Rare Events, Information Theory, and Statistical Physics:
A Conference Celebrating Richard S. Ellis.

Friday, April 12th 2019.
Lederle Graduate Research Tower Room 1634 (16th Floor)
Department of Mathematics and Statistics
UMass Amherst

11:30AM—12noon	Arrival. Tea, Coffee, and Light Snacks		
12:00—12:05PM	Opening Remarks by Nate Whitaker, Head Math & Stats		
12:05—12:50PM	**Paul Dupuis**	**Brown University**	**On the weak convergence approach to large deviations.**
12:50—1:05pm	Q&A + Break		
1:05—1:50PM	**Hugo Touchette**	**Stellenbosch University, South Africa.**	**Large deviation equivalence of stochastic processes.**
1:50--2:05pm	Q&A + Break		
2:05 —2:50PM	**Jon Machta**	**UMass Amherst**	**The Ising spin glass: A frustrating problem for statistical physics.**
2:50—3:00PM	Q&A		
3:00--3:30PM	**TEA BREAK**		
3:30--4:15PM	**Charles Newman**	**Courant Institute, NYU**	**Zeros of Moment Generating Functions and the Riemann Hypothesis.**
4:15—4:30PM	Q&A + Break		
4:30--5:15PM	**Peter Otto**	**Willamette University**	**The Aggregate Path Coupling Method for Mixing Times.**
5:15--5:30PM	Q&A + Break		
5:30--6:15PM	**Bruce Turkington**	**UMass Amherst**	**Relative entropy, information loss rate and model reduction.**
6:15--6:30PM	Q&A + Concluding Remarks.		
7:00PM	**BANQUET (Marriott –UMass Campus Center)**		

Titles and Abstracts

Paul Dupuis (Brown University)

Title: On the weak convergence approach to large deviations

Abstract: Richard Ellis and I introduced what we called the weak convergence approach to large deviations in a book published in 1997. The approach is based on variational representations for certain expected values, which allow one to convert the large deviation problem into one of weak convergence under a law of large numbers scaling. After reviewing the setup in the context of a simple example, I will survey its further development in the years since.

Hugo Touchette (Stellenbosch University, South Africa)

Title: Large deviation equivalence of stochastic processes

Abstract: I will describe my recent work on a generalized notion of ensemble equivalence, which grew out of my work with Richard S. Ellis in 2004-2008. The equivalence applies to probability measures that are not necessarily the classical ensembles of statistical mechanics, and defines, in a loose sense, a minimal distance between measures that guarantee that they give the same macroscopic or long-time description of a random system (e.g., a many particle system or a Markov process).

Jon Machta (UMass Amherst)

Title: The Ising spin glass: A frustrating problem for statistical physics.

Abstract: Ising spin glass models were originally introduced to understand a class of disordered magnetic systems but have proven to be important in a wide range of fields from computer science to biology. Despite more than four decades of study, many basic questions concerning Ising spin glasses remain controversial and unanswered. In this talk I will give a brief overview of the history of the model and a few of the open questions. I will then discuss computational efforts to understand Ising spin glasses and focus on one useful computational tool—population annealing. I will explain the population annealing algorithm and describe some insights concerning Ising spin glasses obtained from population annealing simulations.

Charles Newman (Courant Institute of Mathematical Sciences, NYU)

Title: Zeros of Moment Generating Functions and the Riemann Hypothesis.

Abstract: One fairly standard version of the Riemann Hypothesis (RH) is that a specific probability density on the real line has a moment generating function (Laplace transform) that as an analytic function on the complex plane has all its zeros pure imaginary. In statistical physics, a theorem of Lee and Yang from the 1950s provides a way to generate probability densities with that same property. How closely these two topics are related to each other is of some interest.
We'll review a series of results that span the period from the 1920's to now concerning a perturbed version of the RH which demonstrate at least an historical relation. In the perturbed version, due to Polya, the log of the probability density is modified by a quadratic term.
This gives rise to an implicitly defined real constant known as the de Bruijn-Newman Constant, Lambda. The conjecture and now theorem (Newman 1976, Rodgers and Tau 2018) that Lambda is greater than or equal to zero is complementary to the RH which is equivalent to Lambda less than or equal to zero; The conjecture/theorem is a version of the dictum that the RH, if true, is only barely so. Until very recently, the best upper bound, was a 2009 result of Ki, Kim and Lee that Lambda is strictly less than 1/2. The current upper bound (see Polymath 15) is around 0.22.

Peter Otto (Willamette University)

Title: The Aggregate Path Coupling Method for Mixing Times

Abstract: The mixing time of a Markov chain is a measure of the convergence rate of the state distribution to the chain's stationary distribution and is fundamental in the application of Markov chains in sampling and simulations. In this talk, I will present the method of aggregate path coupling, which in conjunction with large deviation bounds, provides a general framework for proving rapid mixing of Glauber dynamics for a large class of statistical mechanical models which include models that exhibit discontinuous phase transitions which have traditionally been more difficult to analyze rigorously. Joint work with Yevgeniy Kovchegov.

Bruce Turkington (UMass Amherst)

Title: Relative entropy, information loss rate and model reduction

Abstract: Complex, multi-scale models in the physical sciences are typically governed by high-dimensional dynamical systems, and consequently their predictions usually require massive computations. For this reason model reduction is a central issue in modern applied mathematics. In this lecture I will describe a statistical-dynamical approach to deriving reduced models of Hamiltonian systems having very many degrees of freedom. The key to this reduction technique is to find paths in the parameter space of the statistical reduced model that minimize the rate of information loss due to reduction. This loss rate is naturally and intrinsically quantified by incremental relative entropy. To make the talk accessible to a general audience, I will focus on the point vortex system in the plane, which I will motivate as a simple prototype for the quasi-two-dimensional turbulence observed in geophysical fluids. For the many-vortex problem I will illustrate the phenomena being modeled by means of graphics and videos.