香港中文大學
The Chinese University of Hong Kong

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

2022-23
SCIENCE FACULTY
POSTGRADUATE
RESEARCH DAY

8 FEB 2023

Science Empowers Your Dreams

PROGRAMME

09:00 - 09:10	**Opening Remarks & Souvenir Presentation** ***Professor SONG Chunshan,*** Dean of Science
09:10 - 09:25	**Can Autophagy-Regulated Quality Control in Plants Bridge Environmental Sustainability and Sustainable Agriculture?** ***MGBECHIDINMA Chiamaka Linda*** (Year 1 PhD Student in Cell and Molecular Biology)
09:25 - 09:40	***In Vivo* Production of a Bioresponsive Anti-Microbial Protein Crystal for the Treatment of *Helicobacter pylori* Infection** ***ZHANG Wenxiu*** (Year 7 PhD Student in Cell and Molecular Biology)
09:40 - 09:55	**Intermittent Electrolysis for CO_2 Conversion with Renewable Energy** ***XU Zhanyou*** (Year 3 PhD Student in Chemistry)
09:55 - 10:15	**Break (20 minutes)**
10:15 - 10:30	**Local Well-Posedness of Incompressible Current-Vortex Sheet Problems** ***LIU Sicheng*** (Year 4 PhD Student in Mathematics)
10:30 - 10:45	**Spiral Waves in a Bacterial Population** ***LIU Shiqi*** (Year 6 PhD Student in Physics)
10:45 - 11:00	**No-Lose Converging Kernel Estimation of Long-Run Variance** ***LIU Xu*** (Year 2 MPhil Student in Risk Management Science)
11:00 - 11:45	**Poster Presentation (45 minutes)**
11:45 - 12:00	**A Robust Instrumental Variable Estimation Method with Its Applications** ***LIN Yiqi*** (Year 4 PhD Student in Statistics)
12:00 - 12:15	**Heterogeneous Oxidation of Sodium Methanesulfonate in a Chamber: Have We Underestimated Non-Sea-Salt Sulfate Production from the Ocean?** ***NG Sze In Madeleine*** (Year 3 PhD Student in Earth and Atmospheric Sciences)
12:15 - 12:25	**Closing Remarks** ***Professor SONG Chunshan,*** Dean of Science

Welcome Message from the Dean of Science

Professor Chunshan SONG

It is my pleasure to welcome you all to the 2023 Science Faculty Postgraduate Research Day. With the full normalisation of academic activities on CUHK campus after three years of COVID-19 pandemic control measures, we are very pleased to have you join this event in 2023. This year is the 60th Anniversary of CUHK Science Faculty. The Faculty has dedicated itself to supporting the education and research training development of future professionals over the past decades. In order to encourage more postgraduate students to showcase their original research work with professors and fellow students from disciplines across the Faculty, we started the Postgraduate Research Day in 2021 and are glad to introduce a new poster session in addition to the oral session this year.

Conducting research is one of the most important aspects of pursuing advanced degrees such as Master and Doctor of Philosophy. Arguably the most crucial component, original and rigorous research is the hallmark of the research postgraduate programmes in the CUHK Science Faculty. Our PhD programme is committed to educating scholars who will become leaders in their profession. PhD studies of CUHK Science are both individual and collaborative in nature, and all PhD studies are intense regardless of areas in science, which demand a great deal of efforts including time, initiative, and discipline from every candidate. On the other hand, the original and rigorous research has immense value to learning and development in critical and creative thinking and professional growth in research and thinking capability.

With the Faculty's mission of educating and inspiring the next generation of scientific innovators and leaders, we take pride in nurturing the next generation of young researchers who would make a positive impact on society, and for society, supporting the advancement of scientific innovation and the world's sustainable development. Apart from gaining in-depth expertise in their area of research under the supervision of our leading scholars, transferable skills, including generalisable research skills, management, communication, writing and presentational skills, networking and teamwork, personal effectiveness, will help further to advance the intellectual capabilities of our postgraduate students.

In 2021, CUHK unveiled the strategic partnerships to strengthen Hong Kong's presence in Greater Bay Area (GBA) to echo China's "*14th Five-Year Plan*" at the Forum of Guangdong-Hong Kong-Macau GBA Conference. We are pleased to announce that the Memorandum of Agreement (MoA) has been signed on 8 December 2022 for establishing the Joint Institute of Advanced Materials and Green Energy Research (JIAMGER) as a strategic partnership between CUHK and the Great Bay University (GBU) in Dongguan, Guangdong Province. Our Science Faculty will lead CUHK efforts for JIAMGER in collaboration with GBU including offering joint PhD training programmes to contribute to the development of the GBA into an international centre of innovation and technology. CUHK Science Faculty team will be setting up individual and collaborative research laboratories (in photonics, solar PV, soft materials, electrochemical conversion, CO_2 capture, CO_2 utilization, urban-agriculture farming and bio-energy) at JIAMGER on GBU campus in Dongguan. We look forward to recruiting new PhD students (starting in Fall 2023; in disciplines of physics, materials science and engineering, chemistry, life sciences) with full financial support under the GBU-CUHK Joint PhD Training Programme (with first ~2 years at CUHK in Hong Kong, next ~2 years at JIAMGER in GBU Dongguan but still under the same supervisor from CUHK Science Faculty, with a GBU co-supervisor).

Today we are delighted to have 24 selected postgraduate researchers from all units to present at the symposium. Riding on the success of the previous Postgraduate Research Day, we hope the event this time will offer an excellent opportunity for our postgraduates to gain exposure in a scientific meeting, to showcase their original research work and to network with our faculty and staff members and fellow students. We also hope the symposium will facilitate exchange of ideas and help expand students' horizons, bring greater awareness to the importance of, and facilitates the learning of the soft skills of postgraduate students in oral and poster presentation.

I would like to finish my remarks by thanking all presenters and participants, and Professor To Ngai as well as the Science Faculty Office team for organising this event. I wish all of you a great time on the Postgraduate Research Day and continued success in your research endeavours!

Yours sincerely,

Chunshan SONG
Dean of Science and
Wei Lun Professor of Chemistry

Oral Presentation

Abstract

Can Autophagy-Regulated Quality Control in Plants Bridge Environmental Sustainability and Sustainable Agriculture?

MGBECHIDINMA Chiamaka Linda
Year 1 PhD Student in Cell and Molecular Biology
Principal Supervisor: Professor JIANG Liwen

Soil is biogeochemically traced to be a major sink of environmental pollutants, which are organic or inorganic in nature. Although several remediation approaches have been developed to reclaim soils to their pristine conditions, most environmental hydrophobic pollutants and heavy metals remain persistent in soils. Hence, these pollutants are a significant issue of public concern in the health, agriculture, and ecological sectors due to their toxicity and mutagenic effects on plants and humans. Similar to microbes and mammals, higher plants have to cope with the presence of these environmental pollutants during their life history. To sustain physiological activity and survival, plant cells must rapidly replace or modify their genomic or metabolic pathways within several compartments. However, studies on stress induction have revealed several selective and nonselective macromolecular degradation of unwanted components coupled with specific cargo recycling during plant developmental stages. This conserved process defines autophagy as the mediator of autophagosome formation for the sequestration and delivery of cargo for degradation or recycling.

Over the past decade, the molecular and physiological understanding of autophagy has greatly evolved due to its vital role in plant growth and development. Most of the essential machinery required for autophagy is conserved from yeast to plants. At the same time, plants and mammals share a similar mechanistic effect in their autophagy-related (ATG) genes and proteins. Depending on the transport mechanism to the lytic vacuole, chaperone-mediated autophagy, micro-autophagy, and macro-autophagy are the three main autophagy classes in animals and yeasts, whereas macro-autophagy is more studied in plants due to its relatedness to the endoplasmic reticulum (ER), autophagosomes, and vacuole. The recent discovery of the ER–autophagosomal membrane contact site (EACS) and the phosphatidylinositol-4-phosphate (PI4P) regulation of autophagosome formation has opened more frontiers toward understanding stress-meditated macro-autophagy in plants. Macro-autophagy typically occurs at basal levels in plants but can be significantly induced by a wide range of stresses, impacting plant physiology.

Although studies on the survival machinery of plants to biotic and abiotic stresses are currently attracting increasing attention in cellular and developmental investigations, the specific mechanisms of plant autophagic response to hydrophobic pollutants and heavy metals in the environment remains less explored. Herein, it is hypothesized that autophagy-related genes and proteins are an important response of plants to these environmental pollutants for their adaptation and survival. To test this hypothesis at different conditions of environmental hydrophobic pollutants and heavy metals, 1) seedling phenotypic analysis of various ATG mutants will be performed; 2) transgenic *Arabidopsis* GFP-ATG8 autophagosome marker line will be investigated using confocal imaging analysis; 3) western blot analysis will be conducted to ascertain the autophagic turnover and possible tradeoff mechanisms; and 4) the target gene expression and possible transcriptional regulation will be investigated. Taking together, understanding these mechanisms will elicit the remodeling of the autophagic activity in plants upon environmental pollutant stress. Moreover, this study will likely bridge environmental sustainability and sustainable agriculture, contributing to specific UN sustainable development goals (SDGs).

In Vivo Production of a Bioresponsive Anti-Microbial Protein Crystal for the Treatment of *Helicobacter pylori* Infection

ZHANG Wenxiu
Year 7 PhD Student in Cell and Molecular Biology
Principal Supervisor: Professor CHAN Michael Kenneth

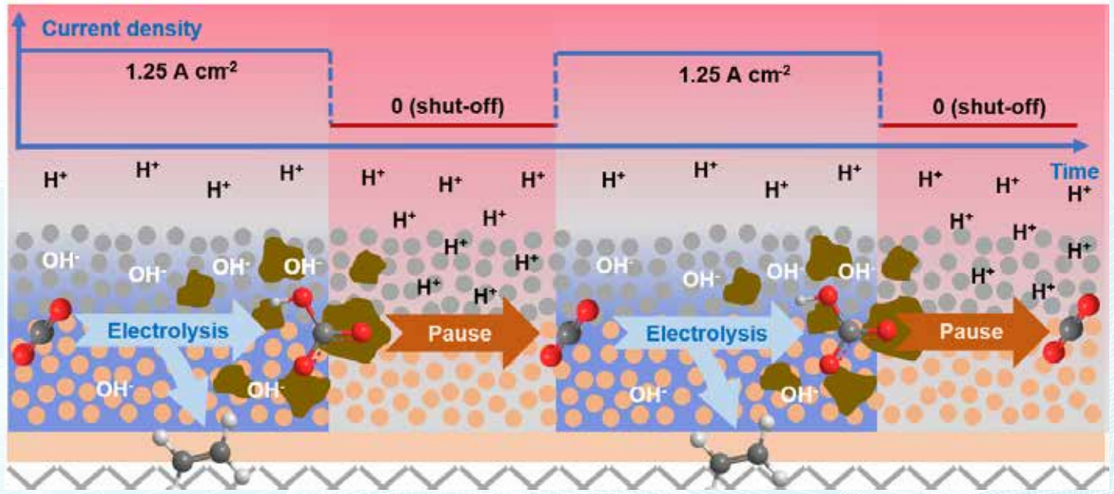
Helicobacter pylori (H. pylori) causes infection in the stomach and is the causative agent of peptic ulcer disease. In some circumstances, chronic infection with *H. pylori* leads to gastric cancer. While antimicrobial peptides (AMPs) have been actively researched as an alternative for the eradication of *H. pylori*, their use in practice is limited by numerous challenges, including their facile degradation in the acidic and protease-rich environment of the stomach, their poor penetration of the gastric mucosa, and the cost of peptide production. In this study, we describe the design and generation of a *H. pylori*-responsive microbicidal protein crystal that helps to overcome these issues. We demonstrate that when orally administered to mice, our microbicidal crystals could effectively eradicate *H. pylori* infection, resulting in the restoration of gut microbiota. This multicomponent crystal, Cry3Aa-MIIA-AMP-P17, is built on the crystal-forming protein Cry3Aa that naturally forms crystals in *Bacillus thuringiensis* and has been genetically fused to a metal ion-inducible cleavage domain (MIIA), an antimicrobial peptide (AMP) and a *H. pylori*-targeting peptide (P17). We show that Cry3Aa-MIIA-AMP-P17 preferentially binds to *H. pylori* compared to gastrointestinal epithelial cells, and that its activated form releases AMP under acidic pH condition only in the presence of *H. pylori*. Furthermore, the Cry3Aa crystal framework is shown to protect its cargo peptide from pH-induced degradation, leading to the enhanced *in vivo* oral efficacy of Cry3Aa-MIIA-AMP-P17 against *H. pylori* infection in C57BL/6 mice. Notably, these crystals exhibit minimal perturbation to the mouse gut microbiota and negligible cytotoxicity to mouse tissues. These results suggest that Cry3Aa-MIIA-AMP-P17 fusion crystals possess the therapeutic potential to treat patients infected with *H. pylori*.

Acknowledgement
This study was supported by funds from the Hong Kong Research Council Health and Medical Research Fund (M.M.L 15140252) and the Center of Novel Biomaterials, The Chinese University of Hong Kong (M.K.C.).

Intermittent Electrolysis for CO_2 Conversion with Renewable Energy

XU Zhanyou
Year 3 PhD Student in Chemistry
Principal Supervisor: Professor WANG Ying

With the increasing of climate issues brought by emission of greenhouse gases, Hong Kong government proposed the "Climate Action Plan" and announced that Hong Kong is aiming at achieving carbon neutrality by 2050. As one of the crucial decarbonization strategies, the application of renewable energy (RE) without carbon dioxide (CO_2) generation is rapidly gaining popularity. With commercially profitable price of RE-generated electricity, the electrochemical CO_2 reduction reaction (CO_2RR) has attracted much attention for its capability of converting the greenhouse gases, CO_2, into value-added chemicals without net carbon emission. However, **coupling with renewable energy gives rise to challenges for typically used constant electrolysis mode** due to the unstable electricity supply caused by periodically changed natural conditions. Herein, we proposed an "intermittent" electrolysis mode which can match the fluctuated RE-generated electricity supply. **We investigated the feasibility of operating intermittent CO_2RR at commercially relevant current density (1.25 A cm^{-2}) and revealed the role of pause for enhancing stability with bicarbonate removal by acidic media.** The intermittent electrolysis with pause significantly promoted the retention ratio of CO_2-to-C_2H_4 partial current density (83.3%) compared to the conventionally used constant electrolysis (69.6%) in 4-hour operation. These findings shed light on the crucial role of intermittent electrolysis mode for efficient CO_2RR system as well as its potential of coupling with renewable energy.



Local Well-Posedness of Incompressible Current-Vortex Sheet Problems

LIU Sicheng
Year 4 PhD Student in Mathematics
Principal Supervisor: Professor XIN Zhouping

In this talk, I will focus on the local well-posedness theory of the free surface magneto-hydrodynamics (MHD) equations.

The motion of electrically conductive fluids (e.g., plasma, liquid metals, salt water, and electrolytes) under the influence of magnetic fields is governed by the MHD systems, whose mathematical theories have numerous significant applications. One of the fundamental differences between MHD and hydrodynamics is that magnetic fields can induce currents in a moving conductive fluid, which in turn polarize the fluid and reciprocally change the magnetic and velocity fields. Mathematically speaking, the effect of the magnetic field is governed by the Maxwell equations and acts as a Lorentz force on the Euler system for the plasma, which can induce many nontrivial interactions and lead to rich phenomena.

A current-vortex sheet is a surface evolving with the magneto-fluids, along which the magnetic and velocity fields have tangential jumps. This type of problems describes the motion of two conducting fluids separated by a free interface. Mathematically, the pure fluid vortex sheet problems exhibit the Kelvin-Helmholtz instability, but magnetic fields can stabilize the fluid motion, so it is natural to study the antagonism between them. Unfortunately, owing to the strong coupling of the magnetic and velocity fields, it is necessary to deal with multiple hyperbolic systems simultaneously, making it difficult to generalize the results for the Euler equations in the absence of the magnetic fields.

All the existing nonlinear well-posedness theories of free interface problems for MHD equations were founded on the crucial premise that the free surface is a graph. However, in reality, the moving surface cannot be represented simply by the graph of a function in many significant cases. To conquer these limitations is exceedingly nontrivial, even for pure fluid cases. Using the partition of unity to characterize the general interface appears feasible, but the analysis of these transition maps is rather involved due to the intense interactions between the fluids in different local charts. Indeed, we opted for a geometric approach to solving the current-vortex sheet problems for general free surfaces. The strategies on the local dynamic motion of a general current-vortex sheet will be indispensable to the study of long-time dynamics, particularly the finite-time formation of splash singularities from a generic perturbation of a current-vortex sheet (even of a graph type).

Our objective is to establish the local well-posedness of the current-vortex sheet problems for 3D general domains so that the theory can be applied to a greater number of physical models in the real world. We established the theory for general closed surfaces provided the existence of surface tension. However, in numerous physical models, the plasma-plasma interface is devoid of surface tension. We showed the nonlinear stabilization effect of the parallel magnetic fields satisfying the Syrovatskij condition for general free surfaces.

Spiral Waves in a Bacterial Population

LIU Shiqi
Year 6 PhD Student in Physics
Principal Supervisor: Professor WU Yilin

Spiral waves are discovered in various chemical, biological and physical systems, such as chemical excitable medium, cardiac tissue, and neural networks. The onset of spiral waves in living systems is often associated with essential living functions. For example, spiral waves of electrochemical activities in neural tissues may serve as a rhythmic organizer in cortex neurons, while those in cardiac tissues may cause ventricular arrhythmia. Here, we discovered a unique type of spiral waves in a bacterial population resulting from cell density variation. The waves are highly stable in space and time and are resilient to perturbations. Our findings provide new insight to the synchronization phenomena and pattern formation in living matter.

No-Lose Converging Kernel Estimation of Long-Run Variance

LIU Xu
Year 2 MPhil Student in Risk Management Science
Principal Supervisor: Professor CHAN Kin Wai

Kernel estimators have been popular for decades in long-run variance estimation. To minimize the loss of efficiency measured by the mean-squared error in important aspects of kernel estimation, we propose a novel class of converging kernel estimators that have the "no-lose" properties including: (1) no efficiency loss from estimating the bandwidth as the optimal choice is universal; (2) no efficiency loss from ensuring positive-definiteness using a principle-driven aggregation technique; and (3) no efficiency loss asymptotically from potentially misspecified prewhitening models and transformations of the time series.

The estimator has a positive bias that diminishes with the sample size so that it is more conservative compared with the typically negatively biased classical estimators. The proposal improves upon all standard kernel functions and can be well generalized to the multivariate case. We discuss its performance through simulation results and two real-data applications including the forecast breakdown test and MCMC convergence diagnostics.

A Robust Instrumental Variable Estimation Method with Its Applications

LIN Yiqi
Year 4 PhD Student in Statistics
Principal Supervisor: Professor SONG Xinyuan

We discuss the fundamental issue of identification in linear instrumental variable (IV) models with unknown IV validity. We revisit the popular majority and plurality rules and show that no identification condition can be "if and only if" in general. With the assumption of the "sparsest rule", which is equivalent to the plurality rule but becomes operational in computation algorithms, we investigate and prove the advantages of non-convex penalized approaches over other IV estimators based on two-step selections, in terms of selection consistency and accommodation for individually weak IVs. Furthermore, we propose a surrogate sparsest penalty that aligns with the identification condition and provides oracle sparse structure simultaneously. Desirable theoretical properties are derived for the proposed estimator with weaker IV strength conditions compared to the previous literature. Finite sample properties are demonstrated using simulations. Further, empirical studies concerning the effect of trade on economic growth and effects with the effect of BMI on diastolic blood pressure.

Acknowledgement
This research is conducted in CUHK under supervisions of Prof. SONG Xinyuan (STAT, CUHK), Prof. FAN Qingliang (ECON, CUHK), and in University of Oxford under supervision of Prof. Frank WINDMEIJER (STAT, University of Oxford) and supported by PGS (CUHK/HKGOV), Overseas Research Award (STAT, CUHK) and Reaching Out Award (HKGOV).

Heterogeneous Oxidation of Sodium Methanesulfonate in a Chamber: Have We Underestimated Non-Sea-Salt Sulfate Production from the Ocean?

NG Sze In Madeleine
Year 3 PhD Student in Earth and Atmospheric Sciences
Principal Supervisor: Professor CHAN Man Nin

Dimethyl sulfide (DMS), produced by oceanic phytoplankton, is a primary source of sulfur in marine boundary layer (MBL). Methanesulfonic acid (CH_3SO_3H, MSA) is ubiquitous in marine and coastal aerosols, which predominantly originates from gas- and aqueous-phase oxidation of DMS. Atmospheric oxidation of DMS is also one of the several sources of non-sea-salt sulfate (nss-SO_4^{2-}) in aerosol particles. Taken together, the atmospheric concentration ratio of MSA to nss-SO_4^{2-} is often considered a proxy for marine biological activity, under the assumption that MSA is chemically stable in the atmosphere. However, such assumption has been challenged by experimentalists utilizing oxidation flow reactors (OFR) to probe chemical transformation of MSA *via* heterogeneous oxidation, indicating that MSA can be efficiently oxidized by hydroxyl radical (OH) at the gas-particle interface to yield nss-SO_4^{2-} and formaldehyde. In our study, we employ Kuopio Atmospheric Simulation Chamber (KASC) at 60 % relative humidity (RH) and 298 K to explore heterogeneous OH oxidation of sodium methanesulfonate (CH_3SO_3Na, NaMS), the sodium salt of MSA which is abundant in MBL. Unlike OFR used in precedent literature, our chamber allows for atmospherically relevant levels of reactants (i.e., OH and NaMS) and reaction time, and therefore provides a more accurate and time-resolved estimation of reaction kinetics. Composition and mass of aerosol particles are quantified by real-time techniques including aerosol mass spectrometer (AMS), extractive electrospray ionization mass spectrometer (EESI-MS), and scanning mobility particle sizer (SMPS). In parallel, a spot sampler collects particles for offline analysis by liquid chromatography-mass spectrometry (LCMS). Gas-phase species are monitored by a proton-transfer-reaction ionization mass spectrometer (PTR-MS).

Based on the pseudo first-order parent decay of NaMS agreed by AMS, EESI-MS, and LCMS, the reaction rate constant $k_{NaMS+OH}$ ranges in (0.97–1.19) x 10^{-12} cm^3 $molecule^{-1}$ s^{-1}, corresponding to atmospheric lifetime of only 6.48 to 7.93 days. Initial value of effective OH uptake coefficient (γ_{eff}) at 60 % RH was calculated to be 2.05 ± 0.5, corresponding to a significant (1145 % ± 256 %) increase with respect to those in literature. In light of the rapid decay determined by our chamber experiment, we speculate that heterogeneous oxidation is a substantial removal of NaMS (and MSA as well) in MBL, underlining that we may have underestimated the conversion of MSA to nss-SO_4^{2-} under strong photochemical activity. At present, this removal process is underrepresented in DMS oxidation scheme and global model, which adds large variability to the interpretation of ambient MSA to nss-SO_4^{2-} ratio. We highlight the need of future work to incorporate this removal process into DMS models, and to reconsider the robustness of MSA to nss-SO_4^{2-} ratio in quantifying marine biological activity across different latitudes.

Acknowledgement
This work (Project ID: C1-KASCs-2) is funded by the European Union's Horizon 2020 research and innovation programme through the ATMO-ACCESS Integrating Activity under grant agreement No. 101008004

Poster Presentation

Abstract

Poster No.	Graduate Division	Presenter	Presentation Title
SLS-01	Life Sciences	LUI Ying Lam	**Investigating the Mechanism of Cerebellar Ataxia: Roles of Yy1 in Purkinje Neuron Development**
SLS-02	Life Sciences	MA Wenlong	**Voltage-Dependent Anion Channels Are Required for Mitochondrial Recycling in *Arabidopsis***
SLS-03	Life Sciences	NGAI Hiu Lam	**Quality Assessment of Senecionis Scandentis Herba (Qianliguang) Using Multi-Methodological Approaches**
SLS-04	Life Sciences	TAI Jingxuan	**Pyrrolysine-Inspired Facile Macrocyclization of Proteins**
CHM-01	Chemistry	CHEUNG Ka Man	**Negatively Curved Molecular Nanocarbons Containing Multiple Heptagons Enabled by the Scholl Reactions of Macrocyclic Precursors**
CHM-02	Chemistry	GUAN Xin	**Non-Covalent Reconfigurable Microgel Colloidosomes with a Well-Defined Bilayer Shell**
PMA-01	Mathematics	CHEN Haiyu	**Regularity of Unipotent Elements in Total Positivity**
PMA-02	Mathematics	ZHANG Hao	**A Robust Non-Blind Deblurring Method Using Deep Denoiser Prior**
PHY-01	Physics	HUANG Junkun	**ROGer - Remote Observing from Greenland**
PHY-02	Physics	LIU Anna	**Gravitational-Wave Millilensing: A New Window to Study Dark Matter**
RMS-01	Risk Management Science	CHU Kai Pan	**A Non-Parametric Approach for Causal Inference in Time Series**
RMS-02	Risk Management Science	JIN Manting	**A Marked Hawkes Model of the Spread of COVID-19**
STA-01	Statistics	SU Di	**Variance Estimation of Spatial Autocorrelated Data under Non-Constant Mean**
STA-02	Statistics	ZHANG Wenyu	**iPoLNG - An Unsupervised Model for the Integrative Analysis of Single-Cell Multiomics Data**
EAS-01	Earth & Atmospheric Sciences	BARKAT Adnan	**Characteristics of Dynamic Earthquake Triggering at Axial Seamount**
EAS-02	Earth & Atmospheric Sciences	ZHENG Yiling	**Evaluating CMIP Model Simulations of the Indian Ocean Dipole - the Role of Monsoon Air-sea Feedback on Its Skewness**

Investigating the Mechanism of Cerebellar Ataxia Roles of Yy1 in Purkinje Neuron Development

LUI Ying Lam
Year 3 PhD Student in Cell and Molecular Biology
Principal Supervisor: Professor KWAN Kin Ming

Purkinje cell (PC), a sole output of the cerebellar cortex, serves as an integration centre in cerebellar networking with its remarkable and massive branched dendritic tree allowing it to integrate a large amount of information for motor coordination and learning processes. Even though PC is a critical part of cerebella circuits, the molecular mechanisms and intrinsic factors regarding its dendrite development are still limited. Here we show that the genetic ablation of *Yy1* in postnatal PC results in cerebellar ataxia phenotype with progressive cerebellar atrophy. The significantly defective PC dendritogenesis in mutant mice causes the weakening of synaptic plasticity and PKCγ expression. Wnt10b, which is a specific activator of the Wnt/β-catenin pathway and expresses particularly in postnatal PC, shows lower transcriptional and translational expression in ataxic mutants. Down-regulation of *Wnt10b* leads to more inactive Gsk3β and lower the β-catenin level without significant transcriptional regulation of Wnt target genes in ataxic mutants. Surprisingly, knocking down *Wnt10b* causes PC retarded dendritogenesis and failure of PKCγ homeostasis, thereby impairing synaptic plasticity. Our current results suggest that Yy1 may regulate *Wnt10b* to control postnatal PC development with a critical role in dendritogenesis.

Voltage-Dependent Anion Channels Are Required for Mitochondrial Recycling in *Arabidopsis*

MA Wenlong
Year 4 PhD Student in Cell and Molecular Biology
Principal Supervisor: Professor KANG Byung Ho

The mitochondrion is an essential organelle in eukaryotes, mediating cellular respiration and intracellular signalling pathways. To maintain a healthy mitochondrial population, dysfunctional and surplus mitochondria are removed through several mechanisms, including mitophagy. Mitophagy is a kind of selective autophagy in which damaged mitochondria are captured by a double membrane structure named autophagosome. Then, the autophagosome delivers its cargo to the lysosome or vacuole for degradation. Autophagy is a highly elaborate "self-eating" process carried out by a series of autophagy-related (ATG) proteins.

In recent decades, many ATG proteins have been identified and their functions in mitophagy have been characterized by studies of yeast and mammalian cells. Although the core autophagy machinery is conserved in plants, the molecular mechanisms of plant mitophagy have not been understood. Moreover, mitophagy receptors in yeast and mammalian cells are not conserved in plant cells.

Recently, our lab demonstrated that depolarized mitochondria after incubation with uncouplers, such as DNP, are recycled by mitophagy in *Arabidopsis*. In fluorescence and electron micrographs of uncoupler-treated cells, we observed aberrant mitochondria selectively enclosed by mitophagosomes. This DNP-induced system provides an experimentally manipulative platform to investigate and monitor the mitophagy process in live plant cells. My research goal is to explore how depolarized mitochondria are recognized and captured by mitophagosomes in plant cells using the uncoupler-induced mitophagy system.

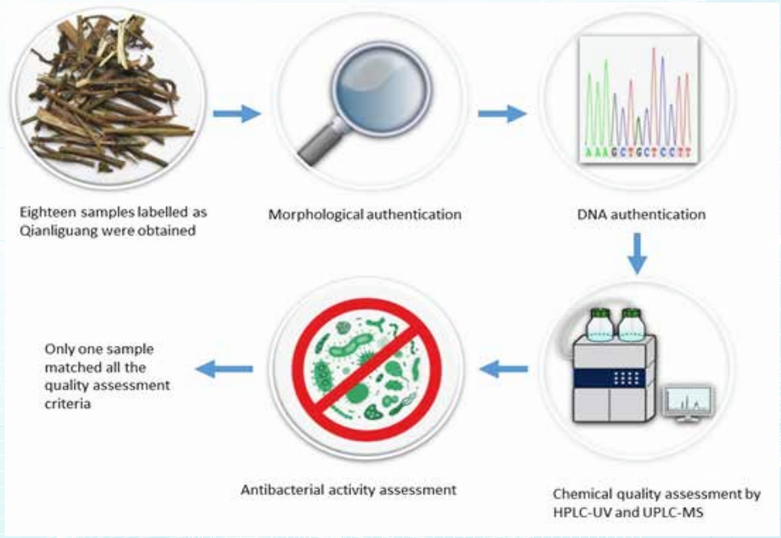
To identify critical regulators in plant mitophagy, we employed YFP-fused ATG8, an autophagy marker, as bait for performing the immunoprecipitation-mass spectrum (IP-MS) assay. Voltage-dependent anion channels (VDACs), a group of proteins abundant in the outer mitochondrial membrane, were enriched in the ATG8-interactome in a DNP-dependent manner. The *Arabidopsis* genome encodes several *VDAC* paralogs, and some VDAC co-immunoprecipitated with YFP-ATG8e after mitochondria depolarization. Protein-protein interaction assays indicated that VDACs interacted with ATG8 directly. Confocal microscopy and transmission electron microscopy images revealed that damaged mitochondria accumulated in *Arabidopsis* cells, and mitophagy was affected in mutants of *VDAC* paralogs. These data provide evidence that VDACs are involved in the autophagic recycling of damaged mitochondria in *Arabidopsis*.

Our results identify VDACs as direct interacting partners of ATG8 after mitochondria depolarization. We showed that VDACs contribute to plant mitophagy, probably as receptors on the mitochondrial outer membrane. It is expected that the critical components of plant mitophagy could be uncovered by analysing the interaction network of VDAC.

Quality Assessment of Senecionis Scandentis Herba (Qianliguang) Using Multi-Methodological Approaches

NGAI Hiu Lam
Year 3 PhD Student in Biochemistry
Principal Supervisor: Professor SHAW Pang Chui

With excellent doctors but poor herb quality, treatment effectiveness is compromised. Adverse incidences caused by substituted or substandard medicinal herbs have been reported in Hong Kong from time to time. We hypothesize the quality of herbs in Hong Kong varies and we select Qianliguang (Senecionis scandentis Herba) as a target of quality assessment by employing a multi-methodological approach. The methods employed include morphological identification, chemical assessment, and bioassay. Qianliguang has antibacterial properties. However, it is poisonous and overconsumption can result in liver damage. Eighteen Qianliguang samples were purchased from herbal shops at various districts in Hong Kong. Samples were first authenticated organoleptically. DNA barcoding at the *psbA-trnH, ITS2,* and *rbcL* loci was then conducted to confirm the species. HPLC-UV was performed to screen for the presence of the chemical compounds and to quantify the flavonoid hyperoside. UPLC-MS was used to quantify the amount of the toxic pyrrolizidine alkaloid (PA) adonifoline. Microdilution assay was performed to show the antibacterial effect on *Streptococcus aureus* and *S. pneumoniae*. Results showed that half of the samples were either adulterated or mixed with other species, and these samples did not contain enough hyperoside to meet the standard requirement. The authentic samples had adonifoline that exceeded the toxicity limit. The antibacterial effects of adulterated samples were not detectable. Our study illustrated the necessity of using a multi-methodological approach for herbal medicine quality assessment. We also showed that Qianliguang samples in the Hong Kong market were either toxic or adulterated. Our investigation evidenced current malpractices in the supply chain. It is therefore essential to improve the quality control of Qianliguang and probably other herbs in the herbal market.

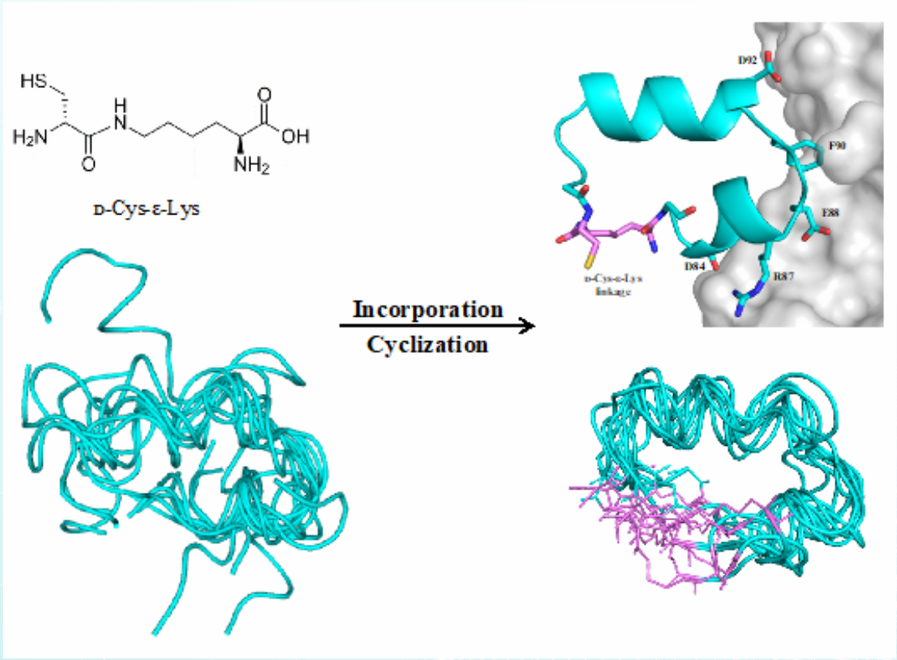


Pyrrolysine-Inspired Facile Macrocyclization of Proteins

TAI Jingxuan
Year 6 PhD Student in Biochemistry
Principal Supervisor: Professor CHAN Michael Kenneth

Protein therapeutics have been widely adopted in clinical treatment of many diseases in recent years, but there are still concerns about their stability *in vivo*. One powerful solution to overcome this challenge is protein cyclization. Cyclic proteins are reported to possess not only higher stability, but also greater binding affinity because of their conformational rigidity. Several chemical and biological methods have been developed for cyclizing different peptide targets, but are limited in either efficiency, chemoselectivity, availability, or the length to be cyclized. Thus, better cyclization methods are desired to fit diverse protein targets.

In this study, we describe a scalable and robust system based on a noncanonical amino acid coupled to the pyrrolysine translational machinery for the generation of lasso-grafted proteins. The noncanonical amino acid D-Cys-ε-Lys is genetically incorporated into proteins with high efficiency mediated by an evolved PylRS/tRNA^{Pyl} pair. This system is then applied to the structurally-inspired cyclization of a 23-mer therapeutic P16 peptide engrafted on a fusion protein, resulting in near-complete cyclization of the target cyclic subunit in under three hours. The resulting cyclic P16 peptide fusion protein possessed much higher CDK4 binding affinity than its linear counterpart. Furthermore, a bifunctional bicyclic protein harbouring a cyclic cancer cell targeting RGD motif on one end and the cyclic P16 peptide on the other is produced and shown to be a potent cell cycle arrestor with improved serum stability.



Negatively Curved Molecular Nanocarbons Containing Multiple Heptagons Enabled by the Scholl Reactions of Macrocyclic Precursors

CHEUNG Ka Man
Year 3 PhD Student in Chemistry
Principal Supervisor: Professor MIAO Qian

Embedding heptagons in polycyclic aromatic frameworks gives rise to three-dimensional molecular nanocarbons with negative curvature, which are not only key fragments of long-sought-after carbon schwarzites but also bring new opportunities to explore unprecedented nanocarbons with interesting properties. This study demonstrates the Scholl reactions of macrocyclic precursors as a general strategy for synthesizing negatively curved molecular nanocarbons containing different numbers of heptagons. The π-backbones containing multiple heptagons are significantly curved and rigid, as revealed by density functional theory calculations and X-ray crystallography. Some of these negatively curved π-backbones are interlocked through both face-to-face and edge-to-face π-π interactions in the crystals. Such unusual π-π interactions have enabled a p-type organic semiconductor although its hole mobility in the field effect transistors is limited by the amorphous nature of the vacuum-deposited films.

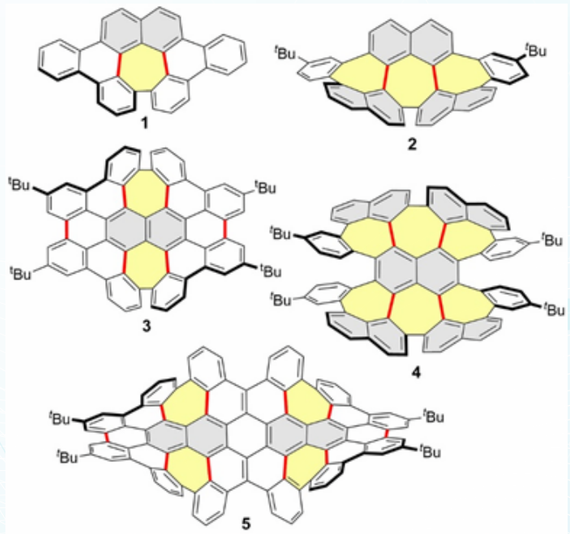


Figure 1 Negatively curved polycyclic arenes **1–5**, where the naphthalene units are highlighted in light grey, and the heptagons and the C–C bonds formed by Scholl reactions are highlighted in light yellow and shown with red bold lines, respectively.

Acknowledgement
We are grateful to the Research Grants Council of Hong Kong (GRF 14300721) for financial support for this work.

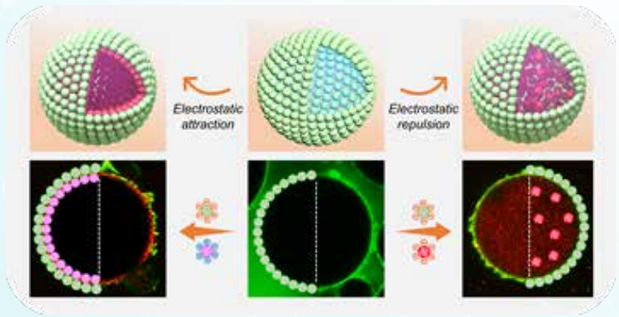
Non-Covalent Reconfigurable Microgel Colloidosomes with a Well-Defined Bilayer Shell

GUAN Xin
Year 4 PhD Student in Chemistry
Principal Supervisor: Professor NGAI To

Microgels have been successfully used to stabilize emulsion droplets. Compared to conventional rigid particles, the use of microgels as stabilizers offers several distinct advantages: (1) being soft and deformable, the deformability of microgels makes it possible to achieve larger interfacial loading, alter the interfacial tension and the interfacial rheological properties; (2) being responsive, microgels allow one to prepare stimuli-responsive emulsions, which is especially desirable in industrial and emerging applications.

Whilst soft microgels have been demonstrated as being extremely interesting stabilizers for emulsions, previous studies mainly focused on the preparation of oil-in-water (O/W) emulsions due to their intrinsic hydrophilicity and thus initially dispersed in water. Very few studies have reported on the preparation of water-in-oil (W/O) emulsions using microgels as the sole emulsifier. In addition, there have been no attempts to control over microgel-assembled structure at the interface, thus limiting our ability to exploit particle monolayers or bilayers more broadly in advanced materials applications. On the other hand, the rheological properties of colloidal bilayers from soft particles self-assembled at interfaces to resulting emulsion characteristics, have not been explored yet.

In this work, we show that octanol-swollen poly(N-isopropylacrylamide)-based microgels can rapidly diffuse from the oil phase onto the water droplet surface, facilitating the formation of stable inverse W/O Pickering emulsions with an elastic microgel monolayer. We elucidate the stabilization mechanism of inverse emulsions and the adsorption kinetic of microgels through experiments and molecular dynamics (MD) simulation. More importantly, these emulsions can be used as templates to produce microgel colloidosomes, herein termed 'microgelsomes', with semipermeable and stimulus-responsive shells that can be fine-tuned from a microgel monolayer to a well-defined bilayer via non-covalent interaction. The microgelsomes can then be used to encapsulate and/or anchor nanoparticles, proteins, vitamin C, bio-based nanocrystals or enzymes. Moreover, the programmed release of these substances can be achieved by using ethanol as a trigger to mediate the shell permeability. Thus, these reconfigurable microgelsomes with a microgel-bilayer shell can respond to external stimuli and demonstrate tailored properties, which have potential applications for heterogeneous catalysis and shed light on the rational design of microreactors and protocell model systems.



Acknowledgements
The authors gratefully acknowledge the financial support from the Hong Kong Special Administration Region (HKSAR) General Research Fund (CUHK14304619, 2130642), the Direct Grant (CUHK4053449), and the Impact Postdoctoral Fellowship Scheme of The Chinese University of Hong Kong.

Regularity of Unipotent Elements in Total Positivity

CHEN Haiyu
Year 3 PhD Student in Mathematics
Principal Supervisor: Professor HE Xuhua

A totally non-negative matrix is a square matrix over real numbers such that all minors are non-negative, i.e., determinants of the square submatrices are all non-negative. One naturally considers if such matrices have similar algebraic properties such as Jordan normal form as the usual matrices on a field. The theory of total positivity is the study of reductive groups over semifield, as a vast generalization of the totally non-negative matrices. He and Lusztig initiated the study of Jordan decomposition of reductive groups over positive real numbers in 2022. For this goal one needs a conjecture stating that every unipotent element of the totally positive part $G_\geq 0$ of a reductive group G is regular in some Levi subgroup of some parabolic subgroup of G. Our work shows that this conjecture is true.

This is the joint work with Mr. XIE Kaitao.

A Robust Non-Blind Deblurring Method Using Deep Denoiser Prior

ZHANG Hao
Year 4 PhD Student in Mathematics
Principal Supervisor: Professor ZENG Tieyong

Blurring will inevitably occur in camera shots. Single image deconvolution has long been a very challenging task and mathematically ill-posed. The existing non-blind deblurring methods are mostly susceptible to noise in the given blurring kernel, which is usually estimated from the observed image. This will produce undesirable ringing artifacts around the recovered edges when the given kernel is not accurate enough. Besides, the noise and outliers in the observed images may also severely degrade the performance of the deblurring methods. Considering these factors, we designed a robust non-blind deblurring method taking all these noises into account. In this work, we propose a kernel error term to rectify the given kernel in the midst of the deconvolution process. A residual error term is also introduced to deal with the outliers caused by noise or saturation. A deep learning denoiser prior is adopted to reserve the fine textures in the recovered image. The experiments show clearly that the proposed method achieves remarkable progress in both the visual quality and the numerical results of the recovered images compared to the state-of-the-art deblurring methods. Extensive results illustrate that the proposed method is also effective for real-world image deblurring applications.

ROGer – Remote Observing from Greenland

HUANG Junkun
Year 1 PhD Student in Physics
Principal Supervisor: Professor LI Huabai

It is shown that magnetic field plays an important role in star formation, but the exact relationship is yet to be proven. One method to observe the magnetic field is to observe the submillimeter dust emission in a molecular cloud since the magnetic field and dust emission polarization are highly correlated.

In reality, observational astronomy involves a constant battle with atmospheric conditions. For submillimeter observations, the situation is more difficult, because water vapour absorbs and emits submillimeter radiation very efficiently. Our observation of magnetic field morphologies in molecular clouds depends on tiny polarization fraction in submillimeter radiation, therefore is even more challenging. A state-of-the-art submillimeter polarimeter removes unpolarized sky noise by taking the difference between two orthogonal polarizations. Detection of orthogonal polarizations is either done by different detectors at the same time or by the same detector at different times. However, none of these methods can completely remove sky noise, since the sky noise changes frequently, and different detectors have different sensitivities.

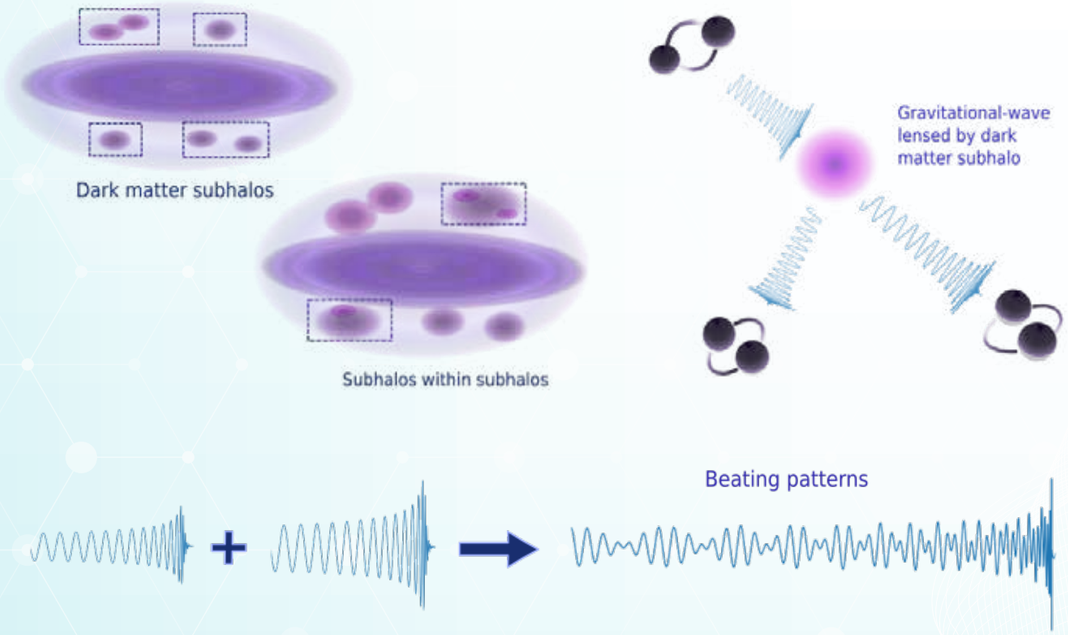
Currently, I am building a Martin-Puplett Interferometer (MPI) to observe the polarized signal. By this specially designed submillimeter polarimeter, the unpolarized noise is canceled due to destructive interference, whereas the polarized signal is reserved and recorded by our detector. The orthogonal polarizations are determined by the same detector at the same time, hence the noise is canceled more effectively. After proving the concept in the laboratory, this method will be applied to the Greenland Telescope Camera, named “ROGer”, currently under construction in CUHK.

Acknowledgement
This project is supported by HK Research Grants Council CRF C4012-20EF and CUHK Group Research Scheme 2020-21.

Gravitational-Wave Millilensing: A New Window to Study Dark Matter

LIU Anna
Year 2 PhD Student in Physics
Principal Supervisor: Professor LI Guang Feng Tjonnie

Gravitational waves will bring forth an altogether new way to probe millilensing, which may allow us to probe the existence of dark matter substructures, and ultimately shed light on the nature of dark matter. Theoretically predicted dark matter objects, such as small subhalos and primordial black holes, can act as millilenses and introduce beating patterns in gravitational waves - if they exist. While millilensing has been investigated more traditionally in the electromagnetic band, gravitational waves present a new complementary approach to millilensing. Here we show that should millilensing signatures appear in the observed gravitational waves, current-generation gravitational-wave detectors are not only able to detect them, but also reveal the astrophysical nature of the lens. Furthermore, we discuss the advantages of using gravitational waves to probe millilensing.



A Non-Parametric Approach for Causal Inference in Time Series

CHU Kai Pan
Year 2 MPhil Student in Risk Management Science
Principal Supervisor: Professor CHAN Kin Wai

This paper addresses the problem of estimating the treatment effect of an action on a time series. The causality is understood in a modified Rubin's framework of potential outcomes. The variance estimator is non-trivial in the sense that the standard estimator for asymptotic variance in time series fails to be consistent in the situation of causal inference. Some existing hypothesis testing procedure for drawing causal inference has been shown to be too conservative in many situations, especially when the mean of the series is far away from zero.

In the poster presentation, we give a precise definition for various types of treatment effects. A fully non-parametric setting is considered. For the time-average effect, we propose a Horvitz-Thompson type estimator and derive a consistent estimator for its variance. The powerfulness of the test based on our proposed estimators is guaranteed without making any parametric or time-independent assumption. We also propose a Nadaraya-Watson type estimator and provide a bootstrap-type simultaneous confidence band procedure for the time-varying effect. Some non-trivial examples are discussed with detailed theoretical results. Monte Carlo experiments are included to demonstrate the finite-sample performance of our proposal.

A Marked Hawkes Model of the Spread of COVID-19

JIN Manting
Year 2 MPhil Student in Risk Management Science
Principal Supervisor: Professor YAU Chun Yip

Self-exciting point process models are often used in seismology and finance to model the events clustered in time or space. A well-known form of such models is the Hawkes process, which is characterized by allowing all past events to affect the intensity of the current time. Inspired by this feature, we show that the Hawkes process is well suited for epidemiology and apply a marked Hawkes model to the spread of COVID-19 in Brazil. Compared to the traditional compartmental models, our proposed model incorporates virus-related information on individual infections by using the Cycle threshold (Ct) value to estimate the dynamic reproduction number of each reported case. We show that the model is competitive with several models used to forecast the pandemic and investigate how Ct values help in the prediction.

Variance Estimation of Spatial Autocorrelated Data under Non-Constant Mean

SU Di
Year 2 MPhil Student in Statistics
Principal Supervisor: Professor CHAN Kin Wai

We provide a unified framework for the difference-based estimator of long-run variance for spatial stationary process. The proposed estimator is robust to both non-constant mean function and autocorrelation structure. No estimation of the mean function nor regression is required. When there is dependency in the spatial data, we prove that the optimal sequences are different from the optimal sequences under only non-constant mean, and we provide the numerical values of new optimal differencing sequences. We give its convergence rate and demonstrate its performance through simulation studies. An R package daves is available for its implementation.

iPoLNG - An Unsupervised Model for the Integrative Analysis of Single-Cell Multiomics Data

ZHANG Wenyu
Year 4 PhD Student in Statistics
Principal Supervisor: Professor LIN Zhixiang

Single-cell multiomics technologies, where the transcriptomic and epigenomic profiles are simultaneously measured in the same set of single cells, pose significant challenges for effective integrative analysis.

In this work, we propose an unsupervised generative model, iPoLNG, for the effective and scalable integration of single-cell multiomics data, where transcriptomic and epigenomic (chromatin accessibility or histone modifications) data were obtained from the same cell. iPoLNG reconstructs low-dimensional representations of the cells and features using computationally efficient stochastic variational inference by modelling the discrete counts in single-cell multiomics data with latent factors.

From a biological perspective, iPoLNG infers two kinds of low-dimensional representations of the high-dimensional single-cell multiomics data: one cell by factor loading matrix and two feature by factor loading matrices. The cell by factor loading matrix can identify distinct cell types and improve clustering accuracy compared to other models that reconstruct the latent space of cells, and the feature by factor loading matrices can characterize cell-type specific markers and facilitate gene ontology (GO) enrichment analysis.

From a technical perspective, iPoLNG presents several advantages. First, it directly models the unique molecular identifiers (UMIs) of single-cell multiomics data and takes into account the sequencing depths of cells, which suggests the discrete counts without any normalization procedure can directly serve as the input of the model. Second, as a scalable algorithm, stochastic variational inference with GPU acceleration in iPoLNG potentially enables the computation of large-scale single-cell datasets with a considerably high speed. It takes less than 15 minutes to implement on datasets with 20,000 cells. Third, the hyperparameters that control the levels of noise across different data modalities in iPoLNG are automatically learned by fitting a simple model to individual data modality, which saves the efforts to tune these hyperparameters.

Acknowledgement
This work was supported by The Chinese University of Hong Kong startup grant (4930181), The Chinese University of Hong Kong Science Faculty's Collaborative Research Impact Matching Scheme (CRIMS 4620033), and Hong Kong Research Grants Council (ECS 24301419, GRF 14301120).

Characteristics of Dynamic Earthquake Triggering at Axial Seamount

BARKAT Adnan
Year 3 PhD Student in Earth and Atmospheric Sciences
Principal Supervisor: Professor TAN Yen Joe

Axial Seamount is an active submarine volcano located at the intersection of the Juan de Fuca ridge and the Cobb hotspot in the northeast Pacific Ocean. A cabled network of seismic and geodetic instruments was established on Axial Seamount in 2014 and has since recorded >150,000 local earthquakes and an eruption in April 2015, making it a unique setting to analyse how seismicity at a submarine volcanic system respond to dynamic stress perturbations. Using a high-resolution micro-seismicity catalogue, we quantify how the seismicity rate and inter-event times at Axial Seamount change in response to the passage of seismic waves from 126 large remote earthquakes. We observe statistically significant episodes of dynamic triggering for around 11% of the global earthquakes, including instances of both instant ($0 < t < 2$ *hr*; t is the p-wave arrival time) and delayed triggering ($2 < t < 24$ *hr*). Initial results do not show strong dependence of triggering strength on the peak ground velocity of teleseismic seismic waves, though the triggering rate for M>8 events is significantly higher. In addition, triggering susceptibility at Axial Seamount appears to vary through its eruption cycle. We will further present results on how triggering relates to stress field orientation, frequency content, duration and changes in permeability using vent field temperature record. Our findings provide useful insights into the physical mechanisms controlling the dynamic earthquake triggering at submarine volcanic environments.

Keywords: Remote triggering, Seismicity rate change, Volcanic inflation, Axial Seamount

Evaluating CMIP Model Simulations of the Indian Ocean Dipole - The Role of Monsoon Air-Sea Feedback on Its Skewness

ZHENG Yiling
Year 2 PhD Student in Earth and Atmospheric Sciences
Principal Supervisor: Professor TAM Chi Yung Francis

The Indian Ocean Dipole (IOD) is the dominant mode of interannual variability in the tropical Indian Ocean, characterized by surface cooling (warming) of the eastern Indian Ocean in its positive (negative) phase. Observed IOD events exhibit distinct amplitude asymmetry in relation to negative nonlinear dynamic heating (NDH) and asymmetric thermal damping. NDH is associated with the asymmetric nonlinear temperature advection and sea surface temperature (SST) response to thermocline changes. The thermal damping is caused by the cloud-radiation-SST feedback, which develops minor additional damping after cold SST anomaly leading to a cloud-free condition. In CMIP5, nearly all models simulate less-skewed IOD compared to the observed. On the other hand, for CMIP6, 6 out of 20 models show realistic skewness.

Further examination reveals that the improvement of IOD skewness in CMIP6 over CMIP5 can be attributed to the former's improved model mean states, particularly the western tropical Indian Ocean (WTIO) SST. Analyses of "less skewed models" indicate that when background SST in WTIO exceeds the SST for maximum precipitation sensitivity, the convective response to SST becomes asymmetric, leading to less zonal wind response and weaker zonal nonlinear advection during positive IOD. The warm SST bias in turn is associated with the weaker Indian summer monsoon. Additionally, ocean stratification also influences the IOD skewness: stronger stratification can lead to larger nonlinear SST response to thermocline changes; this is due to larger vertical temperature gradient resulting in larger nonlinear vertical advection. Our findings imply that substantial efforts should be made in reducing the Indian summer monsoon bias as well as advancing the upper-ocean stratification in the eastern Indian Ocean, for properly representing IOD in Earth System Models.

香港中文大學
The Chinese University of Hong Kong

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