

# Yuan Gao

## Curriculum Vitae

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Math 736, Purdue University, West Lafayette, USA

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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.
- 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, to appear in *Adv. Calc. Var.* (2021). doi: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 learning, 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>
- [26] **Y. Gao**, J.-G. Liu, Random walk approximation for irreversible drift-diffusion process on manifold: ergodicity, unconditional stability and convergence, submitted to *Math. Comp.*. <https://arxiv.org/abs/2106.01344>
- [27] **Y. Gao**, J.-G. Liu, Revisit of macroscopic dynamics for chemical reactions from a Hamiltonian viewpoint, submitted to *J. Stat. Phys.*. <https://arxiv.org/abs/2108.05396>

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## 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.

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## 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.

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## Academic Services

- 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, 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, Journal of Computational Physics, Multiscale Modeling and Simulation.

## 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 *Nonlocal 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 Peierls-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.