Abstracts for the 4th Annual Graduate Student Probability Conference

hosted by
The Department of Mathematics at Duke University and
The Department of Statistics and Operations Research at UNC- Chapel Hill

Friday, April 30, 2010

10:25-10:45 am Sarah Schott & Shawn Drenning

Sarah Schott, Duke University
Speeding up the product estimator using random temperatures
Many problems consist of finding the ratio between the measure of B and the measure of B' where $B' \subset B$. Typically, one of these measures is relatively easy to compute, and in finding the ratio, we can approximate the other. In standard Monte Carlo methods, this ratio is approximated by drawing samples from B, and counting the number that lie in subset B'. But such methods require the number of samples to be of the same order as the ratio itself, which is problematic when B' is exponentially small in the size of B. To overcome this difficulty, the product estimator introduces a sequence of nested subsets between B and B', indexed by a parameter β. In the product estimator, the number of subsets is fixed. In the new approach presented here, the sequence of subsets is adaptive. The resulting algorithm is nearly optimal and much easier to analyze. Moreover, the new method allows for the simultaneous estimation of the size of the set for all values of β.

Shawn Drenning, University of Chicago
Excursion reflected Brownian motion
Excursion reflected Brownian motion in a finitely connected domain in $\mathbb{C}$ is a stochastic process that behaves like Brownian motion away from the boundary components and picks a point according to harmonic measure from ∞ to reflect from whenever it hits a boundary component. In this talk we discuss the construction of this process and some of its properties, in particular the connection to SLE and the Loewner equation for an annulus.

10:50-11:10 am Leila Setayeshgar & Jason Miller

Leila Setayeshgar, Brown University
Efficient importance sampling schemes for a feedforward network
The aim of this talk is to show the construction of efficient importance sampling schemes for a rare-event, namely, the buffer overflow associated with a feed-forward network with discontinuous dynamics. This is done through a piece-wise constant change of measure, and the main task is to change the measure such that the logarithmic asymptotic optimality test is satisfied. To that end, we find an upper bound on the second moment of the importance sampling estimator which yields optimality. Numerical simulations illustrate the validity of theoretical results.

Jason Miller, Stanford University
Fluctuations for the Ginzburg-Landau interface model and universality for SLE(4)
The object of our study is the massless field with strictly convex nearest neighbor interaction on lattice approximations of a bounded, smooth, planar domain D. This is a general model for a (2+1)-dimensional effective interface. We show that linear functionals of the height of the interface converge to the Gaussian free field on D, a conformally invariant random distribution, and that the mean height becomes harmonic in the limit. We also show that the chordal zero height contours converge to variants of SLE(4), a family of conformally invariant random curves.

11:20-11:40 am Zhongyang Li & Hao Lin

Zhongyang Li, Brown University
Local statistics of realizable vertex models
In this paper we study planar "vertex" models, which are probability measures on edge subsets of a planar graph, satisfying certain constraints at each vertex, examples include dimer model and 1-2 model, which we will define. A generalized holographic algorithm is applied to reduce the vertex model problem to counting perfect matchings, and conditions under which the vertex model problem can be realized (reduced holographically) to a planar dimer model are discussed. For finite graphs, we express the local statistics of the realizable vertex model as a linear combination of the local statistics of dimers. Using an $n \times n$ torus to approximate the periodic infinite graph, we study the asymptotic behavior of the free energy and local statistics of realizable vertex models. The convergence rate of covariance of local configurations is determined when the distance between the two vertices goes to infinity. As an example, we simulate the 1-2 model using the technique of Glauber dynamics.

Hao Lin, University of Wisconsin
Boundary asymptotics for the shape of the disordered corner growth model
We consider last passage percolation on the 2-dimensional lattice. The admissible paths are nondecreasing in both coordinates, and the weights associated with sites in the same row are i.i.d. random variables, while the distribution functions corresponding to the rows are themselves randomly drawn from a probability space. We first give an estimate of last passage time when these distributions are Bernoulli. Next we will show, through a series of approximations, that the last passage time function of points close to the y-axis depends only on the "averaged" means and variances of all possible choices of underlying distributions, which generalizes the results that have been derived before in simpler cases.

11:45-12:05 pm Yizao Wang & Yunjiang Jiang

Yizao Wang, University of Michigan
Conditional sampling for max-stable random fields
Max-stable random fields arise in the limit of independent maxima. They play a central role in modeling extreme value phenomena. The conditional distributions of max–stable random fields are notoriously difficult to handle. This makes the prediction problem for such random fields a formidable challenge. We provide an explicit formula for the conditional probability in general max-linear models, including a large class of max-stable random fields. In particular, we reveal the conditional independence structures of these models. Curiously, the conditional probability of max-linear models is closely related to the set covering problem in theoretical computer science. As a consequence, we obtain an algorithm for efficient sampling from conditional distributions. Our method provides an exact and efficient computational solution to the difficult prediction problem for max-linear models. In particular, our method enables us to resample simultaneously the entire random fields, conditioning on the observations of arbitrary locations. To the best of our knowledge, all the known methods focus only on pointwise predictions. Therefore, our work provides important new tools for handling spatio-temporal extremes in environmental, geological, meteorological and other applications. We illustrate our results with simulations over the de Haan–Pereira random fields . This is a joint work with Stilian Stoev.

Yunjiang Jiang, Stanford University
Sharp lower bound for mixing time of Kac random walk in Wasserstein distance
The Kac random walk on $\mathrm{SO}(n)$ is defined as follows: let X in $\mathrm{SO}(n)$ be the current state. We choose two coordinates i, j uniformly at random between 1 and n, and multiply X by a matrix of rotation along the 2-plane spanned by i and j for a uniform angle between 0 and 2π. This continuous state space Markov chain gives a model for an interacting particle system. We prove that $\frac{1}{2}n^2 \log n$ steps is necessary to reach stationarity in L^1 Wasserstein/transportation distance for the Kac random walk on $\mathrm{SO}(n)$. This matches with Roberto Olliviera's upper bound with the correct constant for L^2 Wasserstein distance, hence implies sharpness in both L^1 and L^2. We will state some related simple open questions at the end.

12:10-12:30 pm Subhankar Ghosh & Cristina Tone

Subhankar Ghosh, University of Southern California
Concentration of measures via size biased couplings
Let Y be a nonnegative random variable with mean μ and finite positive variance σ^2, and let Y^s, defined on the same space as Y, have the Y size biased distribution, characterized by

$$\mathbb{E}[Yf(Y)] = \mu\mathbb{E}[f(Y^s)] \quad \text{for all functions } f \text{ for which these expectations exist.}$$

Under a variety of conditions on Y and the coupling of Y and Y^s, including combinations of boundedness and monotonicity, one sided concentration of measure inequalities such as

$$\mathbb{P}\left(\frac{Y-\mu}{\sigma} \geq t\right) \leq \exp\left(-\frac{t^2}{2(A+Bt)}\right) \quad \text{for all } t \geq 0$$

hold for some explicit A and B. The theorem can be applied to a number of situations: the number of bulbs switched on at the terminal time in the so called lightbulb process of Rao, Rao, and Zhang, the number of nonisolated balls in a coverage process, the number of relatively ordered subsequences in a uniform random permutation, etc. Similar concentration results can be obtained for some specific unbounded couplings as well; for example, the number of isolated vertices in the Erdös-Rényi random graph model and generalized variance for multivariate normal random samples. Recently, some more similar concentration results were obtained for coordinates of a random vector $\mathbf{W} \in \mathbb{R}^k$, for which one can obtain an exchangeable tuple $(\mathbf{W}, \mathbf{W}')$ satisfying the condition

$$\mathbb{E}(\mathbf{W}'|\mathbf{W}) = (I_k - \Lambda)\mathbf{W} + \mathbf{R}(\mathbf{W}).$$

Some examples include complete nondegenerate U statistics and doubly indexed permutation statistic. Part of the above is joint work with Larry Goldstein.

Cristina Tone, Indiana University

A functional central limit theorem for empirical processes

We are interested in proving a functional central limit theorem for empirical processes satisfying a strong mixing condition. We first proceed by showing the result for the uniformly distributed case, and then, by the use of the mapping theorem, we extend it to the general case.

2:00-2:20 pm Anna Little & Yufei Liu

Anna Little, Duke University

Intrinsic dimensionality estimation for data sets

We consider a novel approach for estimating the intrinsic dimensionality of high-dimensional point clouds. Assuming that the points are sampled from a k-dimensional manifold embedded in $\mathbb{R}^D$ and corrupted by D-dimensional noise, with $k << D$, we estimate dimensionality via a new multiscale algorithm that generalizes PCA. The algorithm exploits the low-dimensional structure of the data, so that its power depends on k rather than D.

Yufei Liu, Brown University

Large deviations for discontinuous dynamics

We establish a general sample path large deviation principle for Markov jump processes with discontinuous dynamics and explicitly identify the local large deviation rate function. The key assumption is a mild stability condition satisfied by many physically meaningful systems. Roughly speaking, it requires that at any discontinuity interface, the dynamics push towards the interface after "subtracting off common jumps". The analysis is based on the weak convergence approach to large deviations and utilizes a recent uniqueness result for differential inclusions in discontinuous media.

2:25-2:45 pm Tuan Nguyen & Xiangfeng Yang

Tuan Nguyen, Rutgers University

Random covering in $\mathbb{R}^d$ by a union of scaled convex sets

Let $\mathbf{C}$ be a given dimension open convex set of unit volume, with center of gravity at the origin. Let Φ be a Poisson point process in $\mathbb{R}^d \times (0, +\infty)$, $d \geq 1$, of intensity $\lambda \times \mu$, where λ denotes the Lebesgue measure on $\mathbb{R}^d$ and μ is a σ-finite non-negative measure on $(0, +\infty)$. We consider a family of random convex sets $x + z * \mathbf{C}$ in $\mathbb{R}^d$ with $(x, z) \in \Phi$. We investigate the necessary and sufficient conditions for covering an arbitrary line and the whole space with these sets.

Xiangfeng Yang, Tulane University

Asymptotic expansions in limit theorems for stochastic processes and large deviations

First, we give precise asymptotic expansions in limit theorems for locally infinitely divisible processes. Then, by applying above expansions, we get precise results on asymptotics of large deviations for pure jump processes (which are special locally infinitely divisible processes). Last, possible future works will be mentioned.

2:50-3:10 pm Omar Abuzzahab & William Perkins

Omar Abuzzahab, University of Pennsylvania

Evolution of a random linear space process

Let $X_1, X_2, X_3 \ldots$ be an iid sequence of vectors chosen uniformly from a subset U of $\mathbb{F}_2^n$ and let $V_1, V_2, V_3 \ldots$ with $V_t = \langle X_1, X_2, \ldots, X_t \rangle$ be the corresponding sequence of linear spans. A couple of natural questions are: when does the first linear dependence among the X_i's occur (i.e, when is dim $V_t < t$)? and how long until $V_t = \mathbb{F}_2^n$? When U is taken to be the whole space $\mathbb{F}_2^n$ and n is made large these events occur at nearly the same time, but when U is a proper subset they can be very different. I will present my research in the model where U is the set of all vectors with a fixed Hamming weight k. This model generalizes some familiar problems: when $k = 1$ the first question is the Birthday Problem, the second is the Coupon Collector Problem, and when $k = 2$ the first question relates to the appearance of the first cycle in a random graph.

William Perkins, New York University

The forgetfulness of balls and bins

We look at two ways of throwing m balls into n bins: under the STANDARD distribution we throw each ball into a uniformly chosen bin; under the PLANTED distribution we plant the first n balls is a fixed arrangement then throw the remaining $m - n$ balls in uniformly at random. We want to know how many balls we must throw in on top of the planted balls before we 'forget' that we started with a planting. In other words, how large must m be as a function of n so that the two distributions are indistinguishable from each other as measured by their total variation distance. For each possible arrangement of the planted balls, we find the threshold of m at which the total variation distance transitions from 1 to 0. The critical scaling of m ranges between two natural extreme initial arrangements: if we plant one ball in each bin to start, then we set $m = cn^{3/2}$ to get a non-trivial total variation limit; if we plant n balls in one bin, then $m = cn^3$ gives a non-trivial limit.

3:20-3:40 pm Perry Gillespie Jr. & Xin Liu

Perry Gillespie Jr., UNC- Charlotte

The optimal stopping of "loop" Markov chains

Let's consider the optimal stopping set for "Loop" Markov Chains (LMC). They have the following structure: the state space X consists of a common point 0, which we will denote as the origin, and finite or countable number of loops L_j, where $j = 1, 2, ..., k \leq \infty$. We refer to the case when $k < \infty$ as a finite case and otherwise as infinite. Each loop L_j consists of n_j states, including the origin, i.e. $L_j = (0 = n_j, 1_j, 2_j, ..., (n_j - 1))$, where $j = 1, 2, ..., k$. We will also assume that the integers $n_1, ..., n_k$ are such that GCD $(n_1, ..., n_k) = 1$. The transition probabilities of the LMC have a simple structure, either deterministic transitions on the loops, $p(i_j, (i+1)_j) = 1, i = 0, 1, ..., n_j - 1$, and $p\,(0, 1_j) = p_j > 0,\ j = 1, 2, ..., k,\ \sum_{j=1}^{k} p_j = 1$ or a random walk on the loops, i.e. $p(i_j, (i+1)_j) = p_j(i)$, $p(i_j, (i-1)_j) = q_j(i), p(i_j, i_j) = r_j(i)$, $p_j(i) + q_j(i) + r_j(i) = 1$ for all possible values of i, j. Since LMC have relatively simple structure their characteristics, e.g. the stationary (invariant) distribution π, can be calculated in an explicit form. Now, in the finite case, the optimal stopping set always exists, but without a discount it would be trivial. In this case we consider the OS problem with a discount factor, or equivalently with an artificial absorbing state e. We describe the general structure of the optimal stopping set and value function. We will use an excel program to calculate the optimal stopping set. One of the tools to solve this problem and describe its solution is the Elimination Algorithm of Optimal Stopping for Markov Chains. There will be two modification of the Elimination Algorithm that will be implemented, "Full Size Matrix" and "Lift" Algorithm. Finally, we will show that all three methods are equivalent. Also, depending on the size of the loop, we will determine the appropriate method to use.

Xin Liu, UNC- Chapel Hill

Multiscale diffusion approximations for stochastic networks in heavy traffic

Stochastic networks with time varying arrival and service rates and routing structure are studied. Time variations are governed, in addition to the state of the system, by two independent finite state Markov processes X and Y. Transition times of X are significantly smaller than typical inter-arrival and processing times whereas the reverse is true for the Markov process Y. By introducing a suitable scaling parameter one can model such a system using a hierarchy of time scales. Diffusion approximations for such multiscale systems are established under a suitable heavy traffic condition. In particular, it is shown that, under certain conditions, properly normalized buffer content processes converge weakly to a reflected diffusion with drift and diffusion coefficients that are functions of the state process, the invariant distribution of X, and a finite state Markov process which is independent of the driving Brownian motion.

3:45-4:05 pm Paul Varkey & Scott McKinley

Paul Varkey, University of Illinois- Chicago

Stochastic games (part I): Discounted noncompetitive Markov decision processes

In this talk I survey the fields of Markov Decision Processes (MDPs) and Stochastic Games with the aim of communicating the main lines of research, both historic and current, under a unified taxonomy. The dimensions spanned in this classification will include the optimality criterion and the information setting, among others. Required notations and definitions will be established along the way. I will also cover one specific result – the policy-improvement type algorithm for MDPs, due to Blackwell and Howard. The exposition will be supplemented with an insightful example.

Scott McKinley, Duke University

Cooperative dynamics of kinesin and dynein type molecular motors (part I)

Central to cell function is the intracellular transport of biological materials constructed in the cell nucleus that must be delivered to destinations throughout the cell body. Among the key players in this process are biochemical molecular motors from the kinesin and dynein families. These motor proteins are tethered to vesicles containing the intracellular cargo and perform surprisingly anthropomorphic hand-over-hand walks along long microtubule tracks. Each microtubule has a plus and minus end, and the motors have a preferred stepping direction. However, experimental studies show the motor-cargo complex typically undergoes stochastic, bidirectional and saltatory motion. These qualitative features of the motion are currently posited to result from both cooperative and competitive dynamics of multiple motors simultaneously attached to a single cargo. Mathematically, these dynamics pose a number of challenges at three distinct time scales and notions of a stochastic averaging and multi-scale analysis play a vital role. In these talks we will survey recent work and work-in-progress, ultimately pointing to new directions of inquiry, both mathematical and biological.

4:10-4:30 pm Matthew Bourque & Avanti Athreya

Matthew Bourque, University of Illinois- Chicago

Stochastic games (part II): Discounted competitive Markov decision processes

A famous theorem of Shapley proves the existence of value in the class of all behavior strategies, and the existence of stationary Markov optimal strategies for zero-sum finite stochastic games. However, there is no efficient algorithm for calculating the value and optimal strategies for such games in general. In this talk I will define the class of perfect information stochastic games, and an efficient policy-improvement type algorithm for solving them due to Raghavan and Syed.

Avanti Athreya, Duke University

Cooperative dynamics of kinesin and dynein type molecular motors (part II)

Central to cell function is the intracellular transport of biological materials constructed in the cell nucleus that must be delivered to destinations throughout the cell body. Among the key players in this process are biochemical molecular motors from the kinesin and dynein families. These motor proteins are tethered to vesicles containing the intracellular cargo and perform surprisingly anthropomorphic hand-over-hand walks along long microtubule tracks. Each microtubule has a plus and minus end, and the motors have a preferred stepping direction. However, experimental studies show the motor-cargo complex typically undergoes stochastic, bidirectional and saltatory motion. These qualitative features of the motion are currently posited to result from both cooperative and competitive dynamics of multiple motors simultaneously attached to a single cargo. Mathematically, these dynamics pose a number of challenges at three distinct time scales and notions of a stochastic averaging and multi-scale analysis play a vital role. In these talks we will survey recent work and work-in-progress, ultimately pointing to new directions of inquiry, both mathematical and biological.

4:45-5:45 pm **Robin Pemantle: Keynote Address**

Robin Pemantle, University of Pennsylvania

Probability and the analysis of algorithms: examples and open problems

I will survey a number of algorithms that make essential use of randomness, in the sense that randomness is necessary to achieve the best rigorous performance bounds. Analyses of the running times of these algorithms require probabilistic methods beyond the naive methods that are well known in the fields of application, fields such as linear programming, satisfiability testing and factoring. While discussing these, I will point out a number of related open problems.

Saturday, May 1, 2010

10:00-10:20 am Shishi Luo & Julius Esunge

Shishi Luo, Duke University

Calculating the emergence times of new antigenic variants of Influenza A

Influenza A (H3N2) is a rapidly-evolving virus and typically escapes herd immunity by becoming a new antigenic variant within a few flu seasons. The mechanism by which antigenic variants emerge is still not well understood, although the current hypothesis is that a sufficient number of mutations need to accumulate for antigenic change to occur. However, given that one mutation can change at most one amino acid at a time, and given that the human antibody response can usually neutralize infections by a virus very similar to one from a previous infection, it seems that a long time is needed for enough mutations to occur, certainly more than a few flu seasons, if at all. Using a probabilistic model to calculate the expected time to emergence of a new antigenic variant, I show that this is not the case, and in fact it does not take a long time for the requisite number of mutations to accumulate.

Julius Esunge, University of Mary Washington

A class of anticipating linear stochastic differential equations

We present the white noise methods for solving linear stochastic differential equations of anticipating type. Such equations may be solved using the S-transform, an important tool within the white noise theory. This approach provides a useful remedy to the fact that the Itô theory of stochastic integration is inapplicable to such equations.

10:25-10:45 am John McSweeney & Pedro Lei

John McSweeney, Concordia University

Closure approximations for epidemics on networks

Classical stochastic epidemic 'compartmental' models treat populations as groups of well-mixed homogeneously interacting individuals (called the 'mean-field' model). Many populations of course have a spatial or network structure to them - not everyone interacts with everyone else, and some individuals may have more contacts than others. There is now a wealth of extensions of the mean-field approach that incorporate some vestige of the structure of the population, which show good agreement with simulations on various networks. However, very little has been proven for such extended schemes, referred to as 'closure approximations.' We will discuss some pathological cases where certain schemes don't work well in order to conjecture criteria for when a given scheme may be applicable.

Pedro Lei, University of Kansas

Introduction to bifractional Brownian motion

This is an introductory talk about bifractional Brownian motion. The *bifractional Brownian motion* is a centered Gaussian process $B^{H,K} = (B_t^{H,K}, t \geq 0)$, with covariance $R^{H,K}(t,s) = 2^{-K}((t^{2H} + s^{2H})^K - |t-s|^{2HK})$, where $H \in (0,1)$ and $K \in (0,1]$. When $K = 1$, $B^{H,1}$ is a fractional Brownian motion with parameter H.

10:50-11:10 am Hye-Won Kang & Fei Lu

Hye-Won Kang, University of Minnesota

Multiple scaling methods in chemical reaction networks

In this talk, expanding a multiple scaling method developed by Ball, Kurtz, Popovic, and Rempala, we construct a general method of multiple scaling approximations in chemical reaction networks. A continuous time Markov jump process is used to describe the state of the chemical system. In general chemical reaction networks, the species numbers and the reaction rate constants usually have various ranges. Two different scaling exponents are used to normalize the numbers of molecules of the chemical species and to scale the chemical reaction rate constants. Applying a time change, we have different time scales for the limiting processes in the reduced subsystems. The law of large numbers for Poisson processes is applied to approximate non-integer-valued processes. In each time scale, the processes with slow time scale act as constant and the processes with fast time scale are averaged out. Then the limit of the processes of our interest in a certain time scale is obtained in terms of the averaged processes with fast time scale and the initial values of the processes with slow time scale. The general method of multiple scaling approximations is applied to a model of Escherichia coli stress circuit using sigma 32-targeted antisense developed by Srivastava, Peterson, and Bentley. We analyze the system and obtain limiting processes in each simplified subsystem, which approximates the normalized processes in the system with different time scales. Error estimates of the difference between the normalized processes and the limiting processes are given. Simulation results are given to compare the evolution of the processes in the system and the evolution of the approximated processes using the limiting processes in each simplified subsystem. Applying the martingale central limit theorem and using the averaging, we obtain a central limit theorem for deviation of the normalized processes from their limiting processes in the model.

Fei Lu, University of Kansas

Feynman-Kac formula for the heat equation driven by fractional noise with $H < 1/2$

We prove that the Feynman-Kac Formula holds for the d-dimensional stochastic heat equation driven by a multiplicative Gaussian noise, which is a fractional Brownian motion with Hurst parameter $H \in (0, 1/2)$ in time and smooth in space. To this end, we first show that the nonlinear integral in the Feynman-Kac formula exists, with the help of fractional calculus; then using an approximation argument and with the help of Malliavin calculus we prove the solution to the stochastic heat equation is given by the Feynman-Kac formula. The integrability and Hölder continuity of the solution are discussed. The talk is based on joint work with David Nualart and Yaozhong Hu.

11:20-11:40 am Dominik Reinhold & Kei Kobayashi

Dominik Reinhold, UNC- Chapel Hill

Some asymptotic results for near critical branching processes

Near critical single type Bienaymé-Galton-Watson (BGW) processes are considered. It is shown that, under appropriate conditions, Yaglom distributions of suitably scaled BGW processes converge to that of the corresponding diffusion approximation. Convergences of stationary distributions for Q-processes and models with immigration to the corresponding distributions of the associated diffusion approximations are established as well. Although most of the work is concerned with the single type case, similar results for multitype settings can be obtained. As an illustration, convergence of Yaglom distributions of suitably scaled multitype subcritical BGW processes to that of the associated diffusion model is established.

Kei Kobayashi, Tufts University
SDEs driven by time-changed Brownian motion and associated time-fractional differential equations
It is known that if a stochastic process is a solution to a classical Itô stochastic differential equation (SDE), then its transition probabilities satisfy in the weak sense the associated Fokker-Planck equation which involves a first-order time derivative. In many applications, however, Fokker-Planck type equations with a fractional order time derivative are used to model complex processes. Despite their increasing importance, the class of SDEs that is associated with these equations is unknown except in a few special cases. The main theorem establishes that this class of SDEs can be described within the framework of SDEs driven by a time-changed Brownian motion where the independent time-change is given by the inverse of a stable subordinator. We also have generalizations in two directions: to time-changes which are the inverses of mixtures of independent stable subordinators, and to the case where Brownian motion is replaced by a Lévy process. This is joint work with Marjorie Hahn and Sabir Umarov.

11:45-12:05 pm Yaqin Feng & Janna Lierl

Yaqin Feng, UNC- Charlotte
Limit theorems for reaction-diffusion equations with ecological applications
We'll study the models of the FKPP-type (Fisher-Kolmogorov-Petrovsky-Piscunov), especially the critical case. Our goal is to construct the limiting laws for such models, i.e. the random particles fields whose distributions are preserved by the stochastic dynamics, containing births and deaths of the particles and their space motion (diffusion). We consider formally (like in the theory of branching processes) the situations when there is no interaction between particles. However the births and deaths generate some kind of mean-field interaction and the limiting particles field will have strong clustering properties (in comparison to the Poissonian statistics).

Janna Lierl, Cornell University
Estimates for the heat kernel on a uniform domain
I will consider the heat kernel on a subset of a suitable (e.g. Euclidean) metric space, with Dirichlet boundary condition. For the case when the subset is a bounded (inner) uniform domain, I will present global upper and lower bounds for the heat kernel, and describe how the geometry of the domain affects our estimates.

12:10-12:30 pm Ming Fang & Nathaniel Eldredge

Ming Fang, University of Minnesota
Consistent minimal displacement of branching random walks
Let $\mathbb{T}$ denote a rooted b-ary tree and let $\{S_v\}_{v\in\mathbb{T}}$ denote a branching random walk indexed by the vertices of the tree, where the increments are i.i.d. and possess a logarithmic moment generating function $\Lambda(\cdot)$. Let m_n denote the minimum of the variables S_v over all vertices at the nth generation, denoted by $\mathbb{D}_n$. Under mild conditions, m_n/n converges almost surely to a constant, which for convenience may be taken to be 0. With $\bar{S}_v = \max\{S_w : w \text{ is on the geodesic connecting the root to } v\}$, define $L_n = \min_{v\in\mathbb{D}_n} \bar{S}_v$. We prove that $L_n/n^{1/3}$ converges almost surely to an explicit constant l_0. This answers a question of Hu and Shi.

Nathaniel Eldredge, Cornell University
Hypoelliptic diffusions and heat kernels
If an n-dimensional stochastic process is driven (via some SDE) by k independent Brownian motions, with $k < n$, it can be degenerate and get stuck in a submanifold of $\mathbb{R}^n$. Hypoellipticity is a situation in which this does not occur. Such problems have strong links to geometry and PDEs. I will talk about some of these connections and recent results.

2:00-2:20 pm Miranda Holmes-Cerfon & Richard Eden

Miranda Holmes-Cerfon, New York University
Scattering of the internal tide by random topography
The bottom of the ocean is often modeled as flat, yet, just like the surface of dry land, it is actually a landscape of small random bumps. Can this bumpiness affect the ocean circulation? We consider the possibility that it is important in dissipating the internal tide, by looking at how an internal wave is modified as it propagates over small-amplitude random topography. This involves solving a wave equation with a random boundary, but is distinguished from other wave-like equations by the

unique reflection properties of internal waves and their characteristic rays. The solution for periodic topography is easy to derive and leads to energy focusing on a single characteristic trajectory; we show that in the random case the same focusing happens and is related to the properties of an underlying random attractor for the dynamical system describing the wave characteristics. We analyze properties of this dynamical system and use them to derive scaling laws for the energy dissipated by the topography. By applying our results to estimates of the spectrum of the topography for the real ocean, we show that small-amplitude random topography can play an important role in dissipating the internal tide.

Richard Eden, Purdue University

General upper and lower tail estimates using Malliavin calculus and Stein's equations

We consider a centered random variable X satisfying almost-sure conditions involving $G := \langle DX, -DL^{-1}X \rangle$ where DX is X's Malliavin derivative and L^{-1} is the pseudo-inverse of the generator of the Ornstein-Uhlenbeck semigroup. Viens proved Gaussian-type lower and upper bounds on the tail $\mathbb{P}[X > z]$ given lower and upper constant bounds on G. Since Gaussian distributions are a special case of Pearson distributions, we are able to extend Viens' proofs to derive Pearson-type lower and upper bounds on $\mathbb{P}[X > z]$, but this time assuming quadratic upper and lower bounds on G. A key ingredient is the use of Stein's method, including the explicit form of the solution of Stein's equation relative to the function $h = 1_{x>z}$, and its relation to G.

2:25-2:45 pm Meng Xu & Dmytro Karabash

Meng Xu, University of Wyoming

Convergence of particle filtering method for nonlinear estimation of vortex dynamics

In this talk I will formulate a numerical approximation method for the nonlinear filtering of vortex dynamics subject to noise using particle filtering. The convergence of this scheme allowing the observation vector to be unbounded will also be shown.

Dmytro Karabash, New York University

Stein's method for proving Ramsey theory CLTs

Randomly color each k element subset of n element set into one of m colors. Sufficient conditions under which the distribution of the number of $k + l$ element subsets which are colored according to some scheme is close to the Gaussian distribution will be established during the talk via Stein's Method.

2:50-3:10 pm Ricardo Restrepo & Xiaoqin Guo

Ricardo Restrepo, Georgia Tech

Glauber dynamics for the hardcore model on planar trees

In this talk I'll describe the hardcore model on planar trees, pointing out the relation between the mixing time to stationarity of the so called Glauber dynamics and the uniqueness and extremality properties of the induced Gibbs measure.

Xiaoqin Guo, University of Minnesota

Invariance principle for random walks in balanced random environment

Lawler (1982) proved a quenched invariance principle for $\mathbb{Z}^d$ $(d \geq 2)$ random walks in balanced, uniformly elliptic random environment. In this talk, we will show that the quenched invariance priciple still holds in i.i.d. balanced environment under mere ellipticity.

3:20-3:40 pm Antonio Auffinger & Ajay Chandra

Antonio Auffinger, New York University

Direct polymers in a heavy tailed environment

We study the model of Directed Polymers in Random Environment in 1+1 dimensions, where the weight distribution at a site has a tail which decays polynomially with power α, where $\alpha < 2$. After proper scaling of temperature β, we show strong localization of the polymer to a favorable region in the environment where energy and entropy are best balanced. We prove that this region has a weak limit under linear scaling and identify the limiting distribution as family of measures on Lipschitz curves. In particular, we show order n transversal fluctuations of the polymer.

Ajay Chandra, University of Virginia

Hierarchical renormalization

Renormalization first appeared as a method of dealing with divergent Feynman diagrams that arose out of perturbation theory.

The work of Wilson in the seventies made the concept clearer by showing how renormalization also plays a role in statistical physics, in particular one way of looking at renormalization is as the evolution of a potential as we iteratively integrate out randomness on particular length scales. Another development that helped with understanding renormalization was the introduction of hierarchical models by Dyson (1969). We will discuss a project by Abdesselam, Chandra, and Guadagni to construct a complete model of Quantum Field Theory on a hierarchical lattice which has as a first step the adaptation of a result of Brydges, Mitter, and Scoppola (2006) which was done in the Euclidean case.

3:45-4:05 pm Ivan Corwin & Miles Crosskey

Ivan Corwin, New York University

Free energy of the continuum directed random polymer via the weak exclusion process

Directed polymers in 1+1 dimensions are of great interest in physics and more recently mathematics. In this talk we consider a continuum model which is related to both the KPZ equation and the stochastic heat equation. We use a suitable discrete particle system to solve for the exact probability distribution for the free energy of the continuum random polymer. Our distribution also applies to the stochastic heat equation with delta initial data, and to the KPZ equation with "narrow wedge" initial data. This is joint work with G. Amir and J. Quastel.

Miles Crosskey, Duke University

Spectral bounds on empirical operators

Many machine learning algorithms are based upon estimating eigenvalues and eigenfunctions of certain integral operators. In practice, we have only finitely many randomly drawn points. How close are the eigenvalues and eigenfunctions of the finite dimensional matrix we construct in comparison to the infinite dimensional integral operator? In what way can we say these two are close if they do not even operate on the same spaces? To answer these questions, I will be showing some results from a paper "On Learning with Integral Operators" by Rosasco, Belkin, and De Vito.

4:10-4:30 pm Alexander Vandenberg-Rodes & Ravi Srinivasan

Alexander Vandenberg-Rodes, University of California- Las Angelas

Borcea-Brändén stability and the symmetric exclusion process

Ever since the famed Lee-Yang circle theorem appeared over a half-century ago, the location of zeros of partition functions has been a subject of intense scrutiny by statistical physicists. In a series of recent papers, Borcea and Brändén developed an elegant mathematical framework, encompassing such results, by describing when certain geometrical conditions on the zeros of multi-variate polynomials are preserved by linear transformations. I will sketch a bit of their theory, along with an application to the symmetric exclusion process out of equilibrium.

Ravi Srinivasan, University of Texas

Self-similarity in the Kac random walk

The Kac random walk is a jump process on the N-sphere that mimics random interactions among a large collection of particles in an elastic gas. Beyond its usefulness in studying the Boltzmann equation from kinetic theory, it has connections to Gibbs sampling in statistics and is a tractable model in which to study mixing times of Markov chains. Solutions to the Kac master equation can be written as random sums of iid random variables and are well-suited for an analysis analogous to that of limit theorems in classical probability theory. We discuss recent results on convergence to self-similar states, which turn out to be scaled mixtures of stable laws. This talk is largely based on papers by Bobylev, Cercignani, and Gamba (2009) (derived from an analytical viewpoint) and work by Basetti, Ladelli, and Matthes (2010) (using a probabilistic perspective).

4:45-5:45 pm **S.R.S. Varadhan: Keynote Address**

S.R.S. Varadhan, New York University

Central limit theorems, revisited

We will explore martingale methods in proving central limit theorems and consider some unusual applications.

Sunday, May 2, 2010

10:00-10:20 am Cristina Canepa & Hui Ma

Cristina Canepa, Carnegie Mellon University
A model for the federal funds market
We develop a model of bank reserve management and federal funds rate determination. We take into account central bank intervention and periodic reserve requirements, studying the profit-maximizing behavior of banks versus the central bank focusing on the target federal funds rate.

Hui Ma, University of Alabama- Birmingham
Geometric fitting of ellipse, hyperbola, and parabola
The problem of fitting conics such as ellipse, hyperbola and parabola to given points arises in various application areas, e.g. computer vision, statistics, and physics. Geometric fitting, also known as best fitting, is based on minimizing the geometric distances from the given points to the fitted feature. So first, I will discuss several methods of finding the orthogonal distances from the given points to ellipse/hyperbola/parabola. Then a robust and simple implicit algorithm which minimizes the sum of squares of such distances will be proposed and compared with other existing fitting methods.

10:25-10:45 am Elisabeth Kemajou & Ali Al-sharadqah

Elisabeth Kemajou, Southern Illinois University
Pricing of debt and loan guarantees using stochastic differential equations
In the business world, most companies use debt to operate. In addition to equity, corporate bonds (debt financing) are the main source of funds for many businesses. However, depending on the ability of the managers or other reasons, it can happen that a company faces bankruptcy. When a company becomes insolvent, the stock value decreases to zero and the equity holders lose on their investment. Therefore the company goes bankrupt. Naturally, debtholders would like to make sure that their investments are secured. In order to support companies in this situation and encourage new investments, some government agencies provide loan guarantees. In this paper, we derive a formula for the price of an option used for the pricing of corporate defaultable bonds and adopt this approach to the valuation of government loan guarantees for companies in financial distress. We will also valuate the profitability index of a new project. Overall, our analysis shows that loan guarantees may not be an efficient way to prevent bankruptcy since any new debt increases the probability of default. However, loan guarantees may be an efficient way to protect debtholders' investments. The next step will be the derivation of the equations mentioned above with delay.

Ali Al-sharadqah, University of Alabama- Birmingham
Novel ellipse fitting algorithms based on generalized eigenvalue problem
Regression models in which all variables are subject to errors are known as errors-in-variables (EIV) models. The respective parameter estimates have many properties that are not fully understood yet: their exact distributions are very hard to determine, and their moments (mean and variance) are often infinite. We developed an unconventional statistical analysis that allowed us to effectively assess EIV parameter estimates and design new methods with superior characteristics. In this talk we validate our approach in a series of numerical tests.

10:50-11:10 am Allen Hoffmeyer & Seonjoo Lee

Allen Hoffmeyer, Georgia Tech
Approximations of short term options pricing under stochastic volatility models with jumps
This talk is based on a paper by Medvedev and Scaillet which derives closed form asymptotic expansions for option implied volatilities (and option prices). The model is a two-factor jump-diffusion stochastic volatility one with short time to maturity. The authors derive a power series expansion (in log-moneyness and time to maturity) for the implied volatility of near-the-money options with small time to maturity. In this talk, I will discuss their techniques and results.

Seonjoo Lee, UNC- Chapel Hill
Consistency and asymptotic normality of independent component analysis
Independent Component Analysis (ICA) is a data driven method, which is popularly used in many applications such as signal engineering or function Magnetic Resonance Imaging (fMRI). Most current ICA methods utilize the marginal densities of the sources either parametrically or non-parametrically, while there may be more important information within the data such as correlation structure. In this talk, we propose a new method based on maximizing whittle likelihood, mainly to utilize the correlation structure within each source signal vis parametric spectral density estimation. The estimates are shown to be (weakly) consistent and asymptotically normal.

11:20-11:40 am Martin Keutel & Kevin McGoff

Martin Keutel, University of Virginia

Invariance of fluid limits for shortest remaining processing time policies

In an SRPT queue, a server gives preemptive priority to the job with the shortest remaining processing time, that is, the job that can be completed first. This is an important protocol because it is known to minimize the queue length over all work conserving protocols. A variant of this protocol, called non-preemptive SRPT, is simpler to implement because it only applies the rule at the completion time of each job. In this talk, we'll compare the two variants and show that they have the same fluid limits. In particular, we'll argue that essentially the same performance of SRPT can be achieved by using the simpler non-preemptive variant.

Kevin McGoff, University of Maryland

Random shifts of finite type

Let X be a mixing shift of finite type (SFT) of positive entropy, and let $B_n(X)$ be its set of words of length n. Define a random subset S of $B_n(X)$ by independently choosing each word from $B_n(X)$ with some probability p. Let T be the (random) SFT built from the set S. For each $0 \leq p \leq 1$ and n tending to infinity, we compute the limit of the likelihood that T is empty, as well as the limiting distribution of entropy for T. For p near 1 and n tending to infinity, we show that the likelihood that T contains a unique irreducible component of positive entropy converges exponentially to 1. This version of "random SFT" differs significantly from the previous notion by the same name, which has appeared in the context of random dynamical systems and bundled dynamical systems.

11:45-12:05 pm Tomoyuki Ichiba & Yilei Hu

Tomoyuki Ichiba, University of California- Santa Barbara

Branching Brownian martingales

We introduce a class of nonnegative, square-integrable, continuous martingales which are constructed from the branching Brownian particles on the positive half line with an absorbing barrier at the origin. The quadratic variation process of such martingale is absolutely continuous with respect to the Lebesgue measure, where the Radon-Nikodym density is identified as the number of surviving Brownian particles. Its sample paths are obtained from a path-decomposition of a stopped Brownian motion. We propose a model of stock price dynamics driven by propagation of contagious information under such branching mechanism.

Yilei Hu, University of Paris VI & X

Signaling game: a reinforcement learning model

We study a generalized version of the signaling process originally introduced and studied by Argiento, Pemantle, Skyrms and Volkov (2009), which models how two interacting agents learn to signal each other and thus create a common language. We show that the process asymptotically leads to the emergence of a graph of connections between signals and states which has the property that no signal-state correspondence could be associated both to a synonym and an informational bottleneck.

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