# Abstracts

## #1. Algebraic Geometry—*organizer*: Shigeru Mukai, RIMS Kyoto University

**PL** **Shigeru Mukai**
RIMS Kyoto University

***Enriques surfaces and root systems***

Enriques surfaces were found as a counterexample to a conjecture on rationality of function fields of two variables. They are placed between rational and K3 surfaces in all the algebraic surfaces. In this talk I will first explain their basic properties including periods and period lattices.

Then I will discuss Enriques surfaces whose period lattices contains the root lattices of type E6, E7, and E8, etc. I also would like to report the classification, due to Ohashi, of Enriques surfaces which are doubly covered by Kummer's quartics, in terms of root systems.

**1-1** **Jungkai Alfred Chen**
National Taiwan University

***Birational maps in dimension three***

In this talk, I will try to give some more explicit description of these elementary birational maps in dimension three in the minimal model program.

In particular, I will explain a factorization results of these maps, which is a joint work with Christopher Hacon.

**1-2** **Christopher Hacon**
University of Utah

***Boundedness results in birational algebraic geometry***

In this talk, we will survey boundedness results in complex birational algebraic geometry. In particular, we will discuss a result of Tsuji, Hacon-Mc Kernan, and Takayama on the boundedness of birational maps of varieties of general type. We will then discuss several natural generalizations and applications of this result.

**1-3** **Masayuki Kawakita**
RIMS Kyoto University

***Singularities in the minimal model program***

One approach to the termination of flips is to evaluate how singularities are improved by flips. We will discuss an invariant of singularity called the minimal log discrepancy, contrasting with another invariant called the log canonical threshold.

**1-4** **Bumsig Kim**
Korea Institute for Advanced Study

***Stable Quasimaps to Holomorphic Symplectic Quotients***

We apply the stable (twisted) quasimap construction to holomorphic symplectic quotients and obtain moduli spaces with symmetric obstruction theories.

**1-5** **Ichiro Shimada**
Hiroshima University

***Lattices of algebraic cycles in positive characteristics***

By means of the incidence relation of Frobenius images of linear subspaces in a fixed vector space over a finite field of $q$ elements, we construct examples of varieties defined over the finite field such that all the Frobenius eigenvalues on the $l$-adic cohomology are powers of $q$. We then investigate the lattices spanned by the numerical equivalence classes of algebraic cycles on these varieties, and show that some of them yield a dense sphere packing.

## Abstracts

**1-6** **Yu-jong Tzeng**
Stanford University
& Harvard University

***Universal Formulas for Counting Nodal Curves on Surfaces***

The problem of counting nodal curves on algebraic surfaces has been studied since the nineteenth century. On the projective space $\mathbb{P}^2$, it asks how many curves defined by homogeneous degree *d* polynomials have only nodes as singularities and pass through points in general position. On K3 surfaces, the number of rational nodal curves was predicted by the Yau-Zaslow formula. Göttsche conjectured that for sufficiently ample line bundles *L* on algebraic surfaces, the numbers of nodal curves in |L| are given by universal polynomials in four topological numbers. Furthermore, based on the Yau-Zaslow formula he gave a conjectural generating function in terms of quasi-modular forms and two unknown series. In this talk, I will discuss how degeneration methods can be applied to count nodal curves and sketch my proof of Göttsche's conjecture.

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**#2. Combinatorics—*organizer*:** Xuding Zhu, National Sun Yat-sen University

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**PL** **Persi Diaconis**
Stanford University

***Adding numbers, shuffling cards, and an amazing matrix***

The "carries" when a list of numbers are added form a Markov chain (Holte). The transition matrix of this Markov chain also occurs in analyzing the usual method of riffle shuffling cards. The left and right eigen functions are characters of Foulkes (on $S_n$) and Reutenaur (on $lie_n$). The same matrix appears in understanding high Veronese imbeddings of projective varieties. All of this is joint work with Jason Fulman.

**2-1** **Pavol Hell**
Simon Fraser University

***List Homomorphism Problems***

Dichotomy for list homomorphisms for digraphs follows from a general result of A. Bulatov on conservative constraint satisfaction problems. We provide the first polynomial time digraph structure dichotomy classification, similar to early dichotomy list homomorphism results for undirected graphs. This is joint work with Arash Rafiey.

**2-2** **Alexandr Kostochka**
University of Illinois–
Urbana-Champaign

***List Coloring of Simple Hypergraphs***

The *list chromatic number* $\chi_\ell(G)(G)$ of a hypergraph $G=(V,E)$ is the minimum integer *s* such that for every assignment of a list $L_v$ of *s* colors to each vertex *v* of *G*, there is a vertex coloring of *G* in which the color of each vertex is in its list and there are no monochromatic edges. Before 2000, Alon proved that every graph with "high" average degree cannot have small list chromatic number. We prove that the same holds for simple *r*-uniform hypergraphs with a different notion of "high." Recall that a hypergraph is simple if no two edges have more than one common vertex. Note that non-simple *n*-vertex *r*-uniform hypergraphs may have average degree about $(n/r)^{r-2}$ and still be 2-list-colorable. This is joint work with Noga Alon.

## Abstracts

**2-3 Jarik Nešetřil**
Charles University

***Homomorphism Dualities in Optimization, Logic, and Algorithms***

Homomorphism dualities for finite structures express partition problems (such as CSP) by means of forbidden substructures. The finite dualities were characterized explicitly by J.N. and C. Tardif and the structure of dual objects was studied thoroughly.

The finite dualities restricted to a particular class of objects were characterized only very recently. Characterization uses tools from mathematical logic, graph limits and structural combinatorics.

This is a joint work with P. Ossona de Mendez.

**2-4 Zhi-Wei Sun**
Nanjing University

***Super Congruences involving Binomial Coefficients and New Series for Famous Constants***

If a $p$-adic congruence happens to hold modulo a higher power of $p$ then it is called a super congruence. The topic of super congruences involving binomial coefficients is related to the $p$-adic Gamma function, Gauss and Jacobi sums, hypergeometric series, modular forms, Calabi-Yau manifolds, representations of $p$ by certain quadratic forms, and some sophisticated combinatorial identities involving harmonic numbers. Recently the speaker formulated many conjectures on super congruences involving binomial coefficients and revealed that they are related to Euler numbers and series for $p$ or other famous constants. In this talk we will analyze few typical conjectures of the speaker and introduce related progress.

**2-5 *Gerard J. Chang***
National Taiwan University

***On the number of subsequences with a given sum in a finite abelian group***

Suppose $G$ is a finite abelian group and $S$ is a sequence of elements in $G$. For any element $g$ of $G$, let $N_g(S)$ denote the number of subsequences of $S$ with sum $g$. Our purpose is to investigate the lower bound for $N_g(S)$. In particular, we prove that either $N_g(S)=0$ or $N_g(S)\geq 2^{|S|-D(G)}+1$, where $D(G)$ is the smallest positive integer $\ell$ such that every sequence over $G$ of length at least $\ell$ has a nonempty zero-sum subsequence. We also characterize the structures of the extremal sequences for which the equality holds for some groups. This is joint work with Sheng-Hua Chen, Yongke Qu, Guoqing Wang, and Haiyan Zhang.

**2-6 Xingxing Yu**
Georgia Institute of Technology

***$K_5$-subdivisions in 5-connected nonplanar graphs***

A well-known theorem of Kuratowski states that a graph is planar if it contains no subdivision of $K_5$ or $K_{3,3}$. It is also known that any 3-connected nonplanar graph other than $K_5$ contains a subdivision of $K_{3,3}$. Seymour and Kelmans independently conjectured that every 5-connected nonplanar graph contains a subdivision of $K_5$. We establish this conjecture for graphs containing $K_4^-$.

# Abstracts

## #3. Differential Geometry—*organizer*: Seiki Nishikawa, Tohoku University

**PL** **Seiki Nishikawa**
Tohoku University

***Harmonic maps into complex Finsler manifolds***

The notion of harmonic maps has been extended recently to real/complex Finsler manifolds, which form a much larger class than Riemannian/Hermitian manifolds. In this talk, from the viewpoint of variational problems, we will discuss some basic properties of harmonic maps from compact Riemann surfaces into complex Finsler manifolds.

**3-1** **Kazuo Akutagawa**
Tohoku University

***The Yamabe invariant of cylindrical manifolds and computations of the orbifold Yamabe invariant***

We prove some basic results on the Yamabe invariant of a cylindrical manifold, and particularly give a basic estimate from above for the invariant in the case of nonpositive one. We use these results to give some exact computations of the nonpositive Yamabe invariants of *4*-dimensional compact orbifolds with finitely many singular points.

**3-2** **Ben Andrews**
Australian National University

***The fundamental gap on manifolds and on convex domains***

I will present joint work with Julie Clutterbuck, concerning the spectral gap for the Laplacian in various settings. We use estimates on the heat equation to deduce properties of eigenfunctions and eigenvalues. First we give an estimate on the modulus of continuity of solutions to the heat equation, which recovers easily the optimal lower bound for the first eigenvalue on a compact manifold in terms of an upper bound for diameter and a lower bound for Ricci curvature. This estimate was first proved by Kröger using gradient estimates in the spirit of Li and Yau, and includes as special cases the results of Zhong and Yang and of Lichnerowicz.

Secondly, for a convex domain in a manifold with constant sectional curvature $\kappa$, we prove a sharp new log-concavity estimate for the first Dirichlet eigenfunction: Precisely, we show that the decrease in slope of the log of the eigenfunction along any geodesic segment in the domain is no less than that on an interval of the same length for the first eigenfunction of a corresponding one-dimensional model problem. This combines with the modulus of concavity argument to give a sharp lower bound on the gap between the first two eigenvalues for Dirichlet Schrödinger operators in terms of the diameter of the domain, $\kappa$, and a “modulus of convexity” for the potential. The result is a sharp refinement of the result of Singer, Wong, Yau, and Yau, as well as the later improvement by Yu and Zhong. In particular, we prove that the gap on a convex domain in Euclidean space for a Schrödinger operator with convex potential is at least $3\pi^2/D^2$, where $D$ is the diameter of the domain.

# Abstracts

**3-3 Richard Schoen**
Stanford University

***Sharp eigenvalue estimates and area bounds for stationary submanifolds and varifolds in Euclidean space***

We will describe sharp lower bounds on the eigenvalues of the Dirichlet-Neumann map and connections to the geometry of the free boundary problem for the minimal submanifold problem. As a consequence, we will obtain sharp lower bounds on the possible areas of free boundary surfaces and varifolds in the Euclidean ball. This is a joint work with Ailana Fraser.

**3-4 Akito Futaki**
Tokyo Institute of Technology

***Kähler geometry and asymptotic Chow semistability***

I will explain about an example of a Kähler-Einstein manifold which is not asymptotically Chow semistable.

**3-5 Ko Honda**
University of Southern California

***HF=ECH via open book decompositions***

The goal of this talk is to sketch a proof of the equivalence of Heegaard Floer homology (due to Ozsváth-Szabó) and embedded contact homology (due to Hutchings). This is joint work with Vincent Colin and Paolo Ghiggini.

**3-6 Lei Ni**
UC-San Diego

***Ancient solutions to the Ricci flow***

This is a joint work with Barkas and Kong. Ancient solutions arise in the study of Ricci flow singularities. Motivated by the work of Fateev on 3-dimensional ancient solutions we construct ancient solutions to Ricci flow on spheres and complex projective spaces in high dimensions. Our examples differ from Fateev's in the high dimensions, since most of our examples are non-collapsed. The construction generalize/unifies the previous work on Einstein metrics by Bourguignon-Karcher, Jenson, and Ziller, respectively. The existence is reduced to the study of nonlinear ODE systems and finding the related monotonic and conserved quantities under Ricci flow with symmetry. Besides supplying new possible singularity models, the examples supply counter-examples to some folklore conjectures on ancient solutions of Ricci flow on compact manifolds.

# Abstracts

**#4. Electromagnetic Waves—*organizer*:** Ya Yan Lu, City University of Hong Kong

**PL** **Gunther Uhlmann**
University of Washington

***Transformation Optics and Cloaking***

We describe recent theoretical and experimental progress on making objects invisible to detection by electromagnetic waves, acoustic waves and quantum waves. For the case of electromagnetic waves, Maxwell's equations have transformation laws that allow for design of electromagnetic materials that steer light around a hidden region, returning it to its original path on the far side. Not only would observers be unaware of the contents of the hidden region, they would not even be aware that something was being hidden. The object, which would have no shadow, is said to be cloaked. We recount the recent history of the subject and discuss some of the mathematical issues involved.

**4-1** **Gang Bao**
Michigan State University

***Inverse Problems for Maxwell's Equations***

Recent developments on direct and inverse problems for Maxwell's equations will be presented. Issues on analysis and computation will be discussed.

**4-2** **Hyeonbae Kang**
Inha University

***Electromagnetic Reconstruction of Targets Using Fine Properties of Multistatic Response Matrices***

This paper deals with the problem of reconstructing the electromagnetic parameters and the shape of a target from multi-static response matrix measurements at a single frequency. The target is of characteristic size less than the operating wavelength. Using long-wavelength asymptotic expansions of the measurements of high-order, we show how the electromagnetic parameters and the equivalent ellipse of the target can be reconstructed. The asymptotic expansions of the measurements are written in terms of frequency dependent polarization tensors. Moreover, we propose an optimization approach to image geometric details of the target that are finer than the equivalent ellipse. The equivalent ellipse provides a good initial guess for the optimization procedure. The proposed methods are numerically implemented to demonstrate their validity and efficiency. This talk is based on a joint work with Habib Ammari, Eunjoo Kim, and June-Yub Lee.

**4-3** **Hongyu Liu**
University of Washington

***Approximate acoustic and electromagnetic cloaking***

In this talk, we shall be concerned with invisibility cloaking via transformation optics approach in acoustic and electromagnetic wave scattering. Our recent study on approximate cloaking from a regularization viewpoint will be presented.

**4-4 Xudong Chen**
University of Singapore

***Electromagnetic Inverse Scattering Problems Involving Small Scatterers***

The electromagnetic inverse scattering problem of determining the locations and polarization tensors of a collection of small scatterers is investigated. The locations of scatterers are determined by the multiple signal classification (MUSIC) method and the polarization tensors are retrieved by the two-step least squares method. Multiple scattering effect is taken into account and the inverse scattering problem is nonlinear. However, the proposed method does not involve iterative evaluations of the corresponding forward scattering problem. In addition, the method provides better imaging resolution than the standard MUSIC, and applies to degenerate scatterers to which the standard MUSIC does not apply. The underlying mathematical principle and physical insight are discussed in detail.

**4-5 Ya Yan Lu**
City University
of Hong Kong

***Efficient Method for Analyzing Woodpile Structures***

Photonic crystals (PhCs) are periodic structures with a period on the scale of the optical wavelength. They have been extensively investigated for applications to confine, guide, and manipulate light. A particularly interesting three-dimensional (3-D) PhCs is the woodpile structure consisitng of crossed arrays of dielectric rods. We present an efficient numerical method for computing the transmission and reflection spectra for woodpile structures with circular rods. A key step of our method is to calculate an operator (the T2T operator) that map two tangential components of the electromagnetic field to two other tangential components on the boundary of a unit cell.

**4-6 Ting Zhou**
University of Washington

***Reconstructing Electromagnetic Obstacles by the Enclosure Method***

We show that one can determine Perfectly Magnetic Conductor obstacles, Perfectly Electric Conductor obstacles, and obstacles satisfying impedance boundary condition, embedded in a known electromagnetic medium, by making electromagnetic measurements at the boundary of the medium. The boundary measurements are encoded in the impedance map that sends the tangential component of the electric field to the tangential component of the magnetic field. We do this by probing the medium with complex geometrical optics solutions to the corresponding Maxwell's equations and extend the enclosure method to this case. Moreover, using complex spherical waves, constructed by the inversion transformation with respect to a sphere, the enclosure method can recover some non-convex part of the obstacle.

**Junshan Lin**
Michigan State University

***Near-field imaging of the surface displacement on an infinite ground plane***

This work is concerned with the numerical study of the inverse diffraction problem for an unbounded obstacle. The obstacle is a ground plane with local disturbance. A reconstruction scheme based on the integral equation method is proposed to image the surface displacement at near-field, for which evanescent mode is significant compared with the far-field case. The method utilizes the evanescent modes effectively, which significantly improves the spatial resolution of the image. The on-going research project on this topic will also be highlighted.

# Abstracts

## #5. Functional Analysis—*organizer*: Xiaoman Chen, Fudan University

**PL** **Guoliang Yu**
Vanderbilt University

***Geometric complexity and topological rigidity***

In this talk, I will explain how a notion of geometric complexity can be used to study topological rigidity of manifolds. This is joint work with Erik Guentner and Romain Tessera.

**5-1** **Boo Rim Choe**
Korea University

***Survey on the finite-rank product conjecture for Toeplitz operators***

Let $T_u$ be the Toeplitz operator with bounded symbol $u$ on the Bergman space or Hardy space over a classical complex domain such as disk, ball, or polydisk. The subject of this talk is the following long-standing conjecture, which emerged from a classical work of Brown and Halmos (1964) on the Hardy space over the unit disk:

> **Conjecture.** *If* $T_{u_1} \cdots T_{u_N} = 0$*, or, more generally,* $T_{u_1} \cdots T_{u_N}$ *has finite rank, then one of the symbols,* $u_j$ *is zero a.e.*

The one-dimensional Hardy space case has been solved only recently by Aleman and Vukotić (2009) and the several-variable case remains open. The Bergman space case turns out to be more intriguing. The only result for the Bergman space is Luecking's solution (2008) for one single factor over the disk. While these are all the known results for general bounded symbols, there are various partial results with certain additional hypotheses on symbols. In this talk we survey recent results towards the conjecture/problem as well as related results.

**5-2** **Kunyu Guo**
Fudan University

***Multiplication operators defined by covering maps on the Bergman space: the connection between operator theory and von Neumann algebras***

In this talk, we will combine methods of complex analysis, operator theory, and conformal geometry to construct a class of type-II factors in the theory of von Neumann algebras, which arise essentially from holomorphic coverings of bounded planar domains. One will see how types of such von Neumann algebras are related to algebraic topology of planar domains. As a result, we establish fascinating connections to one of the long-standing problems in free group factors. An interplay of analytical, geometrical, operator and group theoretical techniques is intrinsic to this work. This is a joint work with Hansong Huang.

**5-3** **Tsuyoshi Kato**
Kyoto University

***Growth of Casson handles and Yang-Mills gauge theory***

Casson handles are open subsets with boundary, which appear inside smooth four manifolds. They are parameterized by signed infinite trees, and their growth measures complexity of smooth structure. In this talk we show that growth of any CH in K3 surface must be more than bounded type. It implies that the smooth structure is sufficiently "complex." In order to verify this, we construct Yang-Mills gauge theory over non compact smooth four manifolds, particularly over Casson handles of bounded type.

# Abstracts

## #6. Kinetic Equations and Gas Dynamics—*organizer*: Seung Yeal Ha, Seoul National University

**PL** **Tai-Ping Liu**
Academia Sinica
& Stanford University

***Hilbert's Sixth Problem***

Hilbert's Sixth Problem is one of the Hilbert Problems which raises a general program and not a single unsolved problem. From Hilbert's statement, kinetic theory is his main concern. In this talk we review some of the progresses that have been made in recent decades concerning the two types of problems. The first is to derive the Boltzmann equation from the Liouville equation for interacting particles in the Boltzmann-Grad limit. The second is to study the zero mean free path limit in the derivation of fluid dynamics equations. Both limits are highly singular in their own way. We will discuss the rich phenomena pertaining to these limits and raise open problems.

**6-1** **Seung Yeal Ha**
Seoul National University

***Complete synchronization of Kuramoto oscillators***

In this talk, I will discuss complete phase-frequency synchronization for the particle and kinetic Kuramoto models which are very popular model for the synchronization of limit-cycle oscillators. We present sufficient conditions for initial configurations leading to the exponential time-decay toward completely synchronized states characterized by initial configurations and natural frequencies. For the kinetic model, we provide the global existence of measure-valued solutions and their asymptotic behavior.

**6-2** **Kazuo Aoki**
Kyoto University

***Stokes fluid dynamics for a vapor-gas mixture derived from kinetic theory***

When a vapor of a substance is in contact with its condensed phase, evaporation and condensation (or sublimation) take place on the interface between the vapor and the condensed phase. If we try to describe flows of the vapor with evaporation and/or condensation, we have to use kinetic theory even in the continuum limit, since the vapor is not in local equilibrium at the interface. In other words, even if the mean free path of the vapor molecules (or the Knudsen number based on it) is very small, we cannot derive correct fluid dynamics by macroscopic considerations. We can construct correct fluid-dynamic systems for small Knudsen numbers (including the continuum limit) only by considering the zero Knudsen number limit and its neighborhood on the basis of kinetic theory. In this paper, we present an example of the fluid-dynamic system for a vapor-gas mixture derived in this way. More specifically, we consider the situation where the vapor evaporates/condenses in the presence of another component that neither evaporates nor condenses (the noncondensable gas) and restrict ourselves to the steady flows. We further focus our attention on the case where the deviation of the system from the saturated equilibrium state at rest is small. We derive the correct fluid-dynamic system, composed of the fluid-dynamic equations of Stokes type, their correct boundary conditions, and the local corrections in the vicinity of the interface (Knudsen layer), from the linearized Boltzmann equation for a mixture of gases and its kinetic boundary condition at the interface by means of a formal but systematic asymptotic analysis for small Knudsen numbers.

# Abstracts

**6-3 Russel Caflisch**
UCLA

***Monte Carlo Simulation for Coulomb Collisions***

Coulomb collisions between charged particles in a plasma are described by the Landau-Fokker-Planck collision operator. The collision operator can be interpreted as describing discrete binary collisions, each of which is an aggregate of many particle interactions. Takizuka and Abe (1977) formulated a Monte Carlo method for this binary collision law, and Bobylev and Nanbu (2000) developed a mathematical derivation of Monte Carlo methods for Coulomb collisions, including an alternative method of Nanbu (1997). This talk presents a convergence study for the methods of Takizuka and Abe and of Nanbu. We also present an accelerated hybrid method for Coulomb collisions that combines a Monte Carlo particle simulation and a fluid dynamic solver in a single uniform method throughout phase space.

**6-4 Dongho Chae**
Sungkyunkwan University

***On the pressure of the incompressible fluids and the axisymmetric flows***

In this talk we discuss some observations on the divergence free tensor field equation, $\mathrm{div}\, T=0$ in the classical field theories in $\mathbb{R}^N$. For classical fields and compressible fluid equations such that $T \in L^1(\mathbb{R}^N)$ this observation implies a Liouville type of results for stationary fields, while for the time dependent incompressible fluids it says that the region of positivity of the pressure is unbounded in $\mathbb{R}^N$. We can also extend some parts of these results to the case when $T \in L^p(\mathbb{R}^N), p>1$. For the 3D axisymmetric incompressible fluids without swirl it also says that the quantity $\int_{-\infty}^{\infty}(p+v_r^2)dx_3$ decreases monotonically in the radial direction. In the later part of the talk, we discuss observations related to the blow-up problem of the 3D axisymmetric Euler equations.

**6-5 Shinya Nishibata**
Tokyo Institute of Technology

***Asymptotic behavior of solutions to the Euler-Poisson equation in plasma physics***

The main concern of the present talk is mathematical analyses on a boundary layer around a surface of a material with which plasma contacts. The layer, called a sheath in plasma physics, has a larger density of positive ions than that of electrons. The Bohm criterion for formation of the sheath requires that ion velocity should be hyper-sonic. This physical phenomena is studied in the Euler-Poisson equations describing behavior of ionized gas. We show that the sheath is regarded as a planar stationary solution in multi-dimensional half space. Precisely, under the Bohm sheath criterion, we show the existence of the stationary solution, which is time asymptotically stable. Moreover we obtain a convergence rate of the solution towards the stationary solution.

The present result is obtained through the joint research with Mr. Masasi Ohnawa and Dr. Masahiro Suzuki.

# Abstracts

**6-6** **I-Kun Chen**
Academia Sinica

***Maxwellian Bound for thermal transpiration problem and the singularity near the boundary***

We consider the thermal transpiration problem in the kinetic theory. For the gas flow between two plates, it has been shown that the linearized Boltzmann equation can model the transpiration phenomena. Our goal is to study the singularity property near the solid boundary. We show that the solution profile is Maxwellian-like, but with a singularity at zero normal microscopic velocity near the boundary. As a consequence, the macroscopic fluid velocity has a logarithmic singularity near the boundary. We use an iterated scheme, with the "gain" part of the collision operator as a source, appropriate for large Knudsen number considered here. The scheme yields an explicit leading term. The remaining converging terms are estimated through a refined point-wise estimate and Maxwellian upper bound for the gain part. Our analysis is motivated by the previous studies of asymptotic and computational analysis.

## #7. Mathematical Imaging—*organizer*: Zuowei Shen, National University of Singapore

**PL** **Emmanuel Candès**
Stanford University

***Advances in low-rank matrix modeling: some theory and some computer vision applications***

This talk is about a curious phenomenon. Suppose we have a data matrix, which is the superposition of a low-rank component and a sparse component. Can we recover each component individually? We prove that under some suitable assumptions, it is possible to recover both the low-rank and the sparse components exactly by solving a very convenient convex program. This suggests the possibility of a principled approach to robust principal component analysis since our methodology and results assert that one can recover the principal components of a data matrix even though a positive fraction of its entries are arbitrarily corrupted. This extends to the situation where a fraction of the entries are missing as well. In the second part of the talk, we present applications in the area of video surveillance, where our methodology allows for the detection of objects in a cluttered background, and in the area of face recognition, where it offers a principled way of removing shadows and specularities in images of faces. We also show how the methodology can be adapted to simultaneously align a batch of images and correct serious defects/corruptions in each image. This is joint work with X. Li, Y. Ma, and J. Wright.

**7-1** **Zuowei Shen**
National University of Singapore

***Frame-Based Image Restoration***

Efficient algorithms of image restoration and data recovery are derived by exploring sparse approximations of the underlying solutions by redundant systems such as wavelet frames and Gabor frames. Several algorithms and their applications in image restoration will be presented in this talk.

# Abstracts

**7-2** **Bin Dong**
UCLA

***Some Mathematical Models in Biomedical Shape Processing and Analysis***

I will first discuss a tight frame based segmentation model, as well as a fast implementation, for general medical image segmentation problems. This model combines ideas of the frame-based image restoration models with ideas of the total variation-based segmentation models (convexified Chan-Vese model). Then I will move to the topic on biological shape processing and analysis, which is a rather popular topic lately in biomedical image analysis. Within this category, I will mainly discuss the following three topics: surface restoration via nonlocal means; brain aneurysm segmentation in 3-D biomedical images; and multiscale representation (MSR) or shapes and its applications in blood vessel recovery (surface inpainting) and others. Some future work and ongoing projects will be mentioned in the end.

**7-3** **Ji Hui**
National University of Singapore

***Sparse approximation and blind image de-convolution***

Blind image de-convolution is a well-known challenging ill-posed problem in digital photography. In this talk, based on the sparse approximation of images and blur kernels under suitable redundant tight frame systems, I will present a regularization model for blind de-convolution. The resulting L1 norm-related minimization can be efficiently solved using Bregman iteration based approaches. As one application, the proposed approach is applied to remove motion blurring caused by camera shake from digital photos with impressive results, compared favourably against that from existing motion de-blurring methods. It is a joint work with Jian-feng Cai (UCLA), Chaoqiang Liu, and Zuowei Shen (NUS).

**7-4** **Charles K. Chui**
University of Missouri
& Stanford University

***Dimensionality Reduction for Hyperspectral Imaging***

Since human vision is limited to electromagnetic radiation in the frequency band of 400–790 terahertz (1 THz = $10^{12}$ cycles per second), visible light to the human eye is restricted to wavelengths in the range of 390–750 nm (1 meter = $10^9$ nanometers).

With the recent rapid advances of satellite, senor, and computing technologies, it is now feasible to capture and analyze hyperspectral image (HSI) stacks with hundreds and even over a thousand band images. However, the computational aspect for understanding HSI is most challenging. For example, to analyze a 1 megapixel-resolution HSI stack with 200 band images, the matrix kernel for the current effective nonlinear methods has dimension $10^6 \times 10^6$, while the linear PCA method only requires SVD of a $200 \times 200$ matrix. The problem of “dimensionality reduction” is to reduce the kernel size, while preserving the useful data similarity/dis-similarity information, in applying nonlinear methods.

We will discuss the common bottleneck of the current non-linear approaches and our solution to remove it. This is a joint work with Jianzhong Wang.

# Abstracts

**7-5** **Joseph Teran**
UCLA

***Math in the Movies***

As computers get faster and architectures evolve, simulation of the dynamics of natural phenomena is becoming an increasingly indispensable tool for creating virtual worlds in movie special effects and video games. For example, nearly all companies involved in effects for movies and video games have a team dedicated to simulation-based dynamics of water, fire, smoke, explosions, rigid body dynamics and deformable body dynamics for cloth, etc. Although previously considered prohibitively costly for applications like movie special effects, simulation of such phenomena is now much more practical on a moderately powerful pc. Also, the bar has been raised so high for realism in these industries that simulating the physics of such phenomena is necessary to produce effects at the state of the art. In this talk, I will give an overview of some recent results from applied mathematics and scientific computing used for these exciting new applications.

**7-6** **Hongkai Zhao**
UC-Irvine

***A phase space method for recovering index of refraction from travel times***

I will present a phase space method for reconstructing the index of refraction of a medium (or the Riemannian metric of a manifold) from travel time measurements (or geodesics) between boundary points. The algorithm is a hybrid approach that combines both Lagrangian and Eulerian formulations. In particular the Lagrangian formulation in phase space can take into account multiple arrival times naturally, while the Eulerian formulation for the index of refraction allows us to compute the solution in physical space. Also we introduce a data based adaptive procedure to utilize better measurements or shorter geodesics first, which is analogous to layer stripping. We show that with this adaptive procedure, we can incorporate broken geodesics and deal with concave inclusions.

## #8. Nonlinear PDEs—*organizer*: Xu-Jia Wang, Australian National University

**PL** **Xu-Jia Wang**
Australian National University

***The Affine Maximal Surface Equation***

In this talk, we consider the first boundary value problem of the affine maximal surface equation and, more generally, the affine Plateau problem. The affine maximal surface equation is the Euler equation of the affine volume functional. It is a fourth order nonlinear partial differential equation closely related to the Monge-Ampère equation. We formulate the first boundary value problem as a geometric variational problem and prove the existence of maximizers to the problem. To prove the regularity of the maximizers, we establish the *a priori* estimates and prove that the maximizers can be approximated by smooth solutions. To prove the approximation, we employ a penalty argument, which requires us to solve the second boundary value problem. By a fundamental property of locally convex hypersurface, the above argument also leads to the existence and regularity of solutions to the affine Plateau problem.

# Abstracts

**8-1 Juncheng Wei**
Chinese University of Hong Kong

***On the De Giorgi Conjecture and Beyond***

In 1978, De Giorgi conjectured the level set of bounded solution of Allen-Cahn equation

$$\Delta u + u - u^3 = 0 \text{ in } R^N$$

satisfying the monotonicity condition $\frac{\partial u}{\partial y_N} > 0$ must be hyperplanes, at least when $N \leq 8$. Great progress has been made in the past 15 years. Positive answers are given: Ghousoub-Gui ($N$=2), Ambrosio-Cabre ($N$=3), and Savin ($N$=4,5,6,7,8) under a mild condition. In this talk, we give a counterexample in dimension $N$=9 by constructing a solution whose zero level set close to the Bombieri-De Giorgi-Giusti minimal graph. Furthermore, we show that each embedded complete minimal surfaces in $R^3$ with finite total curvature corresponds to a solution of Allen-Cahn in $R^3$. Extension of the De Giorgi conjecture to stable or finite Morse index solutions will also be discussed. (Joint work with Manuel del Pino and M. Kowalczyk.)

**8-2 Bo Guan**
Ohio State University

***Complete hypersurfaces of constant curvature in hyperbolic space with asymptotic boundary at infinity***

In this talk, we discuss recent joint work with Joel Spruck on the problem of finding complete hypersurfaces of constant curvature in hyperbolic space with prescribed asymptotic boundary at infinite.

**8-3 Hitoshi Ishii**
Waseda University

***The Neumann problem for Hamilton-Jacobi equations in view of weak KAM***

I will discuss a formula for the solutions of the Neumann problem for Hamilton-Jacobi equations. The discussion will be concerned with Aubry-Mather sets and optimal control of the associated Skorokhod problem, which the solution formula is based upon.

**8-4 Huaiyu Jian**
Tsinghua University

***A Bernstein theorem for the Monge-Ampere equation and applications***

This talk is based on a joint work with Professor Xu-Jia Wang. We first introduce a new transform for convex functions, then use it and a moving planes method to proves a Bernstein property for a Monge-Ampere equation in half space, and finally use the Bernstein property to prove the global regularity of affine hyperbolic sphere.

## Abstracts

**8-5 Yng-Ing Lee**
(National Taiwan University)

***Self-similar solutions and translating solutions for Lagrangian mean curvature flow***

For any given two transverse Lagrangian planes $L_1, L_2$ in $C^n$ with characteristic angles $\sum_{i=1}^{n} \beta_i < \pi$, we show that there exists a unique closed, embedded Lagrangian self-expander $L$ (up to scaling) of an explicit form, which is diffeomorphic to $\mathcal{S}^{n-1} \times R$ and asymptotic to $L_1 \cup L_2$. If $\sum_{i=1}^{n} \beta_i = \pi - 2\varepsilon$, the Lagrangian angle of $L$ will lie in $(-\varepsilon, \varepsilon)$. This result is sharp as $L_1 \cup -L_2$ is volume minimizing if and only if $\sum_{i=1}^{n} \beta_i \geq \pi$. The Lawlor necks that correspond to the case $\sum_{i=1}^{n} \beta_i = \pi$ are the limits of our examples. Furthermore, we can construct Lagrangian translating solutions with arbitrarily small Lagrangian angle from the self-expanders. These translating solutions are out of expectation, and play a similar role as Cigar/Bryant solitons in Ricci flow.

Self-similar solutions and translating solutions of different types are also constructed.

This is a joint work with D. Joyce and M.P. Tsui.

**8-6 Yu Yuan**
University of Washington

***Singular solutions to special Lagrangian equations with subcritical phase and minimal surface system***

We construct (highly oddly) singular solutions to special Lagrangian equations with subcritical phases and minimal surface systems (in 3d and above). *A priori* estimates breaking family of smooth solutions are also produced correspondingly. Recall *a priori* estimates for special Lagrangian equations with critical and supercritical phases in 2d and 3d, and with very large phase in general dimension are, by now, known. This is joint work with Dake Wang.

### #9. Number Theory—*organizer*: Brian Conrad, Stanford

**PL James Borger**
Australian National University

***Geometry—from algebraic to arithmetic to absolute***

Classical algebraic geometry is about studying solutions to systems of polynomial equations with complex coefficients. In arithmetic algebraic geometry, one digs deeper and studies the arithmetic properties of the solutions when the coefficients are rational, or even integral. From the usual point of view, it's impossible to go deeper than this for the simple reason that no smaller rings are available—the integers have no proper subrings. In this talk, I'll explain how an emerging subject, lambda-algebraic geometry, allows one to do just this and why one might care.

I will not assume any familiarity with algebraic geometry.

## Abstracts

**9-1** **Samit Dasgupta**
UC-Santa Cruz

***An integral Eisenstein-Sczech cocycle on*** $\mathbf{SL_n(Z)}$ ***and p-adic L-functions of totally real fields***

In 1993, Sczech defined an ($n$-1)-cocycle on $SL_n(Z)$ valued in a certain space of distributions. He showed that specializations of this cocycle yield the values of the partial zeta functions of total fields of degree $n$ at nonpositive integers. In this talk, I will describe an integral refinement of Sczech's cocycle. By introducing a "smoothing" prime l, we define an $n$-1 cocycle on a congruence subgroup of $SL_n(Z)$ valued in a space of $p$-adic measures. We prove that the specializations analogous to those considered by Sczech produce the $p$-adic $L$-functions of totally real fields. We also consider certain other specializations that conjecturally yield the Gross-Stark units defined over abelian extensions of these fields. This is joint work with Pierre Charollois.

**9-2** **Cristian Popescu**
UC-San Diego

***Tate modules of Picard 1-motives and applications***

I will report on joint work with Greither on the Galois module structure of Tate modules of Picard 1-motives in positive characteristic and their Iwasawa theoretic analogues in characteristic 0. First, I will describe the construction of the relevant Iwasawa modules; second, I will state and comment on the proof of an equivariant Main Conjecture for these Iwasawa modules; finally, I will discuss applications of these results to refinements of the Brumer-Stark and Coates-Sinnott Conjectures as well as the Equivariant Tamagawa Number Conjecture.

**9-3** **James Borger**
Australian National University

***Witt vectors, lambda-rings, and absolute algebraic geometry***

I'll give a more detailed picture of lambda-algebraic geometry than in my plenary lecture. This will include precise definitions, some $F_1$-style theorems about lambda-varieties of finite type, future directions involving Witt spaces and lambda-varieties not of finite type, and some precise open questions.

**9-4** **Karl Rubin**
UC-Irvine

***Twists of elliptic curves and Hilbert's Tenth Problem***

In joint work with Barry Mazur, we investigate the 2-Selmer rank in families of quadratic twists of elliptic curves over arbitrary number fields. We give sufficient conditions on an elliptic curve so that it has twists of arbitrary 2-Selmer rank, and we give lower bounds for the number of twists (with bounded conductor) that have a given *2*-Selmer rank. As a consequence, under appropriate hypotheses we can find many twists with Mordell-Weil rank zero, and (assuming the Shafarevich-Tate conjecture) many others with Mordell-Weil rank one. Using work of Poonen and Shlapentokh, it follows from our results that if the Shafarevich-Tate conjecture holds, then Hilbert's Tenth Problem has a negative answer over the ring of integers of every number field.

**9-5** **Vinayak Vatsal**
University of British Columbia

***Period integrals of modular forms***

I will talk about work in progress on certain adelic period integrals of modular forms on $SL_2$ and $GL_2$. It turns out that the situation for $SL_2$ is quite different from that of $GL_2$, and I'll try to explain what some of the differences mean for non-vanishing of $L$ functions.

## Abstracts

**9-6 Akshay Venkatesh**
Stanford University

***Torsion in the homology of arithmetic groups***

Arithmetic groups can have a lot of torsion in their homology! I will discuss when I expect this to happen, and the significance for the Langlands program.

The results presented will be joint with Nicolas Bergeron and Frank Calegari.

### #10. Random Systems and PDEs—*organizer*: Fraydoun Rezakhanlou, UC-Berkeley

**PL S.R.S. Varadhan**
Courant Institute

***Large Deviations***

We will explore some new developments in large deviations. They deal with quenched versions when there are multiple sources of randomness and can be used to handle some problems with long-range dependence.

**10-1 Fraydoun Rezakhanlou**
UC-Berkeley

***Gelation for the Marcus-Lushinkov Process***

The Marcus-Lushinkov Process is an simple mean field model of coagulating particles model that converges to homogeneous Smoluchowski equation in the large mass limit. If the coagulation rates grow sufficiently fast as the size of particles get large, giant particles emerge in finite time. This is known as gelation and such particles are known as gels. Gelation comes in different flavors; regular, instantaneous and complete. In the case of an instantaneous gelation, a giant particle is formed in a very short time. If all particles coagulated to form a single particle in a time interval that stays bounded as total mass gets large, then we have a complete gelation. In this talk, I describe conditions which guarantee any of the three possible gelations with explicit bounds on the size of gels and the time of their creations.

**10-2 Tadahisa Funaki**
University of Tokyo

***Hydrodynamic limit for a dynamic model of 2D Young diagrams***

We consider dynamics of two-dimensional Young diagrams by allowing the creation and annihilation of unit squares located at the boundary of the diagrams. The dynamics are naturally associated with the grand canonical ensembles introduced by Vershik ('96), which are uniform measures under conditioning on their area. We show that, as the averaged area of the diagrams diverges, the corresponding height variable converges to a solution of a certain non-linear partial differential equation under the hydrodynamic space-time scaling. The stationary solution of the limit equation is identified with the so-called "Vershik curve." We also discuss the conservative dynamics which have a connection to the surface diffusion, and give some remarks to the 3D case. This is a joint work with Makiko Sasada (University of Tokyo).

# Abstracts

**10-3 Atilla Yilmaz**
UC-Berkeley

***Large deviations for random walk in a random environment***

I will talk about large deviations for nearest-neighbor random walk in an i.i.d. environment on $\mathbb{Z}^d$. There exist variational formulae for the quenched and the averaged rate functions $I_q$ and $I_a$, obtained by Rosenbluth and Varadhan, respectively. $I_q$ and $I_a$ are not identically equal. However, when $d \geq 4$ and the walk satisfies the so-called (T) condition of Sznitman, they are equal on an open set $A_{eq}$. For every *xi* in $A_{eq}$, there exists a positive solution to a Laplace-like equation involving *xi* and the original transition kernel of the walk. This solution lets us define a new transition kernel via the h-transform technique of Doob. This new kernel corresponds to the unique minimizer of Varadhan's variational formula at *xi*. It also corresponds to the unique minimizer of Rosenbluth's variational formula provided that the latter is slightly modified. In other words, when the limiting average velocity of the walk is conditioned to be equal to *xi*, the walk chooses to tilt its original transition kernel by an *h*-transform.

**10-4 Stefano Olla**
CEREMADE, Université Paris-Dauphine
& INRIA, France

***From Hamiltonian dynamics to heat equation: the hydrodynamic limit approach by energy conserving stochastic perturbations***

I will present some results and open questions concerning a system (chain) of anharmonic oscillators, whose Hamiltonian dynamics is perturbed by a stochastic noise that conserves energy. We are interested in the diffusion of energy in a diffusive space-time scaling. Joint work with C. Liverani and M. Sasada.

**10-5 Sunder Sethuraman**
Iowa State

***A scaling limit for a tagged particle in bounded one dimensional zero-range systems***

Zero-range processes follow a collection of random walks moving on a lattice which interact in terms of jump times in the following way: At a site with $k$ particles, a clock rings with rate $g(k)$, and then one of the particles, chosen uniformly, displaces by $j$ with probability $p(j)$. The behavior of the system, in particular the mixing properties, varies depending on the asymptotic growth of the rate $g$.

In this talk, we discuss a nonequilibrium scaling limit for a tagged, or distinguished particle in one dimensional mean-zero zero-range systems with bounded, increasing rates. Previously, in Jara-Landim-Sethuraman (2009), processes with at least linear rates are considered. A different approach is required for bounded rate systems.

**10-6 Alejandro F. Ramírez**
Pontificia Universidad Católica de Chile

***Ballisticity conditions for random walk in random environment***

We consider a random walk in a random environment on a uniformly elliptic i.i.d. environment in dimensions $d \geq 2$. It is conjectured that transience in a given direction implies ballisticity in the same direction. In this talk, we will discuss some progress on this question in terms of a class of ballisticity conditions introduced in 2002 by Sznitman.

This talk is based on joint works with Alexander Drewitz from TU Berlin.