

# Mathematics

@ National University of Singapore



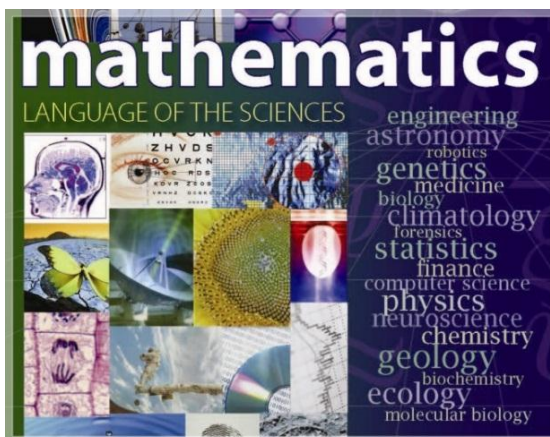
Department of Mathematics  
Faculty of Science

# Faculty & Research

The widespread penetration of mathematics into almost every area of science and technology has vastly expanded the opportunities available to mathematicians, both in traditional areas of pure and applied research and in emerging interdisciplinary areas.

The Department of Mathematics, with the combined capabilities and expertise of more than 70 faculty members and researchers, is engaging research that supports the on-going theoretical development of the mathematical sciences, and that simultaneously promotes the interdisciplinary use of mathematics in science, engineering and other fields.

For an overview of the diversity and focus of our research, we profile the main research groups in the Department in pure mathematics, and in applied and computational mathematics.



## Research Groups (Pure Mathematics)

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### Algebra & Number Theory

Topics of interest include additive and analytic number theory, arithmetic algebraic geometry, automorphic forms, L-functions, cohomology of groups, representation theory of symmetric groups and related algebras.

CHAN Heng Huat (*PhD Illinois*)

CHIN Chee Whye (*PhD Princeton*)

GAN Wee Teck (*PhD Harvard*)

TAN Kai Meng (*PhD Cambridge*)

Victor TAN (*PhD UCLA*)

ZHANG Lei (*PhD Minnesota*)

### Combinatorics & Graph Theory

Topics of interest include extremal combinatorics, probabilistic and algebraic methods in combinatorics, graph theory, finite geometry, combinatorial designs and difference sets, rigidity of structures, as well as their applications in biology such as homology detection and gene duplication in comparative genomics.

KU Cheng Yeaw (*PhD London*)

LEUNG Ka Hin (*PhD Berkeley*)

MA Siu Lun (*PhD Hong Kong*)

NG Kah Loon (*PhD NUS*)

TAY Tiong Seng (*PhD Waterloo*)

ZHANG Louxin (*PhD Waterloo*)

### Dynamical Systems

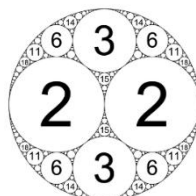
Topics of interest include real and complex one-dimensional dynamics, complex dynamics in several variables, pluri-potential theory and applications in dynamics and related fields, dynamics of group actions on varieties, geometric structures of complex varieties equipped with automorphisms of positive entropy.

DINH Tien Cuong (*PhD Paris 6*)

SHEN Weixiao (*PhD Tokyo*)

TAN Ser Peow (*PhD UCLA*)

ZHANG De-Qi (*PhD Osaka*)



## Geometry & Topology

Topics of interest include algebraic geometry, complex geometry, geometric analysis, global differential geometry and mathematical physics, gauge theory, Higgs bundles, homotopy theory, knot theory, geometric structures on surfaces and three manifolds.

HAN Fei (*PhD Berkeley*)  
Brett McINNIS (*PhD Sydney*)  
TAN Ser Peow (*PhD UCLA*)  
TO Wing Keung (*PhD Columbia*)

Graeme WILKIN (*PhD Brown*)  
WONG Yan Loi (*PhD Berkeley*)  
WU Jie (*PhD Rochester*)  
ZHANG De-Qi (*PhD Osaka*)

## Mathematical Logic & Theoretical Computer Science

Topics of interest include set theory, set theoretic topology, recursion theory, models of Peano arithmetic, reverse mathematics, inductive inference, automata theory and formal languages, information theory and performance modeling.

CHONG Chi Tat (*PhD Yale*)  
Dilip RAGHAVAN (*PhD Wisconsin*)  
Frank STEPHAN (*PhD Karlsruhe*)

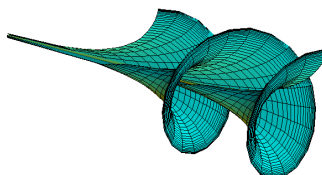
TAY Yong Chiang (*PhD Harvard*)  
YANG Yue (*PhD Cornell*)

## Partial Differential Equations & Geometric Analysis

Topics of interest include problems on conformal geometry and their applications to Riemannian geometry and mathematical physics; Boltzmann equation, conservation laws and nonlinear reaction-diffusion equations.

LEUNG Man Chun (*PhD Michigan*)  
PANG Peter Yu Hin (*PhD Illinois*)

XU Xingwang (*PhD Connecticut*)  
YU Shih-Hsien (*PhD Stanford*)



## Probability

Topics of interest include disordered systems such as random polymer models in random media, interacting particle systems, random matrices, Schramm-Loewner evolution, Stein's method, stochastic differential equations, and applications to computational biology and finance.

Louis CHEN (*PhD Stanford*)  
CHOI Kwok Pui (*PhD Illinois*)  
Steven KOU (*PhD Columbia*)  
SUN Rongfeng (*PhD NYU*)

WANG Dong (*PhD Brandeis*)  
ZHOU Chao (*PhD EcolePoly*)  
ZHOU Wang (*PhD HKUST*)

## Real, Functional & Harmonic Analysis

Topics of interest include classical analysis, differential equations, Sobolev spaces, Banach space theory, operator algebras, time-frequency analysis, nonstandard analysis and applications to economics.

CHEW Tuan Seng (*PhD NUS*)  
CHUA Seng Kee (*PhD Rutgers*)  
GOH Say Song (*PhD Michigan*)  
LEUNG Denny Ho Hon (*PhD Illinois*)

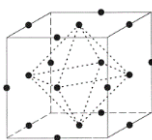
SHEN Zuowei (*PhD Alberta*)  
SUN Yeneng (*PhD Illinois*)  
TANG Wai Shing (*PhD Toronto*)

## Representation Theory & Automorphic Forms

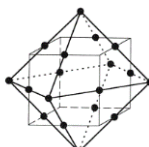
Topics of interest include invariant theory, algebraic combinatorics, unitary representations, branching laws, theta correspondence, automorphic representations and L-functions.

GAN Wee Teck (*PhD Harvard*)  
LEE Soo Teck (*PhD Yale*)  
LOKE Hung Yean (*PhD Harvard*)

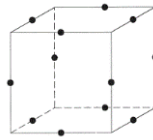
TAN Eng Chye (*PhD Yale*)  
ZHANG Lei (*PhD Minnesota*)  
ZHU Chen-Bo (*PhD Yale*)



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$C_3$



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## Research Groups (Applied and Computational Mathematics)

### Computational Biology & Bioinformatics

The group conducts research in modern biology problems by tapping on strengths in combinatorics, probability and statistics. Our current interests include detection of functional signals in biological sequences and protein networks, algorithms and models for inference of gene duplication history and reconstruction of phylogenetic networks, and discovery of the topological and dynamic principles of transcriptional regulatory networks.

Louis CHEN (*PhD Stanford*)  
CHOI Kwok Pui (*PhD Illinois*)

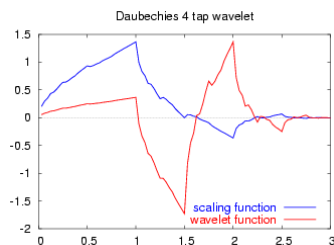
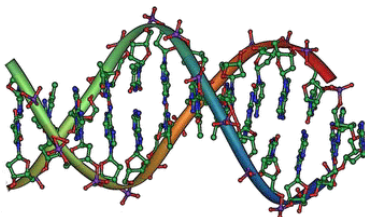
ZHANG Louxin (*PhD Waterloo*)

### Imaging & Vision Science

This multidisciplinary research group emphasizes the synergy of mathematics, engineering and computer science in the areas of imaging science, computer vision, information theory and learning. Topics of interest include wavelet frame methods in imaging science, compressive sensing and low rank matrix completion and their applications, time-frequency and scale-space methods in signal processing, human and computer vision, and the interplay between information theory and statistical learning.

GOH Say Song (*PhD Michigan*)  
JI Hui (*PhD Maryland*)  
SHEN Zuowei (*PhD Alberta*)

TAN Yan Fu, Vincent (*PhD MIT*)  
TAN Hwee Huat (*PhD Adelaide*)



## Mathematical Finance & Mathematical Economics

The group works in the interface of mathematics with finance and economics. Topics of interest include pricing of financial derivatives, portfolio selection, risk measure, fixed income products, credit risk, trading strategy, games with imperfect information or with many players or with location problems, random matching of economic agents, incentive compatibility problems in a large market with asymmetric information.

DAI Min (*PhD Fudan*)

Steven KOU (*PhD Columbia*)

SUN Yeneng (*PhD Illinois*)

ZHOU Chao (*PhD EcolePoly*)

## Numerical Analysis & Scientific Computing

The group focuses on the design and analysis of efficient, accurate and robust numerical methods and their applications to applied sciences and engineering. Topics include numerical linear algebra, computational fluid dynamics, computational materials science, multi-phase/complex fluids, computational quantum and plasma physics, control theory, analysis of finite element and spectral methods, analysis and modeling of complex energy landscapes and barrier-crossing events, multi-scale/multi-physics methods, and emerging applications.

BAO Weizhu (*PhD Tsinghua*)

CHU Delin (*PhD Tsinghua*)

LIU Jie (*PhD Maryland*)

REN Weiqing (*PhD NYU*)

TAN Roger (*PhD La Trobe*)

TOH Kim Chuan (*PhD Cornell*)

## Optimization

The group works mainly on the analysis, design and implementation of algorithms for continuous optimization, possibly with stochastic variables. Topics of interest include conic programming and its applications, interior point methods, nonsmooth Newton methods, augmented Lagrangian methods, iterative methods for large linear systems of equations, feasibility problems, and first order methods.

Jeffrey PANG (*PhD Cornell*)

SUN Defeng (*PhD Chinese Acad.*)

TOH Kim Chuan (*PhD Cornell*)

ZHAO Gong Yun (*PhD Wuerzburg*)

## Selected Recent Publications

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### Pure Mathematics

- **W.-K. To** and S.-K. Yeung, Finsler metrics and Kobayashi hyperbolicity of the moduli spaces of canonically polarized manifold, *Ann. of Math.*, 2014.
- B. Sun and **C.-B. Zhu**, Conservation relations for local theta correspondence, *J. Amer. Math. Soc.*, 2014.
- **W.T. Gan**, Y. Qiu and S. Takeda, The regularized Siegel-Weil formula (the second term identity) and the Rallis inner product formula, *Invent. Math.*, 2014.
- **W.T. Gan** and A. Ichino, Formal degrees and local theta correspondence, *Invent. Math.*, 2014.
- **C.T. Chong**, Theodore A. Slaman and **Y. Yang**, The metamathematics of Stable Ramsey's Theorem for pairs, *J. Amer. Math. Soc.*, 2014.
- J.-F. Cai, B. Dong, S. Osher and **Z.W. Shen**, Image restoration: total variation, wavelet frames, and beyond, *J. Amer. Math. Soc.*, 2012.
- X.Z. Chen and **X.W. Xu**, The scalar curvature flow on  $S^n$  – perturbation theorem revisited, *Invent. Math.*, 2012.
- B. Sun and **C.-B. Zhu**, Multiplicity one theorems: the Archimedean case, *Ann. of Math.*, 2012.
- **W.T. Gan** and S. Takeda, The local Langlands conjecture for  $GSp(4)$ , *Ann. of Math.*, 2011.
- **S.H. Yu**, Nonlinear Wave Propagations over a Boltzmann Shock Profile, *J. Amer. Math. Soc.*, 2010.
- **D.Q. Zhang**, A theorem of Tits type for compact Kahler manifolds, *Invent. Math.*, 2009.
- A. Avila, J. Kahn, M. Lyubich and **W. Shen**, Combinatorial rigidity for unicritical polynomials, *Ann. of Math.*, 2009.



## ***Selected Recent Publications***

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### **Applied and Computational Mathematics**

- C. Ding, **D.F. Sun** and **K.C. Toh**, An introduction to a class of matrix cone programming, *Math. Programming*, 2014.
- **W. Bao** and Y. Cai, Optimal error estimates of finite difference methods for the Gross-Pitaevskii equation with angular momentum rotation, *Math. Comp.*, 2013.
- **D. Chu**, L.Z. Liao, M.K. Ng and X. Zhang, Sparse canonical correlation analysis: New formulation and algorithm, *IEEE Trans. Pattern Anal. Mach. Intell.*, 2013.
- B. Dong, **H. Ji**, J. Li, **Z.W. Shen** and Y. Xu, Wavelet frame based blinded image inpainting, *Appl. Comput. Harmon. Anal.*, 2012.
- Y.J. Liu, **D.F. Sun** and **K.C. Toh**, An implementable proximal point algorithmic framework for nuclear norm minimization, *Math. Programming*, 2012.
- **H. Ji**, S. Huang, **Z.W. Shen** and Y. Xu, Robust video restoration by joint sparse and low rank matrix approximation, *SIAM J. Imaging Sci.*, 2011.
- N. Cai and **S.G. Kou**, Option pricing under a mixed-exponential jump diffusion model, *Management Sci.*, 2011.
- **W. Bao**, Y. Cai and H. Wang, Efficient numerical methods for computing ground states and dynamics of dipolar Bose–Einstein condensates, *J. Comput. Phys.*, 2010.
- J.F. Cai, E. Candes and **Z.W. Shen**, A singular value thresholding algorithm for matrix completion, *SIAM J. Optim.*, 2010.
- X.Y. Zhao, **D.F. Sun** and **K.C. Toh**, A Newton-CG augmented Lagrangian method for semidefinite programming, *SIAM J. Optim.*, 2010.
- **M. Dai**, Q. Zhang and Q. Zhu, Trend following trading under a regime switching model, *SIAM J. Financial Math.*, 2010.
- **Y.N. Sun** and Y.C. Zhang, Individual risk and Lebesgue extension without aggregate uncertainty, *J. Econom. Theory*, 2009.

## ***Editorial Board Membership in over 60 International Journals, including***

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- Computability, Ergodic Theory Dynam. Systems, Internat. Math. Res. Notices, J. Inst. Math. Jussieu, J. Math. Logic, Manuscripta Math., Math. Z., Represent. Theory
- Appl. Comput. Harmon. Anal., Math. Comp., Multiscale Model. Simul., SIAM J. Math. Anal., SIAM J. Sci. Comput.
- Math. Programming A, Math. Programming B, Math. Programming Comput., Math. Oper. Res., SIAM J. Optim.
- Econom. Theory, J. Econom. Dynam. Control, Math. Finance
- Automatica, Genomics, Proteomics & Bioinform., J. Comput. Syst. Sci.

## ***International Awards***

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- BAO Weizhu, 2013, 10th Feng Kang Prize for Scientific Computing by the Chinese Society of Computational Mathematics
- SHEN Zuowei, 2012, Wavelet Pioneer Award by the Society of Photographic Instrumentation Engineers (jointly with Bin DONG, University of Arizona)
- SHEN Weixiao, 2009, Chern Shiing-Shen Prize by the Chinese Mathematical Society

## ***Invited Talks in Selected Major Conferences***

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- International Congress on Industrial and Applied Mathematics (ICIAM), Beijing, China, 2015
  - SHEN Zuowei
  
- International Congress of Mathematicians (ICM), Seoul, South Korea, 2014
  - BAO Weizhu (Mathematics in Science and Technology)
  - GAN Wee Teck (Number Theory)
  - SHEN Weixiao (Dynamical Systems and ODE)
  - YU Shih-Hsien (Partial Differential Equations)
  
- SIAM Conference on Optimization, Darmstadt, Germany, 2011
  - SUN Defeng
  
- International Congress of Mathematicians (ICM), Hyderabad, India, 2010
  - SHEN Zuowei (Numerical Analysis and Scientific Computing)
  
- SIAM Annual Meeting, Pittsburgh, USA, 2010
  - TOH Kim Chuan