Yuan Gao

Curriculum Vitae

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Department of Mathematics, Duke University, Durham, USA
☎ *+1 9196602896*
✉ *yuangao@math.duke.edu*
https://math.duke.edu/∼yuangao/

Position

2021-present **Assistant Professor**, Department of Mathematics, Purdue University, USA

2018-2021 **William W. Elliott Assistant Research Professor**, Department of Mathematics, Duke University, Durham, USA

2017-2018 **Postdoctoral Fellow**, Department of mathematics, The Hong Kong University of Science and Technology, Hong Kong

Education

2012–2017 **Ph.D. in Applied Mathematics**, *Fudan University*, China, *Advisor: Ti-Jun Xiao*, *Thesis: Some Nonlinear Evolution Equations in Material Science with Dissipative Structures.*

2015–2016 **Joint Ph.D. student in Mathematics and physics**, *Duke University*, US, *Advisor: Jian-Guo Liu*

2008–2012 **Bachelor in Mathematics**, *Ocean University of China*, China

2009–2010 **Exchange Student in Mathematics**, *Shandong University*, China

Research Interests

Analysis Calculus of variation, gradient flows, degenerated parabolic equation, monotone operator, control theory, semigroup theory.

Applied math Surface science, contact line dynamics, Bayesian inference, Ginzburg-Landau equation/systems, manifold learning, Markov jump process on lattice/point clouds.

Publications

I. Global existence and singularities for crystal growth model

[1] **Y. Gao**, J.-G. Liu and J. Lu, Continuum limit of a mesoscopic model with elasticity of step motion on vicinal surfaces, *J. Nonlinear Science*, **27**, 873-926 (2017). doi:10.1007/s00332-016-9354-1

[2] **Y. Gao**, J.-G. Liu and J. Lu, Weak solution of a continuum model for vicinal surface in the attachment-detachment-limited regime, *SIAM J. Math. Anal.*, **49**, 1705-1731 (2017). doi:10.1137/16M1094543

[3] **Y. Gao**, H. Ji, J.-G. Liu and T. P. Witelski, A vicinal surface model for epitaxial growth with logarithmic free energy, *Discrete Contin. Dyn. Syst. Ser. B.* **23**, 4433-4453 (2018). doi:10.3934/dcdsb.2018170

[4] **Y. Gao**, J.-G. Liu, X. Y. Lu and X. Xu, Maximal monotone operator theory and its applications to thin film equation in epitaxial growth on vicinal surface, *Calculus Var. Partial Differ. Equ.*, **57**, 55 (2018). doi:10.1007/s00526-018-1326-x

[5] **Y. Gao**, J.-G. Liu and X. Y. Lu, Gradient flow approach to an exponential thin film equation: global existence and latent singularity, *ESAIM: Control Optim. Calc. Var*, **25**, 49 (2019). doi:10.1051/cocv/2018037

[6] **Y. Gao**, Global strong solution with BV derivatives to singular Solid-on-Solid model with exponential nonlinearity, *J. Differ. Equ.*, **267**, 4429-4447 (2019). doi:10.1016/j.jde.2019.05.011

[7] **Y. Gao**, X. Y. Lu and C. Wang, Regularity and monotonicity for solutions to a continuum model of epitaxial growth with nonlocal elastic effects, to appear in *Adv. Calc. Var.* (2021). 10.1515/acv-2020-0114

II. Asymptotics and De Giorgi hyperplane conjecture for vectorial dislocations

[8] **Y. Gao**, J.-G. Liu, T. Lao and Y. Xiang, Mathematical validation of the Peierls–Nabarro model for edge dislocations, *Discrete Contin. Dyn. Syst. Ser. B.*, **26**, 3177-3207, (2021). doi:10.3934/dcdsb.2020224

[9] **Y. Gao**, J.-G. Liu, Long time behavior of dynamic solution to Peierls–Nabarro dislocation model, *Methods and Applications of Analysis*, **27**, 161-198 (2020). doi:10.4310/MAA.2020.v27.n2.a4

[10] H. Dong and **Y. Gao**, Existence and uniqueness of bounded stable solutions to Peierls-Nabarro model for curved dislocation, to appear in *Calculus Var. Partial Differ. Equ.*, **60**, 62, (2021). doi:10.1007/s00526-021-01939-1

[11] **Y. Gao**, J.-G. Liu and Zibu Liu, Existence and rigidity of the Peierls-Nabarro model for dislocations in high dimensions, submitted to *Nonlinearity*. https://arxiv.org/abs/2006.08107

III. Stabilization and controllability with acoustic dynamics boundary conditions

[12] **Y. Gao**, J. Liang, T.-J. Xiao, Observability inequality and decay rate for wave equations with nonlinear boundary conditions, *Elec. J. Differ. Equ.*, **161**,1-12 (2017).

[13] **Y. Gao**, J. Liang and T.-J. Xiao, A new method to obtain uniform decay rates for damped wave equations with nonlinear acoustic boundary conditions, *SIAM J. Control Optim.* **56**, 1303-1320 (2018). doi:10.1137/16M107863X

IV: Algorithms and numerical analysis for contact line dynamics and surfactant

[14] **Y. Gao**, H. Ji, J.-G. Liu and T. P. Witelski, Global existence of solutions to a tear film model with locally elevated evaporation rates, *Physica D*, **350**, 13-25 (2017). doi:10.1016/j.physd.2017.03.005

[15] **Y. Gao** and J.-G. Liu, Gradient flow formulation and second order numerical method for motion by mean curvature and contact line dynamics on rough surface, *Interfaces Free Bound*, **23**, 103-158, (2021). https://arxiv.org/abs/2001.04036

[16] **Y. Gao** and J.-G. Liu, Projection method for droplet dynamics on groove-textured surface with merging and splitting, submitted to *SIAM J. Sci. Comput.*. https://arxiv.org/abs/2005.07851

[17] **Y. Gao** and J.-G. Liu, Surfactant-dependent contact line dynamics and droplet adhesion on textured substrates: derivations and computations, submitted to *Physica D*. https://arxiv.org/abs/2101.07445

V: Crystal surface jump process and Dyson Brownian motion

[18] **Y. Gao**, J.-G. Liu, J. Lu, J.L. Marzuola, Analysis of a continuum theory for broken bond crystal surface models with evaporation and deposition effects, *Nonlinearity*, **33**, 3816-3845 (2020). doi:10.1088/1361-6544/ab853d

[19] Yu Gao, **Yuan Gao** and J.-G. Liu, Large time behavior, bi-Hamiltonian structure and kinetic formulation for complex Burgers equation, *Quart. Appl. Math.* **79**, 55-102 (2021). doi:10.1090/qam/1573

[20] **Y. Gao**, A.E. Katsevich, J.-G. Liu, J. Lu, and J.L. Marzuola, Analysis of a fourth order exponential PDE arising from a crystal surface jump process with Metropolis-type transition rates, to appear in *Pure and Applied Analysis*, (2021). https://arxiv.org/abs/2003.07236

VI: Bayesian inference, manifold leaning, Langevin dynamics on point clouds

[21] G. Jin, H. Pan, Q. Zhang, X. Lv, W. Zhao and **Y. Gao**, Determination of harmonic parameters with temporal variations: An enhanced harmonic analysis algorithm and application to internal tidal currents in the South China Sea, *J. Atmospheric Ocean. Technol.*, **35**,1375-1398, (2018). doi:10.1175/JTECH-D-16-0239.1

[22] **Y. Gao**, J.-G. Liu, A note for parametric Bayesian inference via several gradient flows schemes, *Annals. of Math. Science and Appl.*, **5**, 261-282, (2020). doi:10.4310/AMSA.2020.v5.n2.a3

[23] **Y. Gao**, G. Jin and J.-G. Liu, Inbetweening auto-animation via Fokker-Planck dynamics and thresholding, to appear in *Inverse Problems and Imaging, (2021)*. doi:10.3934/ipi.2021016

[24] **Y. Gao**, J.-G. Liu and N. Wu, Data-driven efficient solvers and predictions of conformational transitions for Langevin dynamics on manifold in high dimensions, submitted to *Appl. Comput . Harmon. Anal.*. https://arxiv.org/abs/2005.12787

[25] **Y. Gao**, T. Li, X. Li and J.-G. Liu, Transition path theory for Langevin dynamics on manifold: optimal control and data-driven solver, submitted to *SIAM Multiscale. Model. Sim.*. https://arxiv.org/abs/2010.09988

Awards

2020 AMS Simons Travel Grant, US.

2019 Silver Award of New World Mathematics Awards, China.

2017 Outstanding graduates of Shanghai, China.

2017 Distinguished paper award of 2017 International Congress of Chinese Mathematicians Best Paper Award, China.

2017 SIAM Student Travel Award to attend SIAM conference on analysis of PDEs, US.

2015 Chinese Government Scholarship, China.

2013,2014 The Ph.D. Scholarship, Fudan University, China.

2010,2011 National Scholarship for Undergraduate Student, China.

2010 National Mathematical Modeling Contest First Prize (team leader), China.

Teaching

2021 **Instructor** Math 212: Multivariable Calculus, Duke University.

2020 **Instructor** Math 353: Ordinary and Partial Differential Equations, Duke University.

2019,2020 **Instructor** Math 557: Introduction to PDE, Duke University, USA.

2019 **Instructor** Math 353: Ordinary and Partial Differential Equations, Duke University.

2018 **Instructor** Math 5351: Mathematical Methods in Science and Engineering, Hong Kong University of Science and Technology, Hong Kong.

2017 **Instructor** Calculus 1B , Hong Kong University of Science and Technology, Hong Kong.

2013,2014 **Instructor** Operations Research, Fudan University, China.

2012,2013 **TA** Mathematical Analysis/Functional analysis, Fudan University, China.

Academic Services

07/2018 Minisymposium co-organizer for SIAM Conference on Mathematical Aspects of Materials Science, Portland, USA

07/2018 Minisymposium co-organizer in the 12th AIMS Conference on Dynamical Systems, Differential Equations and Applications,Taipei.

Journal Refereeing Acta Mathematica Scientia, Discrete and Continuous Dynamical Systems Series B, Discrete and Continuous Dynamical Systems, Engineering Computations, Communications on Pure and Applied Analysis, ESAIM: Control, Optimization and Calculus of Variations, Applied Mathematics Letters, Mathematical Methods in the Applied Sciences, SIAM Journal on Numerical Analysis, Physica D: Nonlinear Phenomena, Communications in Mathematical Sciences, Journal of Differential Equations.

Recent Presentations

06/2021 BIRS Workshop, *Entropic Regularization of Optimal Transport and Applications (Online)*, Banff, Canada

06/2021 *Conformational transitions in biochemical reactions: irreversibility and optimal control*, Workshop on Modeling and Analysis in Molecular Biology and Electrophysiology (2021), China

03/2021 *Optimally controlled random walk on high dimensional point clouds for rare event simulation*, virtual math seminar, Southern University of Science and Technology, China

02/2021 *Adhesion of droplets with surfactant: Onsager's principle, variational inequality, computations*, special virtual math seminar, Purdue, US.

02/2021 *From rare events to almost sure events: optimally controlled random walk on point clouds*, special virtual applied math seminar, University of Waterloo, CA.

01/2021 *Adhesion of droplets with surfactant: Onsager's principle, variational inequality, computations*, virtual multiscale seminar, Illinois Institute of Technology, US.

01/2021 *From rare events to almost sure events: optimally controlled random walk on point clouds*, special virtual math seminar, Washington University in St. Louis, US.

12/2020 *Contact line dynamics on rough surface: gradient flow formulation, topological changes*, Invited speaker in Soft Matter Symposium, Duke Kunshan, China.

12/2020 *From rare events to almost sure events: optimally controlled random walk on point clouds*, special virtual math seminar, NYU, US.

12/2020 *From rare events to almost sure events: optimally controlled random walk on point clouds*, probability seminar, Duke University, US.

07/2020 *Solvers and predictions for conformational transitions based on high dimensional point clouds with manifold structure*, Invited speaker in virtual math seminar, Peking University, China.

06/2020 *Langevin dynamics with manifold structure: efficient solvers and predictions for conformational transitions*, Invited speaker in virtual Applied & Computational Math seminar, Georgia Tech, Atlanta, US.

06/2020 *Curved dislocation and nonlocal Ginzburg-Landau systems*, AIMS2020 Special session (Analysis of Nonlinear PDEs and Applications), Atlanta, US. Postponed.

04/2020 *Gradient flow formulation and numerical simulation for motion by mean curvature and contact line dynamics on rough surface*, Invited speaker in AMS Spring Central Sectional Meeting, Purdue University, IN, US. Canceled.

03/2020 *Nolocal equation/systems: dislocation dynamics and Dyson Brownian motion*, Invited speaker in AMS Spring Southeastern Sectional Meeting, University of Virginia, VA, US. Canceled.

02/2020 *Dislocation and beyond: nonlocal Ginzburg-Landau systems and complex Burgers equation*, PDE seminar, The University of Tennessee, Knoxville, US.

12/2019 *Nonlocal Ginzburg-Landau equation/systems deriving from dislocations models: wellposedness and exponential relaxation*, Invited speaker in PDE seminar, Institute of Mathematics, AMSS, CAS, China.

10/2019 *Static/quasi-static/dynamic models of dislocations: wellposedness and exponential convergence to equilibrium*, Invited speaker in PDE and Analysis seminar, University of Pittsburgh, Pittsburgh, US.

10/2019 *Peierls-Nabarro model for single edge dislocation: mathematical validation and exponential convergence to equilibrium*, Invited speaker in math seminar, Mississippi State University, US.

09/2019 *Static/Quasi-static/Dynamic model of dislocations: wellposedness and exponential convergence to equilibrium*, faculty seminar, Duke University, US.

06/2019 *Peierls-Nabarro model : mathematical validation and exponential convergence to equilibrium*, Invited speaker in math seminar, Peking University, China.

05/2019 *Peierls-Nabarro model for single edge dislocation*, Invited speaker in math seminar, NYU Shanghai.

12/2018 *Gradient flow approach to a class of thin film equations with polynomial or exponential nonlinearity* Invited Speaker in 2018 Young Mathematician Forum, Shanghai Jiao Tong University, China.

07/2018 *Analytic Solution to Nonlocal Equations of Peirtls-Nabarro Models* Invited speaker in in Minisymposium on Analytical Methods for Singular Phenomena in Materials Science, SIAM Conference on Mathematical Aspects of Materials Science, Potland, US.

06/2018 *Steady and Dynamic Solutions to Peierls-Nabarro Model for Dislocations* , Invited speaker in Workshop in Banff: Advanced Developments for Surface and Interface Dynamics - Analysis and Computation, Banff International research station, Canada.

02/2018 *Global existence and finite time singularity for solutions to solid film model and tear film model*, Invited speaker on The 19th Northeastern Symposium on Mathematical Analysis, Hokkaido University, Japan.

12/2017 Invited Speaker in Minisymposium on Nonlinear PDEs in Fluid Mechanics, SIAM Conference on Analysis of Partial Differential Equations, Baltimore, US.

12/2017 *Global strong solution with hidden singularity: application of maximal monotone operator theory to thin film equations in epitaxial growth*, Invited talk on PDE Seminar, University of Maryland, US.

11/2017 *Application of maximal monotone operator in non-reflexive space to degenerate parabolic equations*, Seminar talk, University of Hong Kong, Hong Kong.

06/2017 *Morphological evolution of crystal surfaces below the roughening temperature: from mesoscopic and macroscopic view*, Seminar talk, Hong Kong University of Science and Technology, Hong Kong.