哈工大数学研究院成立 5 周年
暨数学学科博士点设立 35 周年系列学术活动

概率论专题研讨会

2021 年 7 月 8 日 - 10 日

哈尔滨工业大学一校区活动中心 2 楼 214 室

特邀报告人：

马志明	中国科学院，中科院院士
彭实戈	山东大学，中科院院士
严加安	中国科学院，中科院院士
陈增敬	山东大学，教授
董昭	中国科学院，研究员
方诗赞	法国 Bourgogne 大学，教授
巩馥洲	中国科学院，研究员
郭先平	中山大学，教授
李向东	中国科学院，研究员
李增沪	北京师范大学，教授
刘全升	法国 Bretagne-Sud 大学，教授
汤善健	复旦大学，教授
王凤雨	北京师范大学和天津大学，教授
吴臻	山东大学，教授
张土生	中国科学技术大学，教授
张希承	武汉大学，教授

会议组委会：吴黎明，靳水林，李科，田波平，王力，王智拓，张朝恩。

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会议网址：http://im.hit.edu.cn/2021/0618/c8390a255884/page.htm

腾讯会议号：7 月 8 日，834 495 106；7 月 9 日，981 957 685；密码为 1234。

会议日程

7 月 8 日

时间	开幕式		主持人
08:30-08:45	中国科学院院士哈工大常务副校长韩杰才教授致辞		吴黎明
08:45-08:50	合影		

时间	报告人	题目	主持人
09:00-10:00	马志明	信息与编码理论中的概率	吴勃英
10:00-10:20		茶歇	
10:20-11:05	李向东	Hamiltonian flow and Langevin deformation on Wasserstein space	刘伟
11:05-11:50	王凤雨	Exponential convergence in entropy and Wasserstein for McKean-Vlasov SDEs	

时间	报告人	题目	主持人
14:00-15:00	严加安	随机分析与金融数学	吴黎明
15:00-15:45	汤善健	Exponential utility maximization and indifference valuation with unbounded payoffs	
15:45-16:00		茶歇	
16:00-16:45	陈增敬	Two armed bandit problem and nonlinear limit theorems	李娟
16:45-17:30	张土生	Global well-posedness to stochastic reaction-diffusion equations with superlinear drifts driven by space-time white noise	
17:30-17:45		茶歇	
17:45-18:30	张希承	Cauchy problem of stochastic kinetic equations	李科

7 月 9 日

时间	报告人	题目	主持人
08:30-09:30	彭实戈	Distributional uncertainty of the financial time series measured by G-expecations	许全华
09:30-10:15	巩馥洲	Log-Sobolev Inequality on Path Space over Compact Riemannian Manifold Endowed with any Compatible Connection	
10:15-10:35		茶歇	
10:35-11:20	李增沪	A scaling limit theorem for Galton-Watson processes in varying environments	韩月才
11:20-12:05	董昭	Stability of rarefaction wave for stochastic Burgers equation	

时间	报告人	题目	主持人
14:20-15:05	吴臻	Pairs-trading under geometric Brownian motions: an optimal strategy with cutting losses	田波平
15:05-15:50	郭先平	Risk-sensitive piecewise deterministic Markov decision processes	
15:50-16:10		茶歇	
16:10-16:55	方诗赞	Some remarks on the geometry on the Wasserstein space	宋永生
16:55-17:40	刘全升	Convergence rate in the central limit theorem and precise moderate deviations for products of random matrices	

7 月 10 日

上午	自由讨论

报告摘要

7 月 8 日上午

信息与编码理论中的概率
马志明（中国科学院）

摘要：在信息和编码理论中要用到大量的概率。报告人将以香农容量、信源编码定理、信道编码定理，5G 极化码理论等为例，讲述信息编码理论与概率论的密切联系。同时简要介绍我们在这个方向的一些研究进展。

Hamiltonian flow and Langevin deformation on Wasserstein space
李向东（中国科学院）

Abstract: The Monge-Kantorovich optimal transport problem is a minimization problem on the Wasserstein space of probability measures. According to Benamous and Brenier, for the quadratic cost function, the optimal transport map or plan corresponds to the geodesic flow on the Wasserstein space equipped with Otto's Riemannian metric. In this talk, we consider the minimization problem for more general Lagrangian action and the related Hamiltonian flow on Wasserstein space. Moreover, we introduce the Langevin flow on Wasserstein space. The convergence of the Langevin flow will be studied. Joint work with Songzi Li.

Exponential Convergence in Entropy and Wasserstein for McKean-Vlasov SDEs
王凤雨（天津大学）

Abstract: By using Log-Harnack and Talagrand inequalities, the exponential convergence in entropy and Wasserstein distance is derived for both non-degenerate and

degenerate McKean-Vlasov SDEs. Main results are illustrated by non-degenerate or degenerate granular media type equations.

7 月 8 日下午

随机分析与金融数学
严加安（中国科学院）

摘要： 在这次演讲中，我将介绍我对概率论、随机分析和金融数学的一些贡献，包括局部鞅分解基本引理、指数鞅的一致可积性准则、本性下界和条件期望运算的可交换性、转移函数的密度公式、无穷维随机分析、Kreps-Yan 定理、金融数学中的资产定价基本定理和风险度量。

Exponential utility maximization and indifference valuation with unbounded payoffs
汤善健（复旦大学）

Abstract: We solve an exponential utility maximization problem with unbounded payoffs under general portfolio constraints, via the theory of quadratic backward stochastic differential equations with unbounded terminal data. This generalizes the previous work from the bounded to an unbounded framework. Furthermore, we study utility indifference valuation of financial derivatives with unbounded payoffs, and derive a novel convex dual representation of the prices. In particular, we obtain new asymptotic behavior as the risk aversion parameter tends to either zero or infinity.

This is a joint work with Ying Hu and Gechun Liang.

Two armed bandit problem and nonlinear limit theorems
陈增敬（山东大学）

Abstract: In this paper we introduce and study a Bernoulli-like model in the context of nonlinear probabilities, which we call the binary uncertainty model. This work is motivated mainly from the "two-armed bandit" problem. Our model provides a new way to study the "two-armed bandit" problem and, more generally, the distribution uncertainties. In one main result we obtain the central limit theorem for this model, and give an explicit formula for the limit distribution. The limit is shown to depend heavily on the structure of the events or the integrating functions, which demonstrate the key signature of nonlinear structure. We also establish the large deviation principle and, as an application, derive the weak law of large numbers. The large deviation rate function is identified explicitly. These limit theorems provide the theoretical foundation for statistical inferences.
Joint work with Larry Epstein and Feng Shui and Zhang Guodong.

Global well-posedness to stochastic reaction-diffusion equations with superlinear drifts driven by space-time white noise

张土生（中国科学技术大学）

Abstract: We are concerned with the global well-posedness of stochastic reaction-diffusion equations with logarithmic nonlinearity driven by space-time white noise on the whole real line. The essential obstacle is caused by the explosion of the supremum norm of the solution, making the usual truncation procedure invalid. In this paper, we prove that there exists a unique global solution to the stochastic reaction-diffusion equation on the whole real line with logarithmic nonlinearity. Because of the nature of the nonlinearity, to get the uniqueness, we are forced to work with the first order moment of the solutions on the space of continuous functions with a specially designed norm. Our approach depends heavily on the new, precise lower order moment estimates of the stochastic convolution and a new type of Gronwall's inequalities we obtained, which are of interest on their own right.

Cauchy Problem of Stochastic Kinetic Equations

张希承（武汉大学）

Abstract: In this paper we establish the optimal regularity estimates for the Cauchy problem of stochastic kinetic equations with random coefficients in anisotropic Besov spaces. As applications, we study the nonlinear filtering problem for a degenerate diffusion process, and obtain the existence and regularity of conditional probability densities under a few assumptions. Moreover, we also show the well-posedness for a class of super-linear growth stochastic kinetic equations driven by velocity-time white noises.

7 月 9 日上午

Distributional uncertainty of the financial time series measured by G-expecations
彭实戈（山东大学）

Abstract: Financial time series admits inherent uncertainty and randomness that changes over time. To clearly describe volatility uncertainty of the time series, we assume that the volatility of risky assets holds value between the minimum volatility and maximum volatility of the assets. This study establishes autoregressive models to determine the maximum and minimum volatilities, where the ratio of minimum volatility to maximum volatility can measure volatility uncertainty. By utilizing the value at risk (VaR) predictor model under volatility uncertainty, we introduce the risk and uncertainty, and show that the autoregressive model of volatility uncertainty is a powerful tool in predicting the VaR for a benchmark dataset.

Log-Sobolev Inequality on Path Space over Compact Riemannian Manifold Endowed with any Compatible Connection
巩馥洲（中国科学院）

Abstract: We construct a kind of vector field which is infinitesimal quasi-invariant about Wiener measure on path space over a compact Riemannian manifold endowed

with any compatible connection. Then the corresponding integration by parts formula, martingale representation theorem and log-Sobolev inequality are established.

A scaling limit theorem for Galton-Watson processes in varying environments

李增沪（北京师范大学）

Abstract: We prove a scaling limit theorem for discrete Galton-Watson processes in varying environments. A simple sufficient condition for the weak convergence in the Skorokhod space is given in terms of probability generating functions. The limit theorem gives rise to the continuous-state branching processes in varying environments studied recently by several authors.

Stability of rarefaction wave for stochastic Burgers equation

董昭（中国科学院）

Abstract: The large time behavior of strong solutions to the stochastic Burgers equation is considered in this paper. It is first shown that the unique global strong solution to the one dimensional stochastic Burgers equation time-asymptotically tend to a rarefaction wave provided that the initial data $u_0(x)$ satisfies $\lim\limits_{x\to\pm\infty} u_0(x) = u_\pm$ and $u_- < u_+$, that is, the rarefaction wave is non-linearly stable under white noise perturbation for stochastic Burgers equation. A time-convergence rate is also obtained. Moreover, an important inequality (denoted by Area Inequality) is derived. This inequality plays essential role in the estimates, and may have various applications in the related problems, in particular for the time-decay rate of solutions of both the stochastic and deterministic PDEs. As an application, the stability of planar rarefaction wave is shown stable for a two dimensional viscous conservation law with stochastic force. This is joint work with Feimin Huang, Houqi Su.

Pairs-Trading under Geometric Brownian Motions: An Optimal Strategy with Cutting Losses
吴臻（山东大学）

Abstract: In this talk, we introduce pairs trading under a geometric Brownian motion. Pairs trading is about simultaneously trading a pair of stocks. A pairs trade is triggered when their prices diverge and consists of a short position of the strong stock and a long position of the weak one. Pairs trading bets on the reversal of their price strengths. Here, we study the optimal pairs-trading problem under general GBMs with cutting losses, the objective is to trade the pairs over time to maximize an overall return with a fixed transaction cost. Trading with cutting losses is important in practice to limit risk exposure due to unexpected events. In control theory, this is associated with a hard state constraint which is difficult to deal with. In the talk, the optimal policy is characterized by threshold curves obtained by solving the associated HJB equations. We provide sufficient conditions that guarantee the optimality of our trading rules. A numerical example is also provided to illustrate how to implement the results in practice.
(This talk based on the joint paper in Automatica 115,2020 with Dr. Ruyi Liu and Prof. Qing Zhang.)

Risk-sensitive piecewise deterministic Markov decision processes
郭先平（中山大学）

Abstract: This talk is on risk-sensitive piecewise deterministic Markov decision processes, in which the expected exponential utility of a finite-horizon reward is to be maximized, and in which both the transition rates and reward functions are allowed to be unbounded. The Feynman-Kac's formula is developed in our setup, using which along with an approximation technique, we will establish the associated Hamilton-Jacobi-Bellman equation, and show the existence of risk-sensitive optimal policies under suitable conditions.

Some remarks on the geometry on the Wasserstein space
方诗赞（法国 Bourgogne 大学）

Abstract: The talk is based on a joint work with Hao DING. We will revisit the intrinsic differential geometry of the Wasserstein space over a Riemannian manifold, following a series of papers by Otto, Otto-Villani, Lott, Ambrosio-Gigli-Savaré and so on.

Convergence rate in the central limit theorem and precise moderate deviations for products of random matrices
刘全升（法国 Bretagne-Sud 大学）

Abstract: Let g_n be independent and identically distributed $d \times d$ real random matrices. Let $G_n = g_n \ldots g_1$ be the product matrix. Consider the random walk $G_n x$ and its direction $X_n^x = G_n x / |G_n x|$, $n \geq 1$, where $|.|$ is an arbitrary norm in R^d and x is a starting point in R^d with $|x| = 1$. For both invertible matrices and positive matrices, under suitable conditions we prove a Berry-Esseen type bound and an Edgeworth expansion for the couple $(X_n^x, \log |G_n x|)$, about the rate of convergence in the central limit theorem. These results are established using a new smoothing inequality on the complex plane, the saddle point method and spectral gap properties of the transfer operator related to the Markov chain X_n^x. Cramér type moderate deviation expansions as well as a local limit theorem with moderate deviations are also proved for the couple $(X_n^x, \log |G_n x|)$ with a target function φ on the Markov chain X_n^x. As an example of applications, we establish the Berry-Esseen type bound and the Cramér type moderate deviation expansion for a multi-type branching process in a random environment (MBPRE), using the Kesten-Stigum type theorem that we found recently, which enables us to compare precisely a MBPRE with the products of the conditional mean matrices.

数学学院简介

哈尔滨工业大学数学学院前身是创建于 1958 年的计算数学专业，1981 年开始培养基础数学和计算数学专业硕士，1986 年获得基础数学博士学位授予权（是国内最早的两所工科院校之一），1987 年成立数学系，2019 年成立数学学院。2001 年建立了数学学科博士后流动站，2005 年数学学科成为一级学科硕士学位授权点，2010 年数学学科成为一级学科博士授权点，2011 年统计学成为一级学科博士授权点。基础数学是省重点学科（2001 年）和国防科工委重点学科（2002 年）；应用数学是省重点学科（2001 年）。数学学科 2011 年成为省一级重点学科。2013 年基础数学和应用数学成为工信部重点学科。1997 年入选教育部首批七个"工科基础课程（数学）教学基地"之一；2020 年数学类专业入选教育部强基计划和基础学科拔尖学生培养计划 2.0 基地；2020 年获批成立黑龙江应用数学中心。

在教育部第四轮学科评估中，哈尔滨工业大学数学学科位列 A-，统计学位列 B。在 2020 年 10 月《美国新闻和世界报导》（US News）发布的世界大学数学专业排名中，我校数学学科排名全球第 80 位，在内地高校 45 个机构位于第 14 位。在 2021 年发布的世界大学学科排名（QS World University Rankings）中，我校数学学科排名全球第 126 位，在内地高校 36 个机构中位于第 8 位；统计学排名全球第 101-150 位，在内地高校 17 个机构中并列第 7 位。在最新的 ARWU 排名中，数学学科位列全球第 76-100 位，在内地高校 93 个机构中并列第 5 位。

哈尔滨工业大学数学学科自 2013 年 5 月始终保持全球 ESI 前 1% 行列。学院现有专任教师 82 人，博士化率 91.5%；其中，国家杰出青年 1 人，中组部首届青年拔尖人才计划 1 人，教育部新世纪人才 1 人，龙江学者 1 人，中组部"万人青拔"1 人，青年长江学者 1 人，黑龙江省杰出青年基金获得者 1 人，黑龙江省教学名师

4 人，龙江青年学者 1 人，宝钢优秀教师奖 7 人，黑龙江省优秀青年基金获得者 1 人；博士生导师 43 人，硕士生导师 63 人，教授 33 人。

学院现有本科专业三个：数学与应用数学（拔尖学生培养计划 2.0、强基计划（2020）、国家一流本科专业（2020））、信息与计算科学（拔尖学生培养计划 2.0、强基计划（2020）、国家一流本科专业（2019））、统计学（省一流本科专业（2020））。现有在读本科生 307 人，硕士研究生 144 人，博士研究生 195 人。现有：国家级精品资源共享课程 1 门，国家级精品课程 2 门，国家级精品在线开放课程 3 门，省级精品课程 4 门，省级优秀教学团队 1 个，省级优秀教材 2 部，省头雁团队 1 个（数学与人工智能交叉学科创新研究），省级重点实验室（计算与应用数学）1 个，省级领军人才梯队（计算数学）1 个。已培养本科生近 2000 人，硕士生近 1400 人，博士生近 400 人，其中涌现出一大批优秀学子：与境外高水平大学联合培养博士研究生 100 余人；长江学者、国家杰青等高层次人才 10 余人；8 位大学校长、副校长（如：哈工大副校长、电子科技大学副校长等）；国家百篇优博提名奖 3 人；教育部学术新人奖 3 人；20 余位省级学会和国家二级学会理事长及副理事长；校优秀博士学位论文奖 16 人；世界华人数学家大会"新世界数学奖"博士金奖 1 人、本科生银奖 1 人。

数学学科依据国防和社会发展的需求及主流科研方向前沿发展趋势，形成了以传统优势方向为支撑，以新兴与交叉方向为主要生长点的学科格局。主要科研方向有：泛函分析及其应用、代数与数论、常微分方程与动力系统、科学与工程计算、偏微分方程与调和分析、数学物理反问题、运筹控制与优化、概率论与数理统计等。近年来承担国家重点研发计划等国家级课题 50 余项，科研经费千万余元。获黑龙江省科学技术奖一等奖、教育部高校科研优秀成果奖自然科学奖二等奖等多个科研奖项，每年发表高水平学术论文 100 余篇。在全国 SCI 高产机构的排名中，近几年一直在前 20

名，2012 年发表的 SCI 论文数量位居全国数学学科第 3 位。

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数学研究院简介

哈尔滨工业大学数学研究院创建于 2016 年 7 月，首任院长由我校讲席教授许全华担任，研究院直接隶属于学校，是数学学院密不可分的合作伙伴。研究院以基础数学为基石，以从事国际一流的原始创新研究和培养杰出青年数学人才为第一要务，致力于推动数学科学的发展以及数学与物理、工程等领域的交叉研究。

研究院现有科研人员 18 人，其中高层次人才 7 人，分别为：菲尔兹奖获得者吴宝珠；国家海外引才计划：许全华；国家海外引才计划、长江学者：吴黎明；国家海外引才计划（青年）：尹智、李科、熊枭、熊欢。研究院探索实行法国宽松管理模式，不片面追求论文数量或杂志级别，而是着力为科研人员提供利于事业发展的有效平台，积极打造一个愉快、舒适、和谐、向上的工作环境，让每名科研人员都能找到适合自己发展的方式和位置。

数学研究院重点打造现代分析、数论-代数-组合以及概率统计及其应用等优势基础学科方向。五年来，获批各类国家自然科学基金 15 项，博士后基金 7 项，2020 年获批国家自然科学基金重点项目 1 项，填补了我校数学学科在此项目中的空白；学院教师先后在《PNAS》,《Memoirs of the American Mathematical Society》,《Communications in Mathematical Physics》等国内外著名期刊发表高水平论文 50 余篇。研究院组织举办了一系列具有国内外重要影响力的学术会议，先后邀请中国科学院院士田刚、美国加州大学圣塔芭芭拉分校张益唐，以及哈佛大学、美国芝加哥大学、俄罗斯科学院等知名专家学者 300 余人到我校访问交流，并促使我校和法国弗朗什-孔泰大学签订双边合作协议。

我们相信，在学校的大力支持下，数学研究院将进一步加快发展步伐，不断开拓创新，促进学科间的交叉与融合，发展成在国内外具有重要影响的数学研究中心，助力学校"双一流"建设。