<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Seminar &amp; Events Bulletin: Financial/Actuarial Mathematics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wednesday, January 13, 2016</td>
<td>4:00pm-5:00pm</td>
<td>Financial/Actuarial Mathematics -- Johannes Muhle-Karbe (UM) <strong>Equilibrium Models with Small Frictions</strong> -- 1360 East Hall</td>
</tr>
<tr>
<td>Wednesday, February 03, 2016</td>
<td>4:00pm-5:00pm</td>
<td>Financial/Actuarial Mathematics -- Rohini Kumar (Wayne State University) <strong>Small-time asymptotics for fast mean-reverting stochastic volatility models</strong> -- 1360 East Hall</td>
</tr>
<tr>
<td>Wednesday, February 10, 2016</td>
<td>4:00pm-5:00pm</td>
<td>Financial/Actuarial Mathematics -- Dylan Possamai (Paris Dauphine) <strong>Dynamic Programming Approach to Principal-Agent Problems</strong> -- 1360 East Hall</td>
</tr>
<tr>
<td>Friday, February 12, 2016</td>
<td>4:00pm-5:00pm</td>
<td>Financial/Actuarial Mathematics -- Sebastian Hermann (ETH) <strong>Model Uncertainty, Recalibration, and the Emergence of Delta-Vega Hedging</strong> -- 1360 East Hall</td>
</tr>
<tr>
<td>Wednesday, February 17, 2016</td>
<td>3:00pm-4:00pm</td>
<td>Financial/Actuarial Mathematics -- Yavor Stoev (UM) <strong>Quickest change-point detection problems for multidimensional Wiener processes</strong> -- 3088 East Hall</td>
</tr>
<tr>
<td>Wednesday, February 17, 2016</td>
<td>4:00pm-5:00pm</td>
<td>Financial/Actuarial Mathematics -- Abhinav Sinha (EECS, UM) <strong>Network Mechanism Design</strong> -- 1360 East Hall</td>
</tr>
<tr>
<td>Wednesday, February 24, 2016</td>
<td>3:00pm-4:00pm</td>
<td>Financial/Actuarial Mathematics -- Asaf Cohen (UM) <strong>Risk Sensitive Control of the Lifetime Ruin Problem</strong> -- 4096 East Hall</td>
</tr>
<tr>
<td>Wednesday, March 09, 2016</td>
<td>4:00pm-5:00pm</td>
<td>Financial/Actuarial Mathematics -- Chris Miller (UC Berkeley) <strong>Optimal Control of Conditional Value-at-Risk in Continuous Time</strong> -- 1360 East Hall</td>
</tr>
<tr>
<td>Wednesday, March 16, 2016</td>
<td>3:00pm-4:00pm</td>
<td>Financial/Actuarial Mathematics -- Jinniao Qiu (UM) <strong>Weak Solution for Fully Nonlinear Stochastic Hamilton-Jacobi-Bellman Equations and its Applications</strong> -- 3088 East Hall</td>
</tr>
<tr>
<td>Wednesday, March 16, 2016</td>
<td>4:00pm-5:00pm</td>
<td>Financial/Actuarial Mathematics -- Matin Herdegen (ETH) <strong>Sensitivity of Optimal Consumption Streams</strong> -- 1360 East Hall</td>
</tr>
<tr>
<td>Wednesday, March 23, 2016</td>
<td>4:00pm-5:00pm</td>
<td>Financial/Actuarial Mathematics -- Gustavo Schwenkler (Boston University) <strong>The Systemic Effects of Benchmarking</strong> -- 1360 East Hall</td>
</tr>
<tr>
<td>Wednesday, March 30, 2016</td>
<td>4:00pm-5:00pm</td>
<td>Financial/Actuarial Mathematics -- Christian Keller (UM) <strong>TBA</strong> -- 1360 East Hall</td>
</tr>
<tr>
<td>Date</td>
<td>Time</td>
<td>Event</td>
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<tr>
<td>Wednesday, April 06, 2016</td>
<td>4:00pm-5:00pm</td>
<td>Financial/Actuarial Mathematics -- Tom Bielecki (IIT)</td>
</tr>
<tr>
<td>Wednesday, April 13, 2016</td>
<td>4:00pm-5:00pm</td>
<td>Financial/Actuarial Mathematics -- Vadim Linetsky (Northwestern)</td>
</tr>
</tbody>
</table>
Financial/Actuarial Mathematics  
Wednesday, January 13, 2016, 4:00pm-5:00pm  
1360 East Hall  
Johannes Muhle-Karbe (UM)  
Equilibrium Models with Small Frictions

How would the introduction of a small trading friction such as a transaction tax affect financial markets? To answer questions of this kind, one needs to consider equilibrium models, where prices are determined endogenously. Indeed, taxes change agents' individual decision making, which in turn affects the market prices determined by their interactions. The new market environment then again alters the agents' behavior, leading to a notoriously intractable fixed point problem.

In this talk we report on recent progress using asymptotic techniques for small trading frictions. In this practically relevant limiting regime, explicit solutions become available for many of the arising singular control problems, bringing analytical results for the equilibrium problem within reach.

(The talk is based on joint works with Martin Herdegen and Jan Kildeen)

Financial/Actuarial Mathematics  
Wednesday, February 03, 2016, 4:00pm-5:00pm  
1360 East Hall  
Rohini Kumar (Wayne State University)  
Small-time asymptotics for fast mean-reverting stochastic volatility models

We use stochastic volatility models, with fast mean-reverting volatility, to price out-of-the-money (OTM) European call options near maturity. The regime of interest is when time to maturity is small, but large compared to the mean-reversion time of the stochastic volatility. The different time scales of mean-reversion and time to maturity makes this a multi scale problem. To obtain asymptotics of the OTM option price and the corresponding implied volatility, we first prove a large deviation principle for stock price, as time to maturity approaches zero. The large deviation principle is obtained by PDE techniques rather than probabilistic methods. Due to the mutli-scale nature of the problem, the PDE techniques involve averaging viscosity solutions of nonlinear PDEs.

This is joint work with Jean-Pierre Fouque, Jin Feng and Lea Popovic.
Abstract: We consider a general formulation of the Principal-Agent problem from Contract Theory, on a finite horizon. We show how to reduce the problem to a stochastic control problem which may be analyzed by the standard tools of control theory. In particular, Agent’s value function appears naturally as a controlled state variable for the Principal’s problem. Our argument relies on the Backward Stochastic Differential Equations approach to non-Markovian stochastic control, and more specifically, on the most recent extensions to the second order case.

This is a joint work with Jaksa Cvitanic and Nizar Touzi.

We study option pricing and hedging with uncertainty about a Black-Scholes reference model which is dynamically recalibrated to the market price of a liquidly traded vanilla option. For dynamic trading in the underlying asset and this vanilla option, delta-vega hedging is asymptotically optimal in the limit for small uncertainty aversion. The corresponding indifference price corrections are determined by the disparity between the vegas, gammas, vannas, and volgas of the non-traded and the liquidly traded options.

This is joint work with Johannes Muhle-Karbe.
We study the quickest change-point detection problems for the correlated components of a multidimensional Wiener process changing their drift rates at certain random times. These problems seek to determine the times of alarm which are as close as possible to the unknown change-point (disorder) times at which some of the components have changed their drift rates. The optimal times of alarm are shown to be the first times at which the appropriate posterior probability processes exit certain regions restricted by the stopping boundaries. We characterize the value functions and optimal boundaries as unique solutions of the associated free boundary problems for partial differential equations. We provide estimates for the value functions and boundaries which are solutions to the appropriately constructed ordinary differential free boundary problems.

Mechanism Design is a widely used design framework for resource allocation problems involving strategic agents. Decentralization of information is one of the main issues that mechanism design deals with. Recently, this approach has been studied for problems on networked systems where for instance efficient distribution of bandwidth among Internet users is to be achieved. Full implementation is a refinement of mechanism design and is generally more robust in achieving efficient allocations.

In this talk, I will begin by describing the Hurwicz-Reiter model for Mechanism Design and the relevant resource allocation problems for various networks like unicast, multi-rate/multicast and wireless network. Owing to the nuances of these networked problems like restrictions on complexity and hard system constraints on allocation, I will propose restrictions to the mechanism design framework which network problem ought to adhere to. Finally I will present a set of mechanisms that achieve full implementation for the various networks. As we shall see, dual optimization approach plays a key role in designing such mechanisms.
We study a risk sensitive control version of the lifetime ruin probability problem. We consider a sequence of investments problems in Black-Scholes market that includes a risky asset and a riskless asset. We present a differential game that governs the limit behavior. We solve it explicitly and use it in order to find an asymptotically optimal policy.

Joint work with Erhan Bayraktar.

We consider continuous-time stochastic optimal control problems featuring Conditional Value-at-Risk (CVaR) in the objective. The major difficulty in these problems arises from time-inconsistency, which prevents us from directly using dynamic programming. To resolve this challenge, we convert to an equivalent bilevel optimization problem in which the inner optimization problem is standard stochastic control. Furthermore, we provide conditions under which the outer objective function is convex and differentiable. We compute the outer objective's value via a Hamilton-Jacobi-Bellman equation and its gradient via the viscosity solution of a linear parabolic equation, which allows us to perform gradient descent. The significance of this result is that we provide an efficient dynamic programming-based algorithm for optimal control of CVaR without lifting the state-space. To broaden the applicability of the proposed algorithm, we provide convergent approximation schemes in cases where our key assumptions do not hold and characterize relevant suboptimality bounds. In addition, we extend our method to a more general class of risk metrics, which includes mean-variance and median-deviation. We also demonstrate a concrete application to portfolio optimization under CVaR constraints. Our results contribute an efficient framework for solving time-inconsistent CVaR-based dynamic optimization.

This is a joint work with Insoon Yang.
Financial/Actuarial Mathematics  
Wednesday, March 16, 2016, 3:00pm-4:00pm  
3088 East Hall  
Jinniao Qiu (UM)  
Weak Solution for Fully Nonlinear Stochastic Hamilton-Jacobi-Bellman Equations and its Applications

This talk is concerned with the stochastic Hamilton-Jacobi-Bellman (HJB) equation with controlled leading coefficients, which is a type of fully nonlinear stochastic partial differential equation (SPDE). In order to formulate the weak solution for such kind of SPDEs, a class of regular random parabolic potentials are introduced in the stochastic framework. The existence and uniqueness of weak solution is proved, which seems new even for the classical HJB equations. For the partially non-Markovian case, we obtain the associated gradient estimate. The applications in finance and economics will be discussed as well if time allows.

Financial/Actuarial Mathematics  
Wednesday, March 16, 2016, 4:00pm-5:00pm  
1360 East Hall  
Matin Herdegen (ETH)  
Sensitivity of Optimal Consumption Streams

We study the sensitivity of optimal consumption streams with respect to perturbations of the random endowment. At the leading order, the consumption adjustment does not matter: any choice that matches the budget constraint simply shifts the original utility by the marginal value of the perturbation. Nontrivial results obtain at the next-to-leading order. Here, one first solves the problem for a deterministic perturbation, which leads to a "prognosis measure". The desired consumption adjustment for a general endowment perturbation is in turn given by the conditional expectation of the latter, computed under this measure and appropriately weighted with the conditional expectations of the remaining risk-tolerance. As an interesting application, we consider the problem of optimal consumption with small transaction costs.

The talk is based on joint work with Johannes Muhle-Karbe (University of Michigan).
We show that the competitive pressure to beat a benchmark may induce institutional trading behavior that exposes retail investors to tail risk. In our model, institutional investors are different from a retail investor because they derive higher utility when their benchmark outperforms. This forces institutional investors to take on leverage to overinvest in the benchmark. Institutional investors execute fire sales when the benchmark experiences shock. This behavior increases market volatility, raising the tail risk exposure of the retail investor. Ex post, tail risk is only short lived. All investors survive in the long run under standard conditions, and the most patient investor dominates. Ex ante, however, benchmarking is welfare reducing for the retail investor, and beneficial only to the impatient institutional investor.
Dependence between components of multivariate conditional Markov chains: Markov consistency and Markov Copulae

Modeling of evolution of dependence between processes occurring in financial markets is important. Typically, one can identify marginal statistical properties of individual processes, and then one is confronted with the task of modeling dependence between these individual processes so that the marginal properties are obeyed. We have been advocating, for some time now, to address this modeling problem via the theory of Markov consistency and Markov copulae.

In this talk we shall examine the problem of existence and construction of a non-trivial multivariate conditional Markov chain with components that are given conditional Markov chains. In this regard we shall give sufficient and necessary conditions, in terms of relevant conditional expectations, for a component of a multivariate Markov chain to be a Markov chain in the filtration of the entire chain - a property called strong Markov consistency, as well as in its own filtration - a property called weak Markov consistency. These characterization results are proved via analysis of the semi-martingale structure of the chain.

Several financial applications will be indicated.