Yuan Gao

Curriculum Vitae

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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, viscosity solution, weak KAM theory.
Applied math	Surface science, contact line dynamics, Bayesian inference, Ginzburg-Landau equation/systems, manifold learning, Markov jump process on lattice/point clouds, Large deviation and optimal control, Rare events, Irreversible dynamics.

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, *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, *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, *Nonlinearity*, **34**, 7778–7828 (2021). https://doi.org/10.1088/1361-6544/ac24e3

[12] **Y. Gao**, J.-M. Roquejoffre, Asymptotic stability for diffusion with dynamic boundary reaction from Ginzburg-Landau energy, *submitted*, (2022). https://arxiv.org/abs/2201.02105

III. Stabilization and controllability with acoustic dynamics boundary conditions

[13] **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).

[14] **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

[15] **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`

[16] **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://doi.org/10.4171/ifb/451

[17] **Y. Gao** and J.-G. Liu, Surfactant-dependent contact line dynamics and droplet adhesion on textured substrates: derivations and computations, *Physica D*, **428**: 133067, (2021). https://doi.org/10.1016/j.physd.2021.133067

[18] **Y. Gao** and J.-G. Liu, Projection method for droplet dynamics on groove-textured surface with merging and splitting, *SIAM J. Sci. Comput.*, **44**: B310–B338, (2022). https://epubs.siam.org/doi/10.1137/20M1338563

V: Crystal surface jump process and Dyson Brownian motion

[19] **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`

[20] 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`

[21] **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, *Pure and Applied Analysis*, **3**, 595-612, (2021). **https://doi.org/10.2140/paa.2021.3.595**

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

[22] 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`

[23] **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`

[24] **Y. Gao**, G. Jin and J.-G. Liu, Inbetweening auto-animation via Fokker-Planck dynamics and thresholding, *Inverse Problems and Imaging, **15**, 843-864, (2021).* `doi:10.3934/ipi.2021016`

[25] **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, accepted by *Appl. Comput . Harmon. Anal.*. https://arxiv.org/abs/2005.12787

[26] **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. https://arxiv.org/abs/2010.09988

[27] **Y. Gao**, J.-G. Liu, Random walk approximation for irreversible drift-diffusion process on manifold: ergodicity, unconditional stability and convergence, submitted. https://arxiv.org/abs/2106.01344

[28] **Y. Gao**, J.-G. Liu, Revisit of macroscopic dynamics for non-equilibrium chemical reactions from a Hamiltonian viewpoint, submitted. https://arxiv.org/abs/2108.05396

[29] **Y. Gao**, J.-G. Liu, Thermodynamic limit of chemical master equation via nonlinear semigroup, submitted. https://doi.org/10.48550/arXiv.2205.09313

Awards

2022	NSF Award DMS-2204288, 09/2022-08/2025.
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

2022	**Instructor** Math 598: Introduction to Optimal Transport, Purdue University.
2022	**Instructor** Math 366: Ordinary Differential Equations, Purdue University.
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

08/2022-12/2022	Co-organizer for "PSU-Purdue-UMD Joint Seminar on Mathematical Data Science" at Purdue University, West Lafayette, IN.
01/2022-05/2022	Co-organizer for "Mathematical Data Science Seminar for 2022 Spring Semester" at Purdue University, West Lafayette, IN.
09/2022	Minisymposium organizer for SIAM Conference on Mathematics of Data Science, San Diego, CA.
04/2022	External reviewer for PhD thesis. Student: Fei Cao; School of Mathematical and Statistical Sciences Arizona State University; Advisor: Sebastien Motsch

03/2022	Special session co-organizer at the AMS sectional meeting at Purdue University, West Lafayette, IN.
07/2018	Minisymposium co-organizer for SIAM Conference on Mathematical Aspects of Materials Science, Portland, OR.
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, Advances in Nonlinear Analysis, Engineering Computations, Communications on Pure and Applied Analysis, ESAIM: Control, Optimization and Calculus of Variations, Qualitative Theory of Dynamical Systems, Applied Mathematics Letters, Mathematical Methods in the Applied Sciences, Methods and Applications of Analysis, Nonlinear Analysis, SIAM Journal on Numerical Analysis, Physica D: Nonlinear Phenomena, Communications in Mathematical Sciences, Fractal and Fractional, Applied Mathematics and Optimization, Journal of Differential Equations, Journal of Computational Physics, Multiscale Modeling and Simulation, Proceedings of the Royal Society A.

Mentoring

03/2022	Advanced Topics Committee Inquiry for PhD candidate John Haug; Advisor: Aaron Yip
2022	Purdue Undergraduate Research (REU) with undergraduate students: Mahimna S Vyas, Yufan Zhou, Ruochen Zhang Adam R. Kasser.

Recent Presentations

08/2023	ICIAM minisymposium "Frontiers of gradient flows: well-posedness, asymptotics, singular limits", Tokyo, Japan.
07/2023	5-days BIRS workshop on "Applied and Computational Differential Geometry and Geometric PDEs", Banff, Canada.
09/2022	Special Session "Computations and Optimal Control for Biochemical System" at SIAM Conference on Mathematics of Data Science, San Diego, CA.
08/2022	Special Session "Thin film flows: analysis and applications" at SIAM Conference on Nonlinear Waves and Coherent Structures, Bremen, Germany.
07/2022	Stochastics+Dynamics+Data mini workshop at IIT, Chicago, IL.
07/2022	Workshop on interface problems: modeling, theory and numerics, Online.
05/2022	Scientific Computing seminar, Institute of Computational Mathematics, Chinese Academy of Sciences, Online.
04/2022	Optimal transport and Mean field games Seminar, University of South Carolina, US.
04/2022	Special Session "Recent Developments in Nonlocal Modeling and Analysis" at the 2022 Joint Mathematics Meetings Program, Seattle, US.
03/2022	PDE/Analysis Seminar, BICMR, Peking University, China.
03/2022	Special Session "Variational evolution: analysis and multi-scale aspects" at the SIAM PDE conference, Berlin, Germany.

03/2022 Invited program visit on Frontiers in kinetic theory: connecting microscopic to macroscopic scales, Isaac Newton Institute for Mathematical Sciences, Cambridge, United Kingdom

03/2022 Clements Scientific Computing Seminar, Southern Methodist University, Dallas, US.

02/2022 Computational Mathematics Seminar, CCoM, University of California San Diego, La Jolla, US.

01/2022 Bridge to research seminar, Purdue University, West Lafayette, IN, US.

12/2021 PIMS-SFU Computational Math Seminar, Pacific Institute for Mathematic Science, online, CA.

11/2021 CCAM seminar, Purdue University, West Lafayette, IN, US.

11/2021 Invited speaker in Special Session "Calculus of Variation, Nonlinear Waves and their Numerical Realizations", at the AMS sectional meeting, Online.

10/2021 Invited speaker in KU Probability and statistics seminar, University of Kansas, Lawrence, KS, US.

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.