

Applied Math @ Peking University





Introduction

- * Applied mathematics at Peking University has a long history.
- Division of Computational Mathematics was established in 1955 and Division of Probability and Statistics was established in 1956.
- * Three major institutes at PKU:
 - School of Mathematical Sciences, made up of five departments
 Pure Math, Probability and Statistics, Computational Math,
 Information science, Financial math.
 - Beijing International Center for Mathematical Research,
 - Center for Statistical Science.

Applied Math Team



Zhenhuan Teng Emeritus Prof.



Long-An Ying Emeritus Prof.



Weinan E



Pingwen Zhang



Yan GUO (Brown) Changjiang guest Prof.



Jinchao Xu (Penn State) Changjiang guest Prof.



Hongkai Zhao (UC Irvine) Changjiang guest Prof.

More than 20
 regular faculties in
 Computational
 Math, plus strong
 visiting faculties.

Elite AMS undergraduate program

- Applied Mathematics and Statistics (AMS) program was created in 2011. About 20 - 30 students are selected every year.
- Four core courses: Applied stochastic analysis, Applied differential equations and variational methods, Mathematical introduction to data analysis, Algorithms. Plus undergraduate research, each student has a mentor!
- * It is promised to be among the most vibrant undergraduate AMS programs in the world.













Graduate program

- * 12 Ph.D. candidate + 10 Master candidate with computational math major each year.
- PKU Applied Math summer school, supported by NSF and PKU graduate school, aims to train interdisciplinary youth talents. It has been consecutively held since 2002.
- International exchange
 - Oversea study program, short-term visiting scholar, internship, etc.
- Graduate student forum on Numerical PDEs and Computational Math organized by PKU graduate students.

Academic Activities

- * We organize various international conferences and workshops every year, such as
 - * Frontiers of Applied and Computational Mathematics, 2015
 - * International Workshop on Systems Biology, 2014
 - * Workshop on Optimization for Modern Computation, 2014
 - * and more ...
- Each year, we obtain several research funds from National Natural Science
 Foundation of China, Ministry of Science and Technology, and other funding agencies.
 - National Basic Research Program of China (973 Program), RMB 19.0 million, 2014-2019, PI: Weinan E.
 - NSF A3 (China-Japan-Korea) Foresight program, RMB 4.0 million, 2014-2019, PI: Pingwen Zhang.
 - * NSF Innovative Research Group, RMB 8.4 million, 2015-2020, PI: Pingwen Zhang.
 - * NSF Major Research Program, RMB 3.5 million, 2014-2017, PI: Huazhong Tang

Research Area

- Multiscale and stochastic modeling Weinan E, Tiejun LI
- Multiscale modeling and analysis of complex fluids Pingwen ZHANG
- Computational fluid dynamics Huazhong TANG
- Kinetic equations Ruo LI
- Finite element method
 Jinchao XU, Jun HU, Jinbiao WU
- Numerical PDE
 Zhiping LI, Ming WANG, Shihong
 SHAO

- Data sciences
 Weinan E, Bin YU, Yuan YAO
- Computational biology Tiejun Li, Lei ZHANG, Hao GE
- Optimization
 Li GAO, Zaiwen WEN
- Image sciences
 Hongkai ZHAO, Bin DONG, Tie
 ZHOU
- Numerical linear algebra Yunfeng CAI
- Applied PDE Zhifei ZHANG



Weinan E

- * Ph.D. 1989, UCLA
- Changjiang Prof. at PKU and Prof. at Princeton U.
- Member of the Chinese Academy of Sciences
- Dean of YuanPei College at PKU
- President of the Chinese Computational Math. Society
- SIAM R. E. Kleinman Prize, SIAM von Karman Prize, ICIAM Collatz Prize

Research Interests

- Data sciences
- * Kohn-Sham equation and density functional theory
- * Theory and modeling of rare events with applications
- Multiscale modeling and stochastic partial differential equations
- Mathematical theory of solids: from atomic to macroscopic scales

Research highlight

 Microscopic Mechanism for the Melting of a Solid



Samanta-Tuckerman-Yu-E, Science 346, no. 6210 (2014), 729–732 Instability of Laminar
 Shear Flow



(2015)



Pingwen Zhang

- * Ph.D. 1992, PKU
- Changjiang Prof. at PKU **
- Deputy Dean of School of Mathematical Sciences, 2013-2015
- The Second Prize of National Natural Science Awards
- Feng Kang Prize of Scientific Computing
- Invited speaker at **ICIAM2011**

Research Interests

- Modeling and Simulation of Complex Fluids
- Applied Analysis and Numerical Analysis
- Moving Mesh Methods and Applications *

Research highlight

Computable Modeling of Complex Fluids



of Phys. Chem., 117 (2013)

PRL, 104 (2010)



Huazhong Tang

- Ph.D. 1996, Nanjing University of Aeronautics and Astronautics
- * Professor at PKU
- Director in Dept. of Computational Math, 2008-
- National Science Fund for Distinguished Young Scholars, 2009
- Feng Kang Prize of Scientific Computing, 2013

Research Interests

- Computational Fluid Dynamics
- Hyperbolic Conservation Laws
- Moving Mesh Methods

Research highlight

- Local oscillations in finite difference solutions of hyperbolic conservation laws, Math. Comp., 78 (2009).
- On convergence of a domain decomposition method for hyperbolic conservation laws, SIAM J. Numer. Anal., 45 (2007).
- * High resolution schemes for conservation laws and convectiondiffusion equations with varying time and space grids, J. Comput. Math., 24 (2006).
- Adaptive mesh methods for one- and two-dimensional hyperbolic conservation laws, SIAM J. Numer. Anal., 41(2), 2003.



Ruo Li

- * Ph.D. 2001, PKU
- Professor at PKU
- Vice director in Dept.
 of Computational
 Math, 2008-2014
- National Science Fund for Distinguished Young Scholars, 2013

Research Interests

- Kinetic Equations
- * Moving Mesh Method and Its Application
- Applied Numerical Fluid Dynamics

Research highlight

 Moment Model Reduction of Kinetic Equations
 Ruo Li and coworkers discovered simple mathematical
 structure that guarantees global hyperbolicity for the moment
 systems. This opens up a new direction for designing effective
 numerical algorithms for moment approximations of the
 kinetic equations. [CMS 11, no. 2 (2012), CPAM 67, no. 3
 (2014)]



Jun Hu

- Ph.D. 2004, Chinese Academy of Sciences
- Professor at PKU
- Vice director in Dept. of Computational Math, 2014-
- The first Youth Innovation Prize of China Society for Computational Mathematics, 2015
- National Excellent
 Doctoral Dissertation,
 2006

Research Interests

* Finite Element Methods of PDE

Research highlight

Mixed Finite Element Method of Elasticity Problems Finite element methods for the elasticity problem is undoubtedly among the most important problems in finite element methods and has attracted leading experts such as Arnold, Brezzi and Douglas. Jun Hu and collaborators discovered some simple but crucial structure of the discrete stress spaces, and were able to construct simple but optimal mixed finite elements methods for the elasticity problem in all dimensions, with symmetric stress tensor, bringing this classical problem to a satisfactory closure [China Math. 58 (2015); Comput. Math. 33 (2015); SIAM J. Numer. Anal. (2015); arXiv: 1412.0216v2 [math.NA] (2014)].



Tiejun Li

- * Ph.D. 2001, PKU
- Professor at PKU
- National Science
 Foundation for
 Excellent Young
 Scholars, 2012
- New Century Excellent Talents in University of Ministry of Education of China, 2010

Research Interests

- Multiscale modeling of complex fluids
- Stochastic modeling and algorithms
- * Math biology

Research highlight

 Analysis of Algorithms in Chemical Reaction Kinetics tau-leaping methods for the CRK [Multi. Model. Simul. 6 (2007), J. Chem. Phys. (2009); (2011), Comm. Math. Sci. 9 (2011)]

Landscape Theory and Large Deviations



PLoS Comp. Biol. 11 (2015): e1004156



Zaiwen Wen

- * Ph.D. 2009, Columbia
- Research Scientist at BICMR, PKU
- National Science
 Foundation for Excellent
 Young Scholars, 2013
- Youth Science and Technology Award of Operations Research Society of China, 2012

Research Interests

- * Large scale computational optimization with applications in science and engineering.
- * Optimization with Orthogonality Constraints

Research highlight

- * X. Liu, Z. Wen, Y. Zhang, An Efficient Gauss-Newton Algorithm for Symmetric Low-Rank Product Matrix Approximations, SIAM Journal on Optimization
- X. Liu, X. Wang, Z. Wen, Y. Yuan, On the Convergence of the Self-Consistent Field Iteration in Kohn-Sham Density Functional Theory, SIAM Journal on Matrix Analysis and Applications, Vol. 35, No. 2, pp. 546–558Z.
- Wen, M. Ulbrich, A. Milzarek, H. Zhang, Adaptive Regularized Self-Consistent Field Iteration with Exact Hessian for Electronic Structure Calculation, SIAM Journal on Scientific Computing, 35 (2013) A1299–A1324
- Z. Wen, W. Yin, A Feasible method for Optimization with Orthogonality Constraints, Mathematical Programming, 142(2013), 397-434Z.
- Wen, W. Yin, D. Goldfarb, Y. Zhang, A fast algorithm for sparse reconstruction based on shrinkage, subspace optimization and continuation, SIAM Journal on Scientific Computing, 32 (2010) 1832-1857.
- Z. Wen, D. Goldfarb, A Line search Multigrid Method for Large-Scale Nonlinear Optimization, SIAM Journal on Optimization, 20 (2010) 1478-1503.



Bin Dong

- * Ph.D. 2009, UCLA
- Research Scientist at BICMR, PKU
- Qiu Shi Outstanding Young Scholar Award, 2014
- China Recruitment
 Program of Global
 Youth Experts, 2015

Research Interests

- * Wavelets and Wavelet Frames.
- Variational/Optimization Problems.
- * Inverse Problems and (Medical) Imaging.
- * Image Processing and Analysis.
- High Dimensional Data Analysis.

Research highlight

Image Restoration

Most of the existing models and algorithms are transformation based, such as differential operators for PDE based approach and wavelet frame transforms. Bin Dong and collaborators established fundamental connections between wavelet frame based approach and variational methods [Journal of the American Mathematical Society (2012)], [Applied and Computational Harmonic Analysis (2015)].

- Wavelet Frame Based *l*₀-Minimization
- CT and Other Imaging Problems and Image Segmentation



Lei Zhang

- * Ph.D. 2009, Penn State
- Research Scientist at BICMR, PKU
- China Recruitment
 Program of Global
 Youth Experts, 2012

Research Interests

- Scientific computing and Rare events
- Computational material sciences
- Computational biology

Research highlight

 Finding transition state and its applications in materials and biology



Critical nuclei and Minimum energy path during nucleation process, Zhang-Chen-Du, PRL 2007, CiCP 2010, JCP 2012



Noise drives boundary sharpening in the zebrafish hindbrain, Zhang et al, Molecular Systems Biolog 8:613 (2012)



Shufang Xu Numerical Linear Algebra



Zhiping Li Numerical PDE



Li Gao Optimization



Ming Wang Numerical PDE



Tie Zhou Image processing



Jinbiao Wu Finite element method



Tiao Lu Numerical PDE



Shihong Shao Numerical PDE



Yunfeng Cai Numerical linear algebra



Thank you!



