Banff International Research Station

for Mathematical Innovation and Discovery

09w5055 - Statistical Mechanics on Random Structures
15-20 November 2009

MEALS

*Breakfast (Buffet): 7:00 – 9:30 am, Sally Borden Building, Monday – Friday
*Lunch (Buffet): 11:30 am – 1:30 pm, Sally Borden Building, Monday – Friday
*Dinner (Buffet): 5:30 – 7:30 pm, Sally Borden Building, Sunday – Thursday
Coffee Breaks: As per daily schedule, 2nd floor lounge, Corbett Hall
***Please remember to scan your meal card at the host/hostess station in the dining room for each meal.**

MEETING ROOMS

All lectures will be held in Max Bell 159 (Max Bell Building accessible by walkway on 2nd floor of Corbett Hall). LCD projector, overhead projectors and blackboards are available for presentations. *Please note that the meeting space designated for BIRS is the lower level of Max Bell, Rooms 155-159. Please respect that all other space has been contracted to other Banff Centre guests, including any Food and Beverages in those areas.*

SCHEDULE

Sunday

16:00 Check-in begins (Front Desk – Professional Development Centre - open 24 hours)
Lecture rooms available after 16:00 (if desired)
17:30-19:30 Buffet Dinner
20:00 Informal gathering in 2nd floor lounge, Corbett Hall (if desired)
Beverages and small assortment of snacks available on a cash honour-system.

Monday

7:00-8:30 Breakfast
8:35-9:00 Introduction, Welcome to BIRS by BIRS Station Manager and the Organizers, Max Bell 159
9:00-10.30 Lectures
10:30-11.00 Coffee Break, 2nd floor lounge, Corbett Hall
11:00-11.45 Lectures
11:45-13:00 Lunch
13:00 Guided Tour of The Banff Centre; meet in the 2nd floor lounge, Corbett Hall
14:00 Group Photo; meet on the front steps of Corbett Hall
14:15-15:00 Lectures
15:00-15.30 Coffee Break, 2nd floor lounge, Corbett Hall
15.30-17.00 Lectures
17:30-19:30 Dinner

Tuesday

7:00-9:00 Breakfast
9:00-10.30 Lectures
10.30-11.00 Coffee Break, 2nd floor lounge, Corbett Hall
11:00-11.45 Lectures
11:45-13:30 Lunch
13:30-15.00 Lectures
15.00-15.30 Coffee Break, 2nd floor lounge, Corbett Hall
15.30-17.45 Lectures
17:45-19:30 Dinner

Wednesday

7:00-9:00 Breakfast
9:00-10.30 Lectures
10.30-11.00 Coffee Break, 2nd floor lounge, Corbett Hall
11:00-11.45 Lectures
11:45-13:30 Lunch

Free Afternoon

17:45-19:30 Dinner

Thursday

7:00-9:00 Breakfast
9:00-10.30 Lectures
10.30-11.00 Coffee Break, 2nd floor lounge, Corbett Hall
11:00-11.45 Lectures
11:45-13:30 Lunch
13:30-15.00 Lectures
15.00-15.30 Coffee Break, 2nd floor lounge, Corbett Hall
15.30-17.00 Lectures
17:30-19:30 Dinner

Friday

7:00-9:00 Breakfast
9:00-10.30 Lectures
10.30-11.00 Coffee Break, 2nd floor lounge, Corbett Hall
11:00-11.45 Lectures
11.45-12.00 Closing address
11:45-13:30 Lunch

Checkout by 12 noon.

** 5-day workshops are welcome to use the BIRS facilities (2nd Floor Lounge, Max Bell Meeting Rooms, Reading Room) until 3 pm on Friday, although participants are still required to checkout of the guest rooms by 12 noon. **

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Talk Schedule

	Monday 16	*Tuesday 17*	*Wednesday 18*	*Thursday 19*	*Friday 20*
7.00-9.00	*Breakfast (till 8.30)*	*Breakfast*	*Breakfast*	*Breakfast*	*Breakfast*
	Welcome address (8.35-9.00)				
9.00-9.45	*C. Newman*	*A. Montanari*	*A. Percus*	*A. Bianchi*	*N. Kistler*
9.45-10.30	*D. Stein*	*G. Semerijan*	*S. Franz*	*C. Kulske*	*E. Agliari*
10.30-11.00	*CB*	*CB*	*CB*	*CB*	*CB*
11.00-11.45	*C. Giberti*	*M. Aizenman*	*M. Luckzac*	*A. Klimovsky*	*D. Sherrington*
					Closing address (11.45-12.00)
11-45-13.30	*Lunch (till 13.00)*	*Lunch*	*Lunch*	*Lunch*	*Lunch*
	Banff center visit (13.00)				
	Group Photo (14.00)				
13.30-14.15		*A. Dembo*		*M. Marsili*	
14.15-15.00	*M.Damron*	*S. Starr*		*R. Burioni*	
15.00-15.30	*CB*	*CB*		*CB*	
15.30-16.15	*L.P.Arguin*	*S. Dommers*		*N. Macris*	
16.15-17.00	*H.Nishimori*	*A. Barra*		*G. Ben Arous*	
17.00-17.45	*B. Virag*	*L. Zdeborova*			
17.30-19.30	*Dinner (17.45)*	*Dinner (17.45)*	*Dinner*	*Dinner*	

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ABSTRACTS

(in alphabetic order by speaker surname)

Speaker: Elena Agliari (University of Parma)

Title: The autopoietic immune network: A statistical physics perspective

Abstract: A systematic approach to the immune system has been argued already three decades ago, yet, due the lack of a paved mathematical backbone, this was not investigated exhaustively. Here we develop a minimal model, which takes into account the reciprocal affinities among immunoglobulins, giving rise to a random-bond Ising ferromagnet embedded in a diluted network. We first discuss the topology of the emerging underlying graph and the statistical mechanics approach for its study. Then, we derive its thermodynamics and analyse both the equilibrium and the linear response regimes by means of mathematical modeling and extensive numerical simulations. Our results are consistent with experimental data and strongly support the autopoietic nature of the immune system.

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Speaker: Michael Aizenman (Princeton University)

Title: TBA

Abstract:TBA

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Speaker: Louis-Pierre Arguin (New York University)

Title: Uniqueness of the Ground State for the EA model in the Half-Plane II

Abstract: We consider the EA model on the half-plane with Gaussian (or other) couplings, zero external field and periodic boundary conditions in the horizontal coordinate and free boundary conditions in the vertical coordinate. We show that, for almost every realization of the couplings, the distribution on Ground State Pairs (in the metastate sense) is supported on a single pair. These talks, the third and fourth of a four-part series, present results that are joint work of L.-P. Arguin, M. Damron, C. Newman and D. Stein.

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Gerard Ben Arous

" Critical points of Random Morse functions on the Sphere"

Abstract: How many critical points does a random (Gaussian) smooth Morse function have on a large dimensional sphere? How many below a given level and of given index?
In physics this question comes under the name of Complexity of Spherical Spin Glasses.
In a joint work with J.Cerny and A.Auffinger we solve it using Random Matrix Theory.
I will show that the answer presents a surprising structure for the low lying critical poins of Spherical Spin Glasses.

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Speaker: Adriano Barra (Roma University)

Title: The replica symmetric scenario in the analogical neural network

Abstract: We try to present some recent progress in our understanding of neural networks whose patterns are stored continuously (Gaussian weighted) on the real line. Mapping this model into an equivalent bipartite spin-glass, we use a new interpolating scheme to obtain the free energy explicitly in the replica symmetric ansatz. Then we study the rescaled order parameter fluctuations to identify, via their divergences, the critical line defining ergodicity breaking, which indeed matches earlier results by Amit and coworkers in the dichotomic counterpart. Joint work with Francesco Guerra.

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Speaker: Alessandra Bianchi (Bologna University)

Title: Coupling in potential wells: pointwise estimates and exponential laws in metastable systems

Abstract: In many situations of interest, the potential theoretic approach to metastability allows to derive sharp estimates for quantities characterizing the metastable behavior of a given system. In this framework, the average metastable times can be expressed through the capacity of corresponding metastable sets, and capacities can be estimated with the application of two different variational principles. After recalling these basic concepts and techniques, we will describe a new method to couple the dynamics inside potentials wells. Under some general hypothesis, we will show that this yields pointwise estimates and exponential laws on metastable times. Our key example will be the random field Curie-Weiss model.

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Speaker: Raffaella Burioni (Parma University)

Title: Levy walks on one dimensional Cantor Glasses

Abstract: Levy-type walks with correlated jumps, induced by the topology of the medium, are studied on a class of one-dimensional graphs built from generalized Cantor and Smith-Volterra-Cantor sets. The model is inspired by a recent experiment on Levy walks for light in optical disordered materials, the "Levy Glasses". Using scaling relations and the mapping onto the equivalent electric network problem, we discuss the regimes of superdiffusive, diffusive and ballistic

motion as a function of the topological parameters of the sets. The effect of the choice of the initial condition is also discussed. In particular, it is shown that local and average measurements can display different asymptotic behavior.

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Speaker: Michael Damron (Princeton University)

Title: Uniqueness of the Ground State for the EA model in the Half-Plane I

Abstract: We consider the EA model on the half-plane with Gaussian (or other) couplings, zero external field and periodic boundary conditions in the horizontal coordinate and free boundary conditions in the vertical coordinate. We show that, for almost every realization of the couplings, the distribution on Ground State Pairs (in the metastate sense) is supported on a single pair. These talks, the third and fourth of a four-part series, present results that are joint work of L.-P. Arguin, M. Damron, C. Newman and D. Stein.

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Speaker: Amir Dembo (Stanford University)

Title: Unimodularity, random cluster models and Bethe states on sparse random graphs

Abstract: Theoretical models of disordered materials lead to challenging mathematical problems with applications to random combinatorial problems and coding theory. The underlying mathematical structure is that of many discrete variables that are strongly interacting according to a mean field model determined by a random sparse graph. Focusing on random cluster measures on graphs that converge locally to trees we review recent progress in validating the `cavity' prediction for the limiting free energy per spin (this talk is based on collaborations with Andrea Montanari and with Nike Sun).

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Speaker: Sander Dommers (Eindhoven University)

Title: Ising models on power-law random graphs

Abstract: In many real-world networks, such as the Internet and social networks, power-law degree sequences have been observed. This means that, when the graph is large, the proportion of vertices with degree k is asymptotically proportional to k^a, for some a > 1. Often, these networks have a degree distribution with finite mean, but infinite variance (2 < a < 3). We will study a ferromagnetic Ising model on random graphs with a power-law degree distribution and compute the thermodynamic limit of the pressure when the mean degree is finite (a>2).

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Speaker: Silvio Franz (Universite Paris-Sud 11)

Title: Hierarchical Random Energy Models

Abstract: A long standing problem in statistical physics of disordered system is the possible existence of ideal glassy phases beyond Mean Field Theory. In this

talk I will discuss convergent evidences for a finite temperature condensation in a Hierarchical REM coming from 1) exact numerical solution 2) high temperature series 3) stability arguments.

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Speaker: Claudio Giberti (Modena and Reggio Emilia University)

Title: Rigorous and numerical results for the Edwards-Anderson model.

Abstract: The first part of the talk will be devoted to a numerical study of conditional quenched measures in the Edwards-Anderson model. In particular two issues are discussed in the restricted ensemble : the relative fluctuations of different overlaps (related to the property of overlap equivalence) and the structure of overlap correlation (clustering). In the second part of the talk I'll discuss the properties of fluctuations of free and internal energies of two spin glass systems that differ for having some of the interactions flipped. From a bound on fluctuations new overlap identities for the equilibrium state are obtained.

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Speaker: Nicolas Kistler (Bonn University)

Title: REM, GREM and Branching Brownian Motion.

Abstract: Derrida's Random Energy Models (REM and GREM) have played a crucial role in our understanding of the Parisi Theory. It has however become clear that this class of models cannot fully encode the large time properties of more realistic spin glasses of mean-field type. A natural extension of the GREM is the so-called hierarchical field, the continuous counterpart being Branching Brownian Motion (BBM): both models have an in-built hierarchical structure where the number of levels in the underlying tree grows with the size of the system. Contrary to the GREM, for which we have a remarkably accurate, rigorous understanding, the microscopic properties of BBM still remain rather mysterious, even at a heuristic level. I will try to give an account of what is known, and report on some modest progress from an ongoing project with L.-P. Arguin and Anton Bovier.

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Speaker: Anton Klimovsky (Erlangen-Nurnberg University)

Title: Around one and a half Parisi-type formulae for the free energy

Abstract: We start by describing our results on the Sherrington-Kirkpatrick model with multidimensional spins. We identify the candidates for the order parameters and for the Parisi-type functional. These candidates are related to the free energy through a saddle-point variational formula obtained by means of Guerra's interpolation. So far, we were not able to prove the Parisi-type formula for the general a priori distributions of multidimensional spins, though we can do so in the case of the Gaussian distribution. The proof boils down to showing that Guerra's remainder term vanishes on the optimiser of the Parisi-type functional. In the second part of the talk, motivated by recent work of Fyodorov and Sommers concerning the Gibbsian random landscapes generated by isotropic Gaussian random processes indexed by high-dimensional Euclidean balls, we prove the Parisi-type formula for the free energy of a single particle in the random landscape. One of the main messages that can be extracted from our analysis is that the overlap-like order parameters (familiar in the context of disordered spin systems) are

fundamental also in the context of continuous parameter Gaussian processes with isotropic stationary increments (at least, if the parameter space is high-dimensional). The Gaussian processes are allowed to have short- and long-range correlations (e.g., the multiparameter fractional Brownian motion). Depending on whether the Gaussian process has short- or long-range correlations, the order parameter is either a step distribution function with two jumps (one step of replica symmetry breaking) or a continuous distribution function (full replica symmetry breaking), respectively. The both proofs of the Parisi-type formulae are based on the techniques of the remainder term estimates due to Talagrand and exploit the abundantly available rotational symmetries.

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Speaker: Christof Kulske (Groningen University)

Title: The metastate approach to random statistical mechanics systems

Abstract: The metastate is a probabilistic concept to describe random symmetry breaking. It was introduced by Chuck Newman and Dan Stein to describe the behavior of random systems in situations when the Gibbs measure is not unique, by assigning the probability weights to each Gibbs measure with which it appears in sequences of large volumes. We will discuss lattice and mean field systems, including a new geometric characterization of visible and invisible phases in the mean-field setup. (Joint with Giulio Iacobelli).

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Speaker: Malwina Luczak (London School of Economics)

Title: Order-invariant Measures on Causal Sets

Abstract: A causal set is a partially ordered set on a countably infinite ground-set such that each element is above finitely many others. A natural extension of a causal set is an enumeration of its elements which respects the order.

We bring together two different classes of random processes. In one class, we are given a fixed causal set, and we consider random natural extensions of this causal set: we think of the random enumeration as being generated one point at a time. In the other class of processes, we generate a random causal set, again working from the bottom up, adding one new maximal element at each stage.

Processes of both types can exhibit a property called order-invariance: if we stop the process after some fixed number of steps, then, conditioned on the structure of the causal set, every possible order of generation of its elements is equally likely.

We develop a framework for the study of order-invariance which includes both types of example: order-invariance is then a property of probability measures on a certain space. Our main result is a description of the extremal order-invariant measures.

This is joint work with Graham Brightwell.

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Speaker: Nicolas Macris (Ecole Polytechnique Losanne)

Title: Correlations in sparse graph error correcting codes

Abstract: The subject of the talk will be transmission over noisy channels using error correcting codes based on sparse graphs. The optimal decoder based on the posterior measure over the code bits, and its relationship to the sub-optimal belief propagation decoder will be discussed. A proof will be outlined of the exponential decay of correlations between code bits in suitable noise regimes. A consequence is the equality of performance curves for the optimal and belief propagation decoders. These systems can be interpreted as a special class of spin glasses and the analysis proves that the replica predictions are exact.

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Speaker: Matteo Marsili (ICTP Trieste)

Title: Stability and complexity in financial markets
(spin glass techniques for understanding economic equilibria)

Abstract: Trust is at the foundations of market economies, as starkly remarked by the recent financial crisis. Important progress has been made in understanding, from the game theoretic perspective, the mechanisms by which trust can break down, relating it to strategic uncertainty. The aim of this paper is to scale these insights to the system level by analyzing a simple model of a large population of individuals engaged in credit relationships. This economy can converge to a ``good'' equilibrium, where a dense network of credit relations exists and the risk of a run, and subsequent default, is negligible. However, a ``bad'' equilibrium is also possible: Here the credit network is sparse because investors are more nervous and prone to prematurely foreclose their credit relationships, thereby precipitating counter-party default and contagion. The transition between the two equilibria is sharp and both states exhibit a degree of resilience; once a credit crisis tips the system into the sparse state state, the restoration of a dense credit network requires a shift of the parameters well beyond the turning point. At the same time, when the system reverts to the good state, this is robust even to deteriorating conditions.

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Speaker: Andrea Montanari (Stanford University)

Title: A local limit theorem for Ising models on locally tree-like graphs

Abstract: Sequences of graphs that converge locally to trees are of interest for a number of reasons. Among the others, a sequences of sparse random graphs fall in this class for several graph distributions. In this talk we consider Ising models on locally tree-like graphs and prove a complete characterization of the limiting measure when the graphs are regular. In particular, we estabilish a coexistence phenomenon that is was understood so far only in the case of finite-dimensional lattices. [Based on joint work with Elchanan Mossel and Allan Sly]

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Speaker: Hidetoshi Nishimori (Tokyo Institute of Technology)

Title: Absence of a spin glass transition in two dimensions

Abstract:Although numerical evidence is overwhelming for the absence of spin glass transitions in two dimensions, analytical studies are still rare. We have developed a theory to show the absence of finite-temperature spin glass transitions for the Ising spin glass on self-dual lattices. The analysis is

performed by an application of duality relations, the replica method and the gauge symmetry. I will discuss how and when the predictions of this theory can be exact.

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Speaker: Chuck Newman (New York University)

Title: Introduction to Metastates for Edwards-Anderson Models

Abstract: We introduce metastates as probability measures on the space of infinite-volume Gibbs states that may be used to study disordered systems such as the Edwards-Anderson (EA) model with potentially many `competing' states. Extensions to metastates and excitation metastates for competing ground states are also discussed. This talk will be the first of a four-part series, which gives some of the background needed for the second part by Stein concerning domain walls for the two-dimensional EA model (in the full plane) and for the third and fourth parts by Damron and Arguin presenting a new result on uniqueness of ground states in the half plane.

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Speaker: Allon Percus (Claremont Graduate University)

Title: The Peculiar Phase Structure of Random Graph Bisection

Abstract: The phase structure of mincut graph bisection displays certain familiar properties when considered over sparse random graphs, but also some surprises. It is known that when the mean degree is below the critical value of 2 log 2, the cutsize is zero with high probability. We study how the minimum cutsize increases with mean degree above this critical threshold, finding a new analytical upper bound that improves considerably upon previous bounds. Combined with recent results on expander graphs, our bound suggests the unusual scenario that random graph bisection is replica symmetric up to and beyond the critical threshold, with a replica symmetry breaking transition possibly taking place above the threshold. An intriguing algorithmic consequence is that although the problem is NP-hard, we can conceivably find near-optimal cutsizes (whose ratio to the optimal value approaches 1 asymptotically) in polynomial time for typical instances near the phase transition.

Joint work with Gabriel Istrate, Bruno Goncalves, Robert Sumi and Stefan Boettcher.

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Speaker: David Sherrington (University of Oxford)

Title: Dynamics of information-driven and range-free networks: some results, some thoughts and some questions.

Abstract: Range-free (or infinite-range) many-body problems are independent of spatial dimensionality and offer the opportunity for exact solution in the large N limit, through mapping to descriptions in terms of macroscopic variables. These mappings and their subsequent analysis are non-trivial when there is frustration between fast variables and either other control parameters or rules are microscopically quench-disordered or are themselves dynamical with slower characteristic timescales. In quenched cases with equilibrating fast-variable dynamics conventional Boltzmann- statistical mechanics can be utilised but still

with subtle challenges for rigorous analysis. Without such equilibration often some progress can be made at the level of theoretical physics but many challenges remain in complete analysis as well as in rigorous justification.

Such range-free problems are first-pass reasonable models for a number of situations. They are also a natural effective mapping for problems driven by distance-independent information such as occurs for the internet, stock-market indices, news etc. Hence in many man-made social and economic scenarios again there are important effective correlation effects with no separation or spatial dimension-dependence. Coupled with conflicting aims and global sum rules/constraints one again has frustration, typically also with a distribution of individual inclinations.

Network growth is also range-free in certain cases, again typically those driven by internet interaction, simplifying analyses but still leaving interesting issues of optimal algorithms, topological phase transitions, consequences of both uncontrolled and rule-controlled evolution and possible effects of frustration.

In this talk I shall discuss some of these issues, giving some examples but also posing questions for discussion and future study.

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Speaker: Guilhem Semerjian (Ecole Normale Paris)

Title: Quantum spin models on sparse random graphs

Abstract: Classical spin models defined on random graphs have been the object of an intense research activity motivated, among other reasons, by their relationship to random combinatorial optimization problems. The heuristic cavity method allowed to make several qualitative and quantitative predictions about the behaviour of such random systems in their large size limit, some of these predictions having been confirmed rigorously. In this talk I will discuss a more recent development of the heuristic cavity method towards quantum models defined on random graphs. These models can be constructed, for instance, by turning a classical energy function of N Ising spins into an operator acting on the Hilbert space spanned by the 2^N configurations, and adding to it a non-commutative operator as a transverse field. Such models can be represented through path-integrals of imaginary time configurations. The cavity method can then be implemented at the quantum level by devising a sampling procedure of such spin trajectories. The case of frustrated classical spin models (for which finding the minimal energy states can be a difficult task) in a transverse field is of particular interest in view of application to quantum computing.

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Speaker: Shannon Starr (Rochester University)

Title: Thinning Partition Structures

Abstract: A random partition structure is a random point process on [0,1] such that the points add up to 1. We consider a thinning dynamics: independently removing points, keeping each one withprobability p>0, and then rescaling all remaining points to make thesum 1. We assume infinitely many points initially. We prove that all partition structures which are infinitely-divisible with respect to this process are mixtures of Poisson-Kingman processes. The ones which are invariant for all p include the Poisson-Dirichlet structures, which are also the invariant measures for the uncorrelated cavity step dynamics, as proved by Aizenman and Ruzmaikina, and Arguin. But there are also others. This is joint work with Brigitta Vermesi.

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Speaker: Daniel Stein (New York University)

Title: Domain Wall Structure in the Two-Dimensional Edwards-Anderson Model

Abstract: We review a result due to Newman and Stein, for the 2D EA model with Gaussian (or other) couplings and in zero field, which shows that if a coupling-independent boundary condition metastate is supported on incongruent (i.e., statistically dissimilar) ground states, then the symmetric difference between two such states must consist of a single positive-density, simply connected domain wall. This talk will be the second of a four-part series, using results on metastates presented by Newman in the first part and laying the groundwork for a new result, presented by Damron and Arguin in the third and fourth parts, on uniqueness of ground states in the half-plane.

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Speaker: Balint Virag (Toronto University)

One-dimensional random Schrodinger operators and random matrices

Random Schrodinger operators can be thought of as Markov kernels for random walks in a random enviornment of obstacles. In the critical regime, the probability decay for large gaps between eigenvalues of these operators resemble those for random matrices. However, the eigenvalue repulsion is much stronger.

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Speaker: Lenka Zdeborova (Los Alamos National Laboratory)

Title: Revisiting Random Field Ising Model

Abstract: Since the dynamical behavior of the random field Ising model (RFIM) has some glassy features many authors have discussed the existence of a putative spin glass phase in this model. In this talk, I will first show how an elementary, yet rigorous, bound can be derived for the spin glass susceptibility that allows to essentially answer the question. In the second part I will present exact solution of the model on a random graph. I will discuss a method to compute the phase diagram at fixed values of magnetization and its results.