin Rabe, Rutgers University
"New ferroelectrics and antiferroelectrics by design"
Abstract: TBA

Vered Rom-Kedar, Weizmann Institute
"Mechanisms for robust exponential in time acceleration"
Abstract: Consider a particle which moves freely inside a bounded domain (a billiard) and rejects elastically from the domain's boundary. We assume that the boundary of the billiard domain changes in time and restores its shape periodically. Elastic collisions with the moving boundary change the particle kinetic energy. If the average energy gain over multiple collisions is positive, the particle accelerates. This process is often called "Fermi acceleration" since it resembles the mechanism of cosmic particles acceleration by rejecting from magnetic mirrors proposed by Fermi in 1949. When the particle accelerates to sufficiently large speed, the motion of the boundary eventually becomes slow compared to the particle motion, and the system may be considered adiabatic. Indeed, Fermi acceleration can be viewed as the process of energy transfer from a slowly moving heavy object (here - the billiard boundary) to fast light particles. In this respect, the crucial

question is whether energy transfer is possible at all, and if so, how effective it is, i.e. what is the rate of the particle energy growth and how it distributes among an ensemble of particles. It turns out that the answer strongly depends on the shape of the deforming billiard. I will discuss some new mechanisms by which exponential in time acceleration is gained [1,2,3,4].

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[2] V. Gelfreich, V. Rom-Kedar, K. Shah K., D. Turaev, Robust Exponential Acceleration in Time-Dependent Billiards, Phys. Rev. Lett. 106 (2011) 074101.
[3] V. Gelfreich, V. Rom-Kedar, D. Turaev, Fermi acceleration and adiabatic invariants for non-autonomous billiards, Chaos 22 (2012) 033116.
[4] V. Gelfreich, V. Rom-Kedar, D. Turaev, Oscillating mushrooms: adiabatic theory for a non-ergodic system, 2013, http://arxiv.org/abs/1305.2624

Michael Shelley, Courant Institute
"Models of Activity-driven Surface Flows"
Abstract: Active fluids are complex fluids with active microstructure that create non-thermodynamic stresses within the fluid even in the absence of external forcing. A typical example of such a out-of-equilibrium system is a bacterial bath where these stresses can create chaotic mixing flows. However, synthetic systems, which are typically better characterized and controlled, are increasingly available to study. I'll talk about modeling and simulating two such systems, one a so-called "active nematic" arising from mixtures of biopolymers and motor-proteins, and the other involving chemically active particles and related to the Keller-Segel model of chemotaxis. In both cases their dynamics is naturally constrained to immersed surfaces.

Thomas Spencer, Institute for Advanced Study
"Anderson Like Transition For a Susy Model in 3d"
Abstract: TBA

Herbert Spohn, Technische Universität München
"Nonlinear Fluctuating Hydrodynamics and Anharmonic Chains"
Abstract: In thermal equilibrium, anharmonic chains have short range static correlations while dynamic correlations have an anomalously slow decay. We propose a nonlinear extension of fluctuating hydrodynamics, discuss some of its long time predictions, and compare with data from molecular dynamics.

H. Eugene Stanley, Boston University
"New Insights from Statistical Physics into Economics and Finance"
Abstract: TBA

Daniel Stein, New York University
"Free Energy Fluctuations in Systems With Quenched Disorder"
As Phil Anderson noted long ago, a general definition of frustration involves measuring the fluctuations in the coupling energy across a plane boundary between two large blocks of spins. Since that time, a number of studies have shown that obtaining bounds on the energy fluctuations between putative different spin glass thermodynamic states can provide important information on open questions such as numbers of states and the relations between them. While upper bounds on such fluctuations have been obtained, precise lower bounds have been more difficult to derive. I will present a history of these efforts, and briefly discuss recent work that shows that energy fluctuations between certain classes of ``incongruent'' thermodynamic states scale at least as fast as the square root of the volume.

Paul Steinhardt, Princeton University
"Natural quasicrystals"
Abstract: TBA

Dave Thirumalai, University of Maryland

"Filtering noise in a biological signaling network"
Abstract: TBA

Avi Wigderson, Institute for Advanced Study
"Is the Universe Inherently Deterministic or Probabilistic? Perhaps More Importantly - Can We Tell the Difference Between the Two?"
Abstract: Humanity has pondered the meaning and utility of randomness for millennia.
There is a remarkable variety of ways in which we utilize perfect coin tosses to our advantage: in statistics, cryptography, game theory, algorithms, gambling... Indeed, randomness seems indispensable! Which of these applications survive if the universe had no randomness in it at all? Which of them survive if only poor quality randomness is available, e.g. due to imperfect measurement of quantum phenomena, or even weaker somewhat "unpredictable" sources like the weather or the stock market?
Computational pseudo randomness and randomness extraction - two (related) computational theories of randomness, developed in the past three decades, study deterministic structures with random-like behavior, and underlie fundamental problems in a variety of mathematics and computer science areas. They reveal, perhaps counter-intuitively, that almost all applications designed to work under perfect randomness, actually survive in weakly random or even completely deterministic worlds. In the talk I'll explain the main ideas and results of this theory.

Edward Witten, Institute for Advanced Study
"A New Look at the Jones Polynomial of a Knot"
Abstract: TBA

Horng-Tzer Yau, Harvard University
"Eigenvector Statistics of Random Matrix Models"
Abstract: TBA

Lai Sang Young, Courant Institute
"Nonequilibrium steady states for some particle systems"
Abstract: I will discuss some rigorous results on nonequilibrium steady states for a class of particle systems coupled to unequal heat baths. These stochastic models are derived from the mechanical chains studied by Eckmann and Young by randomizing certain quantities while retaining other features of the model. Our results include the existence and uniqueness of nonequilibrium steady states, their relation to Lebesgue measure, tail bounds on total energy and number of particles in the system, and exponential convergence to steady states from suitable initial conditions. This work is joint with Yao Li.