Dr. Kunlun Qi

Contact Information

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Research Interests

Multiscale modeling: Kinetic limit of many-particle system, hydrodynamic limit of kinetic models, semi-classical limit of quantum system;

Theoretical analysis for kinetic equations: Well-posedness and asymptotic behavior of Boltzmann equation and its related models via Fourier approach;

Numerical methods for kinetic equations: Fourier-Spectral methods and fast algorithms for kinetic equations with stability/convergence analysis;

Data-driven and machine-learning based methods: Data assimilation, uncertainty quantification (UQ) and machine-learning moments closure model.

Employment

School of Mathematics, University of Minnesota – Twin Cities

Dunham Jackson Assistant Professor, August 2022 -

- Mentors: Prof. Li Wang, Prof. Mitchell Luskin, Prof. Alex Watson (Math)
  Prof. Richard D. James (Aerospace Engineering and Mechanics)

Department of Mathematics, The Chinese University of Hong Kong

Postdoctoral Fellow, July 2021 - July 2022

- Mentor: Prof. Renjun Duan

Education

Department of Mathematics, City University of Hong Kong

Ph.D. in Mathematics, September 2017 - July 2021

- Supervisor: Prof. Tong Yang

School of Mathematics, South China University of Technology

B.Sc. in Mathematics, September 2013 - July 2017

- GPA: 3.85/4.0, Rank: 2/64
- Minor certificate in Computer Science
- Advisors: Prof. Changjiang Zhu and Prof. Huanyao Wen

Preprints

[16] A fast Fourier spectral method for wave kinetic equation, *preprint upon request*, 2024.
with *Lian Shen* and *Li Wang*

[15] Machine learning-based moment closure model for the semiconductor Boltzmann equation with uncertainties, *submitted*, 2024.
with *Juntao Huang*, *Liu Liu* and *Jiayu Wan*
arXiv: 2412.01932.

[14] Continuous data assimilation for hydrodynamics: consistent discretization and application to moment recovery, *submitted*, 2024.
with *Jingcheng Lu*, *Li Wang* and *Jeff Calder*
arXiv: 2409.03872.

[13] From the Boltzmann equation for gas mixture to the two-fluid incompressible hydrodynamic system, *submitted*, 2024.
with *Zhendong Fang*
arXiv: 2408.03570.

[12] The small Deborah number limit for the fluid-particle flows II: compressible case, *submitted*, 2024.
with *Zhendong Fang* and *Huanyao Wen*

[11] Global existence and moment creation for the inelastic Boltzmann equation for hard potentials without angular cutoff, *submitted*, 2023.
with *Jin Woo Jang*
arXiv: 2206.09636v2.

Publications

[10] Radiative transport in a periodic structure with band crossings, accepted by **SIAM J. Appl. Math.**, 2024.
with *Li Wang* and *Alexander B. Watson*
arXiv: 2402.06828.

[9] On the kinetic description of the objective molecular dynamics, **SIAM Multiscale Model. Simul.**, 22(4), 1646-1682, 2024.
with *Richard D. James* and *Li Wang*
DOI: 10.1137/23M1596727.

[8] The small Deborah number limit for the fluid-particle flows I: incompressible case, **Math. Models Methods Appl. Sci. (M3AS)**, 12(34), 2024.
with *Zhendong Fang* and *Huanyao Wen*
DOI: 10.1142/S0218202524500489.

[7] Convergence of the Fourier-Galerkin spectral method for the Boltzmann equation with uncertainties, **Commun. Math. Sci.**, 22(7), 1897-1925, 2024.
with *Liu Liu*
DOI: 10.4310/CMS.240918035418.

[6] Spectral convergence of a semi-discretized numerical system for the spatially homogeneous Boltzmann equation with uncertainties, **SIAM/ASA J. Uncertain. Quantif.**, 12(3), 812-841, 2024.
with *Liu Liu*
DOI: 10.1137/24M1638483.

[5] Measure valued solution to the spatially homogeneous Boltzmann equation with inelastic long-range interactions, **J. Math. Phys.**, 63, 021503, 2022.
DOI: 10.1063/5.0062859.

[4] A new stability and convergence proof of the Fourier-Galerkin spectral method for the spatially homogeneous Boltzmann equation, **SIAM J. Numer. Anal.**, 59(2), 613-633, 2021.
with *Jingwei Hu* and *Tong Yang*
DOI: 10.1137/20M1351813.

[3] On the measure valued solution to the inelastic Boltzmann equation with soft potentials, **J. Stat. Phys.**, 183, 27, 2021.
DOI: 10.1007/s10955-021-02762-w.

[2] A fast Fourier spectral method for the homogeneous Boltzmann equation with non-cutoff collision kernels, **J. Comput. Phys.**, 423:109806, 2020.
with *Jingwei Hu*
DOI: 10.1016/j.jcp.2020.109806.

Conference Proceedings

[1] Measure-valued Solution to the inelastic Boltzmann equation for hard potentials without angular cutoff, **Proceedings of the 32nd International Symposium on Rarefied Gas Dynamics** (RGD32), **AIP Conf. Proc.**, 2996, 040008, 2024.
with *Jin Woo Jang*
DOI: 10.1063/5.0187383.

Work in Progress

(With *Richard D. James* and *Li Wang*) An anisotropic rescaling velocity method for the homo-energetic Boltzmann equation.

(With *Ru-yu Lai*, *Li Wang* and *Lili Yan*) Inverse problem for the Cucker-Smale kinetic equation.

(With *Jin Woo Jang*, *Jae Yong Lee*, *Liu Liu* and *Zhengyi Zhu*) Machine-learning moments closure model for the multi-phase computations of the semiclassical limit of the Schrödinger equation.

(With *Hao Jia*) Long-time behavior of the homo-energetic Boltzmann equation in the hyperbolic-dominated case.

(With *Dingqun Deng* and *Renjun Duan*) Homo-energetic solution to Boltzmann equation with infinite energy in probability measure space.

Honors and Awards

2023	**SIAM Early Career Travel Award** Society for Industrial and Applied Mathematics (SIAM) and National Science Foundation (NSF)
2023-2024	**UMN Postdoc Award (Honorable Mention)** for Impactful Research University of Minnesota
2022	**Hong Kong Mathematical Society Best Thesis Award** Hong Kong Mathematical Society
2019	**Outstanding Teaching Award** for Teaching Assistants City University of Hong Kong
2017-2021	**UGC-funded Postgraduate Scholarship** The University Grants Committee of Hong Kong
2016	**Top 10 Outstanding Student at SCUT (Highest Student Award)** South China University of Technology
2016	**National Scholarship** Ministry of Education of China
2016	**First Prize in the Chinese Undergraduate Mathematics Competition (Guangdong Division)** Chinese Mathematical Society
2015	**Samsung Scholarship** Samsung China HQ

Services

Reviewer for Academic Journals: *Kinetic and Related Models (KRM)*, *Communications in Computational Physics (CiCP)*, *Applied Mathematics Letters (AML)*.

Conferences Organization: organizer of mini-symposium *"On the Interplay between Kinetic Theory and Quantum Dynamics"* at 10th International Congress on Industrial and Applied Mathematics (ICIAM2023).

Seminars and Workshops Organization: assistant organizer of weekly *"Applied and Computational Mathematics Seminar"* and *"New Trends in Kinetic and Optimal Transport Workshop"* at University of Minnesota.

Mini-course and Summer School Organization: lecturer and assistant organizer of *"MATH-IMS mini-course in Boltzmann Equation"* at The Chinese University of Hong Kong.

Committee Service: DEI Committee member in the School of Mathematics at University of Minnesota.

Academic Visits

The Chinese University of Hong Kong, Hong Kong, May 20 - June 24, 2024.

University of Washington, Seattle, USA, May 16 - 19, 2024.

Tsinghua University, Beijing, China, August 2 - 5, 2023.

South China University of Technology, Guangzhou, China, July 30 - August 2, 2023.

The Chinese University of Hong Kong, Hong Kong, July 23 - 28, 2023.

University of Oslo, Oslo, Norway, March 5 - 9, 2023.

TU Delft, Delft, The Netherlands, March 1 - 3, 2023.

RWTH Aachen University, Aachen, Germany, February 21 - 26, 2023.

Invited and Contributed Talks

Webinar Kinetic and fluid equations for collective behavior, December 2023, French-Korean IRL in Mathematics International Research Laboratory. (Virtual).

6th Annual Meeting of the SIAM Texas-Louisiana Section, November 2023, University of Louisiana at Lafayette, Lafayette, Louisiana, USA.

New Trends in Kinetic and Optimal Transport Workshop, October 2023, University of Minnesota – Twin Cities, Minneapolis, Minnesota, USA.

The 8th Annual Meeting of SIAM Central States Section, October 2023, University of Nebraska – Lincoln, Lincoln, Nebraska, USA.

PDE Seminar, September 2023, University of Minnesota – Twin Cities, Minneapolis, Minnesota, USA.

Mini-symposium at the second HKSIAM Biennial conference, August-September 2023, The Chinese University of Hong Kong, Hong Kong.

Mini-symposium at 10th International Congress on Industrial and Applied Mathematics (ICIAM2023), August 2023, Waseda University, Tokyo, Japan.

Midwest Numerical Analysis Day, April 2023, Iowa State University, Ames, Iowa, USA.

Seminar on Computational Mathematics, March 2023, University of Oslo - Department of Mathematics, Oslo, Norway.

Seminar in PDE and Applications, March 2023, TU Delft - Delft Institute of Applied Mathematics, Delft, The Netherlands.

Weekly Seminar of DFG Energy, Entropy, and Dissipative Dynamics Group, February 2023, RWTH Aachen University, Aachen, Germany.

The 6th Conference on Nonlinear Partial Differential Equation from Fluid Dynamic, November 2022, Ningbo University, Ningbo, China. (Virtual)

Analysis and PDE Seminar, July 2022, South China University of Technology (SCUT), Guangzhou, China.

Modelling and Numerical Simulation of Non-Equilibrium Processes Workshop, January 2022, Institute for Mathematical Sciences, NUS, Singapore. (Virtual)

PDE and Scientific Computing Seminar, October 2021, National University of Singapore, Singapore. (Virtual)

International Conference for Nonlinear PDEs in Fluid Mechanics and Related Topics, October 2021, Zhejiang Normal University, Jinhua, China. (Virtual)

The Pre-32nd International Symposium on Rarefied Gas Dynamics (Pre-RGD32) online

Workshop, July 2021, Seoul, South Korea. (Virtual)

The 5th Conference on Nonlinear Partial Differential Equation from Fluid Dynamic, May 2021, Central China Normal University, Wuhan, China. (Virtual)

Oberseminar Analysis, December 2020, Hausdorff Center for Mathematics, University of Bonn, Germany. (Virtual)

Teaching Experience

Instructor at the University of Minnesota–Twin Cities, 2022 - Present:

2024 Fall	*MATH 5485 Numerical Methods I*
2024 Spring	*MATH 4428 Mathematical Modeling - Section 001 and 002*
2023 Fall	*MATH 5485 Numerical Methods I*
2023 Spring	*MATH 5486 Numerical Methods II*
2022 Fall	*MATH 5485 Numerical Methods I – Section 001 and 002*

Lecturer at The Chinese University of Hong Kong, 2021 - 2022:

2021/22 Term 1	*MATH-IMS Mini-Course in Boltzmann Equation*
2021/22 Term 2	*MATH6042 Topics in Differential Equations II*

Tutor at City University of Hong Kong, 2018 - 2021:

2018/19 Semester A	*MA1200 Calculus and Basic Linear Algebra I*
2018/19 Semester B	*MA1201 Calculus and Basic Linear Algebra II*
2019/20 Semester A	*MA2172 Applied Statistics for Sciences and Engineering*
2019/20 Semester B	*MA0101 Basic Engineering Mathematics I*
2020/21 Semester A	*MA1300 Enhanced Calculus and Linear Algebra I*

Teaching Assistant at City University of Hong Kong, 2018 - 2021:

2019/20 Semester A	*MA8006 Functional Analysis and Applications*
2019/20 Semester B	*MA3511 Ordinary Differential Equations*
2020/21 Semester A	*MA8006 Functional Analysis and Applications*

References

Professor Tong Yang, Chair Professor (Ph.D Supervisor)
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University of Minnesota
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