



香港中文大學理學院  
**FACULTY OF SCIENCE**  
THE CHINESE UNIVERSITY OF HONG KONG

**2026 SCIENCE FACULTY  
POSTGRADUATE  
RESEARCH DAY**

**28 APRIL 2026**



Science *Empowers* Your Dreams  
Learn Science to *Better* the World

## PROGRAMME

09:30 - 09:45	<b>Welcome Remarks &amp; Opening Ceremony</b> <i>Professor SONG Chunshan</i> , Dean of Science
09:45 - 10:00	<b>YY1-Wnt10b Signaling Regulates Purkinje Cell Maturation &amp; Cerebellar Coordination</b> <i>LUI Ying Lam</i> (Year 6 PhD Student in Cell and Molecular Biology)
10:00 - 10:15	<b>Molecular Characterization of Plant Autophagic Responses to Heavy Metal Stress</b> <i>MGBECHIDINMA Chiamaka Linda</i> (Year 4 PhD Student in Cell and Molecular Biology)
10:15 - 10:30	<b>Double Helicene Based Organic Semiconductor and Conductor: Synthesis, Properties and Applications</b> <i>SU Shilong</i> (Year 4 PhD Student in Chemistry)
10:30 - 10:45	<b>Spatial Optimization and Management of Crop-Livestock System for Sustainability in China</b> <i>LUO Biao</i> (Year 4 PhD Student in Earth and Atmospheric Sciences)
10:45 - 11:00	<b>Break (15 minutes)</b>
11:00 - 11:15	<b>Ham Sandwich Model for Origami Design</b> <i>LAI Ka Ho</i> (Year 1 PhD Student in Mathematics)
11:15 - 11:30	<b>Morphology Control in All-Polymer Solar Cells via Volatile Solid Additives</b> <i>FENG Dinglong</i> (Year 3 PhD Student in Physics)
11:30 - 11:45	<b>Application of Machine Learning Techniques for Time Series Model Selection</b> <i>HUNG Kim Pong</i> (Year 2 MPhil Student in Risk Management Science)
11:45 - 12:00	<b>Learning Nonparametric Graphical Model on Heterogeneous Network-Linked Data</b> <i>WANG Yuwen</i> (Year 3 PhD Student in Statistics)
14:00 - 15:45	<b>Poster Pitching &amp; Poster Presentation</b>

# Welcome Message from the Dean of Science

## Professor Chunshan SONG

I am delighted to welcome you to the 2026 Science Faculty Postgraduate Research Day at The Chinese University of Hong Kong.

Established in 2021, this annual event has grown into a valued opportunity for our postgraduate students to share their research, exchange ideas, and learn from one another. It is also a time to observe, to reflect, and to strengthen the skills for effective high-quality research and effective presentation for their research projects. One can learn a lot by carefully observing. Our poster session, together with a two-minute pitch presentation format, continues to encourage concise thinking, focused presentation, and meaningful discussion.

As we mark the sixth event in this series, I would like to note that Postgraduate Research Day highlights not only the evidence and findings generated by our students, but also the diverse ways in which they approach and interpret their work. Good research challenges conventions, drives progress, and shapes the future. As Sir William Lawrence Bragg, Nobel Prize-winning physicist, observed, *“The important thing in science is not so much to obtain new facts as to discover new ways of thinking about them.”* Research advances not only through investigation and data, but through open exchange – by engaging with others’ perspectives, questioning assumptions, and thereby discovering new ways of thinking. Events such as today’s remind us that research is not merely about generating knowledge, but also about how that knowledge is examined, communicated, and advanced.

I am especially pleased that this year we welcome eight non-local presenters, the highest number in the history of this event. This is a truly meaningful milestone. With strong support from the University, our Faculty proudly leads CUHK efforts in building a top-tier academic community that is diverse, inclusive, and welcoming. We firmly believe that students from different cultural backgrounds and academic experiences enrich the depth and quality of research. When people with different perspectives come together, they deepen discussion, sharpen inquiry, and open up new possibilities for collaboration. In this sense, diversity is not simply a matter of representation; it is essential to intellectual growth and to the progress of science.

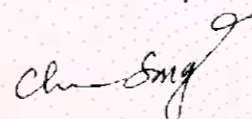
This spirit also reflects the Faculty’s ongoing efforts to strengthen global partnership and international collaboration. Building on last year’s outreach, our Faculty members visited the Universities in these four countries: Hungary (Budapest), Poland (Krakow, Warsaw), Thailand (Bangkok) and Brunei (Bandar Seri Begawan). These engagements have helped broaden our international reach and create stronger pathways for bringing talented researchers from different countries into our community. We are encouraged by this momentum and look forward to continuing to expand our academic connections in the years ahead.

Today is therefore not simply a showcase of research projects. It is also an opportunity to learn from one another, to discover emerging ideas, and to appreciate the dedication behind every project presented. Whether you are presenting, serving on a panel, or taking part in the discussion, your contribution helps make this event worthwhile and enriching for all.

I would like to extend my sincere thanks to Professor NGAI To, our event coordinator, and to all presenters, panel members, Faculty members, and staff whose dedication and hard work have allowed this event to grow and continue successfully into its sixth year. Your invaluable contributions are deeply appreciated, and we very much look forward to the seventh year.

I wish you all a rewarding and fruitful 2026 Postgraduate Research Day. Thank you.

Yours sincerely,



**Chunshan SONG**  
Dean of Science and  
Wei Lun Professor of Chemistry



# Oral Presentation

## Abstract

# YY1-Wnt10b Signaling Regulates Purkinje Cell Maturation & Cerebellar Coordination

LUI Ying Lam

Year 6 PhD Student in Cell and Molecular Biology

Principal Supervisor: Professor KWAN Kin Ming



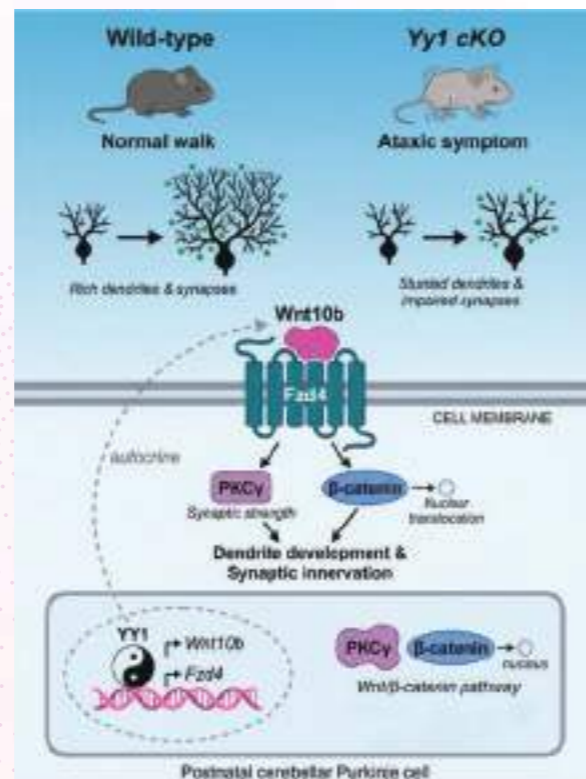
The postnatal development of cerebellar Purkinje cells (PCs) represents a critical window for the establishment of motor coordination, as these neurons serve as the sole output of the cerebellar cortex. Disruptions in PC maturation, specifically in dendritic arborization and synaptogenesis, are primary drivers of cerebellar ataxia, a debilitating movement disorder characterized by a lack of voluntary muscle coordination. Recent clinical studies have identified the ubiquitous zinc-finger transcription factor Yin Yang 1 (YY1) as the causative gene for Gabriele-de Vries syndrome (GADEVS), a rare autosomal dominant neurodevelopmental disorder. Patients with GADEVS frequently present with a broad spectrum of symptoms, including intellectual disability, facial dysmorphism, and notable ataxic symptoms, yet the cell-type-specific mechanisms underlying these cerebellar deficits remain poorly understood.

In this study, we utilized a PC-specific *Yy1* conditional knockout (cKO) mouse model to investigate the role of YY1 in cerebellar maturation. Our results demonstrate that YY1 is indispensable for the structural and functional development of PCs. *Yy1* cKO mice exhibit progressive cerebellar atrophy and severe, early-onset ataxia, accompanied by profound impairments in PC dendritic arborization and spine maturation. These structural defects significantly compromise the integration of sensory-motor information within the cerebellar circuit.

Mechanistically, we identified Wnt10b as a direct transcriptional target of YY1. We show that YY1-mediated activation of Wnt10b and its cognate receptor Fzd4 establishes an autocrine signaling loop that is vital for the proper morphogenesis of Purkinje cells. Functional validation using cerebellar slice cultures revealed that Wnt10b knockdown phenocopies the dendritic defects observed in *Yy1* cKO mice, while the administration of recombinant Wnt10b protein provides a partial rescue of dendrite growth. Furthermore, we demonstrate that this regulatory pathway modulates PC architecture and synaptic function through the activation of PKC $\gamma$  signaling, a pathway frequently implicated in various forms of spinocerebellar ataxia.

Collectively, our findings provide a novel mechanistic link between YY1 dysfunction and cerebellar ataxia, offering critical insights into the pathophysiology of Gabriele-de Vries syndrome and identifying the YY1-Wnt10b-Fzd4-PKC $\gamma$  axis as a potential therapeutic target for neurodevelopmental and degenerative cerebellar disorders.

**Acknowledgement:** We thank Prof. Huating Wang (Department of Orthopaedics and Traumatology, CUHK, Hong Kong) for providing *Yy1* conditional mutant mouse line. We thank Ms. Sze Nee Lim and Mr. Freddie Kwok for their technical support, and Dr. Ka Kui Tong for assisting with the ISH experiments. The work was supported by the grants from the Research Grant Council of the Hong Kong Special Administrative Region (project nos. GRF 14112224, 14114921, CRF C4002-21E and AoE/M-05/12) and The Chinese University of Hong Kong Direct Grant for Research.



Graphical Summary

# Molecular Characterization of Plant Autophagic Responses to Heavy Metal Stress

MGBECHIDINMA Chiamaka Linda

Year 4 PhD Student in Cell and Molecular Biology

Principal Supervisor: Professor JIANG Liwen



Autophagy is a fundamental, evolutionarily conserved catabolic process in eukaryotic cells that facilitates the sequestration and subsequent degradation of cytoplasmic components, such as damaged organelles and denatured proteins. This is mainly achieved through direct vacuolar engulfment (microautophagy) or sequestration within specialized double-membrane vesicles known as autophagosomes (macroautophagy). These vesicles ultimately fuse with lysosomes in animals or vacuoles in yeast and plants, where their contents are recycled or degraded to maintain cellular homeostasis. As sessile organisms, plants use autophagy as a central hub to integrate nutritional, environmental, and hormonal signals to modulate growth, development, and stress resilience. The core autophagy machinery is orchestrated by a diverse set of AuTophagy-related (ATG) genes, which are categorized into functional units, including the ATG1 initiation complex, the phosphoinositide 3-kinase (PI3K) vesicle nucleation complex, the ATG9 lipid delivery system, and the ATG8/ATG12 conjugation systems. Although autophagy has been extensively characterized in response to various abiotic stresses, including nutrient deprivation, heat, drought, hypoxia, and light, its role in mitigating toxicity from ubiquitous environmental pollutants, particularly heavy metals, remains poorly understood. Given the sessile nature of plants and their continuous exposure to soil-borne contaminants, we hypothesize that autophagy may play a pivotal and tightly regulated role in cellular detoxification and homeostasis during heavy metal stresses. To test this hypothesis, we employed autophagy-deficient *Arabidopsis thaliana* mutants in a mixed heavy metal exposure system and assessed key phenotypic parameters, including germination, growth, and survival. Chlorophyll content exhibited a concentration-dependent correlation with viability, underscoring the physiological impact of metal toxicity. Notably, phenotypic recovery varied significantly across mutants defective in distinct autophagy-related (ATG) complexes, suggesting functional diversification within the autophagic machinery. Transcriptomic analysis revealed that core ATG genes are transcriptionally upregulated in response to heavy metal stress. Furthermore, confocal imaging analysis of YFP-ATG8 reporter lines demonstrated a marked increase in autophagosome-like puncta. The super-resolution microscopy and transmission electron microscope (TEM) observations reveal that the heavy metal stresses induce selective autophagy. Collectively, these findings establish heavy metals as potent inducers of autophagy in plants. This ongoing research aims to elucidate the mechanistic basis of autophagy-mediated metal tolerance, offering novel insights for harnessing autophagy in phytoremediation strategies to support sustainable agriculture and environmental protection.

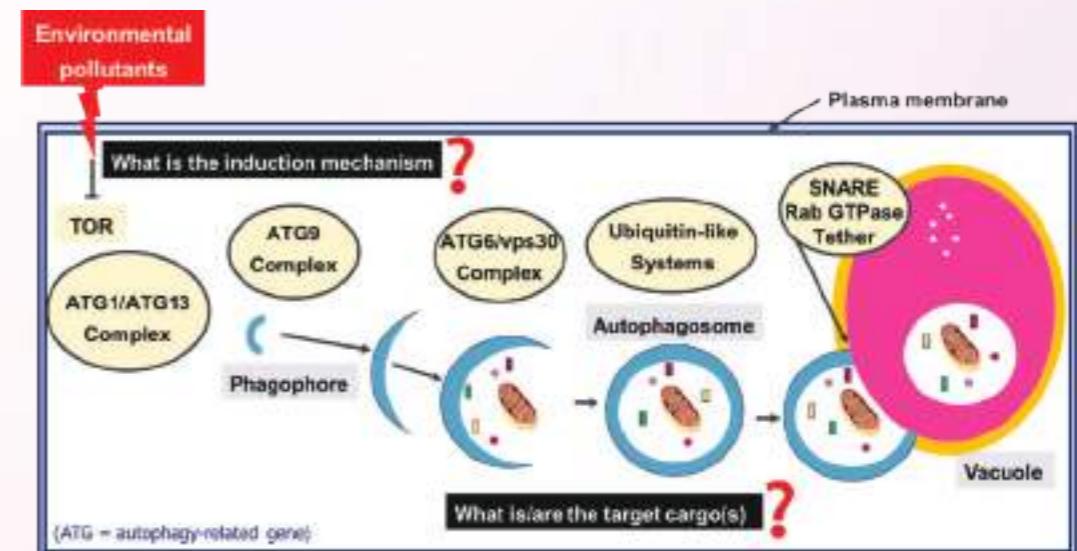


Figure 1. Working model of the study

# Double Helicene Based Organic Semiconductor and Conductor: Synthesis, Properties and Applications

SU Shilong

Year 4 PhD Student in Chemistry

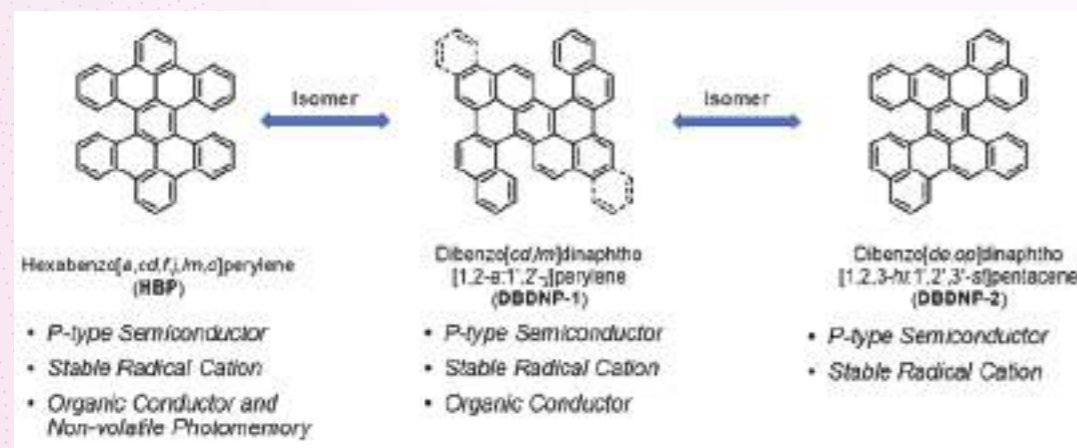
Principal Supervisor: Professor MIAO Qian



Owing to their unique molecular packing arrangements and chiroptical properties, double helicenes have been widely applied in organic electronics. Beyond their successful implementation in organic field-effect transistors, the stable radical cations of double helicenes also serve as an excellent platform for the development of organic conductors.

In this work, we present two novel double[5]helicenes: dibenzo[cd,lm]dinaphtho[1,2-a:1',2'-j]perylene (**DBDNP-1**) and its structural isomer dibenzo[de,op]dinaphtho[1,2,3-hi:1',2',3'-st]pentacene (**DBDNP-2**). Both compounds were synthesized through distinct ring-closure reactions using identical  $\pi$ -conjugated backbone as the starting material. Distinct from their well-established structural isomer hexabenz[a,c,d,f,j,lm,o]perylene (**HBP**), **DBDNP-1** and **DBDNP-2** possess drastically different optoelectronic properties. Nevertheless, all three compounds can be readily oxidized chemically to form persistent radical cations with great stability under ambient conditions.

Functionalized **DBDNP-1** acts as a p-type semiconductor with a field-effect mobility of  $0.48 \text{ cm}^2 \text{ V}^{-1} \text{ s}^{-1}$ , while its radical cation exhibits an electrical conductivity of  $1 \times 10^{-3} \text{ S cm}^{-1}$ . This work further supports the hypothesis that double helicenes are good platform to develop robust radical cations, deepens our understanding of structure–property relationships in helically curved PAHs, and highlights double helicenes as promising materials for next-generation organic optoelectronics such as CPL detectors and spintronic devices.



**Acknowledgement:** We thank Prof. Ying Wang (CUHK Chem, electrochemical reaction), Prof. Qingyun Wan (CUHK Chem, single-crystal conductivity), Prof. Hung Kay Lee (CUHK Chem, EPR spectrum) and Prof. Zheng Zhou (TongjiU Materials, Single crystal XRD) for valuable help. We thank the staff at SSRF BL17B1 beamline of the National Facility for Protein Science in Shanghai (NFPS), Shanghai Advanced Research Institute, CAS, for providing technical support in X-ray diffraction data collection and analysis.

# Spatial Optimization and Management of Crop-Livestock System for Sustainability in China

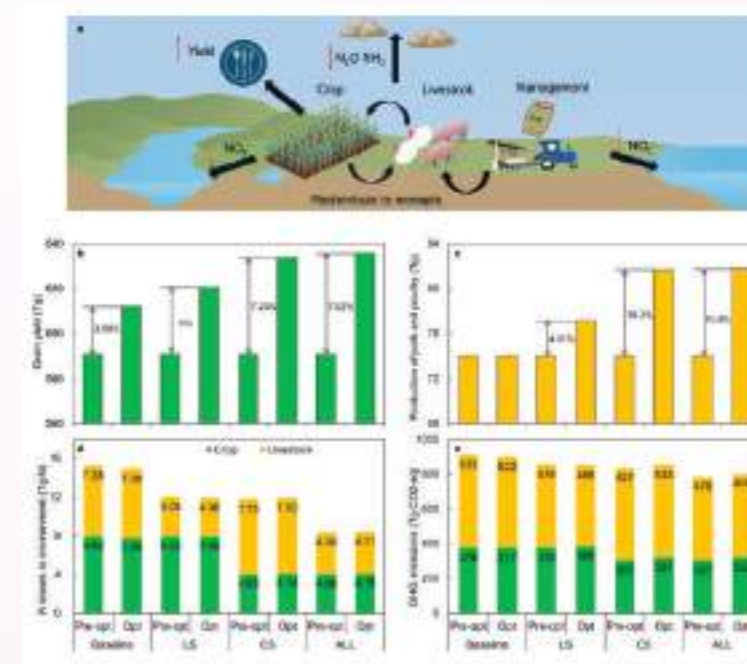
LUO Biao

Year 4 PhD Student in Earth and Atmospheric Sciences

Principal Supervisor: Professor TAI Pui Kuen Amos



The spatial decoupling of crop and livestock production in China, a cornerstone of its agricultural industrialization, has created critical challenges for achieving sustainable food systems. However, the spatial decoupling of crop and livestock systems driven by industrialization and market forces has led to inefficient resource use, excessive nitrogen losses, and growing environmental burdens, particularly in China. Here, we develop a nationally scalable, multi-objective spatial optimization framework that integrates enhanced nitrogen management strategies in both crop and livestock production. Applying this framework across 355 Chinese cities, we identify spatial configurations that can simultaneously boost grain yields (by 3.6–7.6%), maintain farmer incomes, and substantially reduce pollutant emissions, including ammonia (by 1.3–49%), nitrate leaching (3.6–39%), and greenhouse gases (1.3–12%). These improvements are strongest when spatial optimization is paired with integrated crop-livestock management. Our analysis further reveals optimal relocation strategies for key crops and monogastric livestock, offering actionable pathways to rebalance food production and reduce regional pollution disparities. This work demonstrates the untapped potential of spatial planning to unlock synergies among food security, environmental sustainability, and rural development, providing a scalable blueprint for food system transformation in China and beyond.



**Figure.** Proposed change before and after optimization under baseline, LS (livestock-related scenario), CS (crop-related scenario), and ALL (combine scenario): pathways (a), grain yield (b), meat production of pork and poultry (b), N losses to environment (d), and greenhouse gas emissions (e).

# Ham Sandwich Model for Origami Design

LAI Ka Ho

Year 1 PhD Student in Mathematics

Principal Supervisor: Professor LUI Lok Ming



Origami is the Japanese word for "folding paper". It is the art of turning a flat sheet into various folded structures. Miura-Origami is a special form of origami, whose crease pattern forms a tessellation of quadrilaterals. Scientists and engineers from different fields are fascinated by its unique physical properties. Miura folds allow rigid materials to deform while maintaining their structure. Moreover, without changing the material itself, it provides a lightweight, yet structurally stiff form. These advantages make it widely used in material design and engineering applications.

In this presentation, I will discuss our current research progress of designing surface-aligned Miura-Ori patterns. For a given surface, its upper and lower surfaces are constructed, and the folded pattern is embedded between the two surfaces, forming a ham-sandwich-like structure. The folded pattern is then parametrized into a planar domain, and optimized under specific constraints to ensure unfold-ability.

This is a joint work with Hei Tung TSANG, Prof. Gary Pui Tung CHOI, Prof. Ronald Lok Ming LUI. Prof. Ronald Lok Ming LUI is supported by HKRGC GRF (Project ID: 14306723).

# Morphology Control in All-Polymer Solar Cells via Volatile Solid Additives

FENG Dinglong

Year 3 PhD Student in Physics

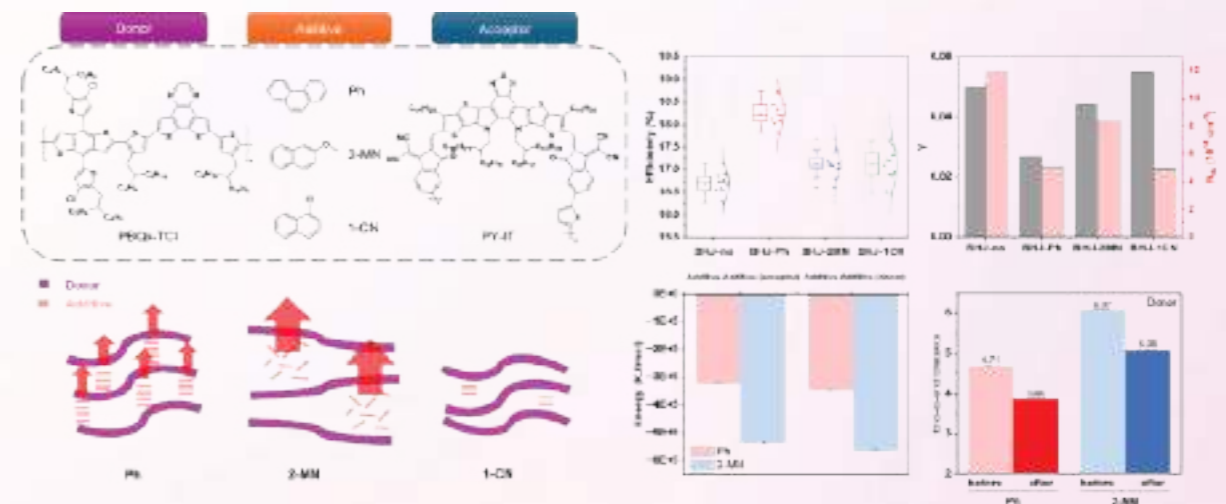
Principal Supervisor: Professor LU Xinhui



All-polymer solar cells (all-PSCs), which employ conjugated polymers as both donor and acceptor, combine the synthetic tunability of non-fullerene acceptor systems with the intrinsic mechanical and thermal robustness of polymeric active layers, making them particularly attractive for large-area manufacturing and flexible applications. However, state-of-the-art all-PSCs still lag behind polymer: small-molecule systems in fill factor (FF) and overall power conversion efficiency (PCE). Additive engineering has emerged as one of the most effective strategies to narrow this gap. Nevertheless, additive selection has largely remained empirical, and the relationships among additive molecular structure, evaporation kinetics, morphology evolution, and specific recombination pathways, especially bimolecular recombination in all-PSCs, are not yet systematically understood.

In this study, we introduced phenanthrene (Ph), a volatile, three-ring-fused aromatic solid additive with a weak tendency toward self-aggregation, as a donor-selective morphology regulator in a benchmark all-PSC system. We identified bimolecular recombination as the dominant recombination pathway and demonstrated that Ph nearly halves Langevin recombination factor ( $\gamma$ ) while maintaining low bulk trap density ( $N_{tb}$ ), resulting in substantial FF and PCE enhancement. By combining multiscale characterization, in-situ optical spectroscopy, and all-atom molecular dynamics simulations, we revealed that the moderate evaporation kinetics of Ph enable cooperative donor and acceptor crystallization, leading to increased fractal dimension, reduced donor-acceptor interfacial area, enhanced crystallinity, and thereby suppressed bimolecular recombination. As a result, Ph-assisted binary and ternary all-PSCs achieved PCE of 18.74% and 19.35%, respectively.

Our findings not only present an effective additive strategy to narrow the performance gap but also establish general additive selection criteria for volatile solid additives, which will surely provide meaningful guidance for the future advancement of practical applications.



**Acknowledgements:** This work is supported by the National Natural Science Foundation of China/RGC Joint Research Scheme (No. N\_CUHK459/24). We also thank the beam time provided by the 23A SWAXS beamline and technical support by Dr. Wei-Ru Wu and Yi-Cheng Lai at NSRRC, Hsinchu.

## Application of Machine Learning Techniques for Time Series Model Selection

**HUNG Kim Pong**

Year 2 MPhil Student in Risk Management Science

Principal Supervisor: Professor YAU Chun Yip



The rapid advancement of machine learning (ML) has significantly improved the accuracy of time series forecasting. However, many ML-based approaches operate as black boxes, limiting interpretability and reducing trust in high-stakes domains such as healthcare and finance. At the same time, traditional statistical model selection criteria, such as the Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC), are designed for general settings and lack the flexibility to handle certain special cases, including near-cancellation scenarios.

In this paper, we propose a hybrid framework that addresses both challenges simultaneously. First, instead of using ML models directly for forecasting, we employ ML as an optimization tool for selecting interpretable time series models, such as Autoregressive Moving Average (ARMA) models. This design reduces the degree of black-box behavior while preserving flexibility and predictive strength. Second, by replacing fixed information criteria with a data-driven ML-based selection mechanism, our approach introduces greater adaptability, enabling more effective handling of complex or atypical model structures.

Experimental results demonstrate that the proposed method outperforms conventional AIC- and BIC-based selection in challenging scenarios, while retaining the interpretability and theoretical guarantees of classical statistical models. Overall, this work provides a practical solution that balances explainability and flexibility in time series forecasting.

## Learning Nonparametric Graphical Model on Heterogeneous Network-Linked Data

**WANG Yuwen**

Year 3 PhD Student in Statistics

Principal Supervisor: Professor WANG Junhui



Graphical models have been popularly used for capturing conditional independence structure in multivariate data, which are often built upon independent and identically distributed observations, limiting their applicability to complex datasets such as network-linked data. This paper proposes a nonparametric graphical model that addresses these limitations by accommodating heterogeneous graph structures without imposing any specific distributional assumptions. The proposed estimation method effectively integrates network embedding with nonparametric graphical model estimation. It further transforms the graph learning task into solving a finite-dimensional linear equation system by leveraging the properties of vector valued reproducing kernel Hilbert spaces. Moreover, theoretical guarantees are established for the proposed method in terms of estimation consistency and exact recovery of the heterogeneous graph structures. Its effectiveness is also demonstrated through a variety of simulated examples and a real application to the statistician coauthorship dataset.

# Poster Presentation Abstract

Poster No.	Graduate Division	Presenter	Presentation Title
SLS-01	Life Sciences	LIU Ganxing	Small Worlds, Big Impacts: How Slimes on Streambed Can Change Mercury Toxic?
SLS-02	Life Sciences	MCCOMBIE Alexandra Rose	Microraptorine Flight Evolution: The Effect of Body Size on <i>Microraptor's</i> Flight
SLS-03	Life Sciences	TAM Warren Ling Yi	Unravelling the Mechanism of Fusarium Wilt Resistance in Cavendish Bananas
SLS-04	Life Sciences	WU Tao	Polyphenols Regulate Reactive Oxygen Species Signaling Pathway in MASH via Persulfidation and Gut Microbiome
CHM-01	Chemistry	LIU Jingyi	CHEMSMART: Chemistry Simulation and Modeling Automation Toolkit for High-Efficiency Computational Chemistry Workflows
CHM-02	Chemistry	TAO Hongyi	Chiral <i>gem</i> -Diborylalkane Reagents: Synthesis and Applications
EES-01	Earth & Environmental Sciences	AYELE Tilahun Mersha	From Ethiopia to Hong Kong: Landslide Susceptibility and Rainfall-Triggered Slope Failures
EES-02	Earth & Environmental Sciences	PARVEEN Saira	Global Annual Production of Disinfection By-Products (Trihalomethanes & Haloacetic Acids) from Drinking Water Chlorination
PMA-01	Mathematics	IBRAR Nida	Numerical Simulation and Analysis of Casson Nanofluids under Magnetic Field Effects: a Comparative Study with FDM/FEM
PMA-02	Mathematics	ISLAM Nazrul	Analytical–Numerical Investigation of Lifting and Non-Lifting Potential Flow around a Circular Cylinder
PHY-01	Physics	HUANG Zixuan	Angle-Resolved Phase-Sensitive Measurement of the Anisotropic Gap Structure in a Topological Superconductor $\beta$ -Bi <sub>2</sub> Pd
PHY-02	Physics	LEONG Hin Wai	Extracting Astrophysics of Active Galactic Nuclei via Gravitational Waves from Binary Black-Hole Mergers
RMS-01	Risk Management Science	CHEN Haoyang	Quantifying Evolutionary Behaviours in Sharing Economies
RMS-02	Risk Management Science	LUI Chak Sum	A Unified Framework for Censored Interquantile Regression under General Biased Sampling Scheme
STA-01	Statistics	KUANG Yiling	Multi-Label Growth Curve Change-Point Model for Characterizing Multifaceted Dynamics in Multivariate Longitudinal Data
STA-02	Statistics	LUO Yongyi	Bayesian Nonparametric Poisson Modeling Reconstructs 3D Structure for Multi-Slice Spatially Resolved Transcriptomic Data

## Small Worlds, Big Impacts: How Slimes on Streambed Can Change Mercury Toxic?

LIU Ganxing

Year 2 PhD Student in Environmental Science

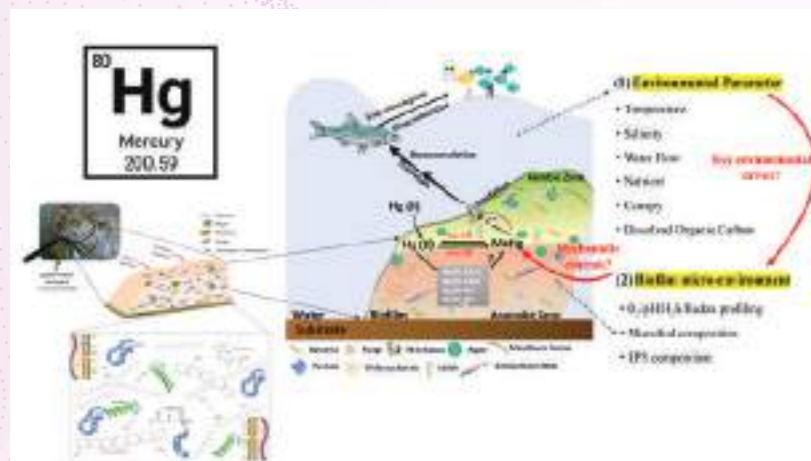
Principal Supervisor: Professor TSUI Tsz Ki Martin



Mercury (Hg) is a natural element emitted through anthropogenic activities, geogenic degassing and legacy emission from lands and oceans. Widely regarded as a global pollutant, Hg can be found in any environmental types even in remote area because its gaseous elemental form can travel over long distances in the atmosphere, contaminating all ecosystems on the planet. Of the particular concern is methylmercury (MeHg), an organic form of Hg that is highly bioavailable and can bioaccumulate and biomagnify through food webs, posing risks to both ecosystem and human health. Long-term exposure to MeHg may cause irreversible neurological damage and is primarily associated with fish consumption. In natural environments, the net MeHg accumulation is governed by the concurrent microbial processes of MeHg formation and breakdown. Therefore, microorganisms play a pivotal role in Hg biogeochemical cycling.

One aspect of particular interest is that a large proportion of microorganisms on Earth are estimated to exist within stream slimes - biofilms. Biofilms are ubiquitous and are important components of natural food webs, with the potential to enhance pollutant level through trophic transfer. They are surface-associated microbial assemblages embedded in a self-produced extracellular polymeric substance (EPS) matrix. Shaped by local environmental conditions, they form highly organized and interactive microbial assemblages that may play important roles in biogeochemical processes such as Hg transformation. However, the role of biofilms in MeHg transformation remains poorly understood.

Here, we investigated biofilm-mediated Hg transformation across diverse aquatic ecosystems in Hong Kong. Unlike previous studies that mainly focused on the functions of specific microorganisms in Hg transformation, we aim to understand how environmental settings shape biofilm community composition and structure, and how these "small microbial worlds" in turn influence Hg cycling. We seek to reveal the ecological organization of biofilms in natural environments and clarify their roles in Hg biogeochemical cycling. This work will advance our understanding of how microscale biological organization contributes to global-scale Hg cycling and may help inform more effective mercury pollution management.



**Acknowledgement:** We are grateful for the support by the General Research Fund awards from the Hong Kong Research Grants Council. We also gratefully acknowledge the support of the Faculty of Science, The Chinese University of Hong Kong.

## Microraptorine Flight Evolution: The Effect of Body Size on *Microraptor's* Flight

MCCOMBIE Alexandra Rose

Year 1 PhD Student in Biology

Principal Supervisor: Professor Michael David PITTMAN



The evolution of flight in birds and theropod dinosaurs is one of the most iconic and important major evolutionary transitions in the history of life. What began as a few volant species of feathered theropod dinosaurs, from the group Paraves, culminated in the evolution of the diverse range of birds we know today. However, despite extensive research, where and when flight evolved in paravian dinosaurs remains hotly debated. Amongst the groups suggested to have evolved powered flight independently are the microraptorines, a clade of small, feathered dinosaurs living alongside early birds, whose evolution may provide key insights into this critical transitional period. By using laser-stimulated fluorescence (LSF) soft-tissue details previously unseen were revealed in multiple *Microraptor* specimens. By using feather and body measurements taken from LSF data the potential for powered flight across various *Microraptor* specimens of various sizes was estimated using wing loading and specific lift as proxies. Results found that all specimens, regardless of body size, met the threshold for wing loading, however the largest individuals did not pass specific lift, even at the highest estimated muscle mass-specific power output values.

These findings show that *Microraptor* possessed aerodynamic ability capable of gliding and perhaps also powered flight. Small to medium sized individuals appear capable of sustaining powered flight whereas larger individuals may have been confined to gliding or short bursts of powered flight. This provides further evidence supporting the hypothesis that flight evolved multiple times among paravian dinosaurs. This study represents the beginning of an integrative exploration into microraptorine flight capability, testing the theory that flight evolved multiple times in theropods.

# Unravelling the Mechanism of Fusarium Wilt Resistance in Cavendish Bananas

TAM Warren Ling Yi

Year 2 PhD Student in Molecular Biotechnology

Principal Supervisor: Professor CHAN Ting Fung Philos



Fusarium wilt, caused by *Fusarium oxysporum* f. sp. *cubense* tropical race 4 (FocTR4), represents one of the most devastating threats to global banana production, with projected economic losses exceeding USD 10 billion by 2040. The Cavendish banana accounts for approximately half of global banana production and is highly susceptible to FocTR4. Attempts to control this disease using traditional physical, chemical, and biological methods have been foiled by FocTR4's resilient nature. Engineering transgenic FocTR4-resistant Cavendish varieties has therefore emerged as the most promising route to securing sustainable banana production globally. A phenotypic screening of over 100 Cavendish accessions has led to the discovery of a highly susceptible accession named ZJ1 and a highly resistant accession named ZJ8.

We have constructed complete, telomere-to-telomere, haplotype-resolved reference genome assemblies of the triploid ZJ1 and ZJ8. Comparative genomics analyses between ZJ1 and ZJ8 uncovered extensive structural variants and nucleotide-level sequence polymorphisms, many of which overlapped with genic sequences and therefore potentially affect gene function and expression.

To prioritise high-confidence candidate resistance genes, we integrated bulk and spatial transcriptomic data into the analysis. Analysis of spatial transcriptomic data revealed a markedly accelerated immune response to FocTR4 infection in ZJ8 relative to ZJ1, offering a compelling mechanistic explanation for the observed resistance phenotype. Ongoing work is focused on dissecting the genetic polymorphisms identified through comparative genomics to precisely define the molecular basis of FocTR4 resistance in ZJ8 — findings that will directly inform transgenic strategies for durable crop protection.

**Acknowledgements:** NSFC/RGC Joint Research Scheme N\_CUHK488/22, Hong Kong PhD Fellowship Scheme (HKPFS)

# Polyphenols Regulate Reactive Oxygen Species Signaling Pathway in Metabolic Dysfunction-Associated Steatohepatitis via Persulfidation and Gut Microbiome

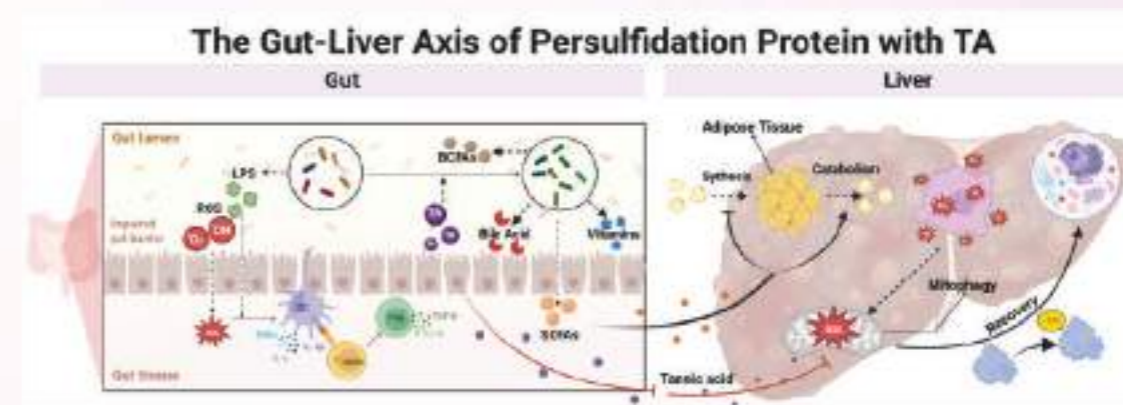
WU Tao

Year 2 PhD Student in Food and Nutritional Sciences

Principal Supervisor: Professor CHEUNG Chi Keung Peter



Metabolic dysfunction-associated steatohepatitis (MASH) is now the most common chronic liver disorder worldwide. Oxidative stress and lipid peroxidation remain central drivers of disease progression. Recent studies suggest that decreased protein persulfidation, a hydrogen sulfide (H<sub>2</sub>S) dependent post-translational modification, further aggravates liver injury. Tannic acid (TA), a plant derived polyphenol with strong antioxidants and anti-inflammatory properties, as a protective agent against MASH. In this study, TA has been demonstrated to reduce the accumulation of Triglycerides and Total Cholesterol in the liver and serum, with ballooning degeneration and lipid droplets alleviated. Also, the inflammation factors Alanine aminotransferase and aspartate aminotransferase declined in the liver. Based on the above, proteins such as the phosphorylation P65, TNF $\alpha$ , and IL6 were detected by Western blot, showing a decrease in TA groups differently. After the TA oral administration, oral glucose administration and insulin tolerance test resulted in significantly blunted glucose excursion with steeper post-peak decline, indicating improved whole-body insulin sensitivity and enhanced glucose tolerance. However, the short chain fatty acids analysis revealed that TA promoted it back to the level of the normal diet group, which supported the results of species abundance in gut microbiota. Definitely, the TA oral administration improved the species diversity and ratio of *Akkermansia\_muciniphila*. Oxidation of proteins plays a key role in the MASH, and persulfidation modification can reverse this process according to studies. Thus, the global persulfidation level of MASH liver increased in the TA100 group. These results suggest that TA can alleviate the reactive oxygen species (ROS) and lipid peroxidation. Notably, the Volcano plot of the TA100 vs. HFD group in persulfidated proteomics shows that 309 proteins are upregulated in persulfidation level and 125 proteins are downregulated in MASH liver, which supported the global persulfidation level western blot results. This study aims to explore the relationship between TA and persulfidation regulation.



**Figure:** an abstract graph for this research.

**Acknowledgement:** Thanks for the instructions from my supervisor, Prof. Peter Chueng, and me.

# CHEMSMART: Chemistry Simulation and Modeling Automation Toolkit for High-Efficiency Computational Chemistry Workflows

LIU Jingyi

Year 1 PhD Student in Chemistry

Principal Supervisor: Professor ZHANG Xinglong

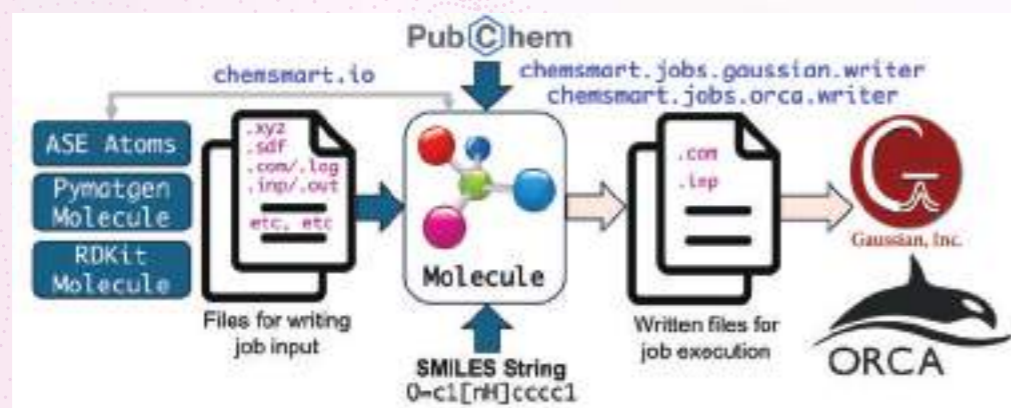


Computational chemistry workflows—such as geometry optimization, transition-state searches, and thermochemical analysis—are often fragmented across multiple software packages and manual scripts, limiting efficiency and reproducibility. As noted in the poster, automation frameworks for molecular systems remain underdeveloped. To address this gap, we present CHEMSMART, a Python-based, modular toolkit that unifies end-to-end molecular quantum chemistry workflows.

CHEMSMART integrates key stages including input preparation, job submission, output parsing, thermochemistry, visualization, and file organization into a single framework. A central *Molecule Object* standardizes data representation (coordinates, charge, multiplicity, metadata), while an interoperability layer enables seamless interaction with engines such as Gaussian and ORCA. Through a flexible command-line interface, users can run both interactive and high-throughput batch workflows across local and HPC environments.

The toolkit supports advanced analyses such as potential energy surface scans and distortion–interaction (activation strain) analysis, as well as thermochemical corrections using quasi-RRHO methods for consistent free energy evaluation. Automated visualization tools generate publication-ready outputs, including molecular structures, orbitals, noncovalent interactions, and spin densities, enabling a reproducible, one-pass workflow from computation to reporting.

By consolidating fragmented processes into a unified platform, CHEMSMART enhances efficiency, scalability, and reproducibility in computational chemistry. Future development will expand software integration, enable multi-scale (QM/MM) simulations, incorporate machine learning potentials, and align data outputs with FAIR principles.



**Acknowledgement:** We acknowledge support from The Chinese University of Hong Kong, Hong Kong Baptist University, and A\*STAR, and thank all contributors to the CHEMSMART project.

# Chiral *gem*-Diborylalkane Reagents: Synthesis and Applications

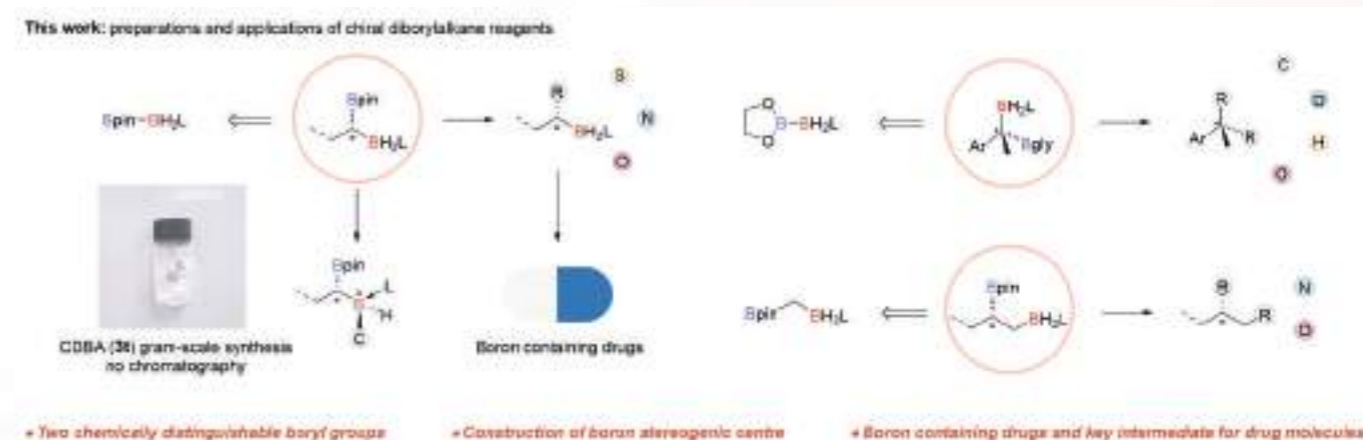
TAO Hongyi

Year 2 PhD Student in Chemistry

Principal Supervisor: Professor LYU Hairong



Recently, *gem*-diborylalkanes have emerged as a new class of versatile boron-containing reagents due to their broad reactivity. However, most *gem*-diborylalkanes are achiral due to the symmetric nature of their two boryl groups, which limits the applications toward enantioenriched products. Here we have successfully developed an asymmetric homologation method to produce chiral diborylalkanes using the unsymmetrical  $sp^2$ - $sp^3$  diboron reagent (UDB), where the two boron groups exhibit chemically distinguishable reactivities, enabling downstream stepwise derivatization. The synthesis of crucial intermediates for drug molecules also exemplifies the versatility of these products, underscoring the utility of the UDB. This method is anticipated to be valuable for the late-stage functionalization of advanced bioactive compounds, offering a powerful tool for enhancing synthetic capabilities in drug discovery and development.



**Acknowledgements:** We acknowledge the CUHK and RGC for financial support. We acknowledge Prof. Z. Xie, Prof. Y. Yeung, Prof. F. Kwong, Prof. J. Xia and Prof. Y. Quan (HKUST) for the support of HPLC instruments. We acknowledge Dr. J. Hu for single-crystal X-ray analyses.

# From Ethiopia to Hong Kong: Landslide Susceptibility and Rainfall-Triggered Slope Failures

**AYELE Tilahun Mersha**

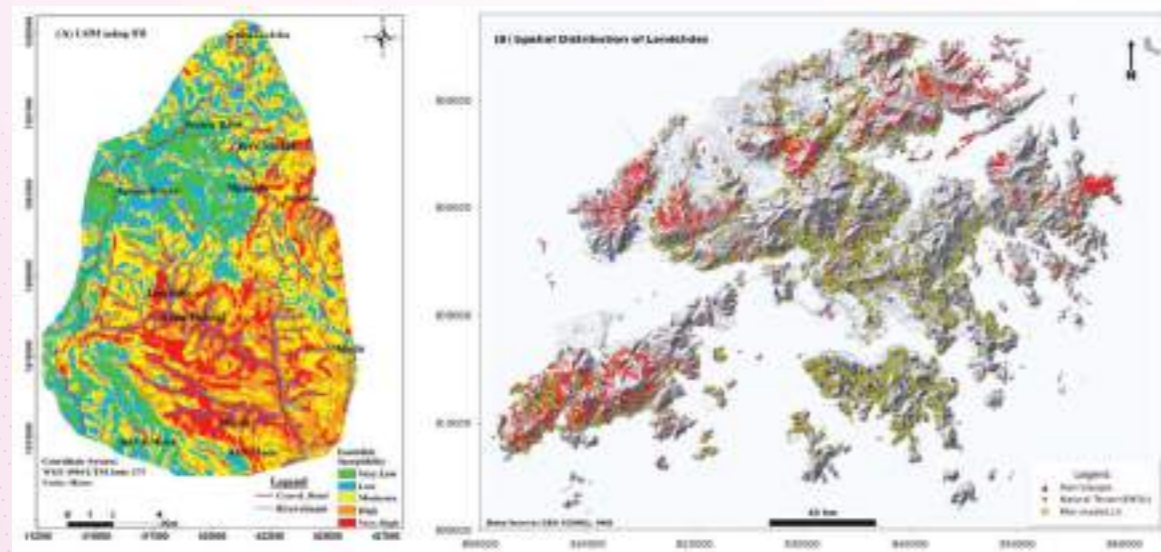
Year 1 PhD Student in Earth and Environmental Sciences

Principal Supervisor: Professor ZHAN Yan



Landslides are a major geomorphic hazard in the Ethiopian Highlands, where steep slopes, intense seasonal rainfall, weathered volcanic rocks, and human land use promote slope instability. This study evaluates landslide susceptibility in the Simada area of northwestern Ethiopia (185.7 km<sup>2</sup>) using two bivariate statistical methods, Frequency Ratio (FR) and Weights of Evidence (WoE) (Mersha & Meten, 2020). A landslide inventory of 576 active and passive landslides was compiled for the rugged Guna Mountain Highlands and divided into training (80%) and validation (20%) datasets. Seven causative factors were analyzed: slope, aspect, curvature, lithology, land use, rainfall, and distance to streams. Landslides are most strongly associated with steep slopes, concave curvature, proximity to streams, weathered basalt, and high rainfall. Validation using the Area Under the Curve (AUC) showed that both models performed well, with FR achieving the better result (88.2%). These findings demonstrate the value of bivariate statistical models for landslide susceptibility mapping and hazard mitigation in Simada (Figure 1A).

Building on this foundation, the Hong Kong study investigates how natural terrain factors and anthropogenic modification influence landslide susceptibility in a highly urbanized landscape, and whether reliable rainfall thresholds and predictive models can be developed under geological heterogeneity and climate change. A high-resolution geospatial database has been compiled from LiDAR-derived topography, geological data, and territory-wide landslide inventories. Preliminary results (Figure 1B) show a strong spatial association between landslides and steep slopes underlain by weathered volcanic rocks. The next stages will derive lithology-specific intensity-duration rainfall thresholds and develop predictive models to estimate landslide probability under extreme rainfall scenarios. Together, these efforts aim to advance from static susceptibility mapping to dynamic forecasting for improved landslide early warning and hazard mitigation in Hong Kong.



**Figure 1.** (A) Landslide susceptibility map of the Simada area, Ethiopia, derived using the Frequency Ratio model. High- and very high-susceptibility zones are concentrated in the south-central and eastern sectors (modified from Mersha & Meten, 2020). (B) Spatial distribution of historical landslides recorded in the Enhanced Natural Terrain Landslide Inventory (red) and the Location of Landslide Incidences (yellow), with rain gauge stations (blue), across Hong Kong during 1984–2024.

**Acknowledgements:** We gratefully acknowledge discussions with Prof. Francis Tam, Prof. Lin Liu, and Prof. Zhen Zhang. AYELE is supported by the CUHK Recruitment Scheme for Non-Mainland Non-Local Students. The development of numerical models and data analysis is supported by the Hong Kong Research Grants Council (ECS-24300324 and GRF-14300325).

# Global Annual Production of Disinfection By-Products (Trihalomethanes & Haloacetic Acids) from Drinking Water Chlorination

**PARVEEN Saira**

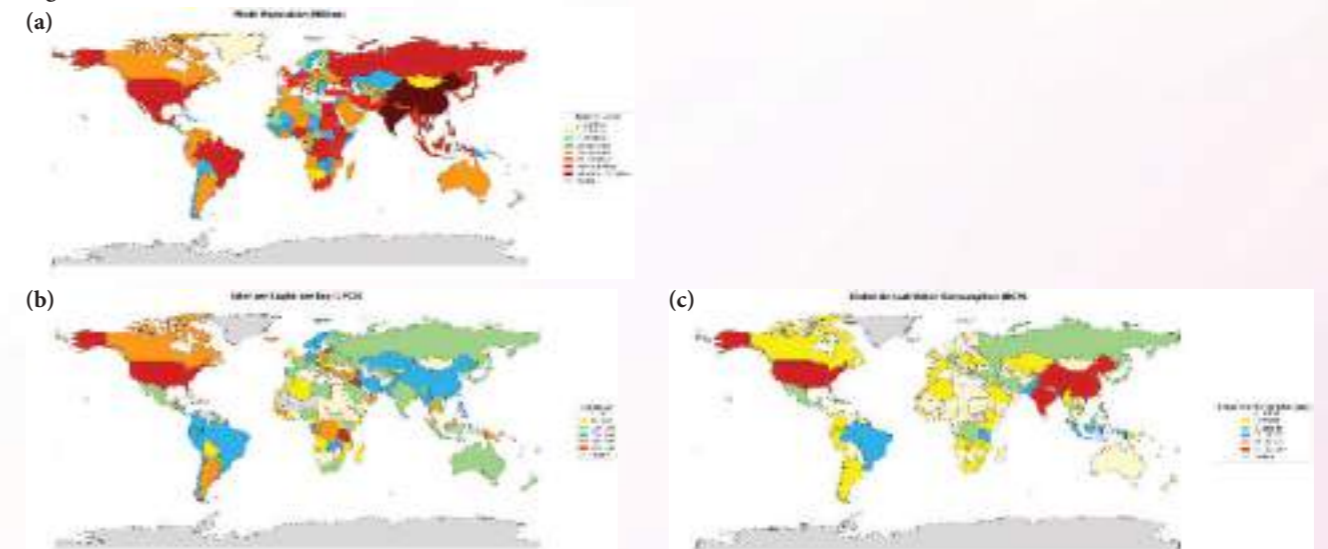
Year 2 PhD Student in Earth and Atmospheric Sciences

Principal Supervisor: Professor CHOW Tat Shing Alex

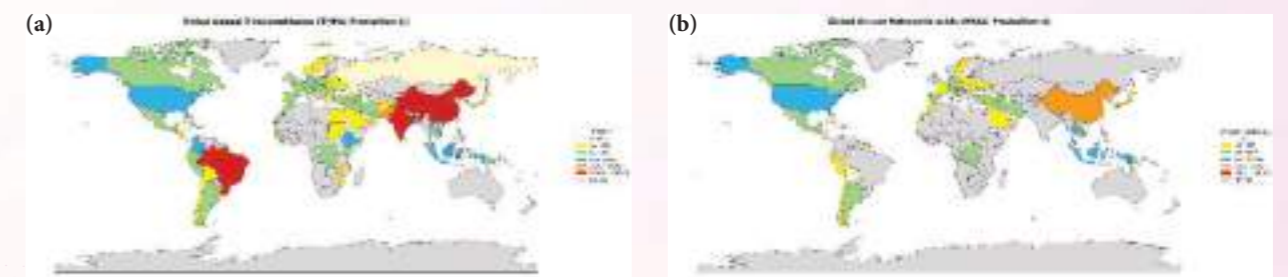


Chlorination is the most accepted form of drinking water disinfection because it is the most effective, less expensive and can be easily operated thus having played a significant role to reduce waterborne diseases within the global context. Nevertheless, chlorine reaction with natural sources of organic matter inevitably puts into being disinfection by-products (DBPs). Some of the most common and widely studied classes of DBPs include trihalomethanes (THMs) and haloacetic acids (HAAs) both of which are regulated contaminants of great social and health concern because of their confirmed carcinogenicity and toxicological properties. This study compiled a global dataset of reported THM and HAA concentrations alongside per capita water consumption data (L capita<sup>-1</sup> day<sup>-1</sup>) from countries across six continents. National population data were integrated to estimate total water consumption, from which annual DBP mass production was derived as the product of total consumption and measured DBP concentrations. Findings indicate strong geographical differences in the production of DBP. Asia proves to be the leading contributor due to the high population density and consumption of water, as its THM and HAA production is estimated at about  $2.66 \times 10^4$  t yr<sup>-1</sup> and  $2.72 \times 10^3$  t yr<sup>-1</sup>. The moderate production levels are observed in North America and (THMs:  $\sim 2.45 \times 10^3$  and  $\sim 1.31 \times 10^3$  t yr<sup>-1</sup>, respectively), and in Australia and Oceania comparatively lower production is observed ( $\sim 1.38 \times 10^2$  t yr<sup>-1</sup>). THM production was always higher as compared to HAAs, in all regions substantiating the fact that THMs are the primary regulated DBP class produced in the course of chlorination. The behavior of these two classes of compounds is further differentiated by environmental fate analysis. Being volatile, THMs dissipate substantially on storage, heating, and domestic water consumption and 70–84% of the concentration is lost to volatilization and atmospheric residence times reach 2–3 months on average. Conversely, HAAs are water soluble and recalcitrant, and are concentrated in water bodies. This ecological segregation follows that there is no regard to dynamic equilibrium, and so the constant and increasing flow of DBPs into the atmosphere and water bodies. The review is the first-order global synthesis of THM and HAA overall global quantification of annual drinking water system THM and HAA production and provides critical insights into their differentiation with contrasting environmental transport fate processes.

**Figures**



**Figure 1:** Spatial distribution of (a) Global Population (Millions), (b) Liter per Capita per Day (LPCD) (c) Total Annual Drinking Water Demand in Billion Cubic Meters (BCM).



**Figure 2:** Estimated global annual production of major disinfection byproducts: (a) Trihalomethanes (THMs) and (b) Haloacetic Acids (HAAs) in tonnes.

**Acknowledgment:** The author would like to express sincere gratitude to the supervisor for their guidance, support, and valuable suggestions throughout this research work. Appreciation is also extended to the faculty and institution for providing the necessary resources and academic environment to complete this study.

# Numerical Simulation and Analysis of Casson Nanofluids under Magnetic Field Effects: a Comparative Study with FDM/FEM

IBRAR Nida

Year 2 PhD Student in Mathematics

Principal Supervisor: Professor CHUNG Tsz Shun Eric



Traditional computational fluid dynamics (CFD) methods for solving Casson magnetohydrodynamic (MHD) nanofluid flow problems are computationally expensive, often requiring hours for parameter sweeps across Reynolds (Re), Hartmann (Ha), Grashof (Gr), Prandtl (Pr), and Schmidt (Sc) numbers. This work presents a **Deep Operator Network (Deeponet)** framework that learns the solution operator mapping boundary conditions and physical parameters to velocity, temperature, pressure, and concentration fields. We demonstrate **45× computational speedup** with **50-76% error reduction** compared to traditional finite difference methods (FDM), achieving  $R^2 > 0.99$  across multiple test cases. The data-driven Deeponet accurately captures physics-consistent parametric trends including magnetic damping, thermal stratification, and concentration boundary layers without explicit PDE residual computation during inference.

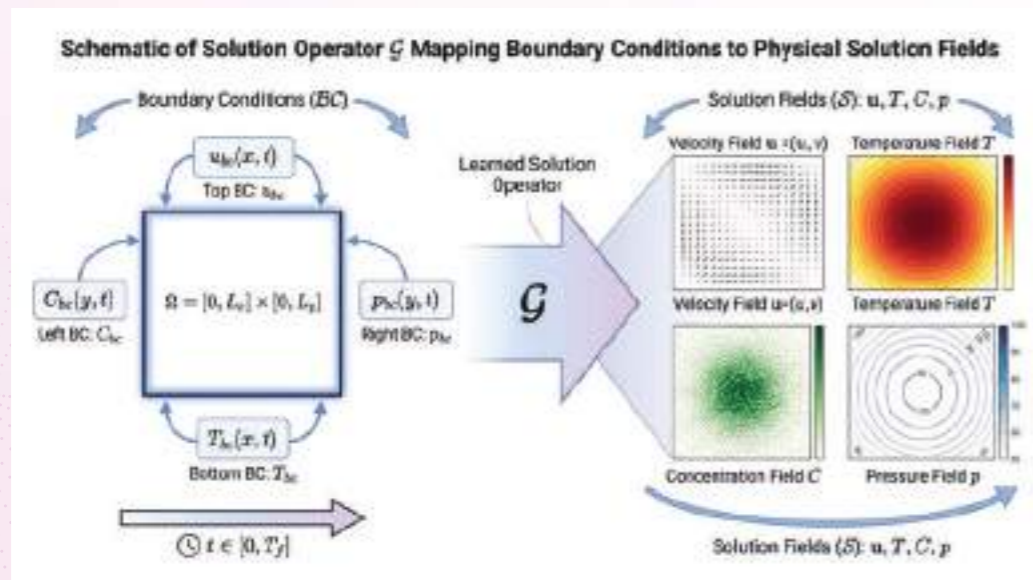


Figure 1: Deeponet Structure

# Analytical–Numerical Investigation of Lifting and Non-Lifting Potential Flow around a Circular Cylinder

ISLAM Nazrul

Year 1 PhD Student in Mathematics

Principal Supervisor: Professor ZOU Jun



This study presents a comprehensive MATLAB-based numerical framework to investigate two-dimensional (2D) incompressible potential flow around a circular cylinder. Flow around a circular cylinder is a fundamental problem in fluid mechanics, serving as a canonical geometry for understanding vortex dynamics and fluid-structure interactions. While potential-flow theory provides critical insights into lift generation via the Kutta–Joukowski theorem, there remains a need for reproducible benchmark datasets that bridge the gap between classical analytical solutions and modern numerical implementations.

The methodology involves a systematic superposition of fundamental flow elements, including uniform flow, doublets, and point-vortex elements. By integrating these components, closed-form analytical expressions for velocity components ( $u$  and  $v$ ) and pressure distributions ( $C_p$ ) were derived and solved numerically. A parametric study was conducted for a range of circulation strengths ( $-50 \leq \Gamma \leq 50$ ), with fixed parameters of  $R=2m$ ,  $v_\infty=1ms^{-1}$ .

The results demonstrate a clear transition from symmetric, non-lifting conditions to asymmetric, lifting flow. For the baseline case ( $\Gamma=0$ ), the flow field remains perfectly symmetric with two stagnation points located at  $\theta=0^\circ$  and  $\theta=180^\circ$ , resulting in zero net lift. Introducing counter-clockwise circulation ( $\Gamma<0$ ) causes downward streamline deflection and a corresponding downward lift force due to increased pressure on the upper surface. Conversely, clockwise circulation ( $\Gamma>0$ ) reverses this asymmetry, generating upward lift.

A key finding of this research is the quantification of stagnation point migration and surface pressure variations as a function of circulation strength. The numerical results show a linear relationship between the lift coefficient and circulation, validating the Kutta–Joukowski theorem with a relative error of less than 3%. This high degree of consistency confirms the robustness of the MATLAB solver. In conclusion, this study provides a unified benchmark dataset and visualization tool essential for aerodynamic verification and preliminary design. Although based on inviscid assumptions, it establishes a solid foundation for future research involving viscous and three-dimensional flow effects.

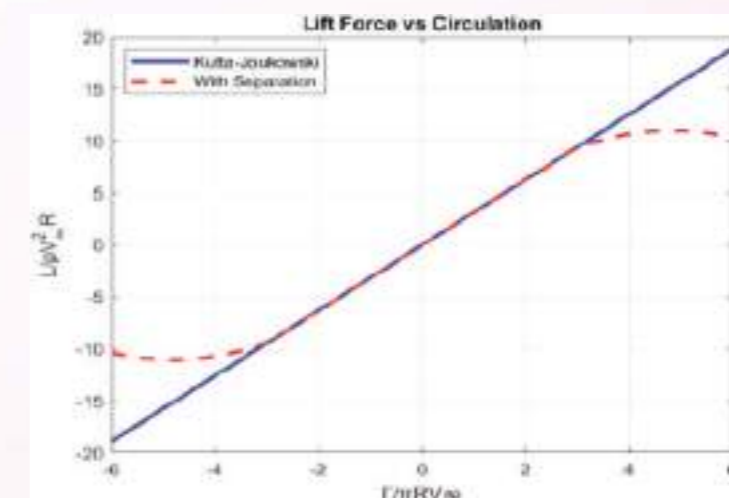


Figure 1: Variation of lift coefficient with circulation, demonstrating a linear relationship that validates the Kutta–Joukowski theorem with high numerical accuracy.

# Angle-Resolved Phase-Sensitive Measurement of the Anisotropic Gap Structure in a Topological Superconductor $\beta$ -Bi<sub>2</sub>Pd

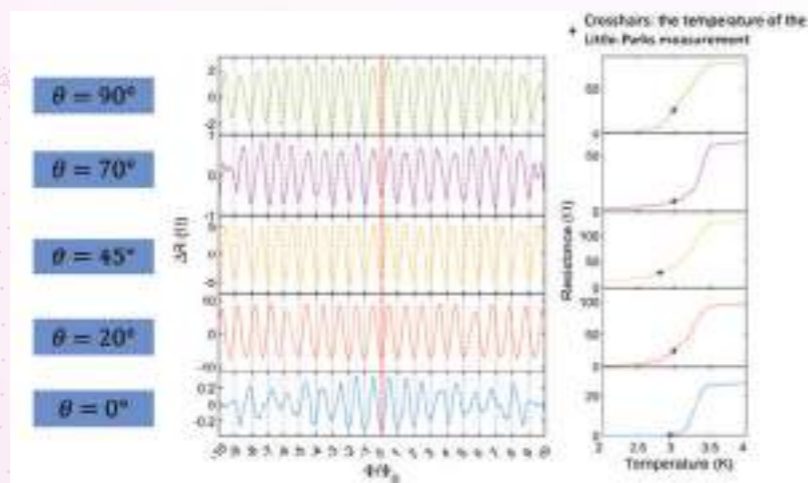
**HUANG Zixuan**

Year 3 PhD Student in Physics

Principal Supervisor: Professor LI Yufan



Topological superconductivity holds the key to realizing fault-tolerant quantum computing. Superconductors hosting topologically non-trivial band structure, often with unconventional pairing symmetry, may give rise to Majorana fermions. These exotic particles are famously known for being their own antiparticles, a unique property that allows construction of noise-resilient topological qubits. Unconventional superconductors intimately connect to topological superconductors. The phase-sensitive experiments provide a powerful probe to resolve the anisotropic gap structures of unconventional superconductors. Notably, an angle-resolved phase-sensitive study definitively established the  $d_{(x^2-y^2)}$  pairing symmetry of the high-TC cuprates. We have recently employed the phase-sensitive experiment to demonstrate the odd-parity pairing symmetry in topological superconductor candidate  $\beta$ -Bi<sub>2</sub>Pd. It confirms an anisotropic gap function of  $\beta$ -Bi<sub>2</sub>Pd that reverses sign upon the inversion of momentum, i.e.,  $\Delta_{\mathbf{k}} = -\Delta_{-\mathbf{k}}$ , consistent with the spin-triplet p-wave pairing state. To gain further insight into the unconventional gap symmetry of  $\beta$ -Bi<sub>2</sub>Pd, we have carried out an angle-resolved phase-sensitive experiment by systematically varying the crystalline orientations at the  $\beta$ -Bi<sub>2</sub>Pd/Nb junctions within the composite ring device. Our preliminary results show that no composite-ring devices of crystalline angle smaller than 90° hosts half quantum flux. More interestingly, non-zero phase shifts emerged in Josephson current-phase relation, indicating the possible angle-dependent phase difference.



**Acknowledgement:** We would like to thank the support by Research Grants Council, University Grants Committee of the Hong Kong SAR (Grant No. CUHK 24302822, No. CUHK 14306823), CUHK Direct Grants (No. 4053668, No. 4053727), National Science Foundation of China (Grant No. 12474153), Guangdong Provincial Quantum Science Strategic Initiative (No. GDZX2301007, No. GDZX2401003).

# Extracting Astrophysics of Active Galactic Nuclei via Gravitational Waves from Binary Black-Hole Mergers

**LEONG Hin Wai**

Year 3 PhD Student in Physics

Principal Supervisor: Professor Otto Akseli HANNUKSELA



Dense environments such as the accretion disks of active galactic nuclei (AGN) are known to be prolific sites for the formation and growth of massive black holes (BHs). When these BHs merge, they emit gravitational waves (GW), which can potentially be gravitationally lensed by the supermassive black hole (SMBH) at the centre of the AGN. Following the merger, the remnant will settle into a BH that acquires both recoil and spin. As it traverses the accretion disk, it can generate an electromagnetic (EM) flare that becomes observable when the remnant emerges from the disk.

Since the first direct detection of GW in 2015, more than 200 GW events have been observed. GWs provide a novel probe of the Universe. Unlike light, they are not obscured by intervening gas or matter, allowing them to carry otherwise inaccessible information about the host environment. In a series of works, I will demonstrate how GW observations of binary black hole (BBH) mergers embedded in AGN disks can be utilised to advance our understanding of AGN physics.

First, I will consider the scenario in which the disk is viewed near face-on and the EM flare is observable, and explore how to improve cosmological measurements with multimessenger astronomy. In particular, I will show that imposing physically motivated criteria on the recoil direction, consistent with the flare emission mechanism, can significantly reduce false-positive associations between GW events and EM counterparts. At the same time, it has the potential to constrain properties of the AGNs.

In contrast, when the disk is nearly edge-on, I will highlight how gravitational lensing by the SMBH can reveal new astrophysical insights. The unique lensing geometry of BBHs in AGNs allows them to exhibit a large opening angle between the lensed GW images. This leads to distinctive GW signal features that will enable unprecedented localisation of BBHs within the galaxy and enhance measurements of the lens, such as its mass.

Looking ahead, next-generation GW detectors are expected to observe more than 100,000 BBH mergers. Observations of these binaries in AGNs will be immensely valuable for understanding the astrophysics of such dense environments, as well as for studying our Universe on a large scale.

**Acknowledgement:** The authors acknowledge support by grants from the Research Grants Council of Hong Kong (Project No. CUHK 14304622, 14307923, 14307724, AoE/P-404/18, and 14300223), the start-up grant from The Chinese University of Hong Kong, the Direct Grant for Research and Research Fellowship Schemes from the Research Committee of The Chinese University of Hong Kong. We acknowledge the use of computing facilities supported by grants from the Croucher Innovation Award from the Croucher Foundation Hong Kong. This research has made use of data or software obtained from the Gravitational Wave Open Science Center (gwosc.org), a service of the LIGO Scientific Collaboration, the Virgo Collaboration, and KAGRA. The authors are grateful for computational resources provided by the LIGO Laboratory and supported by National Science Foundation Grants PHY-0757058 and PHY-0823459. We acknowledge the use of IUCAA LDG cluster Sarathi for the computational/numerical work. The authors also acknowledge the use of the Gwave cluster provided by the Institute for Computational and Data Sciences at Penn State University and supported by National Science Foundation Grants OAC-2346596, OAC-2201445, OAC-2103662, OAC-2018299, PHY-2110594.

# Quantifying Evolutionary Behaviours in Sharing Economies

**CHEN Haoyang**

Year 2 MPhil Student in Risk Management Science

Principal Supervisor: Professor YAM Sheung Chi Phillip

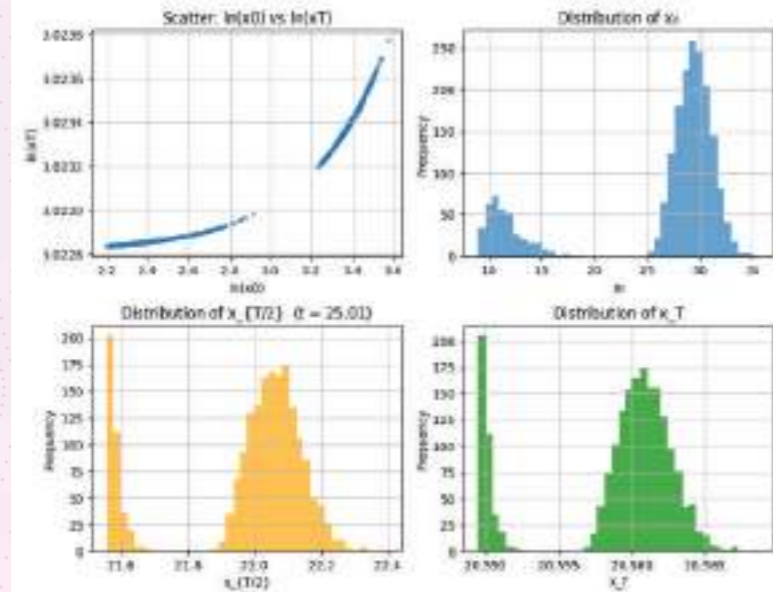


This research addresses the pervasive "free-rider" problem in online resource-sharing communities—where agents are incentivized to download resources without contributing—by proposing a robust, centrally managed reputation system. In this model, agents function as both servers and users, and their reputation is calculated based on the ratio of their contributions to their requests. To prevent long-term exploitation by formerly active members, we introduce an exponential weighting function with a decaying rate ( $r \geq 0$ ) that diminishes the value of historic behaviour over time.

Because solving for individual strategies in large-scale networks is computationally prohibitive, we employ a **mean-field game** framework to model the system as the number of agents approaches infinity. We prove the existence and uniqueness of a Nash equilibrium for this mean-field system. Our theoretical results demonstrate that agent reputations maintain their relative ordering over time and, under a positive discounting rate, the mean reputation converges exponentially to a "reputational attractor" ( $k/r$ ).

Numerical studies using a Picard iteration scheme verify these theoretical findings. We find that while a higher discounting rate discourages early uploads, it successfully sustains later contributions and increases total community activity. These findings suggest that dynamic reputation weighting is a powerful tool for maintaining long-term cooperation in decentralized digital ecosystems.

**Acknowledgement:** The author expresses sincere gratitude to Professor Phillip Yam and Professor Tak Kwong Wong for their invaluable guidance and support throughout this project.



# A Unified Framework for Censored Interquantile Regression under General Biased Sampling Scheme

**LUI Chak Sum**

Year 2 MPhil Student in Risk Management Science

Principal Supervisor: Professor SIT Tony



Time-to-event data in survival analysis are frequently subject to not only right-censoring but also various forms of biased sampling, such as left truncation, length-biased sampling, and case-cohort designs. When sampling bias is ignored, conventional estimation and inference procedures become invalid, leading to misleading conclusions. While quantile regression offers a robust alternative to traditional accelerated failure time and Cox models, existing methods struggle to jointly accommodate time-dependent covariates and general biased sampling schemes within a unified framework.

To address this gap, we propose a unified censored interquantile regression model that handles time-varying covariates under a general biased sampling framework. Our approach extends the accelerated failure time model by assuming local homogeneity of regression coefficients across a contiguous quantile interval, thereby pooling information from neighboring quantiles to improve efficiency. To overcome computational challenges and avoid infeasible solutions during estimation, we introduce the concept of implicit data constraints and develop a novel Guess-Approximate-Search (GAS) algorithm for stable and efficient parameter estimation.

We establish the consistency and asymptotic normality of the proposed estimator. Extensive Monte Carlo simulations demonstrate its finite-sample performance under left truncation, length-biased sampling, and case-cohort designs. The method is further validated through real-data applications. The results confirm that our approach provides interpretable and efficient estimates while properly adjusting for sampling bias, offering a flexible and reliable tool for analyzing complex time-to-event data in practice.

# Multi-Label Growth Curve Change-Point Model for Characterizing Multifaceted Dynamics in Multivariate Longitudinal Data

KUANG Yiling

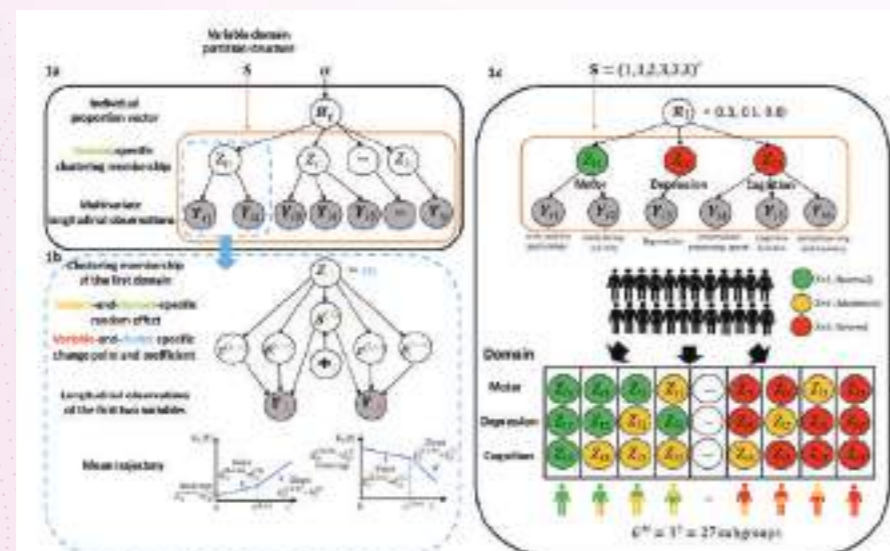
Year 3 PhD Student in Statistics

Principal Supervisor: Professor SONG Xinyuan



Longitudinal studies often exhibit complex heterogeneity across individuals, variables, and time, posing significant challenges for traditional analytical approaches. We propose a multi-label growth curve change-point model (ML-GCCM) that simultaneously addresses between-individual, between-variable, and within-subject temporal heterogeneity in multivariate longitudinal data. The proposed ML-GCCM introduces a flexible latent class structure in which each subject can belong to different trajectory clusters for different subsets of outcome variables (“multi-label” clustering), while also allowing subject-specific change points in progression rates. Theoretically, we demonstrate that ML-GCCM accurately recovers the underlying heterogeneity structure. Empirically, extensive simulation studies show that ML-GCCM outperforms conventional single-label and no-change-point models in terms of model fit and trajectory estimation. We apply ML-GCCM to a Parkinson’s disease cohort, where it effectively identifies clinically interpretable symptom groupings and progression subtypes. Our findings highlight previously obscured patient subgroups with disparate motor and non-motor progression patterns.

**Acknowledgements:** The authors would like to thank Professor Song Xinyuan and Professor Kang Kai for their insightful guidance and support.



**Figure 1:** A schematic illustration of ML-GCCM. (1a): Variable-domain partition structure, where  $p$  observed variables are grouped into  $G$  distinct domains; (1b): Zoomed-in view of domain 1 (dashed blue rectangle in 1a), showing the detailed modeling of  $Y_{i1}$  and  $Y_{i2}$  given  $Z_{i1} = m$ ; (1c): Example application of ML-GCCM to a Parkinson’s disease cohort with  $p = 6$  variables (e.g., limb stability, daily living activity, depression),  $G = 3$  domains (e.g., motor, cognition),  $M = 3$  latent classes (e.g., normal, moderate, severe), resulting in  $G^M = 27$  distinct subgroups based on multidimensional class membership ( $Z_{i1}, Z_{i2}, Z_{i3}$ ).

# Bayesian Nonparametric Poisson Modeling Reconstructs 3D Structure for Multi-Slice Spatially Resolved Transcriptomic Data

LUO Yongyi

Year 2 PhD Student in Statistics

Principal Supervisor: Professor FAN Xiaodan



Spatially Resolved Transcriptomics (SRT) technologies offer unprecedented insights into tissue organization by profiling gene expression while preserving spatial context. A crucial challenge in leveraging these data is the effective integration and joint analysis of multiple adjacent tissue sections (slices), which is necessary to reconstruct the native three-dimensional (3D) tissue architecture and capture complex cellular interactions. Such multi-slice analysis is often complicated by significant, non-linear batch effects arising from tissue sectioning and differential experimental conditions, as well as by the inherent count data structure which exhibits pronounced overdispersion.

To address these limitations, we propose the **Bayesian Nonparametric Poisson Model for 3D reconstruction (BNPM3D)**. This unified statistical framework is specifically designed for the integrated analysis of multi-slice SRT data.

BNPM3D is built on a Poisson-Lognormal Factor Model that directly models raw count data, naturally accommodating overdispersion. A key innovation is the explicit incorporation of a gene-specific multiplicative batch effect into the model’s linear predictor, effectively correcting for non-biological variation across slices.

The core of BNPM3D lies in its novel integration of factor analysis with Bayesian nonparametrics. The latent factors are explicitly modeled via a Gaussian Mixture Model (GMM), where each component corresponds to a spatial domain, enabling flexible, data-driven domain discovery. Crucially, to achieve 3D reconstruction, we generalize the spatial model from 2D to 3D by constructing a graph that incorporates both within-slice and cross-slice neighborhood relationships. This 3D graph structure, integrated through an MRF-constrained Gibbs-type prior on the cluster assignments, allows the model to simultaneously infer spatial domains and establish probabilistic correspondence between spots across adjacent slices, effectively aligning the sections within a unified 3D space.

To address the non-conjugacy of the posterior, we implement a simplified Riemannian Manifold MALA sampler for the latent factors that leverages the posterior’s geometric structure for efficient exploration.

To conclude, BNPM3D provides a principled, end-to-end solution that performs batch effect correction, dimensionality reduction, and spatial-domain identification in a single, coherent framework. Our method ultimately enables the probabilistic reconstruction of a high-resolution 3D expression landscape from multiple SRT slices, representing a significant advance over existing single-slice analysis methods.



香港中文大學理學院  
**FACULTY OF SCIENCE**  
THE CHINESE UNIVERSITY OF HONG KONG

