# 1ST NUS GRADUATE SYMPOSIUM IN MATHEMATICS

**22 April 2013 (Monday)**
**Department of Mathematics**
**S17 #04-06 & #04-05**

**Faculty of Science**
Department of Mathematics

**NUS GRADUATE SYMPOSIUM IN MATHEMATICS**
*22 April 2013, Department of Mathematics, NUS*

# PROGRAMME

| Time/Venue | S17-04-06 (SR1) | S17-04-05 (SR2) |
|---|---|---|
| 08:50 - 09:00 | Opening Address (SR1) | |
| 09:00 - 09:20 | BAO Chenglong | DU Zhikun |
| 09:20 - 09:40 | LI Jia | ZHENG Yu |
| 09:40 - 10:00 | DU Mengyu | LUO Chang |
| 10:00 - 10:20 | ZHAO Xiaofei | ZHANG Rong |
| 10:20 - 10:50 | *Tea break* | |
| 10:50 - 11:10 | CAI Ruilun | CHEN Yingshan |
| 11:10 - 11:30 | HU Hengnan | Daniel PAULIN |
| 11:30 - 11:50 | ZHANG Xiongtao | CHEN Junrui |
| 11:50 - 12:10 | ZHOU Feng | XU Jing |
| 12:10 - 14:00 | *Lunch* | |
| 14:00 - 14:20 | GAO Bing | HUANG Mengmin |
| 14:20 - 14:40 | GAO Rui | WANG Kang |
| 14:40 - 15:00 | GAO Fan | JIA Xiaowei |
| 15:00 - 15:20 | LIU Yiqun | LI Xudong |
| 15:20 - 15:50 | *Tea break* | |
| 15:50 - 16:10 | TANG Ling | DU Linglong |
| 16:10 - 16:30 | LEI Yaoting | YUAN Zihong |
| 16:30 - 16.50 | LI Shangru | ZHANG Hong |
| 16:50 - 17:10 | - | WANG Haitao |

# ABSTRACTS

| TIME | TALK | VENUE |
|---|---|---|
| 08:50 - 09:00 | **Opening Address** | S17-04-06 |
| 09:00 - 09:20 | **BAO Chenglong**<br>*Real time Robust L1 tracker using Accelerated Proximal Gradient Approach*<br><br>Recently sparse representation has been applied to visual tracker by modeling the target appearance using a sparse approximation over a template set, which leads to the so-called L1 trackers as it needs to solve an l1 norm related minimization problem for many times. While these L1 trackers showed impressive tracking accuracies, they are very computationally demanding and the speed bottleneck is the solver to l1 norm minimizations. This paper aims at developing an L1 tracker that not only runs in real time but also enjoys better robustness than other L1 trackers. In our proposed L1 tracker, a new l1 norm related minimization model is proposed to improve the tracking accuracy by adding an l2 norm regularization on the coefficients associated with the trivial templates. Moreover, based on the accelerated proximal gradient approach, a very fast numerical solver is developed to solve the resulting l1 norm related minimization problem. The great running time efficiency and tracking accuracy of the proposed tracker is validated with a comprehensive evaluation involving eight challenging sequences and five alternative state-of-the-art trackers. | S17-04-06 |
| | **DU Zhikun**<br>*Rates of mixing for random perturbations*<br><br>In this talk, we first define a concept mixing rate in dynamical system. then we introduce a useful tool (Young Tower) for studying mixing rates. By using young tower, mixing rate in determinstic case are clear. We try to generalize the results to random systems. | S17-04-05 |

| TIME | TALK | VENUE |
|---|---|---|
| 09:20 - 09:40 | **LI Jia**<br>*Wavelet Frame based CT image reconstructions*<br><br>X-ray computed tomography (CT) has been widely used in diagnosis of cancer and radiotherapy. However it is important to reduce the radiation dose as low as reasonably achievable because the x-ray radiation is harmful to the patients. Moreover, the interior tomography which illuminate a region-of-interest (ROI) can save the radiation dose. Two robust wavelet tight frame based CT reconstruction methods will be introduced for both global reconstruction and interior tomography to reduce the error caused by mechanical inaccurate execution of the huge sparse projection matrix. Numerical simulation results show that our proposed analysis based approach can apparently outperform all the popular methods in terms of both the visual qualities and mean structural similarity.<br><br>Additionally, our proposed synthesis based approach can preserve most useful tiny features and suppress the noise and artifacts. | S17-04-06 |
| | **ZHENG Yu**<br>*The General Tree Reconciliation Problem*<br><br>Tree reconciliation is a key method to inferring evolutionary events for gene families. In this talk, we will review the standard binary tree reconciliation method and then discuss a general reconciliation problem which unifies the phylogenetic tree reconciliation and inference problems. We will show how to exactly solve the general reconciliation problem for some cost functions. | S17-04-05 |

| TIME | TALK | VENUE |
|---|---|---|
| 09:40 - 10:00 | **DU Mengyu**<br>*Low Rank Nearest Correlation Matrix Approximation by a Majorized Penalty Method*<br><br>The rank constrained nearest correlation matrix problem is a kind of least squares problem with SDP constraint, rank constraint and equality constraints. In this talk, we will talk about solving this kind of problem by a majorized penalty method. We first apply the penalty method to deal with the SDP and rank constraint, then we apply the majorization method to solve the penalized version of the problem, in which we need to solve the nuclear norm regularized least squares problems with equality constraints iteratively. The inner problem can be solved by Newton-CG method. | S17-04-06 |
| | **LUO Chang**<br>*Structural controllability and controls of complex networks*<br><br>Structural controllability characterizes whether a network system can be directed to any state within finite time from any initial state. In this talk, I will review some mathematical facts about structural controllability, algebraic and graph-theoretic aspects of structural controllability will be discussed. At the end, how to design control schemes in complex networks (especially transcriptional regulatory networks) based on properties of structural controllability will be covered. | S17-04-05 |

| TIME | TALK | VENUE |
|---|---|---|
| 10:00 - 10:20 | **ZHAO Xiaofei**<br>*Uniformly correct multiscale time integrators for highly oscillatory second order differential equations.*<br><br>In this paper, two multiscale time integrators (MTIs), motivated from two types of multiscale decomposition by either frequency or frequency and amplitude, are proposed and analyzed for solving highly oscillatory second order differential equations with a dimensionless parameter $0<\eps\le1$. In fact, the solution to this equation propagates waves with wavelength at $O(\eps^2)$ when $0<\eps\ll 1$, which brings significantly numerical burdens in practical computation. We rigorously establish two independent error bounds for the two MTIs at $O(\tau^2/\eps^2)$ and $O(\eps^2)$ for $\eps\in(0,1]$ with $\tau>0$ as step size, which imply that the two MTIs converge uniformly with linear convergence rate at $O(\tau)$ for $\eps\in(0,1]$ and optimally with quadratic convergence rate at $O(\tau^2)$ in the regimes when either $\eps=O(1)$ or $0<\eps\le \tau$.<br><br>Thus the meshing strategy requirement (or $\eps$-scalability) of the two MTIs is $\tau=O(1)$ for $0<\eps\ll 1$, which is significantly improved from $\tau=O(\eps^3)$ and $\tau=O(\eps^2)$ requested by finite difference methods and exponential wave integrators to the equation, respectively. Extensive numerical tests and comparisons with those classical numerical integrators are reported, which gear towards better understanding on the convergence and resolution properties of the two MTIs.<br>In addition, numerical results support the two error bounds very well. | S17-04-06 |
| | **ZHANG Rong**<br>*Measure of Julia Sets in Real Polynomial Maps*<br><br>In my presentation, I will give an introduction to problems and known results on Julia sets of positive measure in real and complex one-dimensional dynamics.<br>In 1996 Bruin, Keller, Nowicki and van Strien proved existence of wild attractors for Fibonacci unimodal maps, and a counterpart in the complex setting was studied by Nowicki and van Strien also. The latter paper contains a gap which is currently not fixed. I will introduce some of the key ingredients in their results, which include: real bounds, complex bounds for Fibonacci maps and a probability method to estimate the measure of Julia sets. | S17-04-05 |

| TIME | TALK | VENUE |
|---|---|---|
| 10:50 - 11:10 | **CAI Ruilun**<br>*The Prescribing Q-curvature Problem*<br><br>In conformal geometry, it is a natural problem to prescribe a conformal invariant in under a conformal metric on a given manifold. In 1983, Paneitz introduced a fourth order operator, which is now known as the Paneitz operator.<br><br>It gives rise to a fourth order conformal invariant called Q-curvature. The Prescribing Q-curvature problem has been studied extensively. Many results parallel to the prescribing scalar curvature problem had already been built up.<br><br>In this talk, we try to look at the possibility of using flow method to solve the prescribing Q-curvature problem on sphere in the case that the prescribing function is closed to a constant. | S17-04-06 |
| | **CHEN Yingshan**<br>*Incomplete Information, Trend Following and Liquidity Premia*<br><br>The standard research on dynamic asset allocation concludes that, (i) optimal trading strategies are typically contrarian, by which one buys on downswings and sells on upswings, and (ii) the impact of transaction costs on liquidity premia is an order of magnitude smaller than the cost rate itself. However, these theoretical results seem to be at odds with the empirical evidence. In this paper, we study the optimal investment decision of an investor who is risk averse and who trades in a market that switches stochastically between a bull regime (up trend) and a bear regime (down trend). More importantly, trading in this market is costly, and our investor is not allowed to fully observe the state of the current market regime. We show that, in addition to being a contrarian trader, our investor is also a trend follower, buying on the upswings and selling on the downswings, which seems to be a popular trading strategy among industry practitioners.<br><br>Moreover, relative to the fully observable case, we show that incomplete information about the state of the current regime can significantly amplify the effect of transaction costs on liquidity premia, resulting in magnitudes that are largely comparable to existing empirical findings. | S17-04-05 |

| TIME | TALK | VENUE |
|---|---|---|
| 11:10 - 11:30 | **HU Hengnan**<br>*From Markoff equation to $x^2 + y^2 + z^2 + w^2 = xyzw + \mu$*<br><br>In this talk, we first briefly review the results about Markoff equation $x^2 + y^2 + z^2 = xyz + \mu$.<br><br>Then we are going to discuss the four variable equation $x^2 + y^2 + z^2 + w^2 = xyzw + \mu$. There is a natural Coexter group action on the solutions and the Cayley graph of Coexter group provides a nice geometric interpretation for this action. With the result about the convergence property under so-called BQ-conditions, we can show our new identity. | S17-04-06 |
| | **Daniel PAULIN**<br>*Concentration inequalities for Markov chains*<br><br>Concentration inequalities are non-asymptotic tail bounds for functions of random variables, typically of the form P(\|f(X1,...,Xn)- E(f)\|>t)<exp(-t^2/C). Such inequalities have many applications in diverse fields. In this talk, we will focus on the case when X1,...,Xn are a Markov chain. We show inequalities for this case, that are roughly the mixing time of the chain times weaker than if X1,...,Xn were independent. Finally, we present some applications.<br><br>Reference: Concentration inequalities for Markov chains by Marton couplings. | S17-04-05 |

| TIME | TALK | VENUE |
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| 11:30 - 11:50 | **ZHANG Xiongtao**<br>*Stability of Free Transport Equation between two slabs with nonlinear temperature profile*<br><br>Free transport equation seems to be simple and natrual, but when the equation is between two slabs the situation becomes interesting. I will introduce the construction of the solutions of evolutionary free transport equation and stationary free transport equation respectively and then analyze the convergence of the evolutionary solution to the stationary solution. | S17-04-06 |
| | **CHEN Junrui**<br>*Optimal control model in emission market*<br><br>Tacking climate change is at the top of many agendas. In this context, emission trading schemes are considered as promising tools. The regulatory framework for an emission trading scheme introduces a market for emission allowances and creates a need for risk management by appropriate financial contracts. In this work, a continuous model will be given by HJB approach and the viscosity solution be discussed. We will also address logical principles underlying their valuation and numerical examples. | S17-04-05 |

| TIME | TALK | VENUE |
|---|---|---|
| 11:50 - 12:10 | **ZHOU Feng**<br>*The Delaunay-Fowler type solutions of the conformal scalar curvature equation*<br><br>Given a function K on S^n, can it be realized as the scalar curvature of some conformal metric? Such an interesting geometric problem is equivalent to finding positive solutions of a semi-linear elliptic equation (i.e. the conformal scalar curvature equation).<br><br>In this talk, we will consider a special family of positive solutions of the conformal scalar curvature equation, the so-called Delaunay-Fowler type solutions. The convergence and some asymptotic behavior of the Delaunay-Fowler type solutions will be discussed during the talk. | S17-04-06 |
| | **XU Jing**<br>*ATMI v.s. Volatility Swap Rate: A Multi-Scale Stochastic Volatility Analysis*<br><br>In an earlier paper Peter Carr and Roger Lee argue that under conditions such as continuous stock path, uncorrelated stock return and volatility, the volatility swap rate could be approximated by at the money implied volatility (ATMI). In this talk, I show that in the multi-scale stochastic volatility framework provided by Fouque et al, to the first order, the volatility swap rate could also be approximated by ATMI adjusted by a small correction, even in the presence of implied volatility skew. This would potentially provide a simple and efficient way for the volatility traders to trade volatility in practice. | S17-04-05 |

| TIME | TALK | VENUE |
|---|---|---|
| 14:00 - 14:20 | **GAO Bing**<br>*On deterministic perturbations of non-uniformly expanding interval maps*<br><br>We provide a strengthened version of the famous Jakobson's theorem. Consider an interval map f satisfying a summability condition. For a generic one-parameter family f_t of maps with f_0=f, we prove that t=0 is the Lebesgue density point of the set of parameters for which f_t satisfies both the Collet-Eckmann condition and a strong polynomial recurrence condition. | S17-04-06 |
| | **HUANG Mengmin**<br>*Discontinuous Galerkin Method in Simulation of Streamer Propagation*<br><br>Streamer propagation is an interesting problem in engineering. Scientist would like to study the physics of streamer through numerical simulations. In this talk, a new numerical method, discontinuous Galerkin (DG) method, is posed to capture the features in streamer propagation. Compared with other linear low order method, e.g. finite difference method, the DG method is a powerful method of high resolution and is free of numerical oscillations. Some simulation examples will be shown at the end to indicate the well performance of DG method. | S17-04-05 |

| TIME | TALK | VENUE |
|---|---|---|
| 14:20 - 14:40 | **GAO Rui**<br>*Skew-products of quadratic polynomial over maps in the quadratic family*<br><br>We study a parametrized family of skew-products of quadratic polynomials, where the base maps are taken from the quadratic family. We prove that, for certain coupling function, there exists a parameter set of positive Lebesgue measure, such that every skew-product map associted to this parameter set has two positive Lyapunov exponents almost everywhere and a unique absolutely continuous invariant probability measure. | S17-04-06 |
| | **WANG Kang**<br>*A two-stage approach to blind spatially-varying motion deblurring*<br><br>Image motion deblurring is a fundamental problem in image processing. Many blind motion deblurring methods model the motion blur as a spatially invariant convolution process, in which each observed pixel is the weighted summation of the original image pixel with the same weighting scheme. However, motion blur caused by the camera movement in 3D space during shutter time often leads to spatially varying blurring effect over the image. In this talk, I will introduce an efficient two-stage approach to remove spatially-varying motion blurring from a single photo. | S17-04-05 |

| TIME | TALK | VENUE |
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| 14:40 - 15:00 | **GAO Fan**<br>*The Inverse Galois Problem and Automorphic Forms*<br><br>We will review on some recent results on the inverse Galois problem (IGP), especially the work by D. Zywina. Also we might explore a bit further on some applications of automorphic forms to the IGP, and give expositions on some results by L. Dieulefait and C. Khare etc. | S17-04-06 |
| | **JIA Xiaowei**<br>*Multi-scale analysis and numerical methods for Dirac equation in nonrelativistic limit regime*<br><br>In this talk I will discuss the old numerical methods to solve the Dirac equation, the numerical burden in nonrelativistic limit regime and introduce new methods to release that burden. Also I will talk about the multi-scale analysis in this regime. | S17-04-05 |

| TIME | TALK | VENUE |
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| 15:00 - 15:20 | **LIU Yiqun**<br>*Isolation pair and its induction strength*<br><br>Reverse mathematicians found that instead of ZFC, Peano Arithmetic Axiom is enough to carry out much of fundamental Mathematical results. One of reverse mathematics application to ordinary mathematics is analyzing the equivalence between the Mathematical theorems and induction Axiom based on P-(Peano Arithmetic Axiom without induction).<br><br>The same idea can also apply to analyzing the induction strength of different priority methods used in recursion theory, namely whether the priority argument of infinite algorithm could be carried out under P- plus a proper induction Axiom.<br><br>A classical result in d.c.e degree by S.Ishmukhametov and G.Wu is that a high d.c.e degree is isolated by a low c.e degree. Using the idea and construction in this paper, we turn to a simple case, the construction of isolation pair and discuss whether the infinite injury argument could be performed inside M which is a model of P- + I\sigma_1. | S17-04-06 |
| | **LI Xudong**<br>*Solving semidefinite programming problems with dual block angular structures*<br><br>Semidefinite programming (SDP) problems with block angular structures arise in many fields.<br>As a special case of the class of block angular SDP problems, the class of block angular linear programming (LP) problems has been studied extensively. In this talk, we will first give a brief review about the literatures which focus on solving large scale block angular LP problems. Then, we will focus on designing efficient and robust decomposition based algorithms for solving large scale SDP problems with block angular structure. | S17-04-05 |

| TIME | TALK | VENUE |
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| 15:50 - 16:10 | **TANG Ling**<br>*Calibration of Stochastic Volatility Models: An Optimal Control Approach*<br><br>We proposed an optimal control approach to recover the correlation coefficient term, the risk-neutral drift term, and diffusion term of the volatility or variance process in the stochastic volatility model from the option markets. In contrast to the existing literature, these terms do not possess any special structure and analytical pricing formulas for European options are unavailable.<br><br>We first presented a modified Dupire's equation associated with stochastic volatility models, which allows us to formulate the calibration problem as a standard inverse problem of partial differential equations. Then an optimal control approach with Tikhonov regularization can be used to recover these three terms respectively. | S17-04-06 |
| | **DU Linglong**<br>*Wave propagation around an over-compressive shock profile with large amplitude*<br><br>In this talk, we will present our recent works about the wave propagation around an over-compressive shock profile with large amplitude. Traditionally, the study of wave propagation requires a small assumption on the amplitude to close the energy estimate. Without this small assumption, a new method is designed to construct the wave propagation. We take a rotationally invariant system of viscous conservation laws as an example. The approach starts with a non-decaying compressive wave extraction, followed with the approximate solution for the rest transversal wave. Based on this approximation, we introduce a scheme to construct the transversal wave and prove the convergence of this scheme. With the sharp estimate, one could get the nonlinear stability for the wave propagation. | S17-04-05 |

| TIME | TALK | VENUE |
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| 16:10 - 16:30 | **LEI Yaoting**<br>*Optimal Investment and Consumption with Habit Formation and Illiquid Assets*<br><br>We are concerned with the optimal investment and consumption problem for a constant relative risk aversion (CRRA) investor who faces habit formation and illiquid assets. In our model, there are three assets in the market: a liquid risk-less asset, a liquid risky asset, and an illiquid risky asset that can only be traded at infrequent, stochastic intervals. The target of the investor is to maximize the expected utility of the difference of intermediate consumptions and internal habits (and the terminal liquidated wealth in finite horizon). Here habit formation is an exponentially weighted average of the initial habit and the entire history of past consumption. | S17-04-06 |
| | **YUAN Zihong**<br>*Brunnian groups and Lie(n)*<br><br>There is a connection map $\phi$ : Brunn $\rightarrow$ Lie(n) from Brunnian group Brunn to module Lie(n). Here Lie(n) is a submodule of free Lie algebra. We will analyze the kernel of map $\phi$ and compare it with two commutator groups [Brunn, Un] and [Brunn, Pn]. | S17-04-05 |

| TIME | TALK | VENUE |
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| 16:30 - 16.50 | **LI Shangru**<br>*Optimal Stochastic Switching under Convexity Assumptions*<br><br>We address a method of approximate calculation of optimal control policy applicable to a particular class of stochastic control problems. In these problems, the stochastic dynamics exhibit a certain convexity preserving property. Within our numerically tractable approach, we show a convergence to the value function of the original problem uniformly on compact sets. | S17-04-06 |
| | **ZHANG Hong**<br>*The mean curvature flow approach to the perturbation theorem*<br><br>In 1998, Chang-Xu-Yang (Math. Ann., 310, 473-496, 1998) proved a perturbation result for prescribing mean curvature which is an analogue of the perturbation theorem due to Chang and Yang (Duke Math. J., 64, 27-69, 1991). In their result, one key assumption is that the candidate f for the prescribed mean curvature is sufficiently close to the mean curvature of the standard metric in the sup norm. It is interesting to investigate how large that difference in the sup norm could be. This article partially achieves this goal using the mean curvature flow method. Precisely, we assume that the given candidate $f$ $f$ is smooth positive Morse function which is non-degenerate in the sense that<br><br>$$(\Delta_{S^n} f)^2 + |\nabla f|^2_{S^n} \neq 0 \text{ and } \frac{\max_{S^n} f}{\max_{S^n} f} < 2^{\frac{1}{n-1}}.$$<br><br>We then show that $f$ $f$ can be realized as the mean curvature of some conformal metric provided the Morse index condition holds for $f$ $f$. This shows that the possible best difference in the sup norm is<br><br>$(2^{\frac{1}{n-1}} - 1)/(2^{\frac{1}{n-1}} + 1)$ | S17-04-05 |

| TIME | TALK | VENUE |
|---|---|---|
| 16:50 - 17:10 | **WANG Haitao**<br>*Global well-posedness for semilinear wave equation*<br><br>In this talk, we will present global well-posedness results for semilinear wave equation $u_{tt}-\triangle u+\|u\|^{p-1} u=0$ in 3d for $1<p \leq 5$. For the case $1<p<5$, standard energy estimates and Sobolev inequlity are sufficient to conclude. For the critical case $p=5$, multipliers methods and Morawetz-type estimates are needed. | S17-04-05 |