Third International Congress of Chinese Mathematicians
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Third International Congress of Chinese Mathematicians

Ka-Sing Lau, Zhou-Ping Xin, and Shing-Tung Yau, Editors
Shing-Tung Yau, General Editor

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Preface

Shing-Tung Yau
President,
International Congress of Chinese Mathematicians

In December of 2004, the Third International Congress of Chinese Mathematicians was held at the Chinese University of Hong Kong. The opening ceremony, in the Exhibition Hall of Hong Kong, was attended by a thousand people. As the president of the Congress, I announced that it would dedicated to the memory of our teacher and our leader: Professor Shing-shen Chern, who recently passed away. Professor Chern devoted his life to the advancement of mathematics in general, but especially in China. He was very much supportive of the Congress, having offered many important suggestions and contributed a hundred thousand yuen to it. Unfortunately, he passed away just after he had bought his tickets to travel to Hong Kong and attend the Congress. We mourn the loss of this great mathematician.

We were honored to have President Lu of the Academy of Science agree to serve as the Honorable President of the Congress. He presented the Morningside Medals to certain Chinese mathematicians in recognition of their outstanding work. The medals are awarded by the Morningside Foundation to mathematicians younger than 45 years of age. The Congress saw Morningside Medals awarded to Professor Zhou-Ping Xin of the Chinese University of Hong Kong, and to Professor Kefeng Liu of the University of California at Los Angeles, who received the Gold Medal for Pure Mathematics. Professor Tom Hou of the California Institute of Technology and Professor Chi-Liang Yin of Columbia University shared the Gold Medal for Applied Mathematics. Silver medals were awarded to Professor Xi-Ping Zhu of Zhongshan University of China, to Jin-Yi Cai of Wisconsin University, and to Aiko Liu of the University of California at Berkeley.

The Congress awarded Chern medals to Professor Fang-Hua Lin of the Courant Institute of Mathematics, and to Professor Yanglo of the Morningside Institute of Mathematics. Moreover, in recognition of our overseas friends who have made great contributions to the Mathematics Community in China, we have instituted a new award called the International Cooperation Medal for Mathematics. At the Congress, we had the honor of presenting this special distinction to Professor John Coates of Cambridge University in England.

The Congress spanned five days and covered many areas of mathematics, including pure mathematics, applied mathematics, statistics, and computer science. We were very pleased at the enthusiasm of everyone participating.
The purpose of the International Congress of Chinese Mathematicians is to encourage exchange of ideas between mathematicians all over the world, and this was clearly visible at the 2004 Congress. It is my wish that this coming together will strengthen and promote mathematics in China. Many mathematicians not of Chinese descent came to participate, and we are very grateful for their support and help. We should like very much to invite even more friends to come for our next gathering of the Congress, which is to be held at Zhejiang University in Hangzhou, China.
Welcome Letters

Shing-Tung Yau
Chairman,
International Congress of Chinese Mathematicians

To My Fellow Mathematicians and Distinguished Guests,

As Chairman of the International Congress of Chinese Mathematicians, I would like to welcome you to the Third International Congress of Chinese Mathematicians. Since 1998, the Congress has grown from strength to strength. I am deeply gratified by the response and interest of my fellow mathematicians in this triennial gathering. Over seven hundred mathematicians from around the world are expected to convene for six days of intensive discussions, talks, and presentations.

In the past decade, mathematics has steadily improved in China, Hong Kong, and Taiwan. The dedication and vision of several leading Chinese mathematicians has emboldened a new generation of mathematicians to pursue careers in mathematical research and teaching. In particular, I would like to recognize Professor Yongxiang Lu, the President of the Chinese Academy of Sciences, for his leadership and support in advancing mathematics in China.

At the opening ceremony of each International Congress of Chinese Mathematicians, the winners of the Morningside Medal of Mathematics are honored in a special ceremony for their outstanding achievements in pure and applied mathematics. This year, the second Chern Prize and the first ICCM International Cooperation Award will also be presented to the three individuals for their contributions to the development of mathematics.

The Third International Congress of Chinese Mathematicians would not be possible without the hard work and efforts of many individuals. I would like to express my sincere appreciation to Mr. Ronnie C. Chan, the co-founder of THE MORNINGSIDE GROUP, for his generous support. I would also like to recognize Professors Ka-Sing Lau and Zhouping Xin at The Chinese University of Hong Kong for their leadership in organizing and executing this congress. The members of the various ICCM 2004 committees and the staff at The Institute of Mathematical Sciences at The Chinese University of Hong Kong have played a key role in making this event a tremendous success as well.
Ka-Sing Lau  
Chairman, Department of Mathematics  
The Chinese University of Hong Kong

Zhouping Xin  
Associate Director, The Institute of Mathematical Sciences  
The Chinese University of Hong Kong

Dear Fellow Mathematicians and Guests,

On behalf of the Organizing Committee, we would like to welcome you to the Third International Congress of Chinese Mathematicians (ICCM 2004).

Mathematics has experienced phenomenal growth in Hong Kong in the last decade. Local universities have established leading mathematics institutes and centers conducting major research on pure, applied, and computational mathematics, founded programs to attract eminent mathematicians and promising students, and hosted colloquia on cutting-edge topics. As a result, Hong Kong has developed a core group of internationally renowned researchers. We drew on this large pool of talent in Hong Kong to host ICCM 2004. Over seven hundred distinguished mathematicians and professors from around the world will gather at The Chinese University of Hong Kong to discuss their research work and to speak on the latest developments in mathematics.

The presentation of the Morningside Medal of Mathematics, the Chern Prize, and the ICCM International Cooperation Award marks the beginning of the congress. These awards, which are the highest honors bestowed at ICCM, are given to mathematicians who have made significant contributions to this field, and whose work have had and will continue to impact the future development of mathematical sciences.

Held every three years, the International Congress of Chinese Mathematicians is a considerable undertaking that requires the support of several organizations. ICCM 2004 is made possible by THE MORNINGSIDE GROUP and the organizational efforts of The Institute of Mathematical Sciences and the Department of Mathematics at The Chinese University of Hong Kong. Support from other sponsors and academic institutions in Hong Kong and China also played an invaluable role in ensuring the success of this congress.

We are pleased that you are joining us at the opening ceremony of ICCM 2004.
Distinguished Mathematicians, Guests, and Friends,

On behalf of THE MORNINGSIDE GROUP, I would like to welcome you to the 2004 Morningside Medal of Mathematics Awards Presentation and Symposium, which kicks off the Third International Congress of Chinese Mathematicians (ICCM).

In 1996, then President Jiang Zemin asked Fields Medalist Professor Shing-Tung Yau to help develop excellent Chinese mathematicians. Working together with Professor Yongxiang Lu of the Chinese Academy of Sciences (CAS), the three of us founded the Morningside Center of Mathematics on the CAS campus in Beijing. A building, which won international architectural acclaim, was also constructed where renowned mathematicians from around the world can interact with local talents and engage in mathematics research.

Professor Yau and I have also set up the Morningside Medal of Mathematics. It is given once every three years at the ICCM to young Chinese mathematicians anywhere in the world for their achievements and contributions to this field of science. The Selection Committee is composed of top mathematicians from around the globe, with the only ethnic Chinese being Professor Yau, who also serves as the chair. The first medals were presented in Beijing in 1998, followed by Taipei in 2001. This year, it will be held in Hong Kong, and today we will celebrate the work of seven Morningside Medalists in pure and applied mathematics.

I am honored and pleased to be associated with these meaningful endeavors. It is heartening to see the rise of a generation of young Chinese mathematicians. May they enrich the world with their mathematical revelations, and be an inspiration for others to follow.
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A Chinese Essay in Tribute to Professor Shiing-Shen Chern

向陳省身教授致敬

今年十二月三日，敬愛的陳省身先生在天津以九三高齡與世長辭。耗費傳來，舉世同悲。各種報章、互聯網上都廣泛報導，為一代幾何大師的凋謝而惋惜。在南開大學的靈堂上，更出現大批趕來致哀的群眾，他們很多都是與先生從未謀面的。近代中國著名學者很多，但去世時得到國內外如此的痛惜，先生恐怕是第一人。

毫無疑問，先生在數學上的貢獻將永不磨滅。就像稱呼歐氏幾何一樣，我們也會永遠稱呼陳氏幾何。只要幾何不死，陳氏幾何都永存人心。

先生的知交弟子，遍於天下。建國前，先生主持中央研究院數學所，親自撰寫和油印講義，為我國培養出一批極為出色的學者。其後在芝加哥大學和柏克萊大學數十年，培養了超過四十位博士，發展了大範圍拓樸和幾何學，其工作影響了上世紀數學的發展。先生被稱為近代微分幾何之父，不單是因為他在學問上的成就，他循循善誘，樂於助人的精神，也使這個稱謂實至名歸。

他在柏克萊一手創建的數學所，更是首個由美國政府資助，以美國為中心的數學研究所。至今先生之影響遍及數學各領域，超出了幾何學的範疇。

改革開放後，先生關懷中華民族的數學大業，多次回國。一九八五年更成立南開數學所，立足中國，放眼世界。在過去二十年中，中國的數學水平不斷提高，先生遺願中國在短期內成為數學強國。我們都深為先生的高尚精神所感召，願為先生的偉大理想奔走盡力。

這次世界華裔數學家大會在香港舉行，先生作為名譽主席，不單在精神上支持，來信勉勵，並從他的邵氏獎基金中撥出十萬人民幣作為大會的運作經費，盡心盡力，實在使人感動。我們要化悲痛為力量，為中國的數學盡一分力，發一分光。

先生精神不朽，浩氣長存！

丘成桐

二零零四年十二月十四日
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Morningside Lifetime Achievement Award in Mathematics

Shiing-Shen Chern

Professor Shiing-Shen Chern received the Morningside Lifetime Achievement Award in 2001 for his work on developing the foundation of Chinese mathematics, his epochal contributions to research in differential geometry, and his nurturing of leading mathematicians in China and abroad. Professor Chern is considered one of the greatest geometers of the twentieth century and a pioneer in differential geometry. Some of his major achievements include the Chern characteristic classes in fiber spaces and his proof of the Gauss-Bonnet theorem. In the 1940s, differential geometry was only starting to be understood and studied. Today, it is a major subject area in mathematics largely due to Professor Chern’s research work and his training of talented mathematicians in this field.

Professor Chern was born in 1911 in Jiaxing, Zhejiang province in China. He received his B.S. from Nankai University in 1930, his M.Sc. from Tsinghua University in 1934, and his Ph.D. from the University of Hamburg in Germany. From 1943 to 1945, he was a member of the Institute for Advanced Study at Princeton University. From 1946 to 1948, he was the Acting Director of the Institute of Mathematics at Academia Sinica in Nanjing. From 1949 to 1960, he taught at the University of Chicago before joining the faculty of the University of California, Berkeley. From 1982 to 1984, he was the Founding Director of the Mathematical Sciences Research Institute (MSRI), the world’s premier center for collaborative research across the whole spectrum of mathematical sciences. From 1985 to 1993, he was the Founding Director of the Nankai Institute of Mathematics in Tianjin.
Professor Chern was a member or foreign member of many academies, including Academia Sinica, the U.S. National Academy of Sciences, the Third World Academy of Sciences, the Royal Society of London, L’Academie de Sciences de Paris, the Chinese Academy of Sciences, and the Russian Academy of Sciences. His awards included the U.S. National Medal of Science in 1975, which is the highest honor bestowed by the U.S. President to distinguished scientists and engineers for their pioneering scientific research, the Wolf Prize in 1983, which is one of the most prestigious awards for scientists, and the Shaw Prize in Mathematical Sciences in 2004.

Professor Chern passed away on December 3, 2004. He was a towering figure in mathematics and had a career that spanned continents and cultures. As a teacher and researcher, Professor Chern helped forge links with mathematicians across the globe while advancing knowledge of differential geometry. He founded and served as the founding director of three top mathematical research institutes: the Institute of Mathematics at the Chinese Academy of Sciences, the Mathematical Sciences Research Institute at the University of California, Berkeley, and the Nankai Institute of Mathematics in Tianjin. Professor Chern will remain an inspirational figure to all mathematicians.
Morningside Medal of Mathematics

The Morningside Medal of Mathematics is awarded to outstanding mathematicians of Chinese descent to encourage them in their pursuit of mathematical truth. Gold and silver medals are awarded to mathematicians under the age of forty-five for exceptional achievements in pure and applied mathematics. The Morningside Medals are awarded every three years at the International Congress of Chinese Mathematicians. A committee of internationally renowned mathematicians, chaired by Professor Shing-Tung Yau, selects the medalists.

The first medals were awarded on December 12, 1998 at the First International Congress of Chinese Mathematicians (ICCM 1998) at the Great Hall of the People in Beijing. The second medals were awarded on December 17, 2001 at the Grand Hotel in Taipei at the Second International Congress of Chinese Mathematicians (ICCM 2001). A special Morningside Lifetime Achievement Award in Mathematics and a cash award of US$50,000 were also presented to Professor Shiing-Shen Chern at ICCM 2001. The third medals were awarded on December 17, 2004 at the The Hong Kong Convention and Exhibition Centre in Hong Kong at the Third International Congress of Chinese Mathematicians (ICCM 2004).

Each medalist receives a certificate, medal, and cash award of US$25,000 for a gold medal or US$10,000 for a silver medal. Besides the name of the medalist, each Morningside Medal of Mathematics has the image of a Mobius band and a fundamental domain. They were chosen not only for the simplicity of their image, but also because of their significant contributions to the development of mathematics in the twentieth century.

The Mobius band (also known as the Mobius strip) was discovered in 1858 by the German mathematician and astronomer August Ferdinand Mobius. This curious onesided surface does not have any orientation, yet has a distinct topographical character. It was one of the most important discoveries of the twentieth century, which has profoundly influenced modern physics, classical physics, and modern mathematics, including geometry.

A fundamental domain is related to the concept of a group, which can be used to express symmetry in mathematics. During the late nineteenth century, infinite
discrete group was studied but only until the twentieth century, did it become a main subject area in mathematics. This field of study is not only important in geometry but also in number theory. Practically all the famous developments in modern number theory are related to concepts of fundamental domain and discrete group.
Morningside Medal of Mathematics – Selection Committee

The Morningside Medal of Mathematics Selection Committee is chaired by Professor Shing-Tung Yau. A nomination committee for the Morningside Medal of Mathematics, comprising a maximum of fifty Chinese mathematicians worldwide, nominates individuals based on their research, qualifications, and curriculum vitae. The nomination committee then submits the names of the nominated individuals, along with supporting materials, to the selection committee. After a thorough multi-step review, the selection committee makes a final decision regarding the medalists. The winners of the Morningside Medal of Mathematics are announced at an awards presentation during the opening ceremony of the International Congress of Chinese Mathematicians.

All members of the selection committee, with the exception of the committee chair, are non-Chinese, thereby ensuring the independence and integrity of their decision. The ten members of the 2004 Morningside Medal of Mathematics Selection Committee are:

- **Peter Bickel** (Professor of Statistics at the University of California, Berkeley)
- **John Coates** (The Sadleirian Professor of Pure Mathematics at Cambridge University)
- **Ronald R. Coifman** (Professor of Mathematics and Computer Science at Yale University)
- **David Gieseker** (Professor of Mathematics at the University of California, Los Angeles)
- **Stanley Osher** (Professor of Mathematics, the Director for Special Projects at the Institute for Pure and Applied Mathematics, and the Director of Applied Mathematics at the University of California, Los Angeles)
- **Joel Smoller** (The Lamberto Cesari Chair in Mathematics at the University of Michigan, Ann Arbor)
- **Cumrun Vafa** (The Donner Professor of Science at Harvard University)
- **Leslie G. Valiant** (The T. Jefferson Coolidge Professor of Computer Science and Applied Mathematics at Harvard University)
• **Srinivasa S. R. Varadhan** (Professor of Mathematics at the Courant Institute of Mathematical Sciences at New York University)

• **Shing-Tung Yau** (The William Casper Graustein Professor of Mathematics at Harvard University, the Director of The Institute of Mathematical Sciences at The Chinese University of Hong Kong, and the Director of the Morningside Center of Mathematics at the Chinese Academy of Sciences in Beijing)
Morningside Award Medalists

Morningside Gold Medal of Mathematics:
Recipients
Kefeng Liu, Professor of Mathematics, University of California, Los Angeles
Zhouping Xin, William M. W. Mong Professor of Mathematics, The Chinese University of Hong Kong

Morningside Gold Medal of Applied Mathematics:
Joint Recipients
Thomas Yizhao Hou, Charles Lee Powell Professor of Applied and Computational Mathematics, California Institute of Technology
Zhiliang Ying, Professor of Statistics, Columbia University

Morningside Silver Medal of Mathematics:
Recipients
Jin-Yi Cai, Professor of Computer Science, University of Wisconsin, Madison
Ai-Ko Liu, Assistant Professor of Mathematics, University of California, Berkeley
Xi-Ping Zhu, Professor of Mathematics, Zhongshan University
The Work of Kefung Liu

Jun Li

Dr. Liu is one of the leading young Chinese mathematicians. He has worked on a wide range of mathematical subjects, and has shaped many aspects of the topics he touched.

His first spectacular work is on the rigidity and vanishing of elliptic genus. Elliptic genus was discovered through the joint effort of mathematicians and physicists. It is the index theory of loop spaces. The rigidity conjecture of elliptic genus by Witten were mentioned as one of the three main contributions for Witten’s Fields medal. Taubes gave a proof to a rigidity theorem, which is very complicated. Bott-Taubes simplified it to some extent. In his work, Liu realized the role of modularity to the rigidity conjecture and provided an elegant proof to the known rigidity theorem. He also discovered many new results in this field. His proof reshaped our understanding of the rigidity theorem.

His work on using heat kernel to study moduli spaces of vector bundles over smooth curves was just as profound. By pulling back the heat kernel and then applying localization, he gave a new and simple proof to the Witten’s nonabelian localization; it influenced the later work in this field.

His joint work with B.Lian and S.T. Yau on the Mirror symmetry conjecture of quintic threefolds and its generalization drew even a wider applause. This subject began with Candelas’ amazing generating function on the “numbers” of rational curves in a general quintic CY, derived in early 90 via mirror symmetry conjecture. By using localization technique, Liu and his collaborators derived a set of quadratic relations in the equivariant Chow ring of the linear $\Sigma$-model. They then showed that in many cases, which include many hypersurfaces in toric varieties and balloon manifolds, the “virtual” number of rational curves could be reconstructed from these relations. The Candelas’ formula is a consequence of their work. This work is one of the most important in this subject. It is also the most powerful one, covering many examples in local Mirror symmetry, hypersurfaces in toric varieties and balloon varieties.

Most recently, together with M. Liu and J. Zhou, Liu has proved a conjecture of Marino-Vafa on Hodge integrals on the moduli of stable curves. This conjecture was based on relating open string Gromov-Witten invariants with the Cheng-Simon invariants of three manifolds. Its novel origin ensured its far reach consequence but also came with difficulty in proving this. In their proof, they applied the technique of localization to the moduli space of relative stable maps; it is a beautiful proof; it
is also an important theorem that established many previously unknown identities among Hodge integrals.

His work with X.-F. Sun and S.-T. Yau on the metric geometry of the moduli of Riemann surfaces has reshaped this research subject. The questions to how these metrics, including the Peter-Wilson metric, the hyperbolic metric, and many other metrics, puzzled many mathematicians for decades. In trying to understand their relations, more metrics were introduced. It was only after the work of Liu and his collaborators that a complete picture emerged.

Seeing the list of publications of Liu, it is impossible not to have been impressed by the breath and the depth of his mathematics. He has worked in areas ranging from differential geometry, topology, algebraic geometry to mathematical physics. On each of the area he has touched, he left a permanent mark for the later to follow.
Summary of Main Researches of Zhouping Xin

by Joel Smoller

The focus of researches of Xin has been the field of theoretical and numerical analysis and computations of nonlinear partial differential equations arising from continuum mechanics, such as Euler and Navier-Stokes systems for both compressible and incompressible, and nonlinear Boltzmann type equations, etc. He has made substantial contributions to many problems in various subareas of this field. Some of the highlights of his works include:

Theory of Multi-dimensional Shock Waves

Compared with the recent advances in the one-dimensional theory of shock waves, the theory for the multi-dimension is far from being developed due to the great complexity and lack of understanding. However, such a multi-dimensional theory is of fundamental importance in both mathematical theory and physical applications. It seems necessary to start with some basic problems which are fundamental in fluid dynamics and there are a lot physical experiments and numerical data are available, such as transonic flows with shocks, supersonic past solid bodies, and shock reflection problems, etc. Recently, Xin has achieved some significant results along these lines:

1. Studies on Transonic Shock Waves
   Phenomena involving transonic flows and transonic flows with shocks is a fundamental subject in fluid dynamics, especially gas dynamics. A generic transonic flow pattern involves shocks in general since smooth transonic flows are unstable in the presence of physical boundaries. In [1], jointly with H. Yin, Xin has studied the problem of existence and uniqueness of a transonic shock to the steady flow through a general nozzle with variable sections in both 2-D and 3-D cases. Their approach seems quite powerful and robust in the sense that other problems involving transonic shocks can be treated similarly. In particular, this approach can be used to prove the existence and uniqueness of strong transonic shock for supersonic flow past a 3-dimensional wedge.

2. Studies on Global Shocks for Supersonic Flow Past A Pointed Body
   In [2], with his collaborators, Xin established the global existence and structural stability toward self-similar shock waves of a shock wave solution to the steady supersonic gas flows past an infinite curved and axisymmetric cone. For a steady supersonic flow hitting on a sharp curved
body which is a small perturbation of a circular cone, it is shown in [2]
that an entropy weak solution to this problem exists globally in the whole
space with a pointed shock attached at the tip of the cone and tends to
a self-similar solution corresponding unperturbed circular. Furthermore,
the solution is smooth everywhere except at the global shock and is struc-
turally stable. This settles a fundamental problem in gas dynamics, which
is a well-known difficult problem and has been attacked by many people
without success. The approach in [2] is based on looking for multipliers
for an enlarged linearized system, and hence truly multi-dimensional. The
analysis should shed lights on many other multi-dimensional problems.

Boundary Layer Theory and Prandtl’s System

In the presence of physical boundaries, the asymptotic behavior of viscous flow
for large Reynolds numbers is of great importance physically and is extremely diffi-
cult to study mathematically due to the appearance of the boundary layer phenomen-
a. In 1904, Prandtl proposed a theory which shows that the inviscid ideal flow
can approximate the real fluid only in the region away from the physical bound-
aries and in a thin region near the boundary the fluid velocity changes dramatically
and is governed by the Prandtl’s equations. This is now called Prandtl’s boundary
layer theory and has become an essential part of the fluid dynamics. In collabora-
tion with Yanagisawa, Xin has justified the Prandtl’s theory for the linearized
Navier-Stokes flows and obtained detailed asymptotic structure and optimal rate
of convergence. The nonlinear problem is much more difficult. One of the main
difficulties is the well-posedness of the initial or initial boundary value problems
for the Prandtl’s equations in a Sobolev space. Despite the tremendous efforts
by many people, the best available results along this line until recently are due
to Oleinik who established in a series of work the LOCAL well-posedness in the
class of monotone data. It is a longstanding open problem to achieve the global
well-posedness of the solution to the Prandtl’s system in the Oleinik’s class in the
case that the pressure is favorable. Recently, in [3], joint with his collaborators,
Xin has solved this open problem completely. First, Xin and Zhang established
the global existence of weak solution in the space of bounded total variations by
introducing a splitting method and an elaborated Nash-Moser iteration scheme in
[3]. More recently, Xin, together with Zhang and Zhao, has shown that such a BV
solution depends on the data continuously in $L^1$-norm, and hence is unique. This
is achieved by studying the structure of BV solutions carefully based on geometric
measure theory. Furthermore, they have shown such weak solutions are in fact
classical by developing a general regularity theory for degenerate ultra-parabolic
equations based on the Heisenburg group structure of the linearized equations [3].
This is a result long sought by the experts in the field.

Blow-up of Smooth Solution to the Compressible N-S Equations

Vacuum states play an essential role in the well-posedness theory of solutions to
the viscous compressible Navier-Stokes system, as pointed out by many important
studies due to Hoff-Smoller, P.Lions, etc. In [4], Xin obtains the first and rather
significant results on the finite time blow-up of smooth solutions to the compre-
sible N-S equations with initial density of compact support. The essential idea is
a very elegant analysis of the decay of total pressure based on estimate of moments for the Navier-Stokes equations. This is the first dispersive estimate for the total pressure of the compressible N-S system. As a consequence, he showed that there are no global (in time) bounded smooth solutions to the general compressible Navier-Stokes equations no matter how small the initial data are as long as the initial density has compact support.

**Relaxation Approximation and Relaxation Schemes**

Instead of the usual parabolic regularizing, Xin and Jin first proposed the new idea of relaxation approximations to a class of quasi-linear first order systems of PDE’s such as systems of conservation laws in any space dimensions, Hamilton-Jacobi equations, and equations for curvature-dependent fronts motions, etc. This was first proposed by Xin and Jin in [5] for systems of conservations in arbitrary dimensions, which is now being called Jin-Xin relaxation models. The main idea is that for a given system of conservation laws, one constructs an enlarged hyperbolic system (called relaxation system) with linear constant convection and special nonlinear source terms which are designed so that the solution to the relaxation system relaxes to the solution of the given system of conservation laws fast in the limit of small relaxation. Due to the special structure of the new relaxation systems, they have been able to construct many high resolution numerical schemes (called relaxation schemes).

**Vortex Sheets Motion and Vortex Methods**

One of the most important 2-D incompressible inviscid flows are evolution of vortex sheets in which the vorticity is a finite Radon measure concentrated on a curve and exhibits the classical Kelvin-Helmholtz instability. The existence of classical weak solutions to the 2-D incompressible Euler equations with general vortex sheets is of fundamental importance both mathematically and physically. And the vortex methods (including both the vortex blob methods and pointed vortex methods) are Lagrangian methods which are especially effective to compute such flows and are mostly used in practical engineering computations. Very interesting structure were revealed after singularity in the vortex roll-up in many computations by Kransy by the vortex methods. Analysis of such problems is extremely difficult since the solution is very wild. In [7], Xin and J. Liu gave the first result on the convergence of the vortex method for such “wild” flow consisting of a signed Radon measure globally in time (beyond the conjectured time of the singularity formation in the vortex sheet), and they proved the global convergence to a classical weak solution of approximation solutions generated by the vortex blob methods for the vortex sheets initial data as long as the initial vorticity is of one-sign. One of the main difficulties here is the weak consistency. This analysis was later generalized to the pointed-vortex methods by Xin and J. Liu.

**Dissipative Effects to Systems of Hyperbolic Conservation Laws**

One of the most important problems and the main driving force in mathematical theory of fluid dynamics is understanding the relation between weak solutions to the inviscid hyperbolic systems (such as the compressible Euler equations) and the solutions to the corresponding suitable viscous systems (such as the well-known compressible Navier-Stokes equations, which are parabolic systems in general) in
the limit of small viscosity. This is so partly due to the non-uniqueness of weak solutions to the hyperbolic systems, and the physical significance of the slightly viscous fluid in reality. However, this poses a long standing challenging mathematical problem due to the highly singular nature of the limit in the presence of shock discontinuities and boundaries. Xin has made many important contributions to the subject which includes:

1. Large time asymptotic stability of linear and nonlinear viscous waves
   The complete theory was made by Xin and Szeppesy in [9]. In this theory, they discovered the surprising phenomena that a generic perturbation of a given shock profile produces not only phase shift in the shock profile itself and diffusive waves in the transversal wave directions, but also introduces resonant diffusion waves in the shock waves region due to wave interactions.

2. Vanishing viscosity limit for piecewise smooth solutions to systems of conservation laws
   In [11], Xin and Goodman proved that for general systems, any piecewise smooth solutions with finitely many shock discontinuities which satisfying Lax-entropy conditions are in fact the limits of solutions of the corresponding viscous systems.

Fluid-Dynamic Limit for the Broadwell Model of The Nonlinear Boltzmann Equation in The Presence of Shocks

Fluid-dynamic limit of the kinetic equations such as the Boltzmann equation is much more singular than the viscous system. The general Boltzmann equation of kinetic theory gives a statistical description of a gas of interacting particles. An important property of this equation is its asymptotic equivalence to the Euler and Navier-Stokes systems of compressible fluid dynamics in the limit of small mean free path. All the previous works (due to Grad, Nishida, Caflisch, Caflisch-Papanicoulou, etc.) deal with macroscopic smooth fluid flows (in other words, before shock formations, (this is true for most of the work on the statistical large particle system limit)). In [12], Xin proved the first theorem on the validity of the fluid-dynamic limit to the piecewise smooth fluid flows for the Broadwell equation.

References


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Research Accomplishments of Thomas Yizhao Hou

Stanley Osher

1. Introduction

Thomas Yizhao Hou is the Charles Lee Powell professor of applied and computational mathematics at Caltech, and is one of the leading experts in applied and numerical analysis for vortex dynamics and multiscale problems. His research interests are centered around developing analytical tools and effective numerical methods for vortex dynamics, interfacial flows, and multiscale problems. He received his B.S. from South China University of Technology in 1982 and his Ph.D. from UCLA in 1987. Upon graduating from UCLA, he joined the Courant Institute as a postdoc and then became a faculty member in 1989. He moved to the applied math department at Caltech in 1993, and served as the chair of the department of applied and computational mathematics from 2000 to 2006. Dr. Hou has received a number of honors and awards, including the Computational and Applied Sciences Award from United States Association of Computational Mechanics in 2005, the SIAM Wilkinson Prize in Numerical Analysis and Scientific Computing in 2001, the Francois N. Frenkiel Award from the Division of Fluid Mechanics of APS in 1998, the Feng Kang Prize in Scientific Computing in 1997, a Sloan fellow from 1990 to 1992. He was an invited plenary speaker at the International Congress of Industrial and Applied Mathematics in 2003, and an invited speaker of the International Congress of Mathematicians in 1998. He has been also the founding Editor-in-Chief of the SIAM Journal on Multiscale Modeling and Simulation since 2002.

Dr. Hou was awarded the first Morningside Gold Medal Prize in Applied Mathematics during the Third International Congress of Chinese Mathematicians which was held in Hong Kong from December 17 to 22, 2004. According to the citation of the Morningside Gold Medal Prize, Dr. Hou was honored “for his seminal research on applied partial differential equations, scientific computation and numerical analysis. This research includes convergence of the point vortex method, accurate numerical methods for fluid interfaces with surface tension, analysis of three dimensional vortex sheets, and singularity criteria for the three dimensional Euler equation.” Below I will give a brief review of some of his work cited above.

2. Localized non-blowup criteria for the 3D Euler equations

2.1. A brief review. One of Dr. Hou’s main contributions is to develop localized non-blowup criteria for the 3D incompressible Euler equations and to apply them to study the dynamic depletion of the vortex stretching in the 3D
Euler equations. The question of whether the 3D incompressible Euler equations with smooth initial data can develop a finite time singularity is one of the most challenging open questions in applied mathematics. The understanding of this fundamental question would enhance our understanding of fluid dynamic stability and shed useful light in our understanding of the onset of turbulence. To illustrate some key points, we consider the 3D incompressible Euler equations in the vorticity stream function formulation [14]

\[ \omega_t + u \cdot \nabla \omega = \nabla u \cdot \omega, \]

where \( u \) is velocity and \( \omega = \nabla \times u \) is vorticity. The initial condition is smooth and decays rapidly at infinity. Velocity can be recovered from vorticity through the stream function, \( \psi \), by solving

\[ -\Delta \psi = \omega, \quad u = \nabla \times \psi. \]

The term on the right hand side of (1) is called the vortex stretching term. This term is absent for the two-dimensional problem. Formally, the vortex stretching term has a scaling which is quadratic in vorticity. Due to the presence of the vortex stretching term, there is currently no global regularity result for the 3D Euler equations [14]. The best known result is Beale-Kato-Majda’s blowup criterion [2], which states that a necessary and sufficient condition for the solution to develop a finite time singularity at \( T \) is that \( \int_0^T \| \omega \|_{L^\infty} dt = \infty \). An interesting recent development is a result by Constantin-Fefferman-Majda [3] who showed that the geometric regularity of the unit vorticity vector, \( \xi \), can lead to depletion of nonlinearity. Roughly speaking, they showed that if (i) \( \int_0^T \| \nabla \xi \|_{L^\infty} dt < \infty \) and (ii) \( \| \omega \|_{L^\infty} \) is bounded, there is no blowup of the 3D Euler equations up to \( T \). Another interesting result is a new dynamic stability result by Hou-Li [11] who showed that the special nonlinear structure of the vortex stretching term can lead to surprising dynamic depletion.

There have been many computational efforts in searching for finite time singularities of the 3D Euler equations. One example that has been studied extensively is the interaction of two perturbed antiparallel vortex tubes. This example is interesting because of the vortex reconnection which has been observed for the corresponding Navier-Stokes equations. It is natural to ask whether the 3D Euler equations would develop a finite time singularity in the limit of vanishing viscosity. In [13], Kerr presented numerical evidences which suggest a finite time singularity of the 3D Euler equations for two perturbed antiparallel vortex tubes. His computational results indicated that the maximum vorticity would blow up like \( O(T - t)^{-1} \) and the velocity field blows up like \( O(T - t)^{-1/2} \). The blowup is characterized by two anisotropic length scales, \( \rho \approx (T - t) \) and \( R \approx (T - t)^{1/2} \). Vortex lines near the region of the maximum vorticity were found to be relatively straight. Kerr’s computations have generated a lot of interests and his proposed initial conditions have been considered as “the most attractive candidates for potential singular behavior” of the 3D Euler equations [14].

2.2. A localized non-blowup criterion of Deng-Hou-Yu. In [4, 5], Deng, Hou, and Yu developed a sharp localized non-blowup criterion for the 3D Euler equations. This is one of the important developments in recent years. They showed that the geometric regularity of vortex lines, even in an extremely localized region containing the maximum vorticity, can lead to depletion of nonlinear vortex
stretching, thus avoiding finite time singularity formation of the 3D Euler equations. Specifically, assume that at each time $t$ there exists some vortex line segment $L_t$ on which the local maximum vorticity is comparable to the global maximum vorticity. Further, denote $L(t)$ as the arclength of $L_t$ and $\kappa$ as the mean curvature of $L_t$. Deng-Hou-Yu showed that if (i) the velocity field along $L_t$ is bounded by $C_U(T-t)^{-\alpha}$ for some $\alpha < 1$, (ii) $C_L(T-t)^{\beta} \leq L(t) \leq C_0/\max_{L_t}(|\kappa|, |\nabla \cdot \xi|)$, for some $\beta < 1 - \alpha$, then the solution of the 3D Euler equations remains regular up to $T$. Kerr's computations violate the non-blowup conditions of Constantin-Fefferman-Majda theory [3], but fall in the critical case of the non-blowup theory of Deng-Hou-Yu [4, 5], which corresponds to $\alpha = \beta = 1/2$. To get a definite answer, one needs to check whether the scaling constants, $C_U$, $C_0$, and $C_L$ in conditions (i)-(ii) satisfy an algebraic inequality [5]. However, such scaling constants were not available in [13].

2.3. Dynamic depletion of vortex stretching. To validate Deng-Hou-Yu's non-blowup theory, Hou and Li [12] repeated Kerr's computations using a well-resolved pseudo-spectral method with resolution up to $1536 \times 1024 \times 3072$. This is a very challenging computation. Their numerical results demonstrated that the maximum vorticity did not grow faster than double exponential in time, up to $T = 19$, beyond the singularity time predicted by Kerr's computations [13]. The velocity field was shown to be bounded throughout the computations. With velocity field being bounded, the localized non-blowup criteria of Deng-Hou-Yu [4] can be applied with $\alpha = 0$, $\beta = 1/2$, which implies the non-blowup of the 3D incompressible Euler equations up to $T = 19$. To gain an insight to the dynamic depletion of the vortex stretching term, they examined the degree of nonlinearity in the vortex stretching term. An $O(T-t)^{-1}$ blowup rate in the maximum vorticity would imply that the nonlinearity in the vortex stretching term is quadratic as a function of the maximum vorticity. However, their numerical results showed that the vortex stretching term, when projected to the unit vorticity vector, $\xi$, is bounded by $c\|\omega\|_{\infty} \log(\|\omega\|_{\infty})$. This implies that there is tremendous dynamic depletion in the vortex stretching term. With such upper bound on the vortex stretching term, one can easily show that the maximum vorticity cannot grow faster than double exponential in time. This was indeed confirmed by their numerical results.

The Deng-Hou-Yu localized non-blowup criteria and their numerical validation represent a significant progress in this field in recent years. It makes people re-evaluate the whole blowup scenario of the 3D Euler equations and pay more attention to the dynamic depletion mechanism.

3. Singularity formation in 3D vortex sheets

The Kelvin-Helmholtz instability is a fundamental instability of incompressible fluid flow at high Reynolds numbers. The idealization of a shear layered flow as a vortex sheet separating two regions of potential flow has often been used as a model to study mixing properties, boundary layers and coherent structures of fluids. Although singularity formation has been well studied for 2D vortex sheets using complex analysis, the techniques used for 2D vortex sheets do not generalize naturally to 3D vortex sheets. As a result, there has been not much progress in studying singularity formation of 3D vortex sheets.
In [10], Hou, Hu, and Zhang studied the singularity of 3D vortex sheets using a new approach. First, they derived a leading order approximation to the boundary integral equation governing the 3D vortex sheet. This leading order equation captures the most singular contribution of the integral equation. Moreover, after applying a nonlocal integral transformation to the physical variables, they found that this leading order 3D vortex sheet equation de-generates into a two-dimensional vortex sheet equation in the direction of the tangential velocity jump. This rather surprising result showed that the driving mechanism for singularity formation of 3D vortex sheets is the same as that of 2D vortex sheets. By analyzing the reduced leading order system, they showed that the singularity type of the three-dimensional problem is the same as that of the two-dimensional problem. Moreover, they derived a new 3D vortex sheet model which captures the leading order singular behavior of the 3D vortex sheet equation and can be computed efficiently and accurately using the Fast Fourier Transform. Their extensive numerical studies confirmed the analytic results, and revealed the generic form of the 3D vortex sheet singularity.

SIAM News featured a long article describing their results in March, 2002. The article concludes that “The new results of Hou and his colleagues have brought ‘the ever distant goal’ of understanding turbulence and hydrodynamic instability at least a few steps closer”. Dr. Hou’s Ph.D. students, Gang Hu and Xinwei Yu were awarded the SIAM Charles DiPrima Outstanding Dissertation Prize in Applied Mathematics in 2002 and 2006 respectively.

4. Convergence of the point vortex method

The idea of representing an incompressible, inviscid flow by a collection of moving Lagrangian point vortices is physically appealing and has been used by many physicists. However, the particle velocity induced from other particles may become unbounded as neighboring particles approach one another. For a long time, many leading experts in this field had widely believed that such method was numerically unstable, and the vortex blob method has been introduced to alleviate this difficulty.

In his joint work with Goodman and Lowengrub, Dr. Hou proved a very surprising result [6, 7]: the point vortex method is stable and convergent with second order accuracy for two and three dimensional Euler equations. The key observation is that two neighboring particles are in fact separated by a distance of order $O(h)$, where $h$ is the mesh size of the initial grid. They showed that the $O(h)$ separation is just enough to obtain stability of the point vortex method, by using a classical result due to Calderon-Zygmund. Another important contribution of their analysis was to establish an asymptotic error expansion in the even powers of $h$. Based on these observations, they proved nonlinear stability and convergence of the point vortex method. Their convergence result has changed the landscape of the field and has led to a number of subsequent theoretical developments and many interesting physical applications, especially for fluid interface problems.

5. Stable and efficient numerical methods for interfacial flows

Many physically interesting problems involve propagation of free surfaces. Water waves, boundaries between immiscible fluids, vortex sheets, Hele-Shaw cells, thin-film growth, crystal growth and solidification are some of the better known examples. Numerical simulations for interfacial flows play an increasingly important role in understanding the complex interfacial dynamics, pattern formations,
and interfacial instabilities. Due to the underlying physical instabilities, numerical schemes are known to be very sensitive to numerical instabilities. For many years, it was not clear whether the observed instabilities in numerical calculations were due to physical or numerical instability. One of the main contributions of Dr. Hou's work is to identify the source of numerical instability, to propose a new class of computational methods and to analyze the convergence of these methods.

In [1], Beale Hou, and Lowengrub analyzed the stability of a class of boundary integral methods for interfacial flows with or without surface tension. They found that there is a compatibility condition between the choice of quadrature rule for the singular velocity integral and the choice of a spatial derivative. Many existing boundary integral methods violated this compatibility condition, resulting in unstable discretizations. Their analysis clarified some confusion in the literature regarding the stabilizing effect of surface tension. Based on these observations, they proved the convergence of a class of spectrally accurate boundary integral methods for water waves, and applied these methods to study the stabilizing effect of surface tension for interfacial flows.

Dr. Hou's another contribution for interfacial flows is to introduce a class of efficient and stable boundary integral methods for interfacial flows with surface tension. Due to the high order regularizing effect and the Lagrangian discretization, boundary integral methods suffer from a severe time-step stability constraint for interfacial flows with surface tension. In [8], Hou, Lowengrub, and Shelley successfully removed this stiffness constraint by using an efficient implicit scheme based on a reformulation of the problem. This reformulation uses the arclength metric and tangent angle as new dynamical variables. They then developed an effective Small Scale Decomposition technique to extract the leading order contribution of the stiff terms. This leads to an efficient implicit discretization at the same cost as an explicit method. This method offers a huge factor (thousands or more) of speed-up over the conventional explicit methods. Many applications which were previously unattainable now became possible using their method and new phenomena were discovered. This method has been widely used by many people in several disciplines ranging from fluid dynamics, to materials science, chemistry, and biology. It has made a big impact in these application areas. Using this method, they found a new type of topological singularities for interfacial flows with surface tension, and some surprising regularizing effect of surface tension. Their 1997 Physics of Fluid paper [9] gave an in-depth study of this new type of topological singularities and was awarded the Frenkel Prize by the Fluid Dynamics Division of the American Physical Society in 1998.

References


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The Research of Jin-Yi Cai

Andrew Chi-Chih Yao

Ladies and Gentlemen,

It is my great pleasure to present the work of Professor Jin-Yi Cai, which has won him a prestigious Morningside Silver Medal.

Cai is a distinguished leading researcher in theoretical computer science, who has made significant and lasting contributions over a wide spectrum of topics in theory of computation. I discuss below in some detail one of his sensational accomplishments, in which he resolved two famous conjectures of Juris Hartmanis that had been open for over fifteen years.

A “sparse set” is a set with polynomially bounded density. In 1978 Hartmanis conjectured, in connection with the P versus NP question, that no sparse sets can be P-complete unless P equals LOGSPACE. This came to be known as Hartmanis’ Conjecture for P-hard sparse sets, and regarded as a fundamental question in theory of computation. In 1995 Ogihara made a breakthrough on this seemingly intractable problem by showing that no sparse sets can be P-complete unless P is contained in square logspace. Building on Ogihara’s work, Cai and Sivakumar obtained in their 1995 paper “Sparse hard sets for P” a complete resolution of this conjecture. Later on, Cai and Sivakumar resolved a related conjecture by Hartmanis for NL-hard sparse sets. The proof of Cai and Sivakumar was an amazing masterpiece, requiring several truly ingenious ideas beyond the innovation contained in Ogihara’s work.

Cai has made outstanding contributions on many other subjects, including boolean circuits, graph isomorphism, average-case complexity theory, and the relation between uniform and non-uniform complexity classes. For instance, in 1986 while still a graduate student, Cai proved that subexponential-size bounded-depth circuits cannot compute the parity function even approximately. This has great implications on Turing machine complexity theory. In 2001 Cai obtained the strongest extension todate of the classic Karp-Lipton theorem which relates uniform and non-uniform complexity classes.

In summary, Jin-Yi Cai has been one of the deepest and most productive scholars of his generation in the theory of computation. The awarding of a Morningside
Silver Medal is a fitting recognition of his great scientific accomplishments.

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Ai-Ko Liu’s Work

Tian-Jun Li

Ai-Ko Liu works on 4–manifolds and Mirror symmetry. His accomplishments are mainly in the following three areas: 1. Seiberg-Witten invariants of smooth 4–manifolds; 2. geometry and topology of symplectic 4–manifolds; 3. enumeration of nodal curves in algebraic surfaces and Calabi-Yau 3–folds.

The Seiberg-Witten invariants are smooth invariants of 4–manifolds. For a smooth, closed, oriented 4–manifold M, once a spin$^c$ structure is chosen, its Seiberg-Witten invariants are described by one Z–valued function $SW$ on $H^2(M;\mathbb{Z})$ if $b^+(M) \geq 2$, and by two Z–valued function $SW^+$ and $SW^-$ if $b^+(M) = 1$. In a joint work with T-J. Li, he found the so called general wall crossing formula which calculates the difference $SW^+ – SW^-$. This is a fundamental formula in the Seiberg-Witten theory. In addition, Liu systematically developed the family Seiberg-Witten theory for a fibre bundle of smooth 4–manifolds. Especially, he established several basic formulas including the family wall crossing formula (with T-J. Li), the family blow up formula, and the family switching formula.

A symplectic structure on a smooth manifold $M$ is a closed non-degenerate 2–form $\omega$. The most basic invariant of a symplectic manifold $(M, \omega)$ is the symplectic canonical class $K_\omega$, which is an element in $H^2(M;\mathbb{Z})$. When combined with Taubes’ symplectic Seiberg-Witten theory, the general wall crossing formula has striking applications to symplectic 4–manifolds. The most noteworthy is Liu’s proof of the Gompf conjecture, which says that a minimal symplectic 4–manifold $(M, \omega)$ with $K^2_\omega < 0$ must be rational or ruled. Here $(M, \omega)$ is said to be rational if $M$ is diffeomorphic to $\mathbb{C}P^2$ or $S^2 \times S^2$, and ruled if $M$ is diffeomorphic to an $S^2$–bundle. In addition, he classified symplectic 4–manifolds with metrics of positive scalar curvature. In joint works with T-J. Li, he proved the uniqueness of symplectic structures up to deformation on rational or ruled manifolds, the uniqueness of symplectic canonical class on manifolds with $b^+ = 1$, and determined completely the symplectic cone when $b^+ = 1$.

Finally, Liu applied the family Seiberg-Witten theory to the enumeration of nodal curves in algebraic surfaces and Calabi-Yau 3–folds with spectacular success. In particular, he confirmed a beautiful conjecture of Gottsche expressing the number of nodal curves in a sufficiently ample linear system $L$ on an algebraic surface $M$ in terms of universal polynomials in

$$L^2, \ L \cdot c_1(M), \ c_1(M)^2, \ c_2(M).$$
This formula is a non-linear analogue of the Riemann-Roch formula and includes as a special case the famous Yau-Zaslow conjecture proved by Bryan and Leung. Recently Liu also confirmed the Harvey-Moore conjecture for nodal curves in K3–fibred Calabi-Yau 3–folds.

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The Work of Xi-Ping Zhu

Huai-Dong Cao

Xi-Ping Zhu’s research in past a few years has been focused on geometric flows and its applications. In particular, he has made important contributions to the study of Ricci flow on Kähler manifolds and the understanding of geometry of complete noncompact Kähler manifolds with positive holomorphic bisectional curvature. Below I shall describe some of his important works on the subject.

1. Geometry of complete Kähler manifolds with positive bisectional curvature

Joint with B.-L. Chen, Xi-Ping Zhu found some deep hidden connections between the sign of (positive) curvature and the volume growth rate as well as curvature decay rate. They proved

\textbf{Theorem 1} (2002). Any complete noncompact Kähler manifold $X^n$ with positive bisectional curvature has the following properties:

(a) Volume growth of order at least $n$: $V(x_0, r) \geq Cr^n$ for $1 < r < \infty$.
(b) Average curvature (on geodesic balls) decays at least linearly:

$$\frac{1}{V(x_0, r)} \int_{B(x_0, r)} R(x) dx \leq \frac{C}{1+r}.$$ 

Here, $V(x_0, r)$ denotes the volume of the geodesic ball $B(x_0, r)$ centered at $x_0$ and of radius $r$ and $R$ denotes the scalar curvature.

2. Uniformization of complete Kähler surfaces

In 1980’s, Yau made the following important conjecture: A complete noncompact Kähler manifold $X^n$ of positive holomorphic bisectional curvature is biholomorphic to $\mathbb{C}^n$. Joint with Bing-Long Chen and Siu-Hung Tang, Zhu combined
techniques from Ricci flow and algebraic geometry to prove the following result:

**Theorem 2** (2002). Let $X^2$ be a complete noncompact Kähler surface with bounded and positive (or nonnegative) bisectional curvature. Assume $X$ has Euclidean volume growth: $V(x_0, r) \geq Cr^4$. Then $X^2$ is biholomorphic to $\mathbb{C}^2$.

This improves a previous result by Mok and gives a partial affirmative answer to the above Yau’s conjecture in complex dimension two.

### 3. Sharp Dimension estimates of holomorphic functions

To understand space of holomorphic functions on a complete Kähler manifold is an important problem. In 2003, in a joint work with his three students, Xi-Ping Zhu gave a complete resolution of Yau’s conjecture on dimension estimate of the space of holomorphic functions. They proved:

**Theorem 3** (2003). Let $X^n$ be a complete noncompact Kähler manifold with nonnegative bisectional curvature. Let $P_d(X^n)$ denote the space of holomorphic functions of polynomial growth of order at most $d$ on $X^n$. Then, for all $d > 0$,

$$\dim(P_d(X^n)) \leq \dim(P_{[d]}(\mathbb{C}^n))$$

with equality holds for some positive integer $d$ if and only if $X = \mathbb{C}^n$.

This improves a previous result of Lei Ni, who first proved the above theorem under the additional assumption that $X^n$ has Euclidean volume growth.

### 4. The Ricci flow on compact Kähler manifolds with positive bisectional curvature

Combining the non-collapsing result of Perelman, the Li-Yau-Hamilton inequality of Cao for Kähler-Ricci flow, Xi-Ping Zhu (together with H.-D. Cao and B.-L. Chen) obtained the following

**Theorem 4** (2003). Any solution $g(t)$ to the Kähler-Ricci flow on a compact Kähler manifold $M^n$ with positive bisectional curvature is necessarily nonsingular, i.e., the curvature of $g(t)$ is uniformly bounded independent of $t$ for all $t > 0$. Moreover, there exists a subsequence $\{t_j\}$ such that $g(t_j)$ converges to a Kähler-Ricci soliton.

This answers an important question raised by Hamilton and Yau in mid 80’s.
Chern Prize Recipients

Chern Prize

The Chern Prize in mathematics was established in 2001 in honor of Professor Shiing-Shen Chern, one of the greatest geometers and Chinese mathematicians of the twentieth century. These awards are presented every three years to mathematicians of Chinese descent who have made exceptional contributions to mathematical research or to public service activities in support of mathematics.

2004 Chern Prize Recipients

Lo Yang

Professor Lo Yang is awarded the 2004 Chern Prize for his dedication to the development of mathematics in China and for his role in promoting mathematical activities and endeavors over the past twenty years. Professor Yang is a distinguished mathematician who has made several important contributions to the modular and angular distribution of entire and meromorphic functions and normal families. With Professor Zhang Guanghou, they established the closed relation between the number of deficient values and the Borel directions of entire and meromorphic functions. He also settled some problems posed by David Drasin and W. K. Hayman; in collaboration with Professor Hayman, they solved a conjecture by J. E. Littlewood. Currently, Professor Yang is the Deputy Director of the Morningside Center of Mathematics. He was a former president of the Chinese Mathematical Society, a former director of the Institute of Mathematics, and the founding director of the Academy of Mathematics and Systems Sciences. Professor Yang is a 1962 graduate of Peking University and completed graduate studies at the Institute of Mathematics. He has been a member of the Chinese Academy of Sciences since 1980. His honors include the Hua Lookeng Award, the Ho Lin and Ho Li Award, the Tan Kah Kee Prize, and the National Natural Science Foundation Award.

Fang Hua Lin

Professor Fang Hua Lin is awarded the 2004 Chern Prize for his fundamental contributions to the theory of liquid crystal, harmonic maps, Ginzburg-Landau
equations, the static as well as dynamic theory of topological defects, Skyrme and Faddeev models, and the Navier-Stokes equations. Professor Lin is a pioneer in the study of liquid crystals and published a series of papers that established that the limiting phenomenon in Ginzburg-Landau equations is governed by a finite dimensional system associated to the BBH renormalization energy. Professor Lin is the Silver Professor of Mathematics at New York University, where he also serves on the faculty of the Courant Institute of Mathematical Sciences. In 2004, he was elected to the American Academy of Arts and Sciences. His other awards and honors include the Bocher Prize of the American Mathematical Society in 2002, the Outstanding Research Award from NSF-China in 1998, and the Presidential Young Investigator Award and a Sloan Fellowship in 1989. Professor Lin has held several visiting professorships, including the Ordway Chair at the University of Minnesota in 1999 and the Cheung Kong Professorship at Zhejiang University in 2000 as well as at Fudan University in 1999. He received his B.S. from Zhejiang University and his Ph.D. from the University of Minnesota.
ICCM International Cooperation Award Recipient

ICCM International Cooperation Award

The ICCM International Cooperation Award is presented to an individual who has promoted the development of mathematics in China, Hong Kong, and Taiwan through collaboration, teaching, and support of Chinese mathematicians. The first award is presented at the Third International Congress of Chinese Mathematicians.

Recipient

John Coates

Professor John Coates is awarded the first ICCM International Cooperation Award. For the past twenty years, he has generously given his knowledge and time to Chinese mathematicians which has enabled them to make great strides in all areas of mathematics. As the Sadleirian Professor of Pure Mathematics at Cambridge University, Professor Coates has trained many Chinese students and post-doctoral fellows, and has been a tremendous influence on their growth as a mathematician. He has been a member of the Monrningside Medal of Mathematics Selection Committee since 1998, and was the former Chairman of the Overseas Committee for The Institute of Mathematical Sciences at The Chinese University of Hong Kong. Professor Coates also organized several important workshops in Beijing and Hangzhou, where he devoted himself to helping Chinese mathematicians understand modern mathematics. In 2004, he was made an Honorary Professor at Zhejiang University and the University of Science and Technology of China.
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Photographs

The Third International Congress of Chinese Mathematicians, 2004

Opening Ceremony at the Hong Kong Convention and Exhibition Centre
On the stage (from left to right): Leslie G. Valiant, Mrs. May Chu (the daughter of Professor Shiing-Shen Chern), Lawrence J. Lau (Vice-Chancellor, CUHK), Yongxiang Lu, Shing-Tung Yau, Ronnie Chan and John Coates

Ronnie C. Chan, Co-Founder of THE MORNINGSIDE GROUP, and Chairman of the Hang Lung Group
Shing-Tung Yau, Chairman of the International Congress of Chinese Mathematicians

Yongxiang Lu, Vice-Chairman of the Standing Committee of the 10th National People’s Congress, People’s Republic of China
Mr. Yongxiang Lu presenting the Morningside Gold Medal of Mathematics to Kefung Liu

Mr. Yongxiang Lu presenting the Morningside Gold Medal of Mathematics to Zhouping Xin
Prof. Shing-Tung Yau presenting the Morningside Gold Medal of Applied Mathematics to Thomas Yizhao Hou

Prof. Shing-Tung Yau presenting the Morningside Gold Medal of Applied Mathematics to Zhiliang Ying
Prof. Leslie G. Valiant, selection committee of the Morningside Medal of Mathematics, presenting the Silver Medal to Jin-Yi Cai

Prof. John Coates, selection committee of the Morningside Medal of Mathematics, presenting the Silver Medal to Ai-Ko Liu
Prof. Lawrence J. Lau, the Vice-Chancellor of The Chinese University of Hong Kong, presenting the Silver Medal to Xi-Ping Zhu

2004 Chern Prize recipients, Fang Hua Lin (left) and Lo Yang
Mr. Ronnie Chan presenting the ICCM International Cooperation Award to John Coates

The Morningside Awards Recipients
Prof. Jun Li presenting the research of Kefeng Liu

Prof. Stanley Osher presenting the research of Thomas Yizhao Hou
Prof. Jia-An Yan presenting the research of Zhiliang Ying

Prof. Andrew Yao presenting the research of Jin-Yi Cai
Prof. Tian-Jun Li presenting the research of Ai-Ko Liu

Prof. Huai-Dong Cao presenting the research of Xi-Ping Zhu
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List of Speakers

**Morningside Lectures**
Shock Waves and Cosmology  
JOEL A. SMOLLER (CONJOINT WITH BLAKE TEMPLE)

**Plenary Lectures**
Variational Construction of Diffusion Orbits in Convex Hamiltonian Systems with Multiple Degrees of Freedom  
CHONG-QING CHENG (CONJOINT WITH JUN YAN)
Saddlepoint Approximations and Boundary Crossing Probabilities for Random Fields and Their Applications  
TZE LEUNG LAI
Recognizing Certain Rational Homogeneous Manifolds of Picard Number 1 from Their Varieties of Minimal Rational Tangents  
NGAIMING MOK
Discontinuous Galerkin Methods for Convection Dominated Partial Differential Equations  
CHI-WANG SHU
Singularity Behavior of the Mean Curvature Flow  
XU-JIA WANG
Localisation and Duality  
JIANG JIANG
Surgical Ricci Flow on Four-Manifolds with Positive Isotropic Curvature  
XI-PING ZHU (CONJOINT WITH BING-LONG CHEN)
Special Subvarieties of $\mathcal{A}_g$  
KANG ZUO (CONJOINT WITH ECKART VIEHWEG)

**45-Minute Invited Talks**
Subelliptic PDE’s and SubRiemannian Geometry  
DER-CHEN CHANG (CONJOINT WITH PETER GREINER)
Set Addition and Set Multiplication

MEI-CHU CHANG

The Q-Curvature Flow on a Closed 3-Manifold of Positive Q-Curvature

SHU-CHENG CHANG

Normal Dilations

MAN-DUEN CHOI

Dirichlet Forms and Markov Semigroups on Non-Associative Vector Bundles

CHO-HO CHU (CONJOINT WITH ZHONGMIN QIAN)

Intelligent and Informative Scientific Computing, Trends and Examples

QIANG DU

Decomposition Principle and Random Cascades

AI HUA FAN (CONJOINT WITH JEAN PIERRE KAHANE)

Number-Theoretic Methods in Experimental Designs

KAI-TAI FANG (CONJOINT WITH YUAN WANG)

Local Monodromy of the Kloosterman Sheaf at ∞

LEI FU (CONJOINT WITH DAQING WAN)

On the Generator Problem of von Neumann Algebras

LIMING GE (CONJOINT WITH JUNHAO SHEN)

Collineation Groups of Translation Planes

CHAT YIN HO

Localized Non-Blowup Conditions for the 3D Incompressible Euler Equations

THOMAS YIZHAO HOU (CONJOINT WITH JIAN DENG AND XINWEI YU)

Geometric Invariant Theory and Birational Geometry

YI HU

Large Scale Geometry, Compactifications and the Integral Novikov Conjectures for Arithmetic Groups

LIZHEN JI

Holomorphic Motions and Normal Forms in Complex Analysis

YUNPING JIANG

A Survey of Results on the Ground State of Semilinear Elliptic Equations

MAN KAM KWONG

Separating and Extending Subgroups of a Locally Compact Group

ANTHONY TO-MING LAU (CONJOINT WITH EBERHARD KANIUTH)

On Pseudo-Hermitian CR Manifolds

SONG-YING LI

The Space of Symplectic Structures on Closed 4-Manifolds

TIAN-JUN LI

An Introduction to Chiral Equivariant Cohomology

BONG H. LIAN
LIST OF SPEAKERS

Separation of Bound State Solutions of Systems of Nonlinear Schrödinger Equations
TAI-CHIA LIN (CONJOINT WITH YU-WEN HSU)

On Strong Near-epoch Dependence
ZHENGYAN LIN

Ancient Solutions to Kähler-Ricci Flow
LEI NI

Recent Progress on the Drichlet Problem in Lipschitz Domains
ZHONGWEI SHEN

Scattered Data Interpolation by Box Splines
ZUOWEI SHEN (CONJOINT WITH SHAYNE WALDRON)

Multifractal Analysis of Branching Measure on a Galton-Watson Tree
NARN-RUEIH SHIEH (CONJOINT WITH PETER MÖRTERS)

Mathematics, Mathematics Education and the Mouse
SIU MAN KEUNG

Remarks on Gieseker’s Degeneration and its Normalization
XIAOTAO SUN

A Convergence Result of the Lagrangian Mean Curvature Flow
MU-TAO WANG

On Piecewise Algebraic Variety
REN-HONG WANG

Refinable Functions with Non-Integer Dilations
YANG WANG (CONJOINT WITH XIN-RONG DAI AND DE-JUN FENG)

Some Results on Smale’s Mean Value Conjecture
YUEFEI WANG

On Whitney’s Critical Sets
ZHI-YING WEN (CONJOINT WITH LI-FENG XI)

Bundle Rigidity of Complex Surfaces
BUN WONG (CONJOINT WITH WING-SUM CHEUNG)

The Triangle of Operators, Topologies, Bornologies
NGAI-CHING WONG

Applications of Nevanlinna Theory to Geometric Problems
PIT-MANN WONG

Piecewise Function Generated by the Solutions of Linear Ordinary Differential Equation
ZONGMIN WU

Ear Modeling and Sound Signal Processing
JACK XIN

Convex Duality Theory for Optimal Investment
JIA-AN YAN (CONJOINT WITH JIANMING XIA)
Stability of Basic Wave Patterns for Gas Motions
Tong Yang (Conjoint with Hui-Jiang Zhao)

Hilbert Modular Functions and Their CM Values
Tonghai Yang

CR Equivalence Problem of Strongly Pseudoconvex CR Manifolds
Stephen S.-T. Yau

Backward Stochastic Volterra Integral Equations
Jiongmin Yong

Step-Sizes for the Gradient Method
Ya-Xiang Yuan

The Mathematical Problem of Inertial Waves in Rapidly Rotating Planets and Stars
Keke Zhangm (Conjoint with Xinhao Liao)

The $C^\alpha$ Regularity of a Class of Ultraparabolic Equations
Zhang Liqun

The Positive Mass Theorem Near Null Infinity
Xiao Zhang

Vector Bundles on Non-Primary Hopf Manifolds with Abelian Fundamental Group
Xiangyu Zhou (Conjoint with Weiming Liu)
This volume consists of the proceedings of the Third International Congress of Chinese Mathematicians, held at the Chinese University of Hong Kong in December 2004. The Congress brought together eminent Chinese and overseas mathematicians to discuss the latest developments in pure and applied mathematics.

This two-part proceedings contains the contents of lectures given by the plenary speakers and the invited speakers—the major portion comprising new results—together with some expository and survey articles. Eleven major topics are treated: algebra, number theory and cryptography; algebraic geometry and algebraic topology; geometric analysis; complex analysis and complex geometry; harmonic analysis and functional analysis; applied mathematics; dynamical systems, fractals and wavelets; numerical analysis; PDF; probability, statistics, and financial mathematics; and education.