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IMA NEWSLETTER # 331

1-31 May 2004

2003-2004 Program

PROBABILITY AND STATISTICS IN COMPLEX SYSTEMS

See <http://www.ima.umn.edu/complex/> for a full description of the 2003-2004 program on Probability and Statistics in Complex Systems: Genomics, Networks, and Financial Engineering

IMA schedules are subject to revision, particularly during workshops. See

<http://www.ima.umn.edu/~seminar/sched> and

<http://www.ima.umn.edu/newsletters/> for the latest scheduling information.

PART I: NEWS AND NOTES

<p>IMA Workshop:</p>

<p>Model Implementation, Algorithms and Software Issues</p>
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<p>3-7 May 2004</p>

<p>Organizers: Joseph Langsam (Morgan Stanley), George C. Papanicolaou (Stanford University),</p>

<p>See http://www.ima.umn.edu/complex/spring/c8.html</p>
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PARTICIPATING INSTITUTIONS: Consiglio Nazionale delle Ricerche (CNR), Georgia Institute of Technology, Indiana University, Iowa State University, Kent State University, Lawrence Livermore National Laboratory, Los Alamos National Laboratory, Michigan State University, Mississippi State University, Northern Illinois University, Ohio State University, Pennsylvania State University, Purdue University, Rice University, Sandia National Laboratories, Seoul National University (BK21 Math-SNU), Seoul National University (SRCCS), Texas A&M University, University of Chicago, University of Cincinnati, University of Delaware, University of Houston, University of Illinois (Urbana), University of Iowa, University of Kentucky, University of Maryland, University of Michigan, University of Minnesota, University of Notre Dame, University of Pittsburgh, University of Wisconsin, University of Wyoming, Wayne State University.

PARTICIPATING CORPORATIONS: Boeing, ExxonMobil, Ford, General Electric Company, General Motors, Honeywell, IBM, Lockheed Martin, Lucent, Motorola, Schlumberger, Siemens, Telcordia Technologies, 3M.

Version of June 9, 2004

**IMA "Hot Topics" Workshop:
Compatible Spatial Discretizations for Partial Differential
Equations**

11–15 May 2004

Organizers: Douglas N. Arnold (University of Minnesota), Pavel Bochev (Sandia National Laboratories), Rich Lehoucq (Sandia National Laboratories), Roy Nicolaides (Carnegie-Mellon University), Mikhail Shashkov (Los Alamos National Laboratory),

Supported by the Department of Energy.

See <http://www.ima.umn.edu/complex/spring/discretization.html>

IMA Workshop:

Financial Data Analysis and Applications

24–28 May 2004

Organizers: John C. Heaton (University of Chicago), Bruce N. Lehmann (University of California at San Diego), Andrew W. Lo (MIT),

See <http://www.ima.umn.edu/complex/spring/c9.html>

IMA Website

Comments or suggestions concerning the IMA website may be addressed to

webmaster@ima.umn.edu.

In particular, we appreciate any information about World-Wide Web links appropriate to current and upcoming IMA programs.

PART II: SCHEDULE FOR 1–31 MAY 2004

Monday, May 3

IMA Workshop:

Model Implementation, Algorithms and Software Issues

3–7 May 2004

Organizers: Joseph Langsam (Morgan Stanley), George C. Papanicolaou (Stanford University),

See <http://www.ima.umn.edu/complex/spring/c8.html>

Another aspect of the program in Quantitative Finance and Econometrics is the implementation of models as numerical algorithms and the building of software applications. Financial models for asset pricing need to be versatile in terms of data input, fault tolerant and fast. These stringent requirements often challenge researchers and developers of financial software. The development of software requires, therefore, an understanding of the capabilities of business-type computers, how data is accessed and how mathematical models are implemented at the level of algorithms. By inviting some of the leading practitioners in the area of financial algorithms and software companies, we hope to showcase the state-of-the-art in financial engineering.

Mathematical Areas of Relevance: Numerical solution of HJB equations Optimization Monte Carlo Simulation Random number generators Numerical solution of SDEs Numerical Linear Algebra Stochastic Optimization

All talks are in Lecture Hall EE/CS 3-180 unless otherwise noted.

8:30	Coffee and Registration	Reception Room EE/CS 3-176
9:15	Douglas N. Arnold, Scot Adams, and Organizers	Welcome and Introduction
9:30	Joseph Langsam	Changing Dynamics in the Securities Market

Abstract: Mathematical finance has evolved since the early days of Black-Scholes with the assumptions of lognormal dynamics, constant interest rates, and constant volatility. The growth of the derivatives market and product innovation in new markets has forced “Wall Street” to confront the complexities of far more generalized dynamics. In this talk, I will review the dynamics, complexities, and apparent conundrums in the modeling of a variety of financial products including interest rate, foreign exchange, equity, electricity, and credit products. Many questions will be asked and many problems posed, but few answers will be given and fewer solutions will be offered.

10:20	Discussion	
10:30	Coffee Break	Reception Room EE/CS 3-176
11:00	Steven E. Shreve Carnegie Mellon University	A Two-Person Game for Pricing Convertible Bonds

Abstract: A firm issues a convertible bond. At each subsequent time, the bondholder must decide whether to keep the bond, thereby collecting coupons, or to convert the bond for stock. The bondholder wishes to choose a conversion strategy to maximize the bond value. Subject to some restrictions, the bond can be called by the issuing firm, which acts to maximize equity value and thus minimize bond value. This creates a two-erosn game, and we model the bond price as the value of this game. We show, however, that under the assumption that dividends are paid at a lower rate than the short-term interest rate, this game reduces to one of two optimal stopping problems, and which is the relevant problem can be determined apriori.

Because the dividends paid depend on the value of equity, which in turn depends on the value of the bond, the dynamics of the firm value cannot be specified until the bond pricing problem is solved. As a result, the optimal stopping problems which must be solved lead to nonlinear partial differential equations. These can be solved by a fixed-point method.

This work is Mihai Sirbu’s Ph. D. dissertation.

11:50	Discussion	
12:00	Lunch Break	

1:30	Philip H. Dybvig Washington University	Mandatory or Voluntary Retirement
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Abstract: Saving for retirement is a primary end purpose of many parts of the financial sector, including pension plans, life insurance, and indeed much of retail banking and brokerage. As a step towards understanding these markets, we solve the lifetime consumption and investment problem of a competitive agent who faces voluntary or mandatory retirement. The model includes such realistic features as stochastic age-dependent wage, age-dependent life-table mortality and age-dependent preferences for working as well as a constraint that prevents borrowing against future labor income. The tightly approximated model is solved parametrically in the dual, in closed form up to determination of some constants. The solution uses the technique of Carr (for American Options) and Liu and Loewenstein (for transaction costs) of making the nonstationary problem into a sequence of stationary problems by approximating a fixed horizon by a sequence of stationary random horizons.

2:20	Discussion	
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2:30	Coffee Break	Reception Room EE/CS 3-176
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3:00	Second Chances	Speakers of the day respond to further questions, suggestions, re-frame their main points, look toward future directions.
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3:30	Group Photo	
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3:40	IMA Tea and more (with Poster Session)	400 Lind Hall
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poster	Luca Benzoni University of Minnesota	Stochastic Volatility, Mean Drift, and Jumps in the Short-Term Interest Rate
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Abstract: We find that an intuitively appealing and fairly manageable continuous-time model provides an excellent characterization of the U.S. short-term interest rate over the post Second World War period. Our three-factor jump-diffusion model consists of elements embodied in existing specifications, but our approach appears to be the first to successfully accommodate all such features jointly. Moreover, we conduct simultaneous and efficient inference regarding all model components, which include a shock to the interest rate process itself, a time-varying mean reversion factor, a stochastic volatility factor and a jump process. Most intriguingly, we find that the restrictions implied by an affine representation of the jump-diffusion system are not rejected by the U.S. short rate data. This allows for a tractable setting for associated asset pricing applications.

Joint with Torben G. Andersen (Northwestern University) and Jesper Lund (Nykredit Bank).

poster	Vladimir Kurenok University of Wisconsin at Green Bay	On a Model for the Term Structure of Interest Rate Processes of Stable Type
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Abstract: Let $M(t), t \geq 0$, be an one-dimensional symmetric stable process of index $0 < \alpha \leq 2$. As a model for the term structure of interest rate processes we consider $r(t) = \mathcal{G}(t, M \circ T(t))$ or as special case $r(t) = F\left(f(t) + g(t)M \circ T(t)\right)$ for some functions \mathcal{G}, F, T, f and g . We show that this model includes in particular some models which can be described by the Ito stochastic differential equations driven by the process M . It generalizes also the known Schmidt's model which is a special case of our model if $\alpha = 2$. Moreover, we construct also a sequence of simple processes (random walks) obtained as the sums of i.i.d random variables which belong to the domain of attraction of the corresponding stable distribution. It is proved that this random walk models converge in law to the interest rate processes $r(t)$.

Key Words: Short rate, stochastic differential equations, stable processes, random walk

poster **Michael Ludkovski** Convenience Yield Model with Partial Observations and
Princeton University Exponential Utility

Abstract: We consider the problem of pricing claims for delivery of crude oil or natural gas to a given location. We work with a three factor model for the asset spot, the convenience yield and the locational basis. The convenience yield is taken to be unobserved and must be filtered. Our methodology is indifference pricing with exponential utility. Assuming the basis is independent from the spot, the partially observed stochastic control problem can be expressed as a Feynman-Kac expectation. If the basis is also independent from the convenience yield, the resulting indifference price is trivial. Otherwise, we show how to numerically compute the expectation using a Kalman or particle filter. The basic model may be generalized to include nonlinear dynamics. We finish by performing comparative statics and relating the results to the full information setting.

Joint work with Rene Carmona.

poster **Mathias Rousset** Sampling Prescribed Distributions with Interacting Particle Systems
Université Paul Sabatier

Abstract: We present a new class of interacting Metropolis models having a prescribed limiting distribution. In contrast to traditional Monte-Carlo methods, and when the population size is large, the decay to equilibrium does not depend on the target distribution. Some conclusive simulations are presented, focusing on diffusive models and their implementation.

poster **Mihai Sîrbu** Perpetual Convertible Bonds
Carnegie Mellon University

Abstract: In a similar model to the presentation of Steven E Shreve (“A Two-Person Game for Pricing Convertible Bonds”), we consider the problem of pricing a convertible bond that has no maturity date. The problem reduces to solving a nonlinear ODE and to a min-max argument. The Perpetual Convertible Bond represents the asymptotic behavior for the finite maturity case. The presentation is based on joint work with Igor Pikovsky and Steven E. Shreve.

poster **Shu Wu** Interest Rate Risk and the Forward Premium Anomaly in
University of Kansas Foreign Exchange Markets

Abstract: This paper shows that even adjusted for the time-varying risk premiums implied by the yield curves across countries, uncovered interest rate parity (UIP) is still strongly rejected by the data. Moreover, factors that predict the excess bond returns are found not significant at all in predicting the foreign exchange returns. These results reject the joint restrictions on the exchange rate and interest rates imposed by dynamic term structure models, suggesting that foreign exchange markets and bond markets may not be fully integrated and we have to look beyond interest rate risk in order to understand the exchange rate anomaly.

poster **Yong Zeng** A Class of Micro-Movement Models of Asset Price with
University of Missouri at Kansas City Continuous-Time Bayesian Inference via Filtering

Abstract: A rich class of micro-movement models that describe the transactional price behavior is proposed. The model ties the sample characteristics of micro-movement and macro-movement in a consistent manner. An important feature of the model is that it can be transformed to a filtering problem with counting process observations. Consequently, the complete information of price and trading time is captured and then is utilized in Bayesian inference via filtering for the parameter estimation and model selection. The evolution equations characterizing likelihoods, posteriors, and Bayes factors are derived. Recursive algorithms are constructed via the Markov chain approximation method to compute likelihoods, posteriors, and Bayes factors. The consistencies (or robustness) of the recursive algorithms are proven. Two micromovement models are studied in detail. One is the model built on geometric Brownian motion (GBM) and the other is on the GBM plus jumping stochastic volatility. Simulation results show that the Bayes estimates for time-invariant parameters are consistent, the Bayes estimates for stochastic volatility capture the movement of volatility, and the Bayes factor can effectively select the right model. Real-world applications to Microsoft transaction data are also provided.

2:20	Discussion	
2:30	Coffee Break	Reception Room EE/CS 3-176
3:00	Second Chances	Speakers of the day respond to further questions, suggestions, re-frame their main points, look toward future directions.
3:30	Walk along the Mississippi, weather permitting	

Wednesday, May 5

All talks are in Lecture Hall EE/CS 3-180 unless otherwise noted.

9:00	Coffee	Reception Room EE/CS 3-176
9:30	Ron S. Dembo Algorithmics Incorporated	Risk Measurement; Risk Architecture and the Bank of the Future

Abstract: Measuring the risk of a large financial institution is a gargantuan task. There have been major improvements in doing so over the past few years. These have resulted in the ability of institutions to take on more and more complexity, thereby keeping the risk management treadmill alive and well. We discuss how risk is actually measured, some major new accomplishments, such as real-time risk based on simulation and highlight some of the interesting research problems that are being addressed, such as real-time bank-wide optimization.

10:20	Discussion	
10:30	Coffee Break	Reception Room EE/CS 3-176
11:00	Paul Glasserman Columbia University	Monte Carlo Pricing of American Options: Overview and New Results

Abstract: An American option allows the holder to choose the time of exercise, so valuing such an option entails solving an optimal stopping problem. This “free boundary” problem presents a challenge for Monte Carlo methods. The first part of this talk will be an overview of methods developed in recent years to address this problem. These methods apply weighted backward induction to simulated paths, with weights defined through likelihood ratios, through calibration, or implicitly through regression. The second part of this talk analyzes conditions for convergence as both the number of paths and number of basis functions for regression grow. Using polynomials in the regressions, the number of paths must grow exponentially with the number of basis functions to assure convergence when applied to Brownian motion, faster when applied to geometric Brownian motion. This analysis is based on joint work with Bin Yu.

11:50	Discussion	
12:00	Lunch Break	

1:30	Pierre Collin-Dufresne University of California, Berkeley	Identification and Estimation of 'Maximal' Affine Term Structure Models: An Application to Stochastic Volatility
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Abstract: We propose a canonical representation for affine term structure models where the state vector is comprised of the first few Taylor-series components of the yield curve and their quadratic (co-)variations. With this representation: (i) the state variables have simple physical interpretations such as level, slope and curvature, (ii) their dynamics remain affine and tractable, (iii) the model is by construction 'maximal' (i.e., it is the most general model that is econometrically identifiable), and (iv) model-insensitive estimates of the state vector process implied from the term structure are readily available. (Furthermore, this representation may be useful for identifying the state variables in a squared-Gaussian framework where typically there is no one-to-one mapping between observable yields and latent state variables). We find that the 'unrestricted' $A_1(3)$ model of Dai and Singleton (2000) estimated by 'inverting' the yield curve for the state variables generates volatility estimates that are *negatively* correlated with the time series of volatility estimated using a standard GARCH approach. This occurs because the 'unrestricted' $A_1(3)$ model imposes the restriction that the volatility state variable is simultaneously a linear combination of yields (i.e., it impacts the cross-section of yields), and the quadratic variation of the spot rate process (i.e., it impacts the time-series of yields). We then investigate the $A_1(3)$ model which exhibits 'unspanned stochastic volatility' (USV). This model predicts that the cross section of bond prices is independent of the volatility state variable, and hence breaks the tension between the time-series and cross-sectional features of the term structure inherent in the unrestricted model. We find that explicitly imposing the USV constraint on affine models significantly improves the volatility estimates, while maintaining a good fit cross-sectionally.

2:20	Discussion	
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2:30	Coffee Break	Reception Room EE/CS 3-176
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3:00	Second Chances	Speakers of the day respond to further questions, suggestions, re-frame their main points, look toward future directions.
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Thursday, May 6

All talks are in Lecture Hall EE/CS 3-180 unless otherwise noted.

9:00	Coffee	Reception Room EE/CS 3-176
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9:30	Curtis Randall SciComp Inc.	Software Synthesis - Pricing without Programming
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Abstract: Software synthesis methods applied to the development of derivative pricing and hedging models allow quantitative analysts, researchers, and risk managers to rapidly generate models without programming. The high level language developed for SciFinance will be used to illustrate how a financial compiler generates source code. This presentation will show how a 10 line specification for a complex financial derivative can generate a ready to use model to price the instrument often comprising thousands of lines of source code. Examples will be shown over several asset classes using both PDE and Monte Carlo methods. Attendees will be given a web link to access papers and a free sample pricing code that illustrates the use of software synthesis.

10:20	Discussion	
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10:30	Coffee Break	Reception Room EE/CS 3-176
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11:00	Gregory R. Duffee University of California-Berkeley	Estimation of Dynamic Term Structure Models
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Abstract: This talk discusses the finite sample properties of some of the standard techniques used to estimate modern term structure models. For sample sizes similar to those used in most empirical work, I note three surprising conclusions. First, maximum likelihood produces strongly biased parameter estimates. Second, despite having the same asymptotic efficiency as maximum likelihood, the small sample performance of Efficient Method of Moments (a commonly used method for estimating complicated models) is unacceptable even in the simplest term structure settings. Third, the linearized Kalman filter is a tractable and reasonably accurate estimation technique that I recommend in settings where maximum likelihood is impractical.

11:50	Discussion	
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12:00	Lunch Break	
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1:30	Dmitry Kramkov Carnegie Mellon University	Risk-Tolerance Wealth Processes and Sensitivity Analysis of Utility Based Prices
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Abstract: We present the asymptotic analysis of the marginal utility based prices of contingent claims in incomplete financial models with respect to the number of these claims held in the portfolio. Our main result states that such an approximation preserves a number of important qualitative properties of the original utility based prices if and only if there is a risk-tolerance wealth process. The talk is based on a joint paper with Mihai Sirbu.

2:20	Discussion	
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2:30	Coffee Break	Reception Room EE/CS 3-176
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3:00	Second Chances	Speakers of the day respond to further questions, suggestions, re-frame their main points, look toward future directions.
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6:00	Workshop Dinner	Mangia, 1501 University Ave. S.E.
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Friday, May 7

NOTE THE ABBREVIATED SCHEDULE FOR FRIDAY; FIRST TALK AT 9:10.
All talks are in Lecture Hall EE/CS 3-180 unless otherwise noted.

9:00	Coffee	Reception Room EE/CS 3-176
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9:10	Srdjan D. Stojanovic University of Cincinnati	Pricing Options Under Stochastic Volatility: Complete Solution
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Abstract: We have found, at least from the practical point of view, the complete solution of the option pricing problem for underlying securities obeying stochastic volatility price dynamics. In particular, we have found the exact expression for the “market price of volatility risk.” The pricing problem is reduced to solving an uncoupled system of a Monge-Ampère

type PDE and a Black-Scholes type PDE. The general problem of hedging in such an environment is solved too. Results of computational experiments will be presented as well.

See <http://math.uc.edu/~srdjan/StojanovicPreprintStochasticVolatility.pdf> for a complete version of the paper.

10:00	Discussion	
10:10	Coffee Break	Reception Room EE/CS 3-176
10:20	Louis Scott Morgan Stanley & Co.	Stochastic Volatility and Jumps: Risk Management and Hedging Strategies

Abstract: The talk covers stochastic volatility and jumps from a risk management perspective. Various topics include gap risk in the underlying prices, gap risk in the option implied volatilities, and some analysis of the effects on the greeks (risk exposures). Examples for stock index options are covered. Question: what should you do with the skew in a stress test for stock prices? A typical stress test is to decrease stock prices by 20% and increase the at-the-money implied volatilities by something more than 20%.

11:10	Discussion	
11:20	Coffee Break	Reception Room EE/CS 3-176
11:30	Second Chances	Speakers of the day respond to further questions, suggestions, re-frame their main points, look toward future directions.
11:50	Concluding Remarks by Organizers	
12:00	End of Workshop	

Monday, May 10

The 3:00 IMA break will be in Lind Hall 400.

Tuesday, May 11

IMA “Hot Topics” Workshop:
Compatible Spatial Discretizations for Partial Differential Equations

11–15 May 2004

Organizers: Douglas N. Arnold (University of Minnesota), Pavel Bochev (Sandia National Laboratories), Rich Lehoucq (Sandia National Laboratories), Roy Nicolaides (Carnegie-Mellon University), Mikhail Shashkov (Los Alamos National Laboratory),

Supported by the Department of Energy.

See <http://www.ima.umn.edu/complex/spring/discretization.html>

The numerical solution of partial differential equations (PDE) is a fundamental task in science and engineering. The goal of the workshop is to bring together a spectrum of scientists at the forefront of the research in the numerical solution of PDEs to discuss compatible spatial discretizations. We define compatible spatial discretizations as those that inherit or mimic fundamental properties of the PDE such as topology, conservation, symmetries, and positivity structures and maximum principles. A wide variety of discretization methods applied across a wide range of scientific and engineering applications have been designed to or found to inherit or mimic intrinsic spatial structure and reproduce fundamental properties of the solution of the continuous PDE model at the finite dimensional level. A profusion of such methods and concepts relevant to understanding them have been developed and explored: mixed finite element methods, mimetic finite differences, support operator methods, control volume methods, discrete differential forms, Whitney forms, conservative differencing, discrete Hodge operators, discrete Helmholtz decomposition, finite integration techniques, staggered grid and dual grid methods, etc. This workshop seeks to foster communication among the diverse groups of researchers designing, applying, and studying such methods as well as researchers involved in practical solution of large scale problems that may benefit from advancements in such discretizations; to help elucidate the relations between the different methods and concepts; and to generally advance our understanding in the area of compatible spatial discretization methods for PDE.

Particular points of emphasis will include:

- Identification of intrinsic properties of PDE models that are critical for the fidelity of numerical simulations.
- Identification and design of compatible spatial discretizations of PDEs, their classification, analysis, and relations.
- Relationships between different compatible spatial discretization methods and concepts which have been developed;
- Impact of compatible spatial discretizations upon physical fidelity, verification and validation of simulations, especially in large-scale, multiphysics settings.
- How solvers address the demands placed upon them by compatible spatial discretizations.

All talks are in Lecture Hall EE/CS 3-180 unless otherwise noted.

8:30	Coffee and Registration	Reception Room EE/CS 3-176
9:15	IMA Directors and Organizers	Welcome and Introduction
9:30	Douglas N. Arnold IMA	Differential Complexes and Stability of Finite Element Methods

Abstract: Many of the partial differential equations of mathematical physics are related to differential complexes which determine their structure and well-posedness. Many successful finite element discretizations of these problems can best be understood as arising from piecewise polynomial subcomplexes. The stability of these methods is obtained by relating the

discrete subcomplex to the continuous differential complex via a commuting diagram. The best known case is the de Rham complex, which underlies both electromagnetic and diffusion problems. In this case there are a large number of possible piecewise polynomial subcomplexes of each order. These can be presented systematically using the Koszul complex. The elasticity equations are related to another differential complex which can be related to the de Rham complex through a subtle homological construction. This has led to recent progress in the design of stable mixed finite elements for elasticity in two and three dimensions.

10:20 **Discussion and break**

11:00	Roy Nicolaides Carnegie Mellon University	Compatible Discretizations, Covolume Algorithms and Differential Forms
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Abstract: “Compatible discretizations” have become prominent during the last few years, although they have been under development for at least 15 years. In the finite element setting they are exemplified by “edge” and related elements. Less well known are “mimetic” and “covolume” discretizations which may be considered as generalized finite difference techniques. In most compatible discretizations there are good analogs of exact sequence diagrams, ensuring the existence of analogs of vector identities that are valuable for obtaining good error estimates and reliable numerical results. The covolume approach uses “complementary volumes” to achieve compatible discretizations. The complementary volumes are typically tetrahedra and their corresponding Voronoi polyhedra. Use of these dual meshes is what distinguishes the covolume methodology from other compatible discretizations. This talk will begin with a review of the basic covolume methodology and use it to illustrate the main ideas of compatible discretization, exact sequences of spaces and so forth. Following that it will be shown how the covolume technique can be used to discretize differential forms. There is a remarkable parallel between certain operations on differential forms and the basic constructs appearing in covolume approximations. These will be discussed along with applications to partial differential equations on manifolds.

11:50 **Discussion and lunch break**

1:30	Mikhail Shashkov Los Alamos National Laboratory	Mimetic Finite Difference Methods for Partial Differential Equations and Discrete Vector and Tensor Analysis
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Abstract: In past 10 years we have developed new high-quality, mimetic finite-difference methods based on discrete analog of vector and tensor analysis (DVTA). The basis of DVTA is the design of discrete operators that preserve certain essential properties of, and relationships between, the corresponding analytic operators. The DVTA is the basis for new techniques for large-scale numerical simulations approximating the solution of partial differential equations (PDEs). The new methods provide a significant extension of the well known and useful finite volume methods and are designed to more faithfully represent important properties of physical processes and the continuum mathematical models of such processes. Algorithms based on these techniques are used for modeling high-speed flows, porous media flows, diffusion processes, and electromagnetic problems. In this presentation we will describe DVTA and demonstrate how it can be used to construct high-quality finite-difference methods for PDEs.

2:20 **Discussion and break**

3:00	Second Chances	Speakers of the day respond to further questions, suggestions, re-frame their main points, look toward future directions.
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3:30 **Group Photo**

3:40	IMA Tea and more (Reception and Poster Session)	400 Lind Hall
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poster

Peter Arbenz
ETH Zürich

Eigenvalue Solvers for Electromagnetic Fields in Cavities

Abstract: Joint work with M. Becka, Institute of Computational Science, ETH Zurich R. Geus, Paul-Scherrer Institute, Villingen U. Hetmaniuk, Sandia National Laboratories, Albuquerque.

We investigate the Jacobi-Davidson algorithm for computing a few of the smallest eigenvalues of a generalized eigenvalue problem resulting from the finite element discretization of the time-harmonic Maxwell equation. Various multilevel preconditioners are employed to improve the convergence rate and memory consumption of the eigensolver. We present sequential results of very large eigenvalue problems originating from the design of resonant cavities of particle accelerators. Furthermore we detail our approach for parallelizing our code by means of the Trilinos software framework.

poster

Martin Berggren
Uppsala University

A Vertex-Centered Dual Discontinuous Galerkin Method

Abstract: I will present a new discontinuous Galerkin method for discretizing partial differential equations with a dominating hyperbolic character. At lowest order, the method reduces to a vertex-centered finite-volume method with control volumes based on a dual mesh, and the method can be implemented using an edge-based data structure. Preliminary tests on a model linear hyperbolic equation in 2D indicate a favorable qualitative behavior for nonsmooth solutions, and an optimal convergence rate for smooth solutions when using locally piecewise-linear approximations.

poster

Panagiotis Chatzipantelidis
Texas A&M University

A Finite Volume Element Method for a Nonlinear Elliptic Problem

Abstract: Joint work with: V. Ginting and R.D. Lazarov.

We consider a finite volume discretization of second order nonlinear elliptic boundary value problems on polygonal domains. For sufficiently small data, we show existence and uniqueness of the finite volume solution using a fixed point iteration method. We derive error estimates in H^1 -, L^2 - and L -norm. In addition a Newton's method is analyzed for the approximation of the finite volume solution and numerical experiments are presented.

poster

Snorre H. Christiansen
University of Oslo

Div-curl Lemma for Edge Elements

Abstract: A variant of Murat and Tartar's div-curl lemma is stated and proved for Nedelec's edge elements. In the Galerkin finite element setting one can expect control of L^2 norms of vectorfields and also sufficient control of their curls in H^{-1} . But the divergence is usually just controlled through the integral of the vectorfields against a finite dimensional space of gradients. The proposed lemma is designed to handle this case. The proof uses a uniform norm equivalence related to discrete compactness properties of vector FE spaces and a super-approximation property of scalar FE spaces.

poster

Leszek Demkowicz
The University of Texas at Austin

De Rham Diagram for Projection-Based Interpolation. 3D Optimal p- and hp-Error Estimates

Abstract: I will present the main idea and results for the commuting de Rham diagram for polynomial spaces corresponding to 3D finite elements of variable order generalizing Nedélec tetrahedrons of the first and second type, hexahedron of the first type¹, and prisms of the first and second type. I will discuss shortly the generalization to parametric elements, including the most popular isoparametric elements. For instance, for the tetrahedron of the second type, we have,

$$\begin{array}{ccccccc}
 \mathbb{R} & \rightarrow & H^{\frac{3}{2}+\epsilon}(T) & \xrightarrow{\nabla} & \mathbf{H}^\epsilon(\text{curl}, T) \cap \mathbf{H}^{\frac{1}{2}+\epsilon}(T) & \xrightarrow{\nabla \times} & \mathbf{H}^\epsilon(\text{div}, T) & \xrightarrow{\nabla \circ} & L^2 \\
 \downarrow id & & P^1 \downarrow \Pi & & P^{curl} \downarrow \Pi^{curl} & & P^{div} \downarrow \Pi^{div} & & \downarrow P \\
 \mathbb{R} & \rightarrow & \mathcal{P}_{p_e+1, p_f+1}^{p+1} & \xrightarrow{\nabla} & \mathbf{P}_{p_e, p_f}^p & \xrightarrow{\nabla \times} & \mathbf{P}_{p_f-1, p_e}^{p-1} & \xrightarrow{\nabla \circ} & \mathcal{P}^{p-2}
 \end{array}$$

¹Nedélec's hexahedron of the second type does not satisfy the commuting diagram property

hand, cohomology theory may not be intuitive, but it does provide a formal connection between Maxwell's equations and the lumped parameters occurring in Kirchhoff's laws. Also, cohomological information is efficiently extracted from the data structures used in finite element analysis. A natural question is: Do engineers need to go beyond the linear algebra and sparse matrix techniques associated with homology calculations? It turns out that there are inverse problems involving "near force-free magnetic fields" where the conjectured characterization of the space of solutions, involves computationally intractable topological invariants. Hence, it is imperative to investigate algebraic structures found in the data structures of finite element analysis, which yield topological insights not deducible from cohomological considerations alone.

The Hurewicz map is a well-defined map taking representatives of generators of homotopy groups to their homology classes. In this sense, it provides a natural framework for comparing the intuitive but intractable with the computable but less intuitive. The presentation will develop this theme in the context of computational electromagnetics.

Recent work:

1. Kotiuga, P. R., Topology-Based Inequalities and Inverse Problems for Near Force-Free Magnetic Fields, IEEE Trans. MAG. March 2004.
2. Gross, P. W., Kotiuga, P. R., Electromagnetic Theory and Computation: A Topological Approach. MSRI Monograph series # 48; Cambridge U. P., 2004. ISBN # 0521801605.
3. Suuriniemi, S., Kettunen, L., Kotiuga, P. R., Techniques for Systematic Treatment of Certain Coupled Problems. IEEE Trans. MAG-39, (3), May 2003, pp 1737–1740.

poster

Melvin Leok
Caltech

Discrete Connections on Principal Bundles

Abstract: Connections on principal bundles play a fundamental role in expressing the equations of motion for mechanical systems with symmetry in an intrinsic fashion. A discrete theory of connections on principal bundles is constructed by introducing the discrete analogue of the Atiyah sequence, with a connection corresponding to the choice of a splitting of the short exact sequence.

Equivalent representations of a discrete connection are considered, and an extension of the pair groupoid composition, that takes into account the principal bundle structure, is introduced. Computational issues, such as the order of approximation, are also addressed. Discrete connections provide an intrinsic method for introducing coordinates on the reduced space for discrete mechanics, and provide the necessary discrete geometry to introduce more general discrete symmetry reduction.

In addition, discrete analogues of the Levi-Civita connection, and its curvature, are introduced by using the machinery of discrete exterior calculus, and discrete connections.

This is part of a broader program to develop discrete analogues of differential geometry which are relevant to the systematic construction of computational geometric mechanics.

Joint work with Jerrold E. Marsden (Caltech) and Alan D. Weinstein (Berkeley).

poster

Konstantin Lipnikov
Los Alamos National Laboratory

New Mimetic Discretizations of Diffusion-Type Problems on Polygonal Meshes

Abstract: The determining factor for reliability, accuracy, and efficiency of simulations is accurate locally conservative discretizations. Practice experience shows that the most effective discrete approximations preserve and mimic the underlying properties of original continuum differential operators. One of such approaches, the mimetic finite difference technique based on the support-operator methodology, has been applied successfully to several applications including diffusion, electromagnetics and gas dynamics.

As mathematical modeling becomes more sophisticated, the need for discretization methods handling meshes with mixed types of elements has arisen. On this poster we present new mimetic discretizations on polygonal meshes. AMR meshes, non-matching meshes and meshes with non-convex cells are important examples of polygonal meshes.

Nowadays, a limited use of polygonal meshes is restricted by a small number of accurate discretization schemes. We describe the new mimetic discretizations for a diffusion-reaction problem formulated as a system of two first-order equations. The discretization technique results in a method which is exact for linear solutions. The method is second order accurate for general problems with or without material discontinuities and relatively easy to solve (it produces a symmetric positive definite matrix). The new discretization technique can be extended to polyhedral meshes and some other PDEs.

poster **E. L. Mansfield** Towards a Variational Complex of the Finite Element
University of Kent at Canterbury Method

Abstract: Exact differential complexes are important in the design of finite element approximate schemes. This poster starts with these and discusses how they may be extended to a full variational complex. The motivation is to be able to answer the question, “Can you design a finite element scheme for a system which inherits both variational principle and certain pre-selected conservation laws exactly?” This is joint work with Reinout Quispel (Latrobe University, Australia).

poster **Iliia D. Mishev** Why Mixed Finite Elements are not used in the Petroleum
Exxon-Mobil Industry and what can we do about it?

Abstract: The purpose of this poster is to invigorate the dialogue between the academia and the industry. We start with a short description of the most common formulation used in the petroleum industry to model the fluid flow in porous media and discuss what are the implications for the discretizations. One approach based on primal dual Mixed Finite element method will be considered and some examples given.

poster **Iliaria Perugia** Discontinuous Galerkin Methods for Maxwell’s Equa-
Università di Pavia tions in Frequency-Domain

Abstract: We present recent work on discontinuous Galerkin (DG) methods for the discretization of the Maxwell equations in frequency-domain, based on employing the interior penalty discretization of the curl-curl operator. Direct and mixed methods will be considered for both low-frequency and high-frequency regimes. The performance of the proposed DG methods for Maxwell problems will be demonstrated on a series of model problems with both smooth and singular analytical solutions. Our theoretical and numerical results indicate that DG methods provide viable alternatives to classical conforming edge element discretization schemes.

Joint work with Paul Houston and D. Schoetzau.

poster **Robert N. Rieben** High Order Symplectic Integration Methods for Finite El-
Lawrence Livermore National Labora- ment Solutions to Time Dependent Maxwell Equations
tory

Abstract: We motivate the use of high order integration methods for compatible finite element solutions of the time dependent Maxwell equations. In particular, we present a symplectic algorithm for the integration of the coupled first order Maxwell equations for computing the time dependent electric and magnetic fields in a mixed finite element approach. Symplectic methods have the benefit of conserving total electromagnetic field energy and are therefore preferred over dissipative methods (such as traditional Runge-Kutta) in applications that require high-accuracy and energy conservation over long periods of time integration. We present a conditionally stable, explicit time integration scheme that is up to 5th order accurate along with some numerical examples which demonstrate the superior performance of high order time integration methods.

poster **Beatrice Riviere** Two-Phase Flow Modeling
University of Pittsburgh

Abstract: This poster presents a high order finite element method that naturally handles unstructured meshes and heterogeneous porous media for solving the incompressible two-phase flow problem. In the proposed algorithm, the primary variables are the wetting phase pressure and saturation. They are approximated by discontinuous polynomials of varying degree. The flexibility of discontinuous Galerkin methods has made these methods competitive for modeling flow and transport problems. Some of the advantages include the high order approximation, the easy implementation on unstructured grids, the robustness of the method for equations with discontinuous coefficients and the local mass conservation property. Numerical simulations are given for homogeneous and heterogeneous porous media

poster **Allen C. Robinson** Compatible Discretizations in Lagrangian/Eulerian Resis-
Sandia National Laboratories tive MHD Modeling for Z-pinch Applications

Abstract: We give an overview of the use of compatible discretization techniques used in resistive magnetohydrodynamic (MHD) modeling for Z-pinch simulations at Sandia National Laboratories. Z-pinch MHD physics is dominated by moving

material regions whose conductivity properties vary drastically as material passes through melt and plasma regimes. At the same time void regions are modeled as regions of very low conductivity. This challenging physical situation requires a sophisticated modeling approach matched by sufficient computational resources to make progress in physical understanding. An Arbitrary-Lagrangian-Eulerian (ALE) operator split methodology for modeling the MHD equations on unstructured grids is described. An implicit treatment of the magnetic diffusion equation, represented using low order vector edge and face elements, gives solutions free from parasitic transients. A matching algebraic multigrid must also be applied to deal with the large null space of the stiffness matrix. We also discuss the important issue of constrained transport remapping on unstructured grids and how this can be viewed in the framework of low order face elements. An important issue to be resolved associated with the constrained transport algorithm is the accurate reconstruction of the magnetic flux density field given information on the fluxes on element faces.

Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

poster	Rolf Schuhmann Technische Universität Darmstadt Institut für Theorie Elektromagnetischer Felder (TEMF)	Consistent Material Operators for Geometrical Discretization Methods on Generalized Grids
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Abstract: Geometrical methods for the spatial discretization of Maxwell's equation are able to preserve important properties, like the conservation of charge and energy and the orthogonality of solution spaces. The Finite Integration Technique (FIT) provides for a natural and efficient notation of such approaches, introducing separate matrix operators for (exact) topological and (approximate) material relations. The implementation of the material operators strongly depends on the type of computational grids, but must generally fulfill important consistency and stability properties. In this paper we investigate the accuracy and efficiency of some recently developed material operators for tetrahedral grids. Additionally it will be shown that the requirement for consistency leads to some surprising consequences for the overall simulation scheme.

Joint work with Marco Cinalli and Thomas Weiland.

poster	Rajen Kumar Sinha Texas A&M University	Finite Volume Element Methods for Parabolic Integro-Differential Equation with Nonsmooth Initial Data
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Abstract: Mathematical models describing the nonlocal reactive flows in porous media and heat conduction through materials with memory give rise to parabolic integro-differential equation. We present a semidiscrete finite volume element(FVE) approximation to parabolic integro-differential equation in a two-dimensional convex polygonal domain. More precisely, for homogeneous problem an energy method in conjunction with duality argument is used to obtain an optimal order L^2 -error estimate for positive time when the given initial function is only in L^2 . Analogous results are shown to hold for the error in negative Sobolev norms.

poster	Jean-Marie Thomas University of Pau, France	Finite Element Methods for Non-elliptic but Coercive Problems
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Abstract: One analyze finite element methods for a variational problem: find u in V such that $a(u, v) - k^2(u, v) = l(v)$ for any v in V , where (\cdot, \cdot) is the scalar product of an Hilbert space H , V is an Hilbert space with continuous imbedding of V into H and V is dense in H , $a(\cdot, \cdot)$ is a symmetric non-negative continuous bilinear form on $V \times H$ such that $a(\cdot, \cdot) + (\cdot, \cdot)$ is V -elliptic. Moreover we assume that k^2 is not an eigenvalue of the associated spectral problem. By the finite element method, the discrete problem associated to a finite dimensional subspace of V consists to find u_h in V_h such that $a(u_h, v_h) - k^2(u_h, v_h) = l(v_h)$ for any v_h in V_h . One look for an optimal a priori error bound similar to the Céa Lemma for elliptic problems. In some situations, this result is obtained as soon as h is sufficiently small. In the other situations, we show what additional property must verify V_h for obtaining again the optimal a priori error bound. Applications to the analysis of some time-harmonic systems from elastodynamics, aeroacoustics and electromagnetism will be presented. At last, primal and dual finite element approximations of the Helmholtz equation will be considered.

poster	Jukka Tuomela University of Joensuu	Formal Theory of PDEs and simulation of Fluid Flows
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Abstract: In many physical models there appear constraints or conserved quantities which make the system essentially overdetermined. We propose a new approach to solve numerically these kind of systems of PDEs which is based on the formal theory of PDEs. The idea is to find the involutive form of the system, and use it explicitly in the computations. The involutive form is important because many properties of the system cannot be determined if the system is not involutive. We illustrate our approach by considering a compressible flow problem.

Joint work with Bijan Mohammadi.

Wednesday, May 12

All talks are in Lecture Hall EE/CS 3-180 unless otherwise noted.

9:00	Coffee	Reception Room EE/CS 3-176
9:30	Pavel Bochev Sandia National Laboratories	Variational and Geometric Aspects of Compatible Discretizations

Abstract: PDE models arise in virtually all fields of science and engineering. Their compatible discretizations are finite dimensional models of the physical process that are stable and provide accurate and physically meaningful solutions.

Variational principles take advantage of the intrinsic connections between the structure of many PDEs and optimization problems to identify their compatible discretizations.

Differential complexes provide another tool to encode the structure of a PDE. Differential forms represent global quantities rather than fields, and provide a model for the way we observe the physical process. The idea that differential forms can and should be used to develop compatible (mimetic) discretizations started to permeate computational sciences approximately two decades ago and led to fundamental advances in computational electromagnetics.

Since then, geometrical approaches to discretization have enjoyed a steady and ever increasing interest and appreciation in computational sciences. The goal of this lecture is two-fold. I will show how variational and geometric techniques can complement each other in the quest for accurate and stable discretizations by providing tools for the analysis and the design of compatible models. In doing so I will retrace the key steps that have led to our modern understanding of these connections. To illustrate, as well as to compare and contrast variational identifications of compatibility, I will use the Kelvin and the Dirichlet principles. Factorization diagrams will reveal the geometrical structure of the problem and form the basis for the design of compatible discretizations. Then, with the help of the grid decomposition property and the commuting diagram property I will show the fundamental links between the two approaches.

I will conclude with examples of alternative discrete models that circumvent the rigid structural constraints imposed by compatibility and talk about the advantages and the perils associated with their use.

10:20	Discussion and break	
11:00	Alain Bossavit Laboratoire de Génie Electrique de Paris (LGEP)	Computational Electromagnetism and Whitney Forms

Abstract: This talk will give an overview of the use of Whitney forms in electromagnetism, from 1980 to now, and of desirable developments.

Edge elements (not to be known by that name until about 1986) allowed to solve eddy current problems in dimension 3, a notorious conundrum during the 70's. Within ten years, edge element discretization, Galerkin style, became the established method in computational electromagnetism, (CEM) while efforts to answer the question "why edge elements?" slowly fostered familiarity with Whitney forms and cohomology in the CEM community. Once the central place of cohomology and commutative diagrams was acknowledged, ideas about "mimetic" discretizations, equivalent network methods, etc., could develop in the 90's, and the order of the day, now, is to found an appropriate "discrete exterior calculus" – which holds promises far beyond electromagnetics. Lots of questions remain, however: Convergence issues, Whitney forms on non-simplicial meshes, in particular, will be addressed. (Some new results about the geometric interpretation of degrees

we are applying these algorithms to include: photonic bandgap structures, linear accelerators, wave propagation in random environments, and microwave circuits.

This represents joint work with Joe Koning and Rob Rieben.

4:00	Second Chances	Speakers of the day respond to further questions, suggestions, re-frame their main points, look toward future directions.
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Thursday, May 13

All talks are in Lecture Hall EE/CS 3-180 unless otherwise noted.

9:00	Coffee	Reception Room EE/CS 3-176
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9:30	Ivan Yotov University of Pittsburgh	Superconvergence in Some Locally Conservative Discretization Methods
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Abstract: Mixed finite element methods (MFEM), control-volume mixed finite element methods (CVMFEM), and mimetic finite difference methods (MFDM) are locally mass conservative discretization methods that perform well on diffusion-type problems with rough grids and coefficients. All methods provide accurate approximations of both the scalar variable (pressure) and its flux (velocity). Each method has advantages and disadvantages, which will be discussed. MFEM are naturally formulated as variational methods. CVMFEM were originally developed as finite volume methods, while MFDM are based on discrete operators that preserve critical properties of the differential operators. More recently, CVMFEM and MFDM have been formulated as variational methods and shown to be related to MFEM. We discuss how these relationships can be employed to establish superconvergence for CVMFEM and MFDM in both pressure and velocity. Extensions of these results to mortar discretizations on non-matching grids will also be discussed.

This talk reports on joint work with Markus Berndt, Konstantin Lipnikov, and Misha Shashkov, LANL, Tom Russell, University of Colorado Denver, and Mary Wheeler, University of Texas at Austin.

10:20	Discussion and break	
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11:00	Thomas F. Russell National Science Foundation	Relationships Among Some Locally Conservative Discretization Methods Which Handle Discontinuous Anisotropic Coefficients on Deformed Grids
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Abstract: This talk presents the relationships between some numerical methods suitable for a heterogeneous elliptic equation of the form $-\text{div}(K(x) \text{grad } p) = q$, motivated by applications to subsurface flow (pressure or potential) equations. The methods discussed are the classical Raviart-Thomas mixed finite element method (MFEM), the control-volume mixed finite element method (CVMFEM), the support operators method (SOM), the enhanced cell-centered finite difference method (ECCFDM), and the multi-point flux-approximation (MPFA) control volume method. These methods are all locally mass conservative, and handle general irregular grids with anisotropic and heterogeneous discontinuous conductivity $K(x)$. In addition to this, the methods have in common a weak continuity in the pressure across the edges, which in some cases corresponds to Lagrange multipliers. This weak continuity appears to be an essential property for the accuracy of these methods.

While the methods are applicable in two and three dimensions, the details of the above relationships are presented for logically rectangular quadrilateral grids in 2D. Issues of deformed grids are substantially more complex in 3D. An example (Naff, Russell, and Wilson, Computational Geosciences, 2002) is presented in which the Piola-transformed lowest-order Raviart-Thomas spaces fail to contain the constant-velocity vector fields for a hexahedron that is a trilinear image of a reference cube.

This represents joint work with R. A. Klausen and R. Winther of the University of Oslo, Norway.

11:50 **Discussion and lunch break**

1:30 **Mary Fanett Wheeler** Coupling of MFE or Mimetic Finite Differences with Dis-
The University of Texas at Austin continuous Galerkin for Poro-Elasticity

Abstract: In this presentation we discuss the modeling of Biot’s consolidation model for poro-elasticity in porous media. Here we employ a mixed finite element or a mimetic finite difference method for approximating the pore pressure and a discontinuous Galerkin method for approximating displacements. This approach yields a locally conservative flow field and continuous numerical fluxes and forces. Moreover numerical experiments indicate that the pore pressure is non-oscillatory even in low permeability regions. Theoretical error estimates and computational results will be presented to demonstrate this scheme.

2:20 **Discussion and break**

3:00 **Ivar Aavatsmark** MPFA Discretization on Quadrilateral Grids
University of Bergen

Abstract: The presentation will give an overview of the MPFA methods and its applications in multiphase flow in porous media. Recent progress on the theoretical side will be covered: Convergence proof for one MPFA method, monotonicity properties in the homogeneous case, new variants of the MPFA method, convergence properties when the Edwards splitting is used as preconditioner.

4:00 **Second Chances** Speakers of the day respond to further questions, sugges-
tions, re-frame their main points, look toward future di-
rections.

Friday, May 14

All talks are in Lecture Hall EE/CS 3-180 unless otherwise noted.

9:00 **Coffee** Reception Room EE/CS 3-176

9:30 **Eitan Tadmor** Entropy Stability Theory For Difference Approximations
University of Maryland, College Park of Quasilinear Problems

Abstract: We provide a general overview on the entropy stability of difference approximations in the context of quasilinear conservation laws, and related time-dependent problems governed by additional dissipative and dispersive forcing terms.

As our main tool we use a comparison principle, comparing the entropy production of a given scheme against properly chosen entropy-conservative schemes. To this end, we introduce closed-form expressions for new (families) of new entropy-conservative schemes, keeping the ‘perfect differencing’ of the underlying differential form. In particular, entropy stability is enforced on rarefactions while keeping sharp resolution of shock discontinuities.

A comparison with the numerical viscosities associated with these entropy-conservative schemes provides a useful framework for the construction and analysis of existing and new entropy stable scheme. We employ this framework for a host of first- and second-order accurate schemes. The comparison approach yields precise characterizations of entropy stable semi-discrete schemes for both scalar problems and multi-dimensional systems of equations. We extend these results to the fully discrete case, where the question of stability is settled under optimal CFL conditions using a complementary approach based on homotopy arguments.

10:20 **Discussion and break**

4:00	Second Chances	Speakers of the day respond to further questions, suggestions, re-frame their main points, look toward future directions.
6:00	Workshop Dinner	Bona, 802 Washington Ave S.E.

Saturday, May 15

All talks are in Lecture Hall EE/CS 3-180 unless otherwise noted.

9:00	Coffee Break	Reception Room EE/CS 3-176
9:30	Jim E. Morel Los Alamos National Laboratory	Asymptotic-Preserving Discretization Schemes

Abstract: Asymptotic limits associated with partial differential equations are limits in which certain nondimensional parameters in an equation are made “small” relative to other nondimensional parameters. The asymptotic solution is generally found to satisfy an equation that is much simpler than the original full equation. When the scale lengths associated with the asymptotic solution are much larger than the smallest scale lengths associated with the full equation, it becomes essential from a numerical point of view to use a discretization scheme for the full equation that “preserves” the asymptotic limit. An asymptotic-preserving scheme is one that yields accurate asymptotic solutions whenever the scale lengths associated with the asymptotic solution are resolved by the mesh. If a scheme is not asymptotic-preserving, accurate asymptotic solutions will be obtained only if the smallest scale lengths associated with the full equation are resolved by the mesh. Because asymptotic scale lengths can be arbitrarily larger than the smallest scale lengths of the full equation, this requirement can make asymptotic calculations prohibitively expensive for discretization schemes that are not asymptotic-preserving. We discuss spatial discretization schemes for the radiation transport equation in the asymptotic diffusion limit. The smallest spatial scale lengths associated with the transport equation are on the order of a mean-free-path (the mean-distance between particle interactions). A truncation error analysis for any consistent transport spatial discretization scheme will indicate that convergence to a smooth solution is guaranteed whenever the spatial cell widths measured in mean-free-paths go to zero. However, the scale length associated with the diffusion limit can be arbitrarily large with respect to a mean-free-path. Thus it can be essential to use asymptotic-preserving discretization schemes in highly diffusive calculations. We show that the simple upwind scheme does not preserve the asymptotic diffusion limit, while a discontinuous Galerkin scheme with a linear trial space does preserve this limit. Both theory and computational examples are presented.

10:20	Discussion and break	
11:00	Daniele Boffi Università di Pavia	Compatible Discretizations for Eigenvalue Problems

Abstract: We start with a short review of standard Galerkin approximation of variationally posed eigenvalue problems, where we mainly consider the case of elliptic problems associated with a compact resolvent. Our basic example is the Laplace/Poisson eigenvalue problem. The main result, in this case, can be summarized by the claim that any choice of discrete space sequence, which provides a convergent scheme for the source problem, automatically performs well when applied to the corresponding eigenvalue problem. The main discussion in this talk focuses on the approximation of eigenvalue problems in mixed form. Using again the basic example of the Laplace/Poisson eigenvalue problem, we show that, when using a mixed method for its discretization, the picture is somewhat different from the previous case. The main (counter) example is given by a choice of discrete space sequences such that the classical Brezzi’s conditions are satisfied (whence the source problem is correctly approximated) but, when the eigenvalue problem is considered, several spurious eigenmodes pollute the discrete spectrum. This surprising behavior is proved theoretically and numerically demonstrated. We then review the theory of the discretization of eigenvalue problems in mixed form (joint work with F. Brezzi and L. Gastaldi), where the compatibilities between the discrete space sequences for the good approximation

12:00

Srdjan Stojanovic
University of Cincinnati

Optimal Portfolio Series Formula under Dynamic Appreciation Rate Uncertainty

The IMA Brown Bag Seminar is organized by
Tim Garoni and Tamon Stephen.

Thursday, May 20

The 10:30 IMA break will be in Lind Hall 400.

COMPLEX SYSTEMS SEMINAR, Lind Hall 409:

1:30 pm

Luis Roman
Worcester Polytechnic Institute

A New Measure of Managers Performance Based on the
"Stochastic Discount Factor"

Abstract: Measuring a manager's performance has been the subject of extensive research in recent years, in particular for hedge funds since these are described as skill-based investment strategies. Skill-based strategies obtain returns from the unique skill or strategy of the trader. More recently, hedge fund returns have been shown to be driven largely by market factors such as changes in credit spreads or market volatility, so one can think of their returns as a combination of manager skill and an underlying return to the strategy itself. But, the question of whether fund managers can deliver expected returns in excess of naive benchmarks has long been controversial. Previous studies of hedge funds performance have used single- or multifactor models, and these are also referred to as unconditional approaches. On the other hand, another approach is based on the "Stochastic Discount Factor" (SDF), whose existence is granted in the absence of arbitrage opportunities. However, in general, controversy about results using the SDF, and how it should be implemented have occupied the minds of many researchers interested in performance evaluation. In this talk, we present a new measure of manager's performance assuming that the dynamics of the underlying assets are described by a system of stochastic differential equations. Under this new measure, some of the ambiguities surrounding the SDF can be clarified, and also, when applied to simple cases, it derives some equilibrium equations, which are variants of the Capita Asset Price Model (CAPM).

Friday, May 21

The 10:30 IMA break will be in Lind Hall 400.

Monday, May 24

**IMA Workshop:
Financial Data Analysis and Applications**

24–28 May 2004

Organizers: John C. Heaton (University of Chicago), Bruce N. Lehmann (University of California at San Diego), Andrew W. Lo (MIT),

See <http://www.ima.umn.edu/complex/spring/c9.html>

The use of large-scale econometric data in conjunction with asset pricing models is another aspect of the program. Historical data can be used to test new investment or hedging strategies and to analyze their risk characteristics. Finance theorists have recently used high frequency data to simulate trading strategies and better understand the structure of prices over short time scales. By organizing a workshop around data analysis and econometrics, we shall bring together the communities of quantitative model builders, or "financial engineers", specializing in PDEs and stochastic models, with econometricians, who employ primarily statistical tools.

All talks are in Lecture Hall EE/CS 3-180 unless otherwise noted.

8:30 **Coffee and Registration** Reception Room EE/CS 3-176

9:15 **Douglas N. Arnold, Scot Adams, and Organizers** Welcome and Introduction

9:30 **Philip H. Dybvig** Exploration of Interest Data
Washington University

Abstract: Absent unreasonably strong assumptions, financial theory places almost no restriction on interest rates and bond prices. If the short rate process exists (not even an implication of most preferences we study), then bond and interest derivative prices are given by expected discounted values using the rolled-over spot rate for discounting and risk-neutral (“martingale”) probabilities for computing expectations. Absent theoretical guidance, the choice of interest rate process should ideally be dictated by the data. This presentation explores the interest-rate process starting with the sample version of the quadratic variation of the three-year Treasury Bill discount process, using about 50 years worth of daily data from the Fed’s H15 tape. This analysis updates an analysis done in 1990 with an eye toward looking at the impact of what seems to be a unique regulatory and economic environment today, but the major conclusions are unchanged. A final comment relates the analysis to a result on parameter uncertainty from a FAJ paper with Bill Marshall.

10:20 **Discussion**

10:30 **Coffee Break** Reception Room EE/CS 3-176

11:00 **David E. Runkle** Title: TBA
Piper Jaffrey Company

11:50 **Discussion**

12:00 **Lunch Break**

1:30 **Narasimhan Jegadeesh** Value of Analyst Recommendations: International Evidence
Emory University

Abstract: This paper examines analyst recommendations in the G7 countries and evaluates the value of these recommendations over the 1993 to 2002 period. We find that the frequencies of sell and strong sell recommendations in all countries are far less than that of buy and strong buy recommendations. The frequency of sell recommendations is the lowest in the U.S. We also find that stock prices react significantly to recommendation revisions on the revision day and on the following day in all of these countries except Italy. We find the largest price reactions in the U.S., followed by Japan. We also evaluate trading strategies that buy upgraded stocks and sell downgraded stocks. Here again, we find the highest profits in the U.S., followed by Japan.

2:20 **Discussion**

2:30 **Coffee Break** Reception Room EE/CS 3-176

3:00	Second Chances	Speakers of the day respond to further questions, suggestions, re-frame their main points, look toward future directions.
3:30	Group Photo	
3:40	IMA Tea and more (with Poster Session)	400 Lind Hall
poster	Luca Benzoni University of Minnesota	Stochastic Volatility, Mean Drift, and Jumps in the Short-Term Interest Rate

Abstract: We find that an intuitively appealing and fairly manageable continuous-time model provides an excellent characterization of the U.S. short-term interest rate over the post Second World War period. Our three-factor jump-diffusion model consists of elements embodied in existing specifications, but our approach appears to be the first to successfully accommodate all such features jointly. Moreover, we conduct simultaneous and efficient inference regarding all model components, which include a shock to the interest rate process itself, a time-varying mean reversion factor, a stochastic volatility factor and a jump process. Most intriguingly, we find that the restrictions implied by an affine representation of the jump-diffusion system are not rejected by the U.S. short rate data. This allows for a tractable setting for associated asset pricing applications.

Joint work with Torben G. Andersen (Northwestern University) and Jesper Lund (Nykredit Bank).

poster	Rohitha Goonatilake Texas A&M International University	Development, Evaluation and Analysis of a 20-Year Deferred Annuity Product
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Abstract: This project analyzes an annuity product that suits the needs of today's American family under moderate assumptions. It helps in the study of the pricing accuracy in a mutual life insurance company and to better understand the extent of the analysis and computations involved in developing a 20-year deferred annuity product designed for a group of 1000 people; ages ranging from 30 - 40 years and having a 5 year old child.

poster	Vladimir Kurenok University of Wisconsin-Green Bay	On a Model for the Term Structure of Interest Rate Processes of Stable Type
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Abstract: See <http://www.ima.umn.edu/complex/abstracts/kurenok-abstract.pdf>

poster	Nick Laskin University of Toronto	Jump Dynamics and Stochastic Volatility for Stock Returns
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Abstract: We develop approach to model components of return distribution, which are assumed to be led by a news arrival random process. It is assumed that the compound generalized Poisson process governs information arrivals. The compound generalized Poisson process captures long-memory effect, which results in non-exponential distribution of interarrival times. The conditional variance of returns is decomposed into two components, a smoothly evolving component for standard diffusion of past news impacts and the component related to the information arrival process that generates jump stream with fractional statistics. The developed model predicts impact of large changes in stock returns on volatility. Empirical evidence of the impact jump versus normal return innovations and time-series of jump clustering has been presented.

poster	Kiseop Lee University of Louisville	Estimation of Liquidity Risk by Multiple Change-Point Models
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Abstract: Liquidity risk is often defined as the additional risk in the market due to the timing and size of a trade. Based on a pioneering work of Cetin et al., we develop an estimation method which is practically of use. Our new method estimates

econometricians model UHF data as a MPP, they view UHF data as an irregularly-spaced time series. Here, we take the angle of probabilists and view UHF data as an observed sample path of a marked point process (MPP). Then, we propose a general filtering model for UHF data where the signals are latent processes with time-varying parameters and the observations are in a generic mark space with other observable factors. The latent process and parameters are jointly modeled by a martingale problem and the observable factors are allowed in the stochastic intensity kernel of the MPP. In this way, we obtain a unified framework for many existing models for UHF data.

The powerful tools of stochastic filtering are introduced for developing the statistical foundations of the proposed model. The likelihoods, posterior, likelihood ratios and Bayes factors, are studied. They all are of continuous time, of infinite dimension and are characterized by stochastic differential equations such as filtering equations. To calculate, for example, likelihoods or posterior of a proposed model, consistent algorithms are required. Mathematical foundations for consistent, efficient algorithms are established. There are two general approaches for constructing recursive algorithms. One approach is Kushner's Markov chain approximation method, and the other is *Sequential Monte Carlo* method or *particle filtering* method. The latter approach is more attractive in that it can mitigate and even avoid the "curse of dimensionality" in complex models. Especially, Bayesian inference (estimation and model selection) via filtering are developed for the proposed model.

Tuesday, May 25

All talks are in Lecture Hall EE/CS 3-180 unless otherwise noted.

9:00	Coffee	Reception Room EE/CS 3-176
9:30	Dean Foster University of Pennsylvania	Ponzironi: The Search for Statistically Significant Excess Returns

Abstract: Almost everyone you talk to claims to have a scheme that "beats the market." How should we test such claims? We created a test (based on Bennett's inequality) that only assumes that CAPM excess returns should be martingale. But the claimants scoff at our test and say that it doesn't have sufficient power to show the beauty of their scheme.

With tongue firmly in cheek, we will provide a few schemes that will pass any weakening of our test. This has been a wonderful teaching aid, since the schemes are understandable to MBAs. Finally we will revisit Fama and French's book to market ratio as a way of generating excess returns and ask does it have enough jump to pass our statistical test.

Joint work with Robert A. Stine.

10:20	Discussion	
10:30	Coffee Break	Reception Room EE/CS 3-176
11:00	Ruey S. Tsay University of Chicago	Efficient Estimation of Stochastic Diffusion Models with Leverage Effects and Jumps

Abstract: This talk is concerned with estimating stochastic diffusion models with leverage effects and with or without jumps. Several methods have been proposed in the literature to estimate such models including efficient method of moments (EMM) and Markov chain Monte Carlo (MCMC) method. For MCMC methods, most of the existing methods cannot deal with leverage effects or require intensive computation. We discuss the difficulties of the estimation problem and propose a modified method that can estimate the model efficiently. Simulation and real examples are used to compare estimation results of various methods.

11:50	Discussion	
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12:00 **Lunch Break**

1:30 **Steven Kou** A Tale of Two Growths: Modeling Stochastic Endogenous Growth and Growth Stocks
Columbia University

Abstract: his paper extends the deterministic endogenous R&D growth model to a stochastic endogenous growth model, which is used to study growth stocks. The model provides an understanding of the links between economic growth, monopolistic competition in R&D, and the valuation of growth stocks. With the presence of stochastic shocks, the model leads to a decomposition of the value of growth stocks. The decomposition implies that the value of growth stocks should be very volatile, while the long-run average return is roughly equal to the growth rate of R&D labor. The model also explains an empirical size distribution puzzle observed for the cross-sectional study of growth stocks.

2:20 **Discussion**

2:30 **Coffee Break** Reception Room EE/CS 3-176

3:00 **Second Chances** Speakers of the day respond to further questions, suggestions, re-frame their main points, look toward future directions.

3:30 **Walk along the Mississippi, weather permitting**

Wednesday, May 26

All talks are in Lecture Hall EE/CS 3-180 unless otherwise noted.

9:00 **Coffee** Reception Room EE/CS 3-176

9:30 **Michael A. H. Dempster** Modelling the Global FX Market
University of Cambridge & Cambridge
Systems Associates Limited

Abstract: This talk reports on work undertaken with the support of HSBC to understand the \$1.4 B per day global currency market. After a general introduction, the detailed structure of the global FX market will be described with a focus on the roles of the major market makers and the EBS and Reuters 3000 electronic interdealer markets. Next modelling individual agents, traders and market makers with computational learning techniques based on extensive quote, trade, agent order flow and order book data seen by a market maker will be reported. Finally, work in progress to construct realistic agent simulation models of the essence of the global market will be discussed which attempts to capture the current mechanisms of price discovery – at least over intervals shorter than those at which macroeconomic fundamentals are thought to dominate market movements.

10:20 **Discussion**

10:30 **Coffee Break** Reception Room EE/CS 3-176

11:00	J. Doyne Farmer Santa Fe Institute	Modeling Liquidity, Risk and Transaction Costs in the London Stock Exchange Using Low Intelligence Agents
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Abstract: I will present a variety of empirical results based on a study of the London Stock Exchange. The data set contains about 350M events, including every action by every trader on every stock, making it possible to reconstruct the limit order book at any instant in time. This study has generated a variety of new empirical results, including a characterization of the approximate power law behavior and long-memory effects associated with price returns, order placement, and the spread. My collaborators and I have shown that price changes are largely driven by fluctuations in liquidity. A model for order flow is developed, that when simulated along with its impact on prices, explains many of statistical properties of the data very well. Finally, time permitting, I will present some preliminary results developing an agent ecology of arbitraguers who exploit liquidity demanders, and discuss their affect on prices. These results illustrate first, that there are many strong regularities in market behavior at the microstructure level, and second, that many aspects of these regularities can be understood based on what might be characterized as low intelligence models of agent behavior.

11:50	Discussion	
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12:00	Lunch Break	
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1:30	Greg Duffee University of California at Berkeley	A No-Arbitrage Term Structure Model Without Latent Factors
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Abstract: I present a framework for modeling part of the dynamics of the term structure. The framework can be used to link the term structure to observed variables such as inflation and output. Its partial nature allows us to dispense with yield-based factors (e.g., latent factors) while retaining restrictions associated with no-arbitrage. I apply the model to the joint dynamics of inflation and the term structure. As other research has noted, both short-term and long-term bond yields adjust gradually to a change in inflation. I find that the dynamics of the price of interest rate risk needed to fit this pattern from 1983 through 2003 are implausible. An alternative interpretation is that investors were systematically surprised by the slow adjustment of short-term yields to inflation.

2:20	Discussion	
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2:30	Coffee Break	Reception Room EE/CS 3-176
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3:00	Second Chances	Speakers of the day respond to further questions, suggestions, re-frame their main points, look toward future directions.
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Thursday, May 27

All talks are in Lecture Hall EE/CS 3-180 unless otherwise noted.

9:00	Coffee	Reception Room EE/CS 3-176
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9:30	Xavier Gabaix Massachusetts Institute of Technology	A Theory of Power Law Distributions in Financial Market Fluctuations
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Abstract: Insights into the dynamics of a complex system are often gained by focusing on large fluctuations. For the financial system huge databases now exist which facilitates the analysis of large fluctuations and the characterization of their statistical behavior [1,2]. Power laws appear to describe histograms of relevant financial fluctuations, such as fluctuations

2:30	Coffee Break	Reception Room EE/CS 3-176
3:00	Second Chances	Speakers of the day respond to further questions, suggestions, re-frame their main points, look toward future directions.
6:00	Workshop Dinner	Bona, 802 Washington Ave S.E.

Friday, May 28

All talks are in Lecture Hall EE/CS 3-180 unless otherwise noted.

9:00	Coffee	Reception Room EE/CS 3-176
9:30	Monika Piazzesi University of Chicago	Futures Prices as Risk-Adjusted Forecasts of Monetary Policy

Abstract: Many researchers have used federal funds futures rates as measures of financial markets' expectations of future monetary policy. However, to the extent that federal funds futures reflect risk premia, these measures require some adjustment for risk premia. In this paper, we document that excess returns on federal funds futures have been positive on average. We also document that expected excess returns are strongly countercyclical. In particular, excess returns are surprisingly predictable by employment growth and other business-cycle indicators such as Treasury yields and corporate bond spreads. Excess returns on eurodollar futures display similar patterns. We document that simply ignoring these risk premia has important consequences for the future expected path of monetary policy. We also investigate whether risk premia matter for conventional measures of monetary policy surprises.

10:20	Discussion	
10:30	Coffee Break	Reception Room EE/CS 3-176
11:00	Jun Liu University of California - Los Angeles	Risk, Return and Dividends

Abstract: We characterize the joint dynamics of expected returns, stochastic volatility, and prices. In particular, with a given dividend process, one of the processes of the expected return, the stock volatility, or the price-dividend ratio fully determines the other two. For example, the stock volatility determines the expected return and the price-dividend ratio. By parameterizing one, or more, of expected returns, volatility, or prices, common empirical specifications place strong implicit, and sometimes inconsistent, restrictions on the dynamics of the other variables. Our results are useful for understanding the risk-return trade-off, as well as the predictability of stock returns.

Joint work with Andrew Ang (Columbia University and NBER).

11:50	Discussion	
12:00	Lunch Break	

1:30 **Kent D. Daniel** Testing Factor-Model Explanations of Market Anomalies
Northwestern University

Abstract: A number of recent papers have attempted to explain the size and book-to-market anomalies with either (1) factor models based on economically motivated factors, or (2) with conditional CAPM or CCAPM models with economically motivated conditioning variables. These papers use similar methodologies and similar test assets, and generally fail to reject the proposed models. We argue that these tests may fail to reject because of low statistical power of the tests against reasonable alternative hypotheses, rather than because the models are consistent with the data. We propose an alternative test methodology with higher power against the proposed alternatives, and show that the new test methodology results in the rejection of several of the proposed factor models at high levels of significance.

2:20 **Discussion**

2:30 **Second Chances** Speakers of the day respond to further questions, suggestions, re-frame their main points, look toward future directions.

3:00 **Concluding Remarks by Organizers**

3:10 **End of Workshop**

Monday, May 31

Memorial Day, a University of Minnesota holiday. IMA offices will be closed.

PART III: CURRENT IMA PARTICIPANTS

FIRST YEAR POSTDOCTORAL MEMBERS

NAME	PREVIOUS INSTITUTION
Gerard Awanou	University of Georgia
Karen Ball	Indiana University
Antar Bandyopadhyay	UC Berkeley
Tim Garoni	University of Melbourne
Chuan-Hsiang Han	North Carolina State University
Lea Popovic	UC Berkeley

SECOND YEAR POSTDOCTORAL MEMBERS

NAME	PREVIOUS INSTITUTION
Olga Brezhneva	Russian Academy of Sci.
Herve Kerivin	University Blaise Pascal-France
Tamon Stephen	University of Michigan
Jing Wang	University of Minnesota

POSTDOCTORAL MEMBERS IN INDUSTRIAL MATHEMATICS

NAME	PREVIOUS INSTITUTION	INDUSTRIAL AFFILIATION
Lili Ju	Iowa State University	VA Hospital
Haewon Nam	Texas A & M University	GE
Jun Zhao	Texas A & M University	Schlumberger

LONG TERM VISITORS

NAME	HOME INSTITUTION
Greg Anderson	University of Minnesota
Hee-Jeong Baek	Seoul National University (BK 21 Math-SNU)
Peter Bank	Humboldt University of Berlin
Maury Bramson	University of Minnesota
Rene Carmona	Princeton University
Richard Falk	Rutgers
Hans Foellmer	Humboldt Universitat zu Berlin
Shmuel Friedland	University of Illinois - Chicago
Anne Gundel	Humboldt University Berlin
David C. Heath	Carnegie Mellon
Ulrich Horst	Humboldt Universitat zu Berlin
Naresh Jain	University of Minnesota
Mohammad Kazim Khan	Kent State University
Hye-Ryoung Kim	Seoul National University (BK 21 Math-SNU)
Hyejin Ku	York University
Thomas G. Kurtz	University of Wisconsin
Jeong Hyun Lee	Seoul National University (SRCCS)
Elizabeth L. Mansfield	University of Kent at Canterbury
Richard P. McGehee	University of Minnesota
Amir Niknejad	University of Illinois - Chicago
Greg Rempala	University of Louisville
Luis Jose Roman	Worcester Polytechnic Institute
Arnd Scheel	University of Minnesota
Mihai Sirbu	Carnegie Mellon
Srdjan Stojanovic	University of Cincinnati
Michael Stutzer	University of Colorado - Boulder
Hui Wang	Brown University
Ragnar Winther	Universitetet of Oslo
Yuhong Yang	Iowa State University
Ofer Zeitouni	University of Minnesota

VISITORS IN RESIDENCE (as of 27 April 2004)

Ivar Aavatsmark	Center for Integrated Petroleum Research	5/10/04 – 5/16/04
James J. Angel	Georgetown University	5/23/04 – 5/28/04
Peter Arbenz	ETH Zentrum	5/08/04 – 5/15/04
Clifford Ball	Vanderbilt University	5/23/04 – 5/28/04
Randolph E. Bank	University of California - San Diego	5/10/04 – 5/15/04
Timothy J. Barth	NASA Ames Research Center	5/08/04 – 5/16/04
Luca Benzoni	University of Minnesota	5/23/04 – 5/28/04
Martin Berggren	Uppsala University	5/10/04 – 5/15/04
Florin Bidian	University of Minnesota	5/24/04 – 5/29/04
Pavel Bochev	Sandia National Laboratories	5/10/04 – 5/15/04
James N. Jr. Bodurtha	Georgetown University	5/23/04 – 5/28/04
Daniele Boffi	Universita di Pavia	5/10/04 – 5/16/04
Alain Bossavit	Laboratoire de Genie Electrique de Paris	5/09/04 – 5/16/04
Franco Brezzi	I. A. N. del C. N. R.	5/10/04 – 5/15/04
Thaweepat Buranathiti	Northwestern University	5/10/04 – 5/15/04
Zhiqiang Cai	Purdue University	5/10/04 – 5/15/04
Colette Calmelet	Tennessee State University	5/02/04 – 5/07/04
James B. Carson	RisQuant Energy	5/03/04 – 5/07/04
James B. Carson	RisQuant Energy	5/24/04 – 5/28/04
Jose E. Castillo	San Diego State University	5/10/04 – 5/15/04

Michael Cavaretta	Ford Motor Company	5/22/04 – 5/28/04
Panagiotis Chatzipantelidis	Texas A & M University	5/11/04 – 5/15/04
Zhiwei Chen	University of Maryland	5/23/04 – 5/28/04
Snorre H. Christiansen	Centre of Mathematics for Applications	5/09/04 – 5/16/04
Mark Christon	Sandia National Laboratories	5/10/04 – 5/15/04
Pin Johnny Chung	Chung ALM	5/03/04 – 5/07/04
Pin Johnny Chung	Chung ALM	5/24/04 – 5/28/04
Gregory Ciresi	Courant Institute, New York University	5/02/04 – 5/07/04
Bernardo Cockburn	University of Minnesota	5/10/04 – 5/15/04
Pierre Collin-Dufresne	Cargenie Mellon University	5/05/04 – 5/06/04
Scott Collis	Sandia National Laboratories	5/10/04 – 5/15/04
Peter Cotton	Morgan Stanley	5/02/04 – 5/07/04
Kent D. Daniel	Northwestern University	5/23/04 – 5/28/04
Ron Dembo	Algorithmics Inc.	5/02/04 – 5/07/04
Leszek Demkowicz	University of Texas - Austin	5/10/04 – 5/15/04
Michael Dempster	Cambridge University	5/23/04 – 5/28/04
Hongjie Dong	University of Minnesota	5/11/04 – 5/15/04
Greg Duffee	University of California - Berkeley	5/02/04 – 5/07/04
Greg Duffee	University of California - Berkeley	5/23/04 – 5/28/04
Philip H. Dybvig	Washington University	5/03/04 – 5/05/04
Philip H. Dybvig	Washington University	5/23/04 – 5/28/04
Yalchin Efendiev	Texas A & M University	5/09/04 – 5/16/04
Bjorn Eraker	Duke University	5/02/04 – 5/07/04
Donald J. Estep	Colorado State University	5/10/04 – 5/15/04
J. Doynne Farmer	Santa Fe Institut	5/23/04 – 5/27/04
Stephen Figlewski	New York University	5/23/04 – 5/28/04
Paul F. Fischer	Argonne National Laboratory	5/10/04 – 5/15/04
Narryn Fisher	University of Maryland	5/23/04 – 5/29/04
Dean Foster	University of Pennsylvania	5/24/04 – 5/28/04
Jean-Pierre Fouque	North Carolina State University	5/03/04 – 5/05/04
Peter Fraenkel	Morgan Stanley & Co.	5/02/04 – 5/07/04
Evan Gatev	Boston College	5/23/04 – 5/28/04
Jurgen Geiser	University of Heidelberg	5/10/04 – 5/16/04
Paul Glasserman	Columbia University	5/02/04 – 5/07/04
Victor Goodman	Indiana University	5/23/04 – 5/28/04
Rohitha Goonatilake	Texas A&M International University	5/23/04 – 5/28/04
David Gottlieb	Brown University	5/10/04 – 5/15/04
Xinyang Gu	Ohio Public Employees Retirement System	5/23/04 – 5/28/04
Max Gunzburger	Florida State University	5/10/04 – 5/15/04
Haiming Guo	University of Maryland	5/22/04 – 5/28/04
Lars Hansen	University of Chicago	5/23/04 – 5/28/04
Martin Haugh	Columbia University	5/23/04 – 5/28/04
Bo He	Ohio State University	5/10/04 – 5/16/04
John C. Heaton	University of Chicago	5/23/04 – 5/28/04
Jan S. Hesthaven	Brown University	5/10/04 – 5/15/04
Ulrich Hetmaniuk	Sandia National Laboratories	5/10/04 – 5/15/04
Ralf Hiptmair	ETH Zentrum	5/08/04 – 5/15/04
Anil N. Hirani	California Institute of Technology	5/10/04 – 5/15/04
Michael J. Holst	University of California - San Diego	5/10/04 – 5/15/04
Ronald Hoppe	University of Houston	5/10/04 – 5/16/04
Paul Houston	University of Leicester	5/08/04 – 5/16/04
Thomas J.R. Hughes	University of Texas - Austin	5/10/04 – 5/15/04
Julien Hugonnier	HEC Montreal	5/02/04 – 5/07/04
E. Mckay Hyde	University of Minnesota	5/11/04 – 5/15/04
Eric Jacquier	HEC Montreal	5/23/04 – 5/28/04
Abu Jalal	University of Minnesota	5/03/04 – 5/07/04

Abu Jalal	University of Minnesota	5/24/04 – 5/28/04
Karel Janecek	Carnegie Mellon University	5/02/04 – 5/08/04
Narasimhan Jegadeesh	University of Illinois - Urbana-Champaign	5/24/04 – 5/28/04
Ning Ju	Oklahoma State University	5/10/04 – 5/15/04
Ruben Juanes	Stanford University	5/10/04 – 5/14/04
Yakov Kanter	Morgan Stanley	5/02/04 – 5/07/04
Ioannis Karatzas	Columbia University	5/23/04 – 5/28/04
George Karniadakis	Brown University	5/10/04 – 5/15/04
Prasanth Karumanchi	Purdue University	5/10/04 – 5/15/04
Prasanth Karumanchi	Purdue University	5/23/04 – 5/28/04
Andy Young Han Kim	University of Minnesota	5/24/04 – 5/28/04
Igor Kojanov	University of Minnesota	5/03/04 – 5/07/04
Igor Kojanov	University of Minnesota	5/23/04 – 5/28/04
Lancine Konate	University of Wisconsin	5/23/04 – 5/28/04
Joseph M. Koning	Lawrence Livermore National Laboratories	5/10/04 – 5/15/04
Robert P. Kotiuga	Boston University	5/10/04 – 5/15/04
Steven Kou	Columbia University	5/22/04 – 5/28/04
Dmitry Kramkov	Carnegie Melon University	5/04/04 – 5/09/04
Vladimir Kurenok	University of Wisconsin - Green Bay	5/23/04 – 5/29/04
Yuri Kuznetsov	University of Houston	5/10/04 – 5/16/04
Joseph A. Langsam	Morgan Stanley	5/02/04 – 5/07/04
Bernard Lapeyre	Ecole Nationale des Ponts et Chaussees	5/02/04 – 5/08/04
Nick Laskin	University of Toronto	5/23/04 – 5/28/04
Raytcho Lazarov	Texas A & M University	5/11/04 – 5/16/04
Kiseop Lee	University of Louisville	5/22/04 – 5/28/04
Bruce Lehmann	University of California - San Diego	5/23/04 – 5/28/04
Richard Lehoucq	Sandia National Laboratories	5/10/04 – 5/15/04
Melvin Leok	California Institute of Technology	5/10/04 – 5/15/04
Juyoung Lim	University of Texas - Austin	5/23/04 – 5/28/04
Konstantin Lipnikov	Los Alamos National Laboratory	5/10/04 – 5/16/04
Jun Liu	University of California - Los Angeles	5/23/04 – 5/28/04
Andrew Lo	Massachusetts Institute of Technology	5/23/04 – 5/28/04
Michael Ludkovski	Princeton University	5/01/04 – 5/08/04
Mitchell Luskin	University of Minnesota	5/11/04 – 5/15/04
Erzo Luttmmer	University of Minnesota	5/23/04 – 5/28/04
Huaqiang Ma	University of Maryland	5/23/04 – 5/30/04
Antoinette Maniatty	Rensselaer Polytechnic Institute	5/10/04 – 5/15/04
Donatella Marini	University of Pavia	5/10/04 – 5/15/04
Ilya D. Mishev	ExxonMobil Upstream Research Company	5/08/04 – 5/14/04
Julie C. Mitchell	University of Wisconsin	5/10/04 – 5/15/04
Oana Mocioalca	Purdue University	5/02/04 – 5/07/04
Jim Morel	Los Alamos National Laboratory	5/10/04 – 5/16/04
J. David Moulton	Los Alamos National Laboratory	5/10/04 – 5/15/04
Jean-Claude Nedelec	Ecole Polytechnique	5/10/04 – 5/16/04
Roy Nicolaides	Carnegie Mellon	5/10/04 – 5/15/04
Adam Oberman	University of Texas - Austin	5/10/04 – 5/15/04
Jun Pan	Massachusetts Institute of Technology	5/26/04 – 5/28/04
George C. Papanicolaou	Stanford University	5/01/04 – 5/06/04
Philippe P. Pebay	Sandia National Laboratories	5/10/04 – 5/15/04
Blair Perot	University of Massachusetts	5/10/04 – 5/16/04
Ilaria Perugia	Universita di Pavia	5/10/04 – 5/16/04
Monika Piazzesi	University of California - Los Angeles	5/23/04 – 5/28/04
Valery Y. Polkovnichenko	University of Minnesota	5/23/04 – 5/28/04
Allen M. Poteshman	University of Illinois - Urbana-Champaign	5/24/04 – 5/27/04
Jianliang Qian	University of California - Los Angeles	5/10/04 – 5/15/04
Curtis Randall	SciComp Inc.	5/05/04 – 5/06/04

Edward Ratner	KLA-Tencor	5/10/04 – 5/15/04
Fernando Reitich	University of Minnesota	5/10/04 – 5/15/04
Jean-Francois Remacle	Rensselaer Polytechnic Institute	5/10/04 – 5/15/04
Robert N. Rieben	Lawrence Livermore National Laboratories	5/10/04 – 5/15/04
Beatrice M. Riviere	University of Pittsburgh	5/10/04 – 5/16/04
Allen Robinson	Sandia National Laboratories	5/10/04 – 5/15/04
Mathias Rousset	Universite Paul Sabatier	5/01/04 – 5/07/04
David E. Runkle	Piper Jaffrey Company	5/24/04 – 5/28/04
Jeffrey R. Russell	University of Chicago	5/23/04 – 5/28/04
Thomas F. Russell	NSF	5/10/04 – 5/15/04
Rolf Schuhmann	Darmstadt University of Technology	5/08/04 – 5/15/04
Louis Scott	Morgan Stanley & Co.	5/04/04 – 5/07/04
Apo Sezginer	Invarium	4/29/04 – 5/01/04
Sally Shao	Cleveland State University	5/23/04 – 5/29/04
Mikhail Shashkov	Los Alamos National Laboratory	5/10/04 – 5/16/04
Shagi-Di Shih	University of Wyoming	5/10/04 – 5/15/04
Steven E. Shreve	Cargenie Mellon University	5/02/04 – 5/09/04
A. Christian Silva	University of Maryland	5/23/04 – 5/28/04
Kenneth J. Singleton	Stanford University	5/26/04 – 5/28/04
Rajen Kumar Sinha	Texas A & M University	5/10/04 – 5/15/04
Fallaw Sowell	Carnegie Mellon	5/23/04 – 5/28/04
Eugene H. Stanley	Boston University	5/23/04 – 5/28/04
Stanly Steinberg	University of New Mexico	5/10/04 – 5/15/04
Robert A. Stine	University of Pennsylvania	5/23/04 – 5/28/04
Eitan Tadmor	University of Maryland	5/12/04 – 5/15/04
Michael Tehranchi	University of Texas - Austin	5/23/04 – 5/28/04
Fernando Lisboa Teixeira	Ohio State University	5/10/04 – 5/16/04
Jean-Marie Thomas	Univ. of Pau and the Countries of Adour	5/10/04 – 5/15/04
Gary Nan Tie	The St. Paul Companies	5/03/04 – 5/07/04
Gary Nan Tie	The St. Paul Companies	5/24/04 – 5/28/04
Kathryn A. Trapp	Carnegie Mellon University	5/10/04 – 5/15/04
Ruey S. Tsay	University of Chicago	5/23/04 – 5/25/04
Vyacheslav G. Tsybulin	Rostov State University	5/10/04 – 5/15/04
Tracey Andrew Tullie	North Carolina A&T State University	5/23/04 – 5/28/04
Jukka Tuomela	University of Joensuu	5/10/04 – 5/16/04
Panayot Vassilevski	Lawrence Livermore National Laboratories	5/10/04 – 5/15/04
Alexander Vladimirsky	Cornell University	5/10/04 – 5/15/04
Hong Wang	University of Minnesota	5/03/04 – 5/07/04
Hong Wang	University of Minnesota	5/24/04 – 5/28/04
Xiaodi Wang	Western Connecticut State University	5/01/04 – 5/07/04
Xiaodi Wang	Western Connecticut State University	5/23/04 – 5/28/04
Yun Wang	University of Illinois - Urbana-Champaign	5/23/04 – 5/28/04
Zhenyu Wang	Columbia University	5/23/04 – 5/28/04
Tim Warburton	University of New Mexico	5/10/04 – 5/15/04
Mary Fanett Wheeler	University of Texas - Austin	5/10/04 – 5/15/04
Daniel A. White	Lawrence Livermore National Laboratories	5/10/04 – 5/15/04
Zhengxiao Wu	University of Wisconsin	5/23/04 – 5/29/04
Jinchao Xu	Pennsylvania State University	5/10/04 – 5/15/04
Hongtao Yang	University of Louisiana at Lafayette	5/23/04 – 5/28/04
Jian Yang	University of Illinois - Urbana-Champaign	5/23/04 – 5/28/04
Ivan Yotov	University of Pittsburgh	5/10/04 – 5/15/04
Yong Zeng	University of Missouri - Kansas City	5/02/04 – 5/07/04
Yong Zeng	University of Missouri - Kansas City	5/23/04 – 5/30/04
Bing Zhang	University of Maryland	5/23/04 – 5/30/04
Guofu Zhou	Washington University	5/23/04 – 5/28/04
Stanley E. Zin	Carnegie Mellon	5/23/04 – 5/28/04

See also URL: <http://www.ima.umn.edu/people/>