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Advanced Lectures in Mathematics
Volume 36

Proceedings of the Sixth International Congress of Chinese Mathematicians

Volume I

Companion to the volume
Proceedings of the Sixth International Congress of Chinese Mathematicians,
Volume II

edited by

Chang-Shou Lin · Lo Yang
Shing-Tung Yau · Jing Yu

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Proceedings of the Sixth International Congress of Chinese Mathematicians, Volume I

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Proceedings of the Sixth International Congress of Chinese Mathematicians, Volume II

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ADVANCED LECTURES IN MATHEMATICS

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Number Theory, Automorphic Forms and Arithmetic Geometry

President's Speech to ICCM 2013

Shing-Tung Yau

Today is a festival celebrating the achievements of Chinese mathematicians. Fifteen years have passed by between the first congress in Beijing up until today in Taipei. Professor Lo Yang has a thorough understanding of the many hardships throughout these fifteen years, and yet, in spite of the difficulties, both academic and blood ties between scholars from Mainland, Taiwan, Hong Kong of China, and overseas have fueled enthusiastic participation.

Through the five congresses held so far, scholars have not only received academic benefits, but they have also made many new friends. Chinese mathematicians have become a strong force in the worldwide mathematical community. Based on both the list of winners, as well as the content of the speeches, we can proudly say that our congress has truly reached the world-wide first-class level. There are, of course, still some less studied mathematical disciplines which require much more work, but our young scholars have certainly made outstanding achievements in them.

For example, in probability theory, Horng-Tzer Yau solved the Dyson conjecture. In number theory, we live in an era in which we no longer hesitate. We are no longer staying in the era of Loo-keng Hua, Yuan Wang, Chengdong Pan, and Jingrun Chen. With the help of numerous overseas scholars such as John Coates, Shouwu Zhang, Ching-Li Chai, Jing Yu, Ju-Kang Yu, as well as many other Chinese and non-Chinese scholars, our young scholars have obtained important results over and over again in this important and classical field. This is definitely worthy of encouragement. Indeed, recently Yitang Zhang and Ye Tian have made enormous breakthroughs in classical problems in number theory. Their achievement dated back to the instruction and guidance of their tutors in Beijing: Professor Chengbiao Pan and Professor Chunlai Zhao.

Important achievements by Chinese mathematicians can also be found in algebraic geometry, algebra, and group representation theory, in which Chinese scholars such as Jun Li, Bong Lian, Chin-Lung Wang, Zhiwei Yun, Xuhua He, and Nanhua Xi have made many breakthroughs. They broaden the scope of mathematics disciplines in China beyond traditional strong fields such as geometry and analysis. The helps from many visitors abroad are fundamental to this development. This includes Viehweg, Esnault, Looijenga, and many others.

In geometric analysis, Yum-Tong Siu, Peter Li, Chang-Shou Lin, Kefeng Liu, Xujia Wang, Mu-Tao Wang, Conan Leung, Chiu-Chu Liu, Lizhen Ji, Jixiang Fu, Xiping Zhu, Juncheng Wei and numerous other scholars still perform first-class research. This can clearly be seen from the award winners this year, as well as their speeches. We are grateful to the constant visits of Richard Schoen, Richard Hamilton, Neil Trudinger and others.

In applied mathematics, Zhouping Xin, Sijue Wu, Chongqing Cheng, Chi-Wang Shu, Yizhao Hou, Raymond Chan, and Wen-Wei Lin have contributed excellent work in fluid theory, dynamical systems, computational fluid theory, and numer-

ical linear algebra. In addition to these contributions, Xianfeng Gu has made outstanding advancements in image processing, as has Stephen Yau and Lei Guo on control theory. Chinese applied mathematicians are no longer just focused on classical finite element methods. The visits of Osher, Engquist, Majda and many others have been very useful for our developments.

Under the leadership of Tze-Leung Lai, Wing Hung Wong, Chien-Fu Jeff Wu, Ziliang Ying, Jianqing Fan, and Jun Liu, Chinese statisticians have also attained an important position in the world.

We would like to show our appreciation of the generous support of numerous government leaders and the Morningside Group over the years. We are especially grateful for the strong support of the Chan brothers.

In Mainland, eighteen years ago, Ronnie Chan, Yongxiang Lu (the former president of Chinese Academy of Sciences), Lo Yang, and I founded the Morningside Center of Mathematics at the Chinese Academy of Sciences in Beijing. There we trained a large class of Chinese scholars, coming from all corners of the country. In fact, the talents leading in the new directions in number theory, which I just mentioned, mostly came to the Morningside Center to learn and to perform research. They were not only from Chinese Academy of Sciences, but also from Peking University, Tsinghua University, Sun Yat-sen University, the University of Science and Technology of China, Fudan University, Nankai University, Zhejiang University, as well as many other universities. I am very glad that most of them have gone on to become very good mathematicians, and many of them will deliver speeches in the following five days. After the formation of Morningside Center of Mathematics, several centers of mathematics were formed within the mainland, this includes the center in Zhejiang University, and the Tsinghua Center of Mathematics, where many outstanding mathematicians from Europe and American are joining.

In Taiwan, Professor Zhaoxuan Liu, the former dean of "National Science Council", founded "the National Center for Theoretical Sciences", at my suggestion. This center is located at the Hsinchu Tsing Hua University, and it is split into two divisions: physics and mathematics. The first director was Chang-Shou Lin, who was very successful in fulfilling his duties. Following Chang-Shou Lin, Jing Yu and Wen-Ching Li became the directors of NCTS, and they both did a tremendous job training many talented young scholars in Taiwan, as well as increasing the rate of communication with overseas scholars. Later on, at Taiwan University, Chiao Tung University, and other mathematics research institutes were founded, which also made great contributions to bettering the academic atmosphere.

At the Chinese University of Hong Kong, at my suggestion and with President Charles Kuen Kaos help, the Institute of Mathematics was founded in 1992. Later, it was financed by my fundraising effors through my friends: Robert Kuok Hock Nien, Ka-Shing Li, William Mong Man Wai, Thomas T.T. Chen, and the Hysan Foundation. The Institute hired a group of outstanding mathematicians, and also trained a large number of talented young people. Some of the outstanding students are leading researchers including some Ph.D students who became Benjamin Peirce Fellows at Harvard University.

The first congress was held in Beijing by the Morningside Center of Mathematics, where the leaders of the academy of science and a group of distinguished

government officer came to support the activities. Many prominent mathematicians from abroad representing different countries gave speeches.

The second congress was held in Taipei when, at that moment, there were not many Mainland scholars coming to Taiwan due to the problem of visas. In spite of this, all scholars were very enthusiastic about participating in the congress. We celebrated the ninetieth birthday of Professor Shiing-Shen Chern, who was unfortunately not in very good health, and so his daughter Pu Chern and his son-in-law Paul Ching-Wu Chu attended the congress on his behalf.

The third congress was held in Hong Kong by the Chinese University of Hong Kong. President Yongxiang Lu of the academy of science came to give the opening speech. State councilor Zhi Li Chen sent a letter to congratulate the success of the congress. The congress also decided to memorialize the honorable chairman of the congress, Professor Chern, who had just passed away. Professor Chern has been planning to attend the congress, and had donated one-hundred thousand yuan to the congress.

The fourth congress was held in Hangzhou, and was endorsed by the former party secretaries of the Zhejiang Province, Jinping Xi and Hongzhu Zhao. Yuanchao Li, minister of the Organization Department of the Central Committee and NPC Vice Chairman Yongxiang Lu both sent congratulatory letters. Governor Zushan Lv and other leaders attended the opening ceremony, as well as the welcoming dinner.

The fifth congress was held in Beijing, and was co-organized by Tsinghua University and the Morningside Center of the Chinese Academy of Sciences. This congress was dedicated to the hundredth anniversaries of the births of Professor Shiing-Shen Chern and of Professor Loo-keng Hua. It was held in the Great Hall of the People. There were more than 1600 participants! Its opening ceremony was truly a grand occasion.

Today the sixth congress is held in Taipei, at a time when mathematical achievements are more prosperous, which is incredibly important. We hope that, when we hold the next congress at the Chinese Academy of Sciences, our native speakers will reach the level of the Fields Medal.

We are pleased to say that fifteen years ago Chang-Shou Lin was the first Chinese mathematician residing in Taiwan to receive the Morningside Gold Award in Beijing. He did most of his work in Taiwan. After waiting fifteen years, we are pleased to see that Ye Tian and Xuhua He, who reside in Beijing and Hong Kong, respectively, are receiving the Morningside Gold Award in this congress.

It is our honor to see the participation of President Si-Chen Lee, former president of Taiwan University. He received the Shiing-Shen Chern award, due to his contributions to the mathematical society.

I am sure that many well-to-do Chinese will continue to support this congress, whether through academic works or financially. Chinese mathematics will continue to flourish. I am grateful to the support from all of you.

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Report of ICCM 2013 at Taipei

Jing Yu

The Sixth International Congress of Chinese Mathematicians (ICCM) was held from July 14 to July 19, 2013, in Taipei, China. The opening ceremony took place at the Grand Hotel of Taipei on July 14 Sunday, with about one thousand participants from all over the world. This monumental activity of the whole Chinese mathematical community started with welcome greetings by the ICCM honorary chair Professor Shing-Tung Yau from Harvard University, President Pan-Chyr Yang of Taiwan University, Mr. Ronnie C. Chan, co-founder of the Morningside Foundation and Chairman of Hang Lung Properties, and Professor Jing Yu from the Taida Institute of Mathematical Sciences who also served as chairman of the local organizing committee. This was the second time that ICCM held in Taiwan, the first time was 12 years ago. Despite an unexpected Typhoon invasion to the Taiwan Island on July 11/12, we are very happy to see that almost all the participants this year who scheduled to join managed to do so eventually.

As in each ICCM, people are able to witness the exciting progresses of mathematics made by Chinese mathematicians just recently.

Following now the tradition of ICCM, the big event in the opening ceremony was the Awards presentation, in particular the Morningside Medals. This year, beside the Morningside Gold and Silver Medal, a special Morningside Achievement Award was awarded to Yitang Zhang from the New Hampshire University, for his monumental breakthrough in Number Theory, proving the abundance of bounded gaps between consecutive primes. This brilliant success throws new lights on the entire development of analytic number theory. Another medal first awarded this year is the Morningside Mentor Award in Mathematics, given to Chengbiao Pan, a retired professor from China Agricultural University who held adjoint position at Peking University for many years.

There are two 2013 Morningside Gold medals. One was awarded to Xuhua He of HKUST for his fundamental contributions to arithmetic geometry, algebraic groups, and representation theory. The other Gold Medal awarded to Ye Tian, AMSS of the Chinese Academy of Sciences, for his deep and original work on the congruence number problem. The 2013 Morningside medal of applied mathematics was awarded to Xianfeng David Gu, for his contributions to computational geometry, imaging, and graphics.

There are four Morningside Silver Medals awarded this year. The recipients are Chieh-Yu Chang of Tsing Hua University, Xiaoqing Li of State University of New York at Buffalo, Hao Xu of Harvard University, and Tai-Peng Tsai of the University of British Columbia.

Professor Jean-Pierre Serre at the College de France, Fields Medalist, also recipient of both the Abel Prize, and the Wolf prize, was awarded the 2013 ICCM International Cooperation Award. Professor Serre has been visiting Taiwan biannually since 2009, and greatly impacted and encouraged many young mathematicians.

The two 2013 Chern Prize recipients are former President Si-Chen Li of the Taiwan University, for public service in support of mathematics, and Professor Bong Lian of Brandeis University, for fundamental contributions to mathematical physics.

The July 14 afternoon activity at the Grand hotel started with a Symposium, Unlocking our future: how government policies can foster fundamental science development. This symposium has Dr. Gerald L. Chan, co-founder of Morningside, as moderator, with panelists: Chi-Huey Wong, the President of "the Academia Sinica", Yan-Hwa Wu, President of Chiao Tung University, and Way Kuo, President, President of City University of Hong Kong. The second part of this Grand Hotel Symposium consist of two fascinating talks aiming at general audience, "the art of bridge building" delivered by Professor C.L. Liu of the Tsing Hua University, and "juggling mathematics and magic" delivered by Professor Ronald Graham of UC San Diego.

Honorary guest Jin-Pyng Wang, President of "the Legislative Yuan", joined the ICCM opening activity at the Grand Hotel in the evening of the opening day. Besides greeting the morning ICCM awardee, he also took part in the 2013 New World Mathematics Awards presentation ceremony. The New World Awards presentation is another tradition of ICCM, sponsored by the New World Development Company Limited, awarding prizes to the best recent Ph.D. Thesis, Master Thesis, and Bachelor Thesis in mathematics. July 14 evening, this award was presented to 27 students, among them are 7 gold Prizes for Doctor Thesis.

Venue of 2013 ICCM after the first day is sited on the Campus of Taiwan University, in a set of comfortable well-equipped lecture rooms that is situated in the beautiful drunken moon lakeside. Every morning of July 15–19, ICCM began with a distinguished one hour lecture by an international honorary guest: Jean-Pierre Serre on historical remarks of cohomology, John H. Coates on the Conjecture of Birch and Sinnerton-Dyer, Dorian Goldfeld on the relative trace formula for unipotent groups, Björn Engquist on multiscale simulations of dynamical systems with oscillatory solutions, and Stanley Osher on what sparsity and l1 optimization can do for you. These talks are followed by the one hour plenary lectures, there are six such lectures every day, covering a broad landscape of both pure and applied mathematics, and addressing to the most important recent progresses. The abstracts of all these inspiring lectures are appended with this report. We are editing a more complete account of these lectures into Proceedings of the Six ICCM to be published in near future.

There were 152 invited 45-minute talks, dividing into 10 sections:

1. Number Theory, Automorphic Forms, and Arithmetic Geometry, 25 talks.
2. Algebra, History of Mathematics, 9 talks.
3. Discrete Mathematics, Combinatorics, 8 talks.
4. Algebraic Geometry, Complex Geometry, 18 talks.
5. Geometric Analysis, Differential Geometry, Symplectic Geometry, 17 talks.
6. Topology, Geometry and Mathematical Physics, 17 talks.
7. Statistical Theory, Methods, Applications, Probability, Financial Mathematics, 11 talks.

8. Dynamical Systems, Control Theory, Optimization, Functional Analysis, Fractals, 18 talks.
9. Computational Mathematics, Imaging, Mathematical Biology, 17 talks.
10. Partial Differential Equations, 12 talks.

There were also 96 contributed talks, each given 20 minutes.

Among the participants of the Six ICCM, there are over 400 coming from mainland, it took lots efforts to process their travel documents to Taiwan. Although there are now direct flights from all major cities of mainland to Taiwan, the travel documents still have to be approved by authorities from both Mainland and Taiwan which is certainly time consuming. ICCM is by far the largest scale academic interaction across the strait. We are able to manage it this time without genuine obstacles.

The sponsoring organizations of the 2013 ICCM Conference include: Taiwan University (Taida Institute for Mathematical Sciences, Center of Advanced Studies for Theoretical Sciences, Department of Mathematics), "National Science Council" ("National Center for Theoretical Sciences", Department of International Cooperation), Ministry of Economic Affairs, the Yau Center of Chiao Tung University, and the Taipei City Government.

Abstracts of the Special Lecture, Morningside Lectures, and Plenary Lectures

Special Lecture

Historical remarks on cohomology (by *Jean-Pierre Serre*, Collège de France)

Abstract. The introduction of cohomological methods in algebra, complex variables, algebraic geometry and number theory is one of the characteristics of last century mathematics. The lecture will describe how some of these methods came into being, with special emphasis on étale cohomology and Weil conjectures.

Morningside Lectures

On the conjecture of Birch and Swinnerton-Dyer (by *John H. Coates*, University of Cambridge)

Abstract. The lecture will discuss the important progress on the conjecture of Birch and Swinnerton-Dyer made by Tian in his recent work on the classical congruent number problem, and its possible generalization to other elliptic curves.

The relative trace formula for unipotent subgroups (by *Dorian Goldfeld*, Columbia University)

Abstract. The relative trace formula of Jacquet has played a fundamental role in recent advances in number theory. The goal of my lecture will be to explain and introduce a very explicit version of the relative trace formula for the quotient $U\backslash G/U$ when $G = GL(n)$ and U is a unipotent subgroup. In the second part of the lecture, I will show how to obtain applications of the relative trace formula to some well known problems in analytic number theory.

Multiscale simulations of dynamical systems with oscillatory solutions (by *Björn Engquist*, The University of Texas at Austin)

Abstract. The heterogeneous multiscale method is a framework that can be used to design and analyze numerical methods for stiff ordinary differential equations with oscillatory solutions. Microscale simulations are applied in subsets of the computational domain in order to approximate the averaged dynamical system. We will discuss the difficulty of finding macroscale variables and present new techniques for avoiding this difficulty. We will compare with related methods and give numerical examples.

What sparsity and $l1$ optimization can do for you (by *Stanley Osher*, University of California, Los Angeles)

Abstract. Sparsity and compressive sensing have had a tremendous impact in science, technology, medicine, imaging, machine learning and now, in solving multiscale problems in applied partial differential equations, developing sparse bases for Elliptic eigenspaces and connections with viscosity solutions to Hamilton-Jacobi equations.

$l1$ and related optimization solvers are a key tool in this area. The special nature of this functional allows for very fast solvers: $l1$ actually forgives and forgets errors in Bregman iterative methods. I will describe simple, fast algorithms and new applications ranging from sparse dynamics for PDE, new regularization paths for logistic regression and support vector machine to optimal data collection and hyperspectral image processing. This is joint work with many people.

Plenary Lectures

Leaves and local Hecke symmetry (by *Ching-Li Chai*, Institute of Mathematics, "Academia Sinica"/University of Pennsylvania)

Abstract. Let M be a PEL type moduli space over an algebraic closure of the prime field with p elements; points of such a moduli space corresponds to isomorphism classes of abelian varieties with prescribed symmetries of a fixed type. A leaf in M is the locally closed subvariety obtained by fixing all p-adic invariants of these PEL type abelian varieties. A conjecture of Oort predicts that every prime-to-p Hecke orbit in M is Zariski dense in the leaf containing this Hecke orbit. In this talk we will present an overview of questions and results related to this conjecture, as well as recent progress in two aspects.

The first is a scheme-theoretic definition of the notion of leaves, more than a dozen years after its birth.

The new definition allows a natural construction of group-like structures on the formal completion at a point of a leaf, generalizing the Serre-Tate canonical coordinates for ordinary abelian varieties.

The second is a method for computing a weak asymptotic expansion of the action of the local stabilizer subgroup on the formal completion of a point of M.

This method will be illustrated in the case of the Lubin-Tate action, which occurs in moduli spaces of PEL type $U(n, 1)$.

Parameter estimation in systems and control (by *Han-Fu Chen*, Academy of Mathematics and Systems Science, Chinese Academy of Sciences)

Abstract. Many problems from systems and control such as system identification for linear systems and for a large class of nonlinear systems as well, adaptive regulation and iterative learning control (ILC) for stochastic systems, principal component analysis, adaptive filtering, blind identification in communication, and a certain kind of problems from networked systems and signal processing and many others can be reduced to problems of parameter estimation. The unknown parameters may be viewed as roots of functions, and parameter estimation can be transformed to a root-seeking problem based on observations on an unknown function called as the regression function. However, the resulting root-seeking problem can hardly be solved by the classical Robbins-Monro (RM) algorithm, because for its convergence a set of restrictive conditions are required.

The stochastic approximation (SA) algorithm with expanding truncations (SAAWET) is then introduced, and for its convergence a general convergence theorem (GCT) is presented. SAAWET is successfully applied to solving problems from systems and control. As a matter of fact, all problems listed above have been solved under reasonable and checkable conditions. Moreover, all solutions are provided in a recursive way, which is convenient for applications. This approach suggests solving the problems by two steps: first, transform problems to estimation of parameters or to root-seeking problems with appropriately selected regression function, then apply SAAWET with emphasis on proving satisfaction of the conditions required by GCT.

To demonstrate such an approach to solving problems from systems and control, the identification of the multivariate Hammerstein system is analyzed, and the recursive identification algorithms for both the linear and the nonlinear parts of the system are presented. All estimates given by the recursive algorithms are strongly consistent under reasonable conditions. Finally, the proposed algorithms are used to numerically identify a two-dimensional Hammerstein system. It is shown that the simulation results are consistent with the theoretical analysis.

Sixty years of compactifications of $\mathbb{C}^n$ (by *Baohua Fu*, Academy of Mathematics and Systems Science, Chinese Academy of Sciences)

Abstract. I shall give an overview of the study of compactifications of $\mathbb{C}^n$ as projective algebraic manifolds with $b_2 = 1$, a problem asked by Hirzebruch in 1954. Recent progress on equivariant compactifications will also be discussed. This is based on joint works with Jun-Muk Hwang.

Sliced inverse regression with interaction detection (by *Jun Liu*, Harvard University)

Abstract. Previously we have proposed a Bayesian partition model for detecting interactive variables in a classification setting with discrete covariates. This framework takes advantage of the structure of the naive Bayes classifier and introduces latent indicator variables for selecting variables and interactions. In our effort to extend the methods to continuous covariates, we found interesting connections with semi-parametric index models and the Sliced Inverse Regression method. In index models, the response is influenced by the covariates through an unknown function of several linear combinations of the predictors. Our finding of the Bayesian

formulation of such models enabled us to propose a set of new models and methods that can effectively discover second-order effects and interactions among the covariates. A two-stage stepwise procedure based on likelihood ratio test is developed to select relevant predictors and a Bayesian model with dynamic slicing scheme is derived. The performance of the proposed procedure in comparison with some existing method is demonstrated through simulation studies. This is based on the joint work with Bo Jiang.

A Langlands program for covering groups (by *Wee Teck Gan*, National University of Singapore)

Abstract. In this talk, I will survey some recent results (by many people) about a possible extension of the Langlands program to a class of covering groups studied by Beylinski and Deligne. These include the definition of the L-group of a covering group, the classification of local representations, the theory of the trace formula and endoscopy and the study of the automorphic discrete spectrum.

Ricci flow and classification of certain four-manifolds (by *Bing-Long Chen*, Sun Yat-sen University)

Abstract. It has been well known that Ricci flow has played a vital role in 3-dimensional topology. The Ricci flow with surgery in dimension 4 has already been developed in a seminal paper by R. Hamilton in 1997. It was expected that Ricci flow may also exert a great role in 4-dimensional geometry and topology. I hope this talk will serve as a step toward this subject. The main result of this talk, obtained from the study of the Ricci flow, is to show a complete classification of compact 4-manifolds whose certain generalized Yamabe invariants are positive. This classification is an analogue of a classification theorem of R. Schoen and S.T. Yau in 1970's on 3-manifolds with positive ordinary Yamabe invariants. This lecture is based on author's two joint papers with X.P. Zhu, one joint paper with S.H. Tang and X.P. Zhu.

Shock reflection-diffraction, von Neumann's conjectures (by *Gui-Qiang Chen*, University of Oxford)

Abstract. Shock waves are fundamental in nature. When a shock impinges an obstacle (steady or flying), shock reflection-diffraction phenomena occur. One of the most fundamental problems in mathematical fluid mechanics is shock reflection-diffraction by wedges. The complexity of reflection-diffraction configurations was first reported by Ernst Mach in 1878, who first observed two patterns of configurations. The problems remained dormant until the 1940s when John von Neumann, as well as other mathematical/experimental scientists, began extensive research into all aspects of shock reflection-diffraction phenomena. Moreover, the reflection-diffraction configurations are the core configurations in the structure of multidimensional Riemann solutions, which are building blocks and local structure of general entropy solutions and determine global attractors and asymptotic states of the solutions for multidimensional hyperbolic systems of conservation laws.

The shock reflection-diffraction problems involve several core mathematical difficulties we have to face in solving nonlinear partial differential equations in

mechanics and geometry. These include nonlinear equations of mixed hyperbolic-elliptic type, nonlinear degenerate elliptic equations, nonlinear degenerate hyperbolic equations, free boundary problems for nonlinear degenerate equations, corner singularity/regularity especially when free boundaries meet degenerate curves, a priori estimate techniques, among others.

In this talk we will start with various shock reflection-diffraction phenomena and historic perspectives, their fundamental scientific issues, and their theoretical roles in the mathematical theory of multidimensional hyperbolic systems of conservation laws. Then we will describe how the global shock reflection-diffraction problems can be formulate as free boundary problems for nonlinear conservation laws of mixed hyperbolic-elliptic type. Finally we will discuss some recent developments in solving von Neumann's conjectures and establishing a mathematical theory of shock reflection-diffraction, including the existence, stability, and regularity of global regular configurations of shock reflection-diffraction by wedges. Further connections, trends, and open problems on the topics will also be addressed.

Bounded gaps between primes (by *Yitang Zhang*, The University of New Hampshire)

Abstract. Let p_n denote the n-th prime. It is proved that

$$\lim_{n\to\infty} \inf(p_{n+1} - p_n) < 7 \times 10^7.$$

The first step of the proof is to reduce the problem to evaluating and comparing certain arithmetic sums, following the recent work of Goldston, Pintz and Yildirim. Then the major problem we encounter is to bound the error terms efficiently. To this end we introduce a stronger version of the Bombieri-Vinogradov theorem that is motivated by the work of Bombieri, Friedlander and Iwaniec. Some important results in algebraic geometry are needed to complete the proof.

Dynamics of rational maps (by *Guizhen Cui*, Academy of Mathematics and Systems Science, Chinese Academy of Sciences)

Abstract. In 1980s, Thurston gave a topological characterization for post-critically finite rational maps. It is a fundamental result in complex dynamics with many important applications. In this talk, we will introduce our recent progress about Thurston's theory. We will present the generalization of Thurston theorem to geometrically finite rational maps, and some applications to the structure of Julia sets.

Period integral calculus (by *Bong H. Lian*, Brandeis University)

Abstract. We will discuss an interplay between special function theory and complex geometry. We begin with an example that goes back to Euler, Gauss and Legendre who studied elliptic integrals as solutions to differential equations that bears their names. We will then consider the modern incarnation and generalizations of their constructions—known as period integrals—but from a more geometrical viewpoint. We will describe recent progress in understanding these period integrals and some of their remarkable properties.

Monge-Ampère equation and optimal transportation (by *Xu-Jia Wang*, Australian National University)

Abstract. The optimal transportation is to find an optimal mapping of transferring a mass density to another one such that the total cost is minimized. This problem was first introduced by Monge in 1781. Monge's cost function is propositional to the distance the mass is transferred, namely $c(x, y) = |x-y|$, but more general costs are allowed. The optimal transportation has found a variety of applications and has been extensively studied since then. In 1940s Kantorovich introduced a dual functional, and by which, for a large class of cost functions, the optimal mapping can be determined through the potential function satisfying a Monge-Ampère type equation.

The Monge-Ampère equation also arises in many geometric problems and has been studied by Aleksandrov, Calabi, Pogorelov, Cheng-Yau, and Caffarelli, among many others. In this talk we will first introduce the optimal transportation and review the existence of optimal mappings. We then focus on the regularity of the optimal mappings. By studying the Monge-Ampère equation of the potential function, sharp conditions on the cost function have been found by the speaker and his collaborators. For Monge's cost function $|x-y|$, which does not satisfy the sharp conditions, we have also obtained the existence of optimal mappings, and established interesting regularity and singularity results of the mapping.

A Survey of local models of Shimura varieties (by *Xinwen Zhu*, Northwestern University)

Abstract. A local model is projective scheme over the ring of integers of a p-adic field which is supposed to étale locally model the integral structure of the Shimura variety of parahoric level structure. Classically, local models were constructed as moduli spaces of linear algebra structures and were studied mostly on a case by case basis. We will report the recent progress of this subject, including the group theoretical definition of local models, their algebro-geometric properties, and the applications.

Recent results on rigidity of CR morphisms between compact strongly pseudo convex CR manifolds (by *Stephen Yau*, Tsinghua University)

Abstract. Strongly pseudoconvex CR manifolds are boundaries of Stein varieties with isolated normal singularities. We prove that any non-constant CR morphism between two $(2n-1)$-dimensional strongly pseudoconvex CR manifolds lying in an n-dimensional Stein variety with isolated singularities are necessarily a CR biholomorphism. As a corollary, we prove that any non-constant self map of $(2n-1)$-dimensional strongly pseudoconvex CR manifold is a CR automorphism. We also prove that a finite étale covering map between two resolutions of isolated normal singularities must be an isomorphism. This is a joint work with Yu-Chao Tu and Huaiqing Zuo.

The interplay between computation and analysis in the study of Clay Millennium problem on Navier-Stokes equations (by *Thomas Yizhao Hou*, California Institute of Technology)

Abstract. Whether the 3D incompressible Navier-Stokes equations can develop a finite time singularity from smooth initial data with finite energy is one of the Seven Millennium Problems posted by the Clay Mathematical Institute. We review some

recent theoretical and computational studies of the 3D Euler equations which show that there is a subtle dynamic depletion of nonlinear vortex stretching due to local geometric regularity of vortex filaments. Our study reveals a surprising nonlinear stabilizing effect that the convection term plays in stabilizing the solution. This is demonstrated through two reduced models of the 3D incompressible Navier-Stokes equations which shows that local flattening of the vortex structure and the effect of convection could lead to dynamic depletion of the vortex stretching term. Finally we present a new class of solutions to the 3D Euler and Navier-Stokes equations which could lead to a strong nonlinear alignment in the vortex stretching term and have the potential to develop a finite time singularity.

Congruent number problem (by *Ye Tian*, Morningside Center of Mathematics/Academy of Mathematics and Systems Science, Chinese Academy of Sciences)

Abstract. Recall that a positive integer is call a congruent number if it is the area of a right triangle with rational sides. The congruent number problem is to determine if a given positive integer is congruent and if so, find corresponding right triangles. It is known by Heegner that any prime or twice prime congruent to 5, 6, 7 modulo 8 is a congruent number. In this lecture, we construct congruent numbers with many prime factors, which extends Heegner's work.

Seiberg-Witten theory and Heegaard Floer theory (by *Yi-Jen Lee*, The Chinese University of Hong Kong)

Abstract. I will outline an equivalence proof of the Seiberg-Witten-Floer homology and the Heegaard Floer homology, and its expected extensions.

Automorphic period, L-function and relative trace formula (by *Wei Zhang*, Columbia University)

Abstract. We will present some recent progress on the study of period integrals of automorphic forms on classical groups, with an emphasis on their relation to L-functions. There are various approaches; but we will mainly discuss the approach of relative trace formula, started by Jacquet.

Compact embedded rotational hypersurfaces with constant mean curvature in a sphere (by *Haizhong Li*, Tsinghua University)

Abstract. The study of constant mean curvature (CMC) surfaces in spaces of constant curvature is one of the classical subjects in differential geometry. There are many beautiful results on this topic. By constructing a holomorphic quadratic differential for CMC surfaces, H. Hopf showed that any CMC two-sphere in Euclidean space is a round sphere. Then S.S. Chern extended Hopf's result to CMC two-spheres in 3-dimensional space forms. The famous Hopf conjecture asks that whether a compact CMC surface in Euclidean space is necessarily a round sphere? In 1980s, H.C. Wente gave a counter example of this conjecture by constructing a compact immersed CMC torus in Euclidean space. In 1950s, A.D. Alexandrov showed that if a compact CMC surface is embedded in Euclidean space, hyperbolic space or a hemisphere, then it must be totally umbilical. The minimal surface is the surface with constant mean curvature zero. It was conjectured by H.B. Lawson in 1970s that the only embedded minimal torus in three-sphere is the Clifford torus.

In 1980s, U. Pinkall and I. Sterling conjectured that embedded tori with CMC in three-sphere are surfaces of revolution. In March of 2012, Simon Brendle solved the Lawson conjecture. After that, in April of 2012, Ben Andrews and Haizhong Li gave a complete classification of CMC embedded tori in the three-sphere. When the constant mean curvature is equal to zero or $\pm 1/\sqrt{3}$, the only embedded torus is the Clifford torus. For other values of the mean curvature, there exists embedded torus which is not the Clifford torus, Ben Andrews and Haizhong Li gave a complete description of such surfaces. As a Corollary, Andrews-Li's Theorem solved the famous Pinkall-Sterling conjecture. In this lecture, we will talk about some basic facts of CMC surfaces and give explanations of key ideas of proofs of Lawson conjecture and Pinkall-Sterling conjecture.

Some mathematical problems in design of experiments (by *Ching-Shui Cheng*, Institute of Statistical Science, "Academia Sinica")

Abstract. I will discuss some mathematical problems that arise in statistical design of experiments. Several examples will be used to illustrate connections between design of experiments and finite projective geometry, coding theory and graph theory. Key results will be reviewed and some open questions will be presented.

Geometric transitions and quantum invariance (by *Chin-Lung Wang*, Taida Institute for Mathematical Sciences)

Abstract. A basic question in the study of higher dimensional geometry is to understand the relations of various invariants under geometric transitions among them. For example, the analytic continuation of quantum cohomology under K equivalent maps is extensively studied in recent years. In dimension 3, the famous Reid fantasy asks if various Calabi-Yau 3-folds are indeed connected via certain extremal transitions. It is even expected that conifold transitions may form the building blocks. This talk surveys some of the developments on the above aspects with emphasize on the relation of quantum $A + B$ models under transitions.

Global solutions of the Euler-Maxwell two-fluid system in 3D (by *Yan Guo*, Brown University)

Abstract. The fundamental "two-fluid" model for describing plasma dynamics is given by the Euler-Maxwell system, in which compressible ion and electron fluids interact with their own self-consistent electromagnetic field. We prove irrotational, smooth and localized perturbations of a constant background with small amplitude lead to global smooth solutions in three space dimensions for the Euler-Maxwell system.

Reflection groups, non-negative curvature and Tits geometry (by *Fuquan Fang*, Capital Normal University)

Abstract. A reflection in a euclidean space (sphere) is one of the fundamental notions of symmetry of geometric figures. It plays a central role in Killing and Cartan's work on Lie algebra in 19th century. Reflections groups on a hyperbolic space is important in hyperbolic geometry, and the first example goes back to F. Klein and Poincaré. In this talk I will present

(a) A complete classification of reflection groups and the equivariant structures of complete non negatively curved manifolds; and

(b) A complete classification of positively curved polar manifolds of cohomogeneity at least 2, which is achieved partially based on Tits geometry.

This is a joint work with Karsten Grove and G. Thorbergsson.

A brief survey on high order numerical methods for convection dominated problems (by *Chi-Wang Shu*, Brown University)

Abstract. Convection dominated partial differential equations are used extensively in applications including fluid dynamics, astrophysics, electro-magnetism, semiconductor devices, and biological sciences. High order accurate numerical methods are efficient for solving such partial differential equations, however they are difficult to design because solutions may contain discontinuities and other singularities or sharp gradient regions. In this talk we will survey several types of high order numerical methods for such problems, including weighted essentially nonoscillatory (WENO) finite difference methods, WENO finite volume methods, discontinuous Galerkin finite element methods, and spectral methods. We will discuss essential ingredients, properties and relative advantages of each method, and comparisons among these methods. Recent development and applications of these methods will also be discussed.

Enumerative geometry: from classical to modern (by *Yu-Jong Tzeng*, Harvard University)

Abstract. The subject of enumerative geometry goes back at least to the middle of the 19th century. It studies the number of geometric objects in a given class that satisfy a number of incidence or tangency conditions. For example:

(a) How many lines pass through distinct 2 points?
(b) How many lines pass through 4 general lines in 3-space?
(c) How many degree d rational curves on a general quintic 3-fold? (finite?)

The field has been very active in the last twenty years due to its interaction with physics, which provides motivation for many theories and conjectural formulas. One of the most famous problem in enumerative geometry is computing Severi degrees, which are the numbers of degree d plane curves with a given number of nodes and pass through an appropriate number of points in general position. The computation of Severi degrees, as well as counting nodal curves on other surfaces are great examples of classical problems which were open for long time and can finally be solved by modern techniques now. Furthermore, a recent conjecture of Gottsche states that there should be a universal formula that computes the number of nodal curves in a sufficiently ample linear system on any surface. In this talk I will first give an indication of what enumerative geometry is about, then give a survey about different curve-counting theories. Finally I will focus on the Gottsche's conjecture and its generalizations.

Rigidity in the Langlands correspondence and applications (by *Zhiwei Yun*, Stanford University)

Abstract. In the theory of Langlands correspondence for function fields, rigid automorphic representations and rigid local systems provide explicit and workable

examples. We give two applications of such rigid objects. One is the construction of motives over number fields with exceptional Lie groups as Galois groups, answering a question of Serre. The other is the solution of the inverse Galois problem for certain finite groups of Lie type.

Finite and infinite soliton and kink-soliton trains of nonlinear Schrödinger equations (by *Tai-Peng Tsai*, University of British Columbia)

Abstract. I will first review known results on multi-solitons of dispersive partial differential equations, which are special solutions behaving like the sum of many weakly-interacting solitary waves. I will then describe my recent joint work with Dong Li and Stefan Le Coz: Assuming the composing solitons have sufficiently large relative speeds, we prove the existence and uniqueness of a soliton train which is a multi-soliton composed of infinitely many solitons. We also give a new construction of multi-solitons and prove uniqueness in an exponentially small neighborhood. In the 1D case, we can add to the infinite train an additional half-kink, which is a solution with a non-zero background at minus infinity.

Hall algebras and quantum groups arising from period 2 derived categories (by *Jie Xiao*, Tsinghua University)

Abstract. Inspired by the recent work of Bridgeland, we extend the derived Hall algebras to that from a period 2 derived category. This gives a successful model to realize the quantum groups globally. The talk is based on a joint work with X. Chen and F. Xu.

Universality of random matrices, Dyson's Brownian and De Giorgi-Nash-Moser theory of parabolic regularity (by *Horng-Tzer Yau*, Harvard University)

Abstract. Eugene Wigner's revolutionary vision predicted that the energy levels of large complex quantum systems exhibit a universal behavior: the statistics of energy gaps depend only on the basic symmetry type of the model. These universal statistics show strong correlations in the form of level repulsion and they represent a new paradigm of point processes that are characteristically different from the Poisson statistics of independent points.

Simplified models of Wigner's thesis have recently become mathematically accessible. For mean field models represented by large random matrices with independent entries, the celebrated Wigner-Dyson-Gaudin-Mehta (WDGM) conjecture asserts that the local eigenvalue statistics are universal. For invariant matrix models, the eigenvalue distributions are given by a log-gas with potential V and inverse temperature $\beta = 1, 2, 4$. For $\beta \notin \{1, 2, 4\}$, there is no natural random matrix ensemble behind this model, but the analogue of the WDGM conjecture asserts that the local statistics are independent of V.

In this lecture, we review the recent solution to these conjectures for both invariant and non-invariant ensembles.

We will demonstrate that the local ergodicity of the Dyson Brownian motion is the intrinsic mechanism behind the universality. Furthermore, we will show that the universality of gap distribution requires to prove a Holder regularity

of a discrete parabolic equation with random coefficients. For this purpose, we incorporate the ideas of parabolic regularity via a De Giorgi-Nash-Moser approach.

Representation theories of Lie algebras and Lie superalgebras (by *Shun-Jen Cheng*, Institute of Mathematics, "Academia Sinica")

Abstract. We shall discuss the representation theories of Lie algebras and Lie superalgebras of classical types, and explain how these two apparently different theories are connected.

Structure-preserving algorithms for Riccati-type equations: rediscovery, redevelopment and applications (by *Wen-Wei Lin*, Chiao Tung University)

Abstract. In this talk, we attempt to tell the interesting story about the recent rediscovery and revival of the once faded and almost forgotten doubling algorithm for the discrete-time algebraic Riccati equation. Armed with some new insight and theoretical redevelopment, the method, now called the structure-preserving doubling algorithm (SDA), is first linked to palindromic eigenvalue problems. Generalizations were then developed for continuous-time, nonsymmetric and PCP algebraic Riccati equations and nonlinear matrix equations, for a vast array of applications in vibration analysis, surface acoustic wave simulation, optimal control, stochastic systems, transport theory, time-delayed systems, nano research, etc. We shall present some key theoretical results associated with selected important applications, and a summary of the recent discovery that the SDA can be adapted to solve large-scale problems of dimension n, with an computational complexity and memory requirement.

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Awards of ICCM 2013

Morningside Medal of Mathematics Selection Committee

The Morningside Medal of Mathematics Selection Committee comprises a panel of world renowned mathematicians and is chaired by Professor Shing-Tung Yau. A nomination committee of around 50 mathematicians from around the world nominates candidates based on their research, qualifications, and curriculum vitae. The Selection Committee reviews these nominations and recommends up to two recipients for the Morningside Gold Medal of Mathematics, up to two recipients for the Morningside Gold Medal of Applied Mathematics, and up to four recipients for the Morningside Silver Medal of Mathematics. The Selection Committee members, with the exception of the committee chair, are all non-Chinese to ensure the independence, impartiality and integrity of the awards decision.

Members of the 2013 Morningside Medal of Mathematics Selection Committee are:

Richard E. Borcherds

Professor Borcherds is Professor of Mathematics at the University of California at Berkeley. His research interests include Lie algebras, vertex algebras, and automorphic forms. He is best known for his work connecting the theory of finite groups with other areas in mathematics. Professor Borcherds was awarded the Fields Medal in 1998 for his work in algebra and geometry, in particular for his proof of the Moonshine conjecture.

John H. Coates

Professor Coates is Emeritus Sadleirian Professor of Pure Mathematics at the University of Cambridge. He is a number theorist, with particular research interests in Iwasawa theory and the arithmetic of elliptic curves. He frequently visits Asia, and is currently a Distinguished Professor at the Pohang University of Science and Technology, South Korea. Professor Coates is the first recipient of the ICCM International Cooperation Award in 2004.

Simon Donaldson

Professor Donaldson is Royal Society Research Professor at Imperial College. His research interests include differential geometry and its connections with differential topology and algebraic geometry. Professor Donaldson is a Fellow of the Royal Society, and a foreign member of the academies of France, Sweden and the United States. He is a recipient of the Fields Medal (1986), the Crafoord Prize in Mathematics (1994), the King Faisal International Prize for Science (2006), and the Shaw Prize in Mathematical Sciences (2009).

Björn Engquist

Professor Engquist is the Computational and Applied Mathematics Chair Professor at the University of Texas at Austin. His recent work includes homogenization theory, multi-scale methods, and fast algorithms for wave propagation. He is

a member of the Royal Swedish Academy of Sciences, the Royal Swedish Academy of Engineering Sciences, and the Norwegian Academy of Science and Letters. He was a Guggenheim Fellow (1991), and received the first James H. Wilkinson Prize in Numerical Analysis and Scientific Computing (1982), the Peter Henrici Prize (2011), and the Birkhoff Prize in Applied Mathematics (2012).

Gerd Faltings

Professor Faltings is a Director of the Max Planck Institute for Mathematics in Germany. His research interests include number theory and algebraic and arithmetic geometry. Professor Faltings taught at Princeton University and the University of Wuppertal before joining the Max Planck Institute for Mathematics in 1994. Past honors include the Fields Medal (1986), a Guggenheim Fellowship (1988), the Gottfried Wilhelm Leibniz Prize (1996), the Karl Georg Christian von Staudt Prize (2008), and the Heinz Gumin Prize (2010).

James G. Glimm

Professor Glimm is a Distinguished Professor of Applied Mathematics at the State University of New York at Stony Brook. He has made original contributions in a variety of areas in pure and applied mathematics, including operator algebras, quantum field theory, statistical physics, partial differential equations and scientific computing. His past honors include a Guggenheim Fellowship (1963), the Dannie Heineman Prize for Mathematical Physics (1980), the Leroy P. Steele Prize (1993), and the U.S. National Medal of Science (2002).

Dorian M. Goldfeld

Professor Goldfeld is a Professor of Mathematics at Columbia University. His primary research interests include number theory and cryptography. Past honors include a Sloan Research Fellowship (1977), the Vaughan Prize (1985), and the Frank Nelson Cole Prize in Number Theory (1987). He is a Fellow of the American Academy of Arts and Sciences, the Editor of Acta Arithmetica and The Ramanujan Journal, and co-founder and board member of SecureRF.

Benedict H. Gross

Professor Gross is the George Vasmer Leverett Professor of Mathematics at Harvard University and former Dean of Harvard College. He has made several fundamental contributions to mathematics, namely number theory and algebraic geometry. Past honors include a Marshall Scholarship (1972–1974), a MacArthur Fellowship (1986), and the Frank Nelson Cole Prize in Number Theory (1987).

Victor W. Guillemin

Professor Guillemin is Professor of Mathematics at the Massachusetts Institute of Technology. His research interests are differential geometry and symplectic geometry. He is a Fellow of the American Academy of Arts and Sciences and the U.S. National Academy of Sciences. Past honors include a Guggenheim Fellowship (1988), a Humboldt Research Fellowship (1988), and the Leroy P. Steele Prize for Lifetime Achievement (2003). He is the Editor-in-Chief of the Journal of Symplectic Geometry.

Yuri I. Manin

Professor Manin is a Professor Emeritus at the Max Planck Institute for Mathematics and Northwestern University. Professor Manin's work includes algebraic geometry, number theory, differential equations, and mathematical physics, and his main research preoccupation of the last decade was quantum cohomology. Past honors include the Moscow Mathematical Society Award (1963), the Lenin Prize (1967), the Dutch Mathematical Society Brouwer Medal (1987), the Frederic Esser Nemmers Prize in Mathematics (1994), the Rolf Schock Prize in Mathematics (1999), the King Faisal International Prize for Science (2002), the Cantor Medal by the German Mathematical Society (2002), and the János Bolyai International Prize by the Hungarian Academy of Sciences (2010).

Stanley J. Osher

Professor Osher is a Professor of Mathematics at the University of California at Los Angeles, and has joint faculty appointments at the Electrical Engineering and Computer Science Departments. He is also the Director of Special Projects at the University's Institute for Pure and Applied Mathematics. He is the co-inventor and developer of many numerical methods for computational physics and image processing. Past honors include a Sloan Research Fellowship (1972), the NASA Public Service Group Achievement Award (1992), the Computational Mechanics Award by the Japan Society of Mechanical Engineering (2002), the Ralph E. Kleinman Prize (2005), and the Computational and Applied Science Award by the U.S. Association for Computational Mechanics (2007).

Shing-Tung Yau

Professor Yau is the William Caspar Graustein Professor of Mathematics at Harvard University, Director of The Institute of Mathematical Sciences at The Chinese University of Hong Kong, and Director of the Morningside Center of Mathematics at the Chinese Academy of Sciences. His research interests include differential geometry, differential equations, and general relativity. He is a member of several academies including "Academia Sinica", the Chinese Academy of Sciences, the Russian Academy of Sciences, and the U.S. National Academy of Sciences. Professor Yau has been one of the key individuals behind the founding of the Morningside Center of Mathematics, the Morningside Medal of Mathematics, and the International Congress of Chinese Mathematicians. Past honors include the Fields Medal (1982), the Crafoord Prize in Mathematics (1994), the U.S. National Medal of Science (1997), and the Wolf Prize (2010).

Morningside Special Achievement Award in Mathematics

Yitang Zhang

Dr. Zhang is awarded the Morningside Special Achievement Award in Mathematics for his proof of the restricted twin prime conjecture. For many years, number theorists have speculated that there are infinitely many twin primes, or pairs of primes with gaps equal to 2, and this has remained one of the oldest open problems in mathematics. In 2013, Dr. Zhang astounded the mathematical

world by showing there exists infinitely many pairs of prime numbers with gaps less than 70000000. His paper "Bounded Gaps between Primes" was accepted for publication by the Annals of Mathematics in record time.

Dr. Zhang received his B.S. and M.S. degrees from Peking University, and later his doctorate degree from Purdue University in 1991. Before securing an academic position, he had worked at various jobs before being hired in 1999 by the University of New Hampshire as a substitute lecturer, and a full-time lecturer since 2005. Although Dr. Zhang never held a regular research position and had some hardships in his career, his passion and devotion to mathematics never waned, and in 2013 he marveled the mathematical world with his revelations. Dr. Zhang's perseverance against the odds, and his steadfast pursuit for mathematical truth, is an inspiration to us all.

Citation for Yitang Zhang (By John H. Coates, Emeritus Sadleirian Professor of Pure Mathematics, University of Cambridge)

The work of Yitang Zhang on the twin prime conjecture breaks entirely new ground, and is unquestionably one of the most surprising and important results in modern number theory.

Prime numbers are the building blocks of arithmetic, and the study of their distribution has always been one of the major themes of research in number theory. The particular question of proving that there are infinitely many primes p such that $p + 2$ is also a prime is probably very ancient, although its written history only seems to have started in the 19th century. As our theoretical understanding of some aspects of the distribution of prime numbers grew, great efforts have been made by number theorists from the early 20th century until the present day to attack this so called twin prime conjecture. The best earlier result in its direction was established by the Chinese mathematician Jing-Run Chen in 1966, when he proved that there are infinitely many primes p such that $p + 2$ is either a prime or the product of two primes. It is remarkable that the decisive progress on this problem has now been made by another Chinese mathematician Yitang Zhang. In a manuscript which has greatly surprised the mathematical world, Zhang has proven that there is some fixed integer c, less than 70000000, such that there are infinitely many primes p with the property that $p + c$ is also a prime. No result of this kind, establishing the existence of infinitely many prime pairs with a constant gap between them, has ever been proven before.

While it is too technical to enter into the detailed mathematical aspects of Zhang's work here, his starting point was the work of Goldston, Pintz, and Yildirim, published in 2009 and 2010, which, very roughly speaking, proved a slightly weaker form of the assertion that there are infinitely many prime pairs which differ by less than the square root of the logarithm of the smaller prime in the pair. This result created very considerable interest, but the leading experts in the field failed to make the all important improvement to get a constant gap between the pairs of primes. Now Zhang has brilliantly succeeded in doing this, by combining these methods of Goldston, Pintz, and Yildirim, with his own original variant of some deep earlier work by Bombieri, Fouvry, Friedlander, and Iwaniec from the 1980's. This is a mathematical achievement of the highest order. Yitang Zhang richly deserves a Morningside Special Achievement Award in Mathematics for this work.

Morningside Medals of Mathematics

2013 Morningside Gold Medal of Mathematics

Xuhua He

Professor He is awarded the 2013 Morningside Gold Medal of Mathematics for his contributions to several fundamental problems in arithmetic algebraic geometry, algebraic groups, and representation theory. He joined The Hong Kong University of Science and Technology (HKUST) in 2008, and is now an Associate Professor of Mathematics. After receiving his Ph.D. in mathematics from the Massachusetts Institute of Technology, he had worked at the Institute for Advanced Study and the State University of New York at Stony Brook before joining HKUST. Professor He's research interests include algebraic group theory, representation theory, combinatorics, algebraic geometry, and arithmetic geometry. Together with his collaborators, Professor He has solved long-standing open problems on Deligne-Lusztig theory and on Galois cohomology of algebraic groups. His work was reported by Professor Tonny Albert Springer at the International Congress of Mathematicians in 2006, and Professor Claire Voisin at the Bourbaki Seminar in 2011.

Ye Tian

Professor Tian is awarded the 2013 Morningside Gold Medal of Mathematics for his in-depth and original work in arithmetic algebraic geometry, especially on the congruent number problem. He is Professor at the Morningside Institute of Mathematics and the AMSS at the Chinese Academy of Sciences. He received his B.S. and M.S. degrees in pure mathematics from Sichuan University, and his Ph.D. in mathematics from Columbia University. He then worked at the Institute for Advanced Study and McGill University before joining the Morningside Institute and the AMSS in 2006. Professor Tian's research interests include arithmetic geometry and number theory. Together with his collaborators, Professor Tian solved some long-standing open problems on Birch and Swinnerton-Dyer conjecture and Diophantine equations. He is one of the recipients of the 2007 Morningside Silver Medal of Mathematics.

2013 Morningside Gold Medal of Applied Mathematics

Xianfeng David Gu

Professor Gu is awarded the 2013 Morningside Gold Medal of Applied Mathematics for his fundamental contributions to computing conformal structures, computer graphics, medical imaging, and 3-dimensional imaging. He is currently an Associate Professor of Computer Science at the State University of New York at Stony Brook. He received his B.S. in mathematics from Tsinghua University, and his M.S. and Ph.D. degrees from Harvard University under the supervision of Professor Shing-Tung Yau. Professor Gu solved with Professor Yau the fundamental problem of computing conformal structures of surfaces with arbitrary topologies based on Hodge theory. This breakthrough lays the foundation of computational

conformal geometry, which Professor Gu applies to many fields in engineering and medicine. He is the winner of the U.S. National Science Foundation CAREER Award (2005), the National Natural Science Foundation of China Overseas Chinese Young Scholars Award (2006), and the recipient of several U.S. National Science Foundation and U.S. National Institute of Health awards and grants.

2013 Morningside Silver Medal of Mathematics

Chieh-Yu Chang

Professor Chang is awarded the 2013 Morningside Silver Medal of Mathematics for his important contributions to the transcendental number theory in function field. He is an Assistant Professor of Mathematics at Tsing Hua University in Hsinchu. He received his Ph.D. in mathematics from Tsing Hua University at Hsinchu, and completed his postdoctoral research at "the National Center for Theoretical Sciences" and Central University. Professor Chang's research interest revolves around the transcendence theory over function fields in positive characteristic, which originates from the foundations that Professor Jing Yu established in the 1980s and 1990s. In recent years, Professor Chang's work is focused on characteristic p multiple zeta values, their transcendence theory and associated arithmetic/geometric properties.

Xiaoqing Li

Professor Li is awarded the 2013 Morningside Silver Medal of Mathematics for her important research on the analytic properties of automorphic L-functions and their applications. She is an Associate Professor of Mathematics at the State University of New York at Buffalo. She received her Ph.D. in mathematics from Rutgers University under the supervision of Professor Henryk Iwaniec, and received her postdoctoral training at Columbia University for two years. Professor Li's research interests include analytic number theory, automorphic forms and L-functions. Her work has contributed to one of the most important problems in number theory, the Lindeloff hypothesis, which is to prove the sharp upper bound of L-functions on the one half line.

Hao Xu

Dr. Xu is awarded the 2013 Morningside Silver Medal of Mathematics for his significant contributions to the intersection theory on the moduli of curves and other related moduli spaces. He received his Ph.D. in mathematics from Zhejiang University under the supervision of Professor Kefeng Liu. He is currently a Research Fellow at Harvard University. Dr. Xu works on intersection theory on moduli spaces of curves and mathematical problems arising in deformation quantization, by using tools from integrable systems, Kähler geometry, Bergman kernels, Feynman diagrams and spectral graph theory. In 2007, he received the Zhong Jiaqing Mathematics Award from the Chinese Mathematical Society, and the New World Mathematics Award Ph.D. Thesis Gold Award at the International Congress of Chinese Mathematicians.

Tai-Peng Tsai

Professor Tsai is awarded the 2013 Morningside Silver Medal of Mathematics for his contributions to the dynamics of nonlinear Schrödinger equations and the regularity and singularity of the incompressible Navier-Stokes equations. He is Professor of Mathematics at the University of British Columbia, and had been a Courant Instructor at New York University from 1998 to 2001, and worked at the Institute for Advanced Study from 2001 to 2002. Professor Tsai received his B.S. in mathematics from Taiwan University and his Ph.D. from the University of Minnesota. His primary research interests include asymptotics and singularities of solutions of partial differential equations of fluid and quantum mechanics. In 2006, he received the André Aisenstadt Prize from the Centre de Recherches Mathématiques in Montreal.

ICCM International Cooperation Awards

The ICCM International Cooperation Award is awarded to an individual who has made significant contributions to the development of mathematics in mainland, Hong Kong, and Taiwan of China through collaboration, teaching, and supporting Chinese mathematicians. The award was established in 2004 and is presented every three years at the International Congress of Chinese Mathematicians (ICCM).

This year, the Selection Committee of the ICCM International Cooperation Award consists of six members, including Professor Shing-Tung Yau, President of ICCM (chair), Professor Shiu-Yuen Cheng of The Hong Kong University of Science and Technology, Professor Chang-Shou Lin of Taiwan University, Professor Kefeng Liu of the University of California at Los Angeles and Zhejiang University, Professor Lo Yang of the Chinese Academy of Sciences, and Professor Horng-Tzer Yau of Harvard University.

2013 ICCM International Cooperation Award

Jean-Pierre Serre

Professor Serre is awarded the 2013 ICCM International Cooperation Award for his great achievements and foundational contributions in number theory, algebraic geometry, and algebraic topology, and also for his efforts and support to the Chinese mathematical community. He received his Ph.D. from the Sorbonne in 1951, and from 1956 onwards he was the Chair in Algebra and Geometry at the Collège de France until he retired in 1994 and became an Honorary Professor. As an octogenarian, Professor Serre has been visiting Taiwan biannually since 2009, offering a series of inspiring lectures at "the National Center for Theoretical Sciences" on his cutting edge research in number theory and arithmetic geometry, and has greatly impacted the Taiwan mathematical community.

Professor Serre has made foundational contributions in algebraic topology, algebraic geometry, and number theory. In his 1951 thesis, he applied the now-called Leray-Serre spectral sequence to establish connections between the homology and homotopy groups of a space, and computed the homotopy groups of spheres. In 1955 he introduced algebraic coherent sheaves on varieties, extending cohomology

theory to algebraic geometry. One year later, he introduced the GAGA theory, connecting analytic geometry and algebraic geometry. Together with John Tate, Professor Serre shaped the landscape of modern algebraic number theory, and introduced and developed algebraic K-theory, Galois cohomology and p-adic Galois representations. Professor Serre has been elected to many national academies, in particular the academies of France, Sweden, United States, and the Netherlands. He has received numerous awards, including the Fields Medal in 1954 (the youngest recipient ever), the Prix Gaston Julia in 1970, the Balzan Prize in 1985, the Leroy P. Steele Prize for Mathematical Exposition in 1995, the Wolf Prize in 2000, and the first Abel Prize in 2003. Professor Serre has been awarded honorary degrees from 13 universities, and has been made a Commander Legion d'Honneur and High Officer Ordre National du Merite by the French government.

Chern Prizes

The Chern Prize was established in 2001 in honor of Professor Shiing-Shen Chern, a mathematician, an educator, and one of the greatest geometers of the 20 century. Presented every three years at the International Congress of Chinese Mathematicians (ICCM), the Chern Prize is awarded to mathematicians of Chinese decent who have made exceptional contributions to mathematical research or to public service activities in support of mathematics.

This year, the Selection Committee of the Chern Prize consists of six members, including Professor Shing-Tung Yau, President of ICCM (chair), Professor Shiu-Yuen Cheng of The Hong Kong University of Science and Technology, Professor Chang-Shou Lin of Taiwan University, Professor Kefeng Liu of the University of California at Los Angeles and Zhejiang University, Professor Lo Yang of the Chinese Academy of Sciences, and Professor Horng-Tzer Yau of Harvard University.

2013 Chern Prize

Si-Chen Lee

Professor Lee is awarded the 2013 Chern Prize in recognition of his efforts and contribution to upgrade the research of mathematics in Taiwan, and with his vision and determination, fully endorsing the establishment of a first-class mathematical community within Taiwan University. He received his Ph.D. in electrical engineering from Stanford University in 1981. His research has led to the innovative development of ledge-type heterojunction bipolar transistor (HBT) in 1985, which has become the norm in manufacturing HBT power amplifiers, dominating the cell phone production in billions of units every year. Professor Lee is an Institute of Electrical and Electronics Engineers (IEEE) Fellow. He received many accolades, including the Dr. Sun Yat-Sen Academic Award (1987), five consecutive Outstanding Research Awards by "the National Science Council" (1986–1996), the IEEE Third Millennium Medal (2000), the Medal of Electrical Engineering from the Association of Chinese Electrical Engineers (2002), and the 47th Academic Award (Engineering and Applied Science) by "the Ministry of Education" (2003).

Bong Lian

Professor Lian is awarded the 2013 Chern Prize for his fundamental contributions to the investigation of Calabi-Yau mirror symmetry and representation theory of vertex operator algebras. He is a Professor of Mathematics at Brandeis University. He received his B.A. from the University of Toronto, and his Ph.D. from Yale University. His research areas are representation theory, Calabi-Yau geometry, and string theory. Among his achievements include his thesis on semi-infinite cohomology theory, which has become a primary tool in the representation theory of the Virasoro algebra. In 1996, he worked with Kefeng Liu and Shing-Tung Yau to solve the outstanding mirror conjecture that is fundamental in enumerative geometry and string theory. This work was also done independently by A. Givental. In 2010, Professor Lian worked with Ruifang Song and Shing-Tung Yau, and jointly developed a new approach, called tautological systems, to study the Riemann-Hilbert problem for period integrals. Recently, on a joint research work with Spencer Bloch, An Huang, Vasudevan Srinivas, Shing-Tung Yau and Xinwen Zhu, Professor Lian solved the completeness problem for tautological systems of period integrals in a number of important cases. He was a Sloan Dissertation Fellow (1990) and a Guggenheim Fellow (2003).

Morningside Mentor Award in Mathematics

Chengbiao Pan

Professor Pan is awarded the Morningside Mentor Award in Mathematics for his tireless efforts in training first class mathematicians. The Morningside Mentor Award in Mathematics is created to recognize the impact of mathematicians who invest in students' well-being through teaching, and in so doing, they pass onto their students a lifelong desire to learn, and inspire them to pursue their goals in mathematics and research work. Professor Pan is not only an inspiration to fellow mathematicians, academic professionals and students, but also a catalyst for positive change, growth, and innovation in the field of mathematics education.

Professor Pan was a Professor at the College of Science at China Agricultural University since 1986, and had held an adjunct position at the Department of Mathematics at Peking University since 1977, until his retirement in 2008. Professor Pan has devoted his work to the field of mathematics, particularly the teaching and research of analytic number theory, and has co-authored numerous academic works in Chinese including Goldbach Conjecture, Algebraic Number Theory, Elementary Number Theory, Condensed Number Theory, and Guide to Modular Forms. Besides his research work, Professor Pan was the former editor of Acta Mathematica Sinica and Advances in Mathematics, and a former committee member of the Chinese Mathematical Olympiad. He is a dedicated teacher and mentor toany aspiring mathematicians. Dr. Yitang Zhang of the University of New Hampshire and recipient of the 2013 Morningside Special Achievement Award in Mathematics, Professor Chaohua Jia of the Chinese Academy of Sciences, and Professor Wenzhi Luo of The Ohio State University, to name a few, have all benefited from his tutelage.