The New World Mathematics Awards*

by the Editors

Mathematics and mathematics education are of great significance in the human pursuit of knowledge and truth. They are the foundations of science and technology. In 2007, Dr. Henry Cheng (Managing Director of New World Development Company Limited) and Professor Shing-Tung Yau (Harvard University) initiated the "New World Mathematics Awards" (NWMA). The purpose of this program is to encourage outstanding Chinese mathematics students worldwide in their pursuit of mathematical truth.

The NWMA is sponsored by the New World Development Company Limited and China Young Leaders Foundation (Chairman: Chi Kong Cheng), and Tsinghua University at Beijing. Chinese undergraduate, master and PhD mathematics students all over the world are encouraged to apply this award. The thesis topics may be pure or applied mathematics (including probability, statistics, biomathematics etc.).

Application Process

The candidate should submit the thesis, an application form, and one recommendation letter. The application form may be filled in online and the thesis be uploaded on the webpage of NWMA.

Selection Process

All submissions are subjected to a two-round review conducted by a scientific committee and then an international committee chaired by Professor Yau Shing-Tung. All members of these committees are world-renowned mathematicians.

* Visit http://msc.tsinghua.edu.cn/NWMA2014/.

Qualification

This program is open to all undergraduate, master and PhD mathematics Chinese students.

The submitted thesis must be successfully defended and accepted by the students' college/university. Students have to show some evidence or document that the defense of thesis was finished.

International Committee

Shing-Tung Yau

Professor Shing-Tung Yau is the William Casper Graustein Professor of Mathematics at Harvard University. He is the inaugural Director of the Mathematical Sciences Center of Tsinghua University. Professor Yau has made fundamental contribution to differential geometry, differential equations and mathematical physics. Professor Yau is honored by numerous prestigious prizes and awards, including Oswald Veblen Prize (1981), John J. Carty Award for the Advancement of Science (1981), Fields Medal (1982), Humboldt Research Award, Alexander von Humboldt Foundation (1991), Crafoord Prize (1994), United States National Medal of Science (1997), China International Scientific and Technological Cooperation Award (2003), and Wolf Prize in Mathematics (2010). He is a member of the United States National Academy of Sciences, a member of Russian Academy of Sciences, a foreign member of

the Chinese Academy of Sciences, and a member of Academia Sinica.

Ben Andrews

Professor Ben Andrews is a senior fellow of Mathematical Sciences Institute, Australian National University, and Professor of the Mathematical Sciences Center of Tsinghua University. Professor Andrews works on differential geometry and related partial differential equation and is well known for his work in geometric evolutions. He is a leading international geometric analyst, who specializes in Riemannian geometry, submanifold geometry, heat flows, image processing, interface model and reaction- diffusion system. In 2011, Professor Andrews solved one of the most celebrated open problems in mathematics, the fundamental gap conjecture for the eigenvalues of the Laplacian, and he proved Firey's conjecture on the shape of rolling stone in 1999. He was an invited speaker at the International Congress of Mathematicians in Beijing, 2002. He was awarded the medal of Australian Mathematical Society in 2003. In 2012, Professor Andrews became a fellow of the American Mathematical Society, and he was elected a fellow of Australian Academy of Science in March 2013.

John H. Coates

Professor John H. Coates is the Sadleirian Professor of Pure Mathematics at the University of Cambridge. His research work concerns number theory, arithmetical algebraic geometry and Iwasawa theory. He became Head of the Department of Pure Mathematics and Mathematical Statistics at Cambridge in 1991, served as president of the London Mathematical Society during 1988–1990 and as vice-president of the International Mathematical Union from 1991 to 1995, as a member of Council of the Royal Society during 1992–1994. Professor Coates was elected a fellow of Emmanuel College in Cambridge twice, a fellow of the Royal Society of London in 1985 and awarded Senior Whitehead Prize by the London Mathematical Society in 1997. Professor Coates is the first receipt of the ICCM International Cooperation Award (2004).

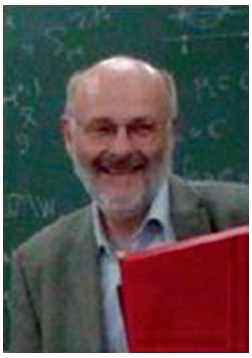
Björn Engquist

Professor Björn Engquist is Director of the Parallel and Scientific Computing Institute. Engquist currently holds the Computational and Applied Mathematics Chair at the Institute for Computational Engineering and Sciences at the University of Texas at Austin. He has been a leading contributor in the areas of multiscale modeling and scientific computing, and a productive educator of applied mathematicians. His research field is computational and applied mathematics and numerical methods for differential equations with applications to multi-scale modeling, electromagnetism, and fluid mechanics. Engquist has authored more than 100 scientific publications and advised 31 PhD students. He is a recipient of numerous distinctions and awards: a member of the Royal Swedish Academy of Sciences and the Royal Swedish Academy of Engineering Sciences, and an invited speaker at the International Congress of Mathematicians (1982 and 1998), European Congress of Mathematics (1992), and European Congress of Fluid Mechanics (1991). He was selected to the Norwegian Academy of Science and Letters in 2011.

Dorian Goldfeld

Dorian Goldfeld is a professor at Columbia University. He is a member of the editorial board of *Acta Arithmetica* and of *The Ramanujan Journal*. He is a co-founder and board member of SecureRF, a corporation that has developed the world's first linear-based security solutions. Professor Goldfeld's research interests include various topics in number theory. In his thesis, he proved a version of Artin's conjecture on primitive roots on the average without the use of the Riemann Hypothesis. In 1987 he received the Frank Nelson Cole Prize in Number Theory, for his solution of Gauss' class number problem for imaginary quadratic fields. He has also held the Sloan Fellowship (1977–1979) and in 1985 he received the Vaughan prize. In April 2009 he was elected a Fellow of the American Academy of Arts and Sciences. In 2012 he became a fellow of the American Mathematical Society.

Eduard Looijenga



Professor Eduard Looijenga has been a Professor of Mathematics at the University of Utrecht. Professor Looijenga's research started in singularity theory, but migrated via Torelli problems to locally symmetric varieties, then to mapping class groups and moduli spaces of curves. His recent work is concerned with automorphic forms with poles that are associated with moduli problems and with the algebraic geometry of Wess–Zumino–Witten systems. One of his major works is a solution of the Zucker conjecture concerning identification of the L2-cohomology of an arithmetic Hermitian locally symmetric space and the intersection cohomology of the Baily-Borel compactification of the space. Professor Looijenga was an invited speaker at the ICM in 1978 and at the ECM in 1992. Currently he is a member of the Royal Netherlands Academy of Arts and Sciences, and an editor of *The Michigan Mathematical Journal* and *Journal of The European Mathematical Society*. In 2013, he will become a Professor of the Mathematical Sciences Center of Tsinghua University.

Stanley J. Osher

Professor Stanley Osher is a Professor of Mathematics and the Director of Applied Mathematics at University of California at Los Angeles, and the Director of Special Projects at the Institute for Pure and Applied Mathematics. His research work concerns level set methods for computing moving fronts involving topological changes, the development of methods for approximating hyperbolic conservation laws and Hamilton-Jacobi equations and total variation and other partial differential equations based image processing techniques. Professor Osher was awarded the 2003 ICIAM Pioneer Prize, the 2005 SIAM Kleinman Prize, 2007 USACM Computational and Applied Sciences Award, 2009 Fellow of Society of Industrial and Applied Mathematics, and was the plenary speaker of International Conference of Mathematicians 2010. He is elected to the American Academy of Arts and Sciences in 2009 and to the National Academy of Sciences in 2010.

Lo Yang

Professor Lo Yang was the Director of Institute of Mathematics (1987–1995) and the President of Academy of Mathematics and System Science (1998–2002), CAS. Now he is the professor and Chairman of Scientific Committee of AMSS. He was elected as the academician of the Chinese Academy of Sciences in 1980. Besides, he was the President (1992–1995) of Chinese Mathematical Society. Professor Yang was mainly engaged in the research on complex analysis. He has made a through study of deficient values and deficient functions. He, cooperated with Guang-hou Zhang, established for the first time a close relation between the numbers of deficient values and Borel directions of entire and meromorphic functions. Among his research on normal families, he built the relationship between normal families and fix-points, as well as that between normal families and differential polynomials. He also made the systematic research on the angular distribution: finding a new kind of singular direction and establishing a necessary and sufficient condition for the distribution of singular directions. Distribution Theory was published by the Springer-Verlag. He was invited as the main or invited speaker for over 20 international conferences and delivering lectures in 60 famous universities in the world.

Horng-Tzer Yau

Horng-Tzer Yau is a professor of Harvard University. Professor Yau is a leader in the fields of mathematical physics, analysis and probability. He is a powerful analyst who has introduced important tools and concepts to study probability, stochastic processes, nonequilibrium statistical physics and quantum dynamics. His insight and skilled teaching are invaluable to students. He has also been a member of the Institute for Advanced Study in Princeton, in 1987–1988, 1991–1992, and 2003, and a member of the American Academy of Arts and Sciences. He is a member of the editorial boards of *Communications in Mathematical Physics, Journal of Statistical Mathematics, Asian Journal of Mathematics and Communications on Pure and Applied Mathematics*. He received Henri Poincaré Prize, MacArthur Fellowship and Morningside Gold Medal of Mathematics in 2000 and 2001. He is elected a fellow of the US National Academy of Sciences in 2013.

Scientific Committee

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The NWMA was announced at the ICCM 2007 conference. From 2009, it has been announced annually.

Recipients of the 2011 New World Mathematics Awards

Doctor Thesis Awards, Gold Prize

Shan Peng, Université Paris 7

Thesis title: Canonical bases and gradings associated with rational double affine Hecke algebras

Abstract: This thesis consists of three chapters. In Chapter I, we define the i-restriction and i-induction functors on the category $\mathcal{O}$ of the cyclotomic rational double affine Hecke algebras. Using these functors, we construct a crystal on the set of isomorphism classes of simple modules, which is isomorphic to the crystal of a Fock space. Chapter II is a joint work with Michela Varagnolo and Eric Vasserot. We prove a conjecture of Miemietz and Kashiwara on canonical bases and branching rules of affine Hecke algebras of type D. In Chapter III, we prove a conjecture of Leclerc and Thibon on the graded multiplicities associated with the Jantzen filtration of Weyl modules over v-Schur algebras.

Advisor: Eric Vasserot
Current affiliation: C L E Moore Instructor, MIT

Si Li, Harvard University

Thesis title: Calabi-Yau Geometry and Higher Genus Mirror Symmetry

Abstract: We study closed string mirror symmetry on compact Calabi-Yau manifolds at higher genus. String theory predicts the existence of two sets of geometric invariants, from the A-model and the B-model on Calabi-Yau manifolds, each indexed by a non-negative integer called genus. The A-model has been mathematically established at all genera by the Gromov-Witten theory, but little is known in mathematics for B-model beyond genus zero.

We develop a mathematical theory of higher genus B-model from perturbative quantization techniques of gauge theory. The relevant gauge theory is the Kodaira-Spencer gauge theory, which is originally discovered by Bershadsky-Cecotti-Ooguri-Vafa as the closed string field theory of B-twisted topological string on Calabi-Yau three-folds. We generalize this to Calabi-Yau manifolds of arbitrary dimensions including also gravitational descendants, which we call BCOV theory. We give the geometric description of the perturbative quantization of BCOV theory in terms of deformation-obstruction theory. The vanishing of the relevant obstruction classes will enable us to construct the higher genus B-model. We carry out this construction on the elliptic curve and establish the corresponding higher genus B-model. Furthermore, we show that the B-model invariants constructed from BCOV theory on the elliptic curve can be identified with descendant Gromov-Witten invariants on the mirror elliptic curve. This gives the first compact Calabi-Yau example where mirror symmetry can be established at all genera.

Advisor: Shing-Tung Yau
Current affiliation: Professor, MSC, Tsinghua University

Recipients of the 2012 New World Mathematics Awards

Xiangyu Liang, University of Paris Sud 11

Thesis title: Ensembles et cônes minimaux dans les espaces euclidiens (Minimal sets and cones in Euclidean spaces)

Abstract: In the thesis we discuss the theory of minimal sets.

In the first part we study 2-dimensional Almgren minimal cones in $\mathbb{R}^4$, which is the first useful and necessary step to study Almgren minimal sets. We establish the Almgren minimality of the union of a pair of almost orthogonal planes in $\mathbb{R}^4$. The method is also generalized to prove the minimality of the almost orthogonal union of several planes or hyperplanes, as well as the almost orthogonal union of a plane and a Y in $\mathbb{R}^5$.

In the second part we introduce a definition of topological minimal sets, which is a generalization of that of Mumford-Shah-minimal sets. We prove some properties of topological minimal sets, and make a first step towards a characterisation of topological minimal sets. We restrict also the potential class of those Almgren minimal sets in $\mathbb{R}^3$ which are not cones.

Advisor: Guy David
Current affiliation: Postdoctoral Research Fellow, University of Warwick

Siu-Cheong Lau, The Chinese University of Hong Kong

Thesis title: SYZ Mirror Symmetry for Toric Calabi-Yau Manifolds

Abstract: This thesis gives a procedure to carry out SYZ construction of mirrors with quantum corrections by Fourier transform of open Gromov-Witten invariants. Applying to toric Calabi-Yau manifolds, one obtains the Hori-Iqbel-Vafa mirror together with a map from the Kähler moduli to the complex moduli of the mirror, called the SYZ map.

It is conjectured that the SYZ map equals to the inverse mirror map. In dimension two this conjecture is proved, and in dimension three supporting evidences of the equality are studied in various examples. Since the SYZ map is expressed in terms of open Gromov-Witten invariants, this conjectural equality established an enumerative meaning of the inverse mirror map.

Moreover a computational method of open Gromov-Witten invariants for toric Calabi-Yau manifolds is invented. As an application, the Landau-Ginzburg mirrorsof compact semi-Fano toric surfaces are computed explicitly.

Advisor: Naichung Conan Leung
Current affiliation: Benjamin Peirce lecturer, Harvard University

Zhiren Wang, Princeton University

Thesis title: On Higher Rank Commutative Actions by Toral Automorphisms

Abstract: We study rigidity properties of $\mathbb{Z}^r$-actions by toral automorphisms. Such actions form an important class of examples of higher rank commutative algebraic actions, and are interesting from an arithmetic point of view as under certain assumptions they are conjugate to the natural action of a subgroup of units from a number field K on some compact quotient of $K\bigotimes_{\mathbb{Q}}\mathbb{R}$. In 1983, Berend proved that a faithful $\mathbb{Z}^r$-action α on $\mathbb{T}^d$ by automorphisms is topologically rigid, which means any orbit is either finite or dense, if and only if $r \geq 2$ and α is hyperbolic and contains totally irreducible toral automorphisms. In this thesis we present three different extensions to Berend's result.

When α satisfies Berend's conditions and is a Cartan action, i.e. α is not contained in a faithful commutative action of strictly higher rank by toral automorphisms, we show a quantitative version of its rigidity by generalizing Bourgain, Lindenstrauss, Michel and Venkatesh's recent one-dimensional result. We also give an application of our quantitative estimate to the geometry of numbers in number fields.

Next, we show that when α has higher rank and total irreducibility but fails to be hyperbolic, there is still rigidity in the weaker sense that any point has a dense orbit unless it lies in the central foliation through some rational point. More generally, the result applies to the partial action by those toral automorphisms from a $\mathbb{Z}^r$-action that are roughly isometric along a given set of eigenspaces.

The last part of this thesis represents a joint work with my advisor Prof. Elon Lindenstrauss, in which we investigate two-fold self-joinings of a Cartan action by toral automorphisims. We consider the diagonal $\mathbb{Z}^r$-action $\alpha_\Delta = \alpha \times \alpha$ on $(\mathbb{T})^{2d}$, where α satisfies Berend's conditions and is Cartan. When $r \geq 3$, we establish a rigidity property that asserts any orbit closure is homogeneous and has dimension 0, d or $2d$. However for $r = 2$, we construct a counterexample of non-homogeneous orbit closure.

Advisor: Elon Lindenstrauss
Current affiliation: Gibbs Assistant Professor, Yale University

Recipients of the 2013 New World Mathematics Awards

Doctor Thesis Awards-Gold Prize

Han Wu, Ecole Polytechnique Federale de Lausane

Thesis title: Subconvexity problem for $GL_2 \times GL_1$

Abstract: Let F be a number field, π an irreducible automorphic representation of $GL_2(F)\backslash GL_2(\mathbb{A}_F)$ with unitary central character, and χ a Hecke character of analytic conductor Q. We are interested in bounding $L(1/2, \pi \bigotimes \chi)$ in terms of Q.

If π is cuspidal, then we get a Burgess-like bound as $L(1/2, \pi \bigotimes \chi) \ll Q^{\frac{1}{2}-\frac{1}{8}(1-2\theta)+\epsilon}$, where $0 \leq \theta \leq 1/2$ is any exponent towards the Ramanujan-Petersson conjecture. The implicit constant depends polynomially on the analytic conductor of π.

If π is the unitary Eisenstein series representation induced by the trivial character, then we get $L(1/2, \pi \bigotimes \chi) \ll Q^{\frac{1}{2}-\frac{1}{12}(1-2\theta)+\epsilon}$ As a consequence, we get a subconvex bound for the L-function $L(1/2, \chi) \ll Q^{\frac{1}{4}-\frac{1}{24}(1-2\theta)+\epsilon}$.

The proof is based on an idea of unipotent translation originated from P. Sarnak then developed by P. Michel and A. Venkatesh, combined with the method of amplification.

Advisor: Philippe Michel
Current affiliation: Department of Mathematics, ETH Zurich

Yu-Shen Lin, Harvard University

Thesis title: Open Gromov-Witten Invariants on Elliptic K3 Surfaces and Wall-Crossing

Abstract: We defined a new type of open Gromov-Witten invariants $\tilde{\Omega}^{Floer}$ on hyperKäher manifolds with holomorphic Lagrangian fibration (not necessary compact). Using this new invariant, we prove a version of correspondence theorem between holomorphic discs give rise to non-trivial invariants and tropical discs. Moreover, we prove the above two invariants are the same in an local model and provide an non-trivial example of wall-crossing phenomenon of the open Gromov-Witten invariants on K3 surfaces. We also connect the invariants $\tilde{\Omega}^{Floer}$ with discs counting on Calabi-Yau 3-folds with K3 fibration vian an real analogue of Noether-Lefschetz theory.

Advisor: Shing-Tung Yau
Current affiliation: Szegö Assistant Professor, Stanford University

Doctor Thesis Awards-Silver Prizes

Frederick Tsz-Ho Fong, Stanford University

Thesis title: New Results on the Singularity Analysis of the Kahler-Ricci Flow

Advisor: Richard Schoen
Current affiliation: Jacob D. Tamarkin Assistant Professor Department of Mathematics, Brown University

Jonathan Luk, Princeton University

Thesis title: Linear and Nonlinear Wave Equations on Black Hole Spacetimes

Advisor: Igor Rodniansk
Current affiliation: CLE Moore Instructor and NSF Postdoc

Master Thesis Awards-Silver Prize

Yue-Xun Wang, Capital Normal University

Thesis title: Remarks on Blow-up of Smooth Solutions to the Compressible Fluid with Constant Viscosity and Degenerate Viscosity

Advisor: Zhou-Ping Xin, Quan-Sen Jiu
Current affiliation: PhD Mathematical Sciences Center, Tsinghua University

Dan Zhai, Beijing Normal University

Thesis title: Investigation on the Application of the TDGL Equation in Macromolecular Microsphere Composite Hydrogel

Advisor: Hui Zhang