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

2020-21 Science Faculty Postgraduate Research Day

8 JAN 2021

Empowers Your Dreams

PROGRAMME

AM Session

09:15 – 09:30	**Opening Remarks by Dean & Souvenir Presentation** *Professor SONG Chunshan* *Dean of Science*
09:30 – 09:50	**The Pollen Tube Tip-Vesicles** *LIU Zhiqi* *Year 3 PhD Student in Cell and Molecular Biology*
09:50 – 10:10	**Studying the Functional Link between Cerebellum and Autism in a Preclinical Autism Mouse Model** *MA Sum Yi* *Year 4 PhD Student in Cell and Molecular Biology*
10:10 – 10:30	**The Histone Modification H3k4me3 Marks Functional Genes in Soybean Nodules** *WANG Qianwen* *Year 6 PhD Student in Molecular Biotechnology*
10:30 – 10:50	**Dissecting the Pathogenic Mechanisms of Spinocerebellar Ataxia Induced by *CCDC88C* Mutations in Mice** *YANG Huan* *Year 2 PhD Student in Biochemistry*
10:50 – 11:00	**Break**
11:00 – 11:20	**Simulating Physics at the Extremes: The Birth and Behaviour of Compact Objects** *CHEONG Chi Kit* *Year 4 PhD Student in Physics*
11:20 – 11:40	**Cosmos Compasses – How to Read Them and What Have We Learned** *GU Qilao* *Year 5 PhD Student in Physics*

PM Session

12:55 – 13:00	**Introduction**
13:00 – 13:20	**Catalytic Artificial Organelles, Multi-Enzyme Assemblies for Terpene Biosynthesis** *WEI Qixin* *Year 4 PhD Student in Chemistry*
13:20 – 13:40	**Synthesis and Reactivity of Tantalum Alkyne Complexes Supported by Linked Cyclopentadienyl-Carboranyl Ligand** *YANG Jingting* *Year 5 PhD Student in Chemistry*
13:40 – 14:00	**A Fast and Stable Direct Sampling Method for Computerized Tomography** *HAN Fuqun* *Year 1 PhD Student in Mathematics*
14:00 – 14:20	**Weak Galerkin Method for Electrical Impedance Tomography** *LIANG Ying* *Year 5 PhD Student in Mathematics*
14:20 – 14:40	**Break**
14:40 – 15:00	**Interquantile Smoothness in Censored Quantile Regressions** *CAI Zexi* *Year 2 MPhil Student in Risk Management Science*
15:00 – 15:20	**Bayesian Causal Mediation Analysis with Latent Mediators and Survival Outcome** *SUN Rongqian* *Year 2 PhD Student in Statistics*
15:20 – 15:40	**Oxidation of Organosulfates at the Aerosol Surface: A Missing Source of Atmospheric Aerosol Sulfate** *XU Rongshuang* *Year 3 PhD Student in Earth & Atmospheric Sciences*
15:40 – 16:00	**The Frictional Strength on Faults: A Critical Factor in Controlling Earthquake Occurrence** *YAO Suli* *Year 4 PhD Student in Earth & Atmospheric Sciences*
16:00	**Closing Remarks** *Professor SONG Chunshan* *Dean of Science*

Welcome Message from the Dean of Science

I am pleased to welcome all of you to the First Science Faculty Postgraduate Research Day.

Conducting original research is a very important part of postgraduate education in a world-class university. With the Faculty's mission of educating and inspiring the next generation of scientific innovators and leaders, we greatly value research in postgraduate education as young researchers represent the future of scientific innovation and the world's sustainable development. The world-class research environment with excellent academic atmosphere and cutting-edge research in the Science Faculty enable our postgraduate students work together with leading scientists to contribute to the advancement of knowledge and addressing the global challenges. Apart from gaining in-depth expertise in their area of research under the supervision of our leading scholars, the critical thinking and creative thinking involved in first-class research will help to advance the thinking skills and intellectual capabilities of our postgraduate students. The research education also helps expand students' horizon on how impactful research contributes to the advance in science and technology and the development of the society.

Riding on the great success in the Science Faculty Research Day 2020 organised online in August 2020 amidst the COVID-19 pandemic, we hold the first Postgraduate Research Day where postgraduates in the Faculty can share their research ideas with professors and fellow students. The event offers an excellent opportunity for our postgraduates to gain exposure in a scientific meeting, to showcase their original research work and to network with our research staff members and students.

We are very pleased to have 14 excellent young researchers selected from different units this year. We hope the symposium could bring scientists who are in their early research career together to showcase their significant progress in advancing multidiscipline science as well as explore and articulate the impact of their research. This event builds a supportive environment favourable for networking and knowledge exchange among young researchers, and to think about how explicitly engaging with impactful research can benefit their future careers in both academia and public engagement. We also hope this event will bring greater awareness for the importance of, and facilitates the learning of the soft skills of postgraduate students in communication and presentation.

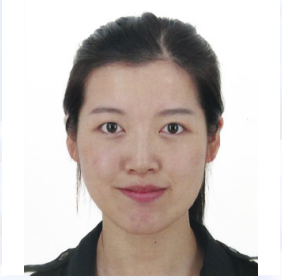
I wish all of you a great time on the Postgraduate Research Day and continued success in your research endeavours!

Yours sincerely,

SONG Chunshan

The Pollen Tube Tip-Vesicles

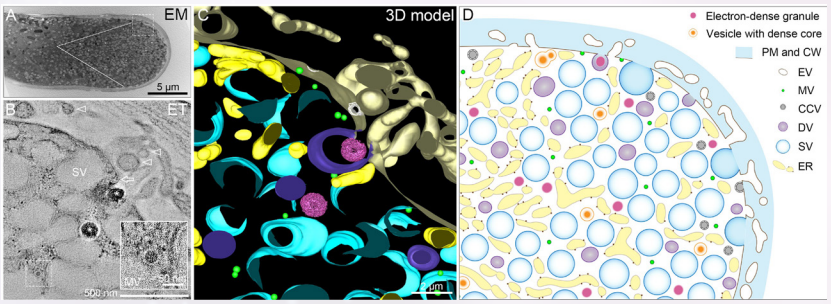
LIU Zhiqi
Year 3 PhD Student in Cell and Molecular Biology
Supervisor: Professor JIANG Liwen



Flowering plants life cycle starts from zygote formed by a fertilization event. Upon acceptance, pollen grain undergoes hydration and germination into the stigma, delivering male reproductive cells to their female counterpart in embryo sac by a vigorously growing pollen tube. Such hustling polarity growth is featured by abundant vesicles responsible for both exocytosis and endocytosis in the tip region of the pollen tube. However, the nature, identity and specific function of these highly dynamic tip-vesicles remain largely elusive in plants.

We have recently developed and used whole-cell electron tomography (ET) with nanometer resolution in 3D to study organelle biogenesis and relationship (e.g. autophagosome, multivesicular body and vacuole) in plant cells. More recently, we have also provided proof-of-concept evidence of developing the Cryo-FIB (Focus Ion Beam) and Cryo-ET tools for identifying transport vesicles in pollen tubes.

We hypothesize that the Tip-Vesicles (TVs) of pollen tubes contain multiple populations with distinct functions in plants. We thus aim to study the nature, identity and specific function of TVs as well as their underlying mechanisms using our newly established cutting-edge techniques (e.g. 3D TEM and Cryo-FIB/Cryo-ET) in combination with our well-established molecular, cellular, biochemical and genetic approaches. First, we will build the first whole-cell 3D ET and Cryo-ET maps of apical pollen tips for subsequent analysis and identification of transport vesicles or TVs in their native state. Second, we will test and develop protocols to purify TVs from pollen tubes for their subsequent verification and characterization by immune-negative staining TEM and cryo-ET analysis. Third, we will perform proteomic analysis on purified TVs via tandem mass spectrum analysis for protein identification and subsequent characterization of selective candidates. Our preliminary high-resolution ET maps of lily pollen tube tips (figure) showed that the TVs contain different populations according to their morphology, content and size. In addition, fusion profiles with the plasma membrane (PM) implying exocytosis or endocytosis were also observed, thus supporting our hypothesis. This study will provide new insights about the nature and functions of TVs in plants.

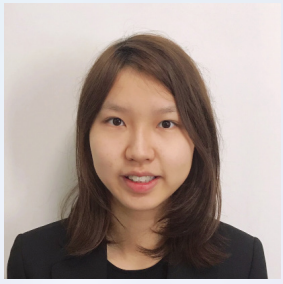


ACKNOWLEGEMENTS

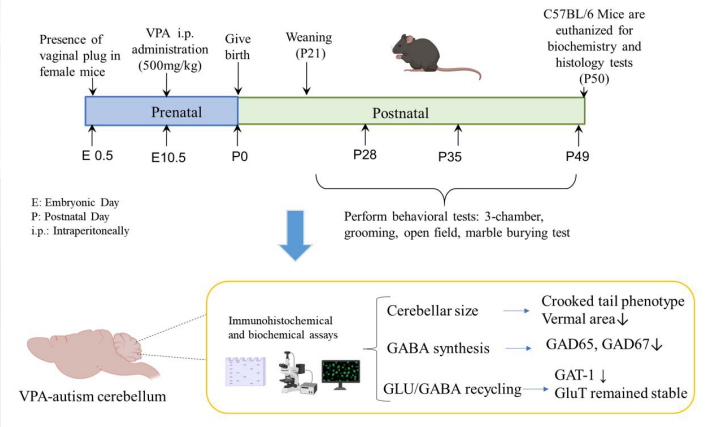
This work was supported by grants from the National Natural Science Foundation of China, the Research Grants Council of Hong Kong and CUHK Research Committee to L. Jiang.

Studying the Link between Cerebellum and Autism in a Pre-clinical Autism Mouse Model

MA Sum Yi
Year 4 PhD Student in Cell and Molecular Biology
Supervisor: Professor KWAN Kin Ming

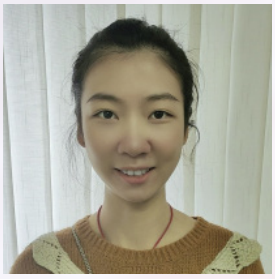


Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder which is characterized by social communication deficit and repetitive behaviour. In the past few years, increasing clinical evidence showed that the cerebellum may contribute to ASD. Although some have suggested the possibility of change of glutamate decarboxylase in the cerebellum, the argument remains controversial and is limited to the alteration in transcriptional level. This study aimed to investigate the cerebellar structure and determine the expression of rate-limiting GABAergic decarboxylases and transporters in GABA signalling of the autism cerebellum. The risk of births diagnosing with ASD was significantly increased by in utero exposure to an antiepileptic drug, valproic acid (VPA). Furthermore, rodents prenatally exposed to this drug display behavioural phenotypes characteristics of the human condition. In this study, pregnant C57BL/6 mice were intraperitoneally injected with a dosage of 500 mg/kg VPA on embryonic day 10.5 for autistic behavioural induction. The results showed that prenatal exposure of VPA may lead to crooked tail defect, a reduced cerebellar size and white matter area during adolescence. For mouse models with autistic behaviour, they showed reduced cerebellar GAD65, GAD67 and GAT-1 protein expression in both immunoprotein and immunofluorescence assays. GAD65 and GAD67, the two major enzymes to be responsible for GABA production, were found downregulated at the molecular layer and Purkinje cell layer of the cerebellum, respectively. GAT-1 was reduced at the areas nearby the Purkinje cells indicating the GABA recycling at the presynaptic compartments of the cerebellum was affected. Our findings reveal the potential of the cerebellum to be an etiology of environmentally induced autism. The changes in cerebellar structure and altered GABA signalling pathway provide targets for future clinical studies.



The Histone Modification H3K4me3 Marks Functional Genes in Soybean Nodules

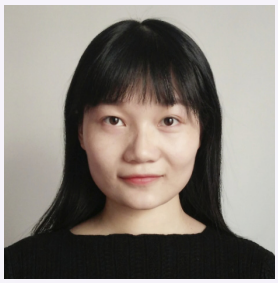
WANG Qianwen
Year 6 PhD Student in Molecular Biotechnology
Supervisor: Professor LAM Hon-Ming



Soybean could develop the specialized organs called root nodules for symbiotic nitrogen fixation. Studies showed that developmental processes are regulated by epigenetic marks such as histone H3 lysine 4 trimethylation (H3K4me3). Here we characterized the high-confidence transcriptomic data and genome-wide patterns of H3K4me3 marks in soybean roots and mature nodules symbiotic with *Sinorhizobium fredii*. As expected, changes in H3K4me3 levels were positively associated with the transcription levels of functional genes in the nodules. The up-regulation of H3K4me3 levels was not only present in leghaemoglobin and nodulin-related genes, but also in most of the genes involved in nitrogen and carbon metabolic pathways. On the contrary, a loss of H3K4me3 marks was found in several key transcription factor genes, including four *GmWRKYs*, and was correlated with the down-regulation of the defence-related network in nodules. Hence we have uncovered a regulatory network that could contribute to nodule maintenance. In addition, genes regulating the transmembrane transport of metal ions, phosphates, sulphates, peptides, and sugars were differentially modified with H3K4me3, revealing the complex regulation of transmembrane transportation during symbiosis. All these findings demonstrate massive reprogramming of gene expressions via alterations in H3K4me3 levels in the genes in mature soybean nodules, thus supporting the role of H3K4me3 in maintaining nodule functions.

Dissecting the Pathogenic Mechanisms of Spinocerebellar Ataxia Induced by *CCDC88C* Mutations in Mice

YANG Huan
Year 2 PhD Student in Biochemistry
Supervisor: Professor CHAN Ho Yin Edwin



Spinocerebellar ataxias (SCAs) are a group of heterogeneous cerebellar dominant disorders which cause adult-onset progressive deterioration of the cerebellum in the brain. The cerebellum controls locomotor control and speech, SCA patients present ataxic symptoms, including problems with coordination and balance, poor hand-eye coordination and abnormal speech. Our group identified novel mutations in the *Coiled-Coil Domain Containing 88C (CCDC88C)* gene which cause SCA type 40 (SCA40). We previously showed that the *CCDC88C* p.R464H and p.D43N mutations induce hyperphosphorylation of c-Jun N-terminal kinase (JNK), which leads to caspase-3 activation. However, the detailed pathogenic mechanisms of disease progression have yet been elucidated. In order to explore the pathogenic mechanisms involved in SCA40, two lines of *Ccdc88c* p.R464H and p.D43N knock-in mouse models were established. Preliminary behaviour test results showed that p.R464H mutant groups showed significant impairment of mobility in four types of behaviour tests, including rotarod, balance beam, hanging wire and open-field, whereas p.D43N mutant groups only showed significance in hanging wire and open-field tests. Hematoxylin-eosin and immunofluorescence staining suggested mild morphological changes and cellular degeneration in lobule I/II of the cerebellum. Western-blotting results showed that the phosphorylated JNK increased in both heterozygote and homozygote mutant mice. In conclusion, p.R464H and p.D43N Ccdc88c mutant protein cause cellular degeneration in the anterior domain of cerebellum and affect the movement and balance ability in SCA40 mouse models, and the degeneration may be related to the activation of JNK apoptotic pathway. Further study aims to identify more signalling pathways activated by the mutations in *CCDC88C* gene as well as find out the role of the mutations on the biological properties of CCDC88C protein through mouse and cell disease models, thereupon to give insights into pathogenic mechanisms involved in SCA40.

Simulating Physics at the Extremes: The Birth and Behaviour of Compact Objects

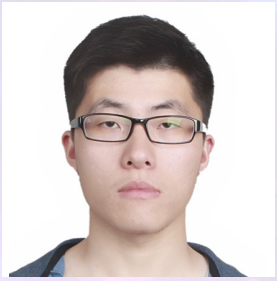
CHEONG Chi Kit
Year 4 PhD Student in Physics
Supervisor: Professor Tjonnie LI

The formation and behaviour of compact objects are highly complex and relativistic phenomena that require numerical simulation to model accurately. Most of the existing studies on core-collapse supernovae and oscillating neutron stars are based on Newtonian gravity or effective potentials. However, the compactness of a (proto-)neutron star, defined as the ratio of the Schwarzschild radius to its radius, is far larger than massive stars. For these systems, Newtonian gravity will no longer be valid and ignoring relativistic strong-field effects could return inaccurate results. In particular, few studies have considered relativistic strong-fields effects for the post-bounce evolution of proto-neutron stars and the oscillation of hypermassive / cold neutron stars.

We use a new multidimensional general-relativistic hydrodynamics code to investigate the proto-neutron star formation in core-collapse supernovae and the corresponding g-mode oscillation, and the properties of the oscillating (hypermassive / cold) neutron stars. In particular, we present the influence of general relativity on neutron-star evolution, the f/r-mode instabilities and gravitational-wave asteroseismology.

Cosmos Compasses – How to Read Them and What Have We Learned

GU Qilao
Year 5 PhD Student in Physics
Supervisor: Professor LI Hua Bai



Stars form from the gravitational collapse of molecular clouds which are full of dust and gas, and their lives end with dozens of new elements being created. Understanding the birth and death of a star is one of the most important fields in modern astronomy.

During the star forming process, magnetic field plays an important role: magnetic pressure supports a cloud against self-gravity collapse, ordered magnetic field hinders gas rotation and contraction but also defines a direction to help gas accumulation, magnetic field also affects the star formation efficiency and rate. Polarization observation is a main method to observe the morphology of magnetic field. In order to achieve such observation, we made a polarimeter, APol, which would be equipped onto a radio telescope, to observe submillimetre polarization that uncovers the information from interstellar magnetic field.

A better understanding of magnetic field helps astronomers establish a better model to explain how star forms.

Catalytic Artificial Organelles, Multi-Enzyme Assemblies for Terpene Biosynthesis

WEI Qixin
Year 4 PhD Student in Chemistry
Supervisor: Professor XIA Jiang

Multienzyme complexes, or metabolons, are natural assemblies or clusters of sequential enzymes in biosynthesis. Spatial proximity of the enzyme active sites results in substrate channelling effect, streamlines the cascade reaction, and increases the overall efficiency of the metabolic pathway. In our lab, we are inspired to mimic the design of nature, and devise the synthetic multienzymes complexes as the catalytic nanomachineries inside lab workhorses such as *Escherichia coli* to attain a higher control of the metabolic flux and maximize the production of valuable natural compounds, such as beta-carotenoids, amopha-4,11-diene and a-farnesene.

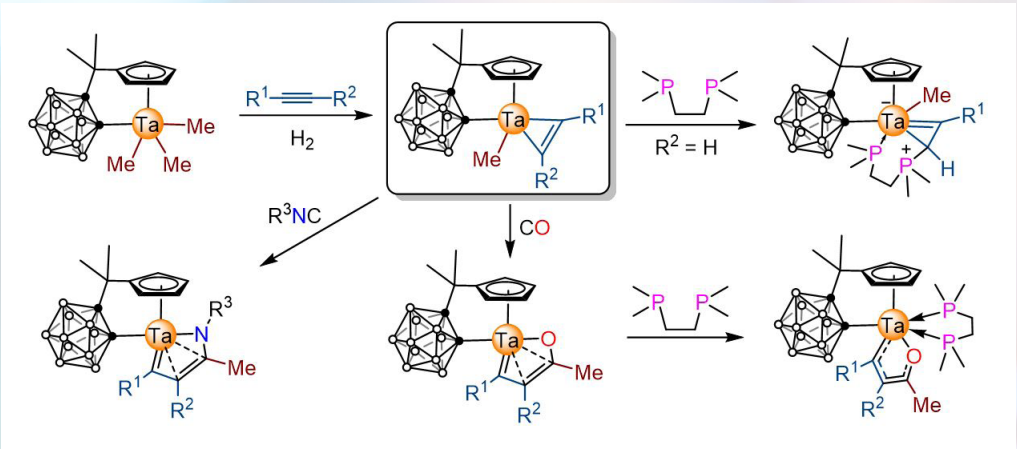
This is a joint work with Professor Shannon Wing-Ngor Au from the School of Life Sciences, CUHK.

Synthesis and Reactivity of Tantalum Alkyne Complexes Supported by Linked Cyclopentadienyl-Carboranyl Ligand

YANG Jingting
Year 5 PhD Student in Chemistry
Supervisor: Professor XIE Zuowei

Alkyne reagents have been applied as versatile ligands in organometallic chemistry. While alkynes readily form adducts with low-valent late transition metals, the early-transition-metal alkyne complexes are generally derived from reduction of a high-valent metal centre in the presence of an alkyne. Herein, we report a facile, one-pot method to synthesize a series of tantalum alkyne complexes from a Ta(V) alkyl complex, where using strong reducing agent is avoided. Such synthetic method is suitable for both terminal and internal alkynes bearing various functional groups.

Moreover, the reactivity of these tantalum alkyne complexes towards unsaturated molecules has been investigated. By treatment with carbon monoxide or isonitriles, these tantalum alkyne complexes produced nonplanar five-membered metallacycles. Interestingly, the chelation of a bidentate phosphine ligand could planarize the five-membered ring and gave a six-electron metallafuran complex. On the other hand, direct reaction of the phosphine ligand with alkynylated tantalum compounds afforded η^2-vinyl complexes. The structures of these novel tantalum complexes have been unambiguously characterized by single crystal X-ray analyses.

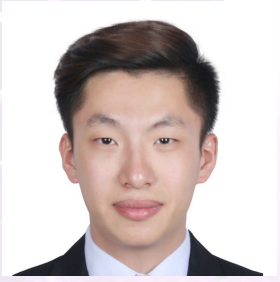


ACKNOWLEGEMENTS

This work was supported by a grant from the Research Grants Council of HKSAR.

A Fast and Stable Direct Sampling Method for Computerized Tomography

HAN Fuqun
Year 1 PhD Student in Mathematics
Supervisor: Professor ZOU Jun



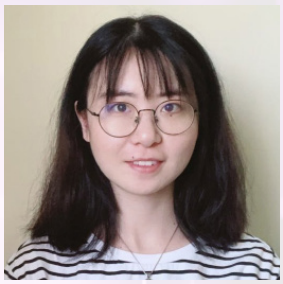
We propose a novel direct sampling method (DSM) for the effective and stable inversion of the Radon transform. This problem arises when we aim at recovering an object from its projections in the computed tomography (CT). The DSM is based on a generalization of the important almost orthogonality property in classical DSMs to fractional order Sobolev duality products and to a new family of probing functions. The fractional order duality product proves to be able to greatly enhance the robustness of the reconstructions in some practically important but severely ill-posed inverse problems associated with the Radon transform. We present a detailed analysis to better understand the performance of the new probing and index functions, which are crucial to stable and effective numerical reconstructions.

From the perspective of the numerical computations, the DSM can be computed with low computational efforts and simultaneously with the measurement process. With these features, the new DSM is expected to find applications in tackling some ill-posed inverse problems associated with the Radon transform, such as those arising from security scanning, cancer detection, and portable CT scanner. Numerical experiments are carried out to compare the DSM with a popular existing method, and to illustrate the efficiency, stability, and accuracy of the DSM.

This is a joint work with Professor Yat Tin Chow from University of California, Riverside.

Weak Galerkin Method for Electrical Impedance Tomography

LIANG Ying
Year 5 PhD Student in Mathematics
Supervisor: Professor ZOU Jun



In this work, we propose and analyse a weak Galerkin method for the electrical impedance tomography based on a bounded variation regularization. We use the complete electrode model as the forward system that is approximated by a weak Galerkin method with lowest order. The error estimates are studied for the forward problem, which are used to establish the convergence of this weak Galerkin algorithm for the inverse problem. Numerical examples are presented to verify the effectiveness and efficiency of the weak Galerkin algorithm for the electrical impedance tomography.

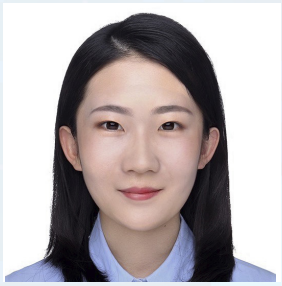
Interquantile Smoothness in Censored Quantile Regressions

CAI Zexi
Year 2 MPhil Student in Risk Management Science
Supervisor: Professor Tony SIT

Quantile regression has emerged as a useful and effective tool in the modelling of survival data, and has been widely adopted to handle data heterogeneity. Despite recent advancements in this area, non-smooth components involved in censored quantile regression estimators may result in numerically unstable results, which, in turn, may lead to unnatural interpretations and potentially unreliable conclusion. We propose an estimating equation-based approach to obtain consistent estimators of the regression coefficients of interest via a smoothing technique to circumvent such difficulty. Without imposing more stringent conditions, our proposed estimator is shown to be asymptotically equivalent to a plain estimator, based on which its consistency and asymptotic normality are hence established. An extension to handle functional covariate data is also discussed. To alleviate the heavy computational burden of bootstrap-based variance estimations, we also propose an efficient resampling procedure that considerably reduces the computational time. Numerical studies presented demonstrate that the proposed estimator is much smoother across different quantile levels, and can achieve better efficiency than a plain estimator under various finite-sample settings. The application of the proposed method is illustrated using three survival datasets.

Bayesian Causal Mediation Analysis with Latent Mediators and Survival Outcome

SUN Rongqian
Year 2 PhD Student in Statistics
Supervisor: Professor SONG Xinyuan

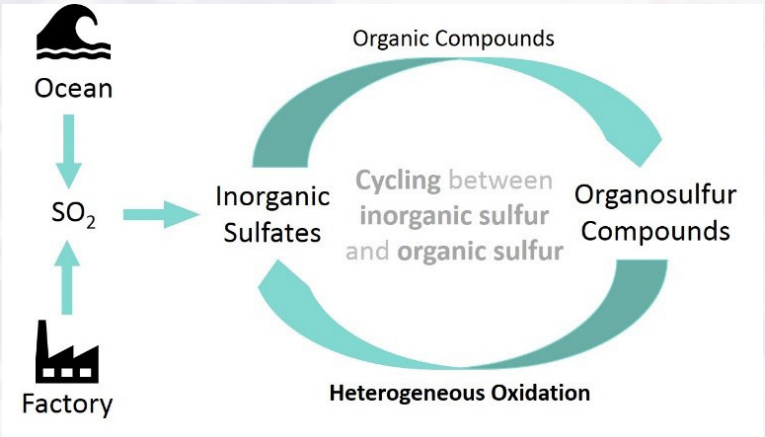


This study develops a joint modelling approach that incorporates latent traits into causal mediation analysis with multiple mediators and a survival outcome. A linear structural equation model is used to characterize the latent mediators with several highly correlated observable surrogates and depicts the relationships among multiple parallel or causally ordered mediators and the exposure. A proportional hazards model is used to derive the path-specific causal effects on the scale of hazard ratio under the counterfactual framework with a set of sequential ignorability assumptions. A Bayesian approach with Markov chain Monte Carlo algorithm is developed to perform efficient estimation of the causal effects. Empirical performance of the proposed method is verified through simulation studies. The proposed model is motivated by the Alzheimer's Disease Neuroimaging Initiative (ADNI) study to investigate the causal mechanism of how carrying APOE-ε4 alleles affects the neurodegenerative progression to dementia (or time-to-dementia), where hippocampus atrophy, ventricle expansion, and cognitive impairment are possible mediators according to medical background. However, cognitive impairment is an underlying latent construct that cannot be directly observed and has to be measured from several aspects including memory, language, and attention by observable surrogates. Besides, cognitive impairment can also be casually affected by hippocampus atrophy and ventricle expansion. Ignoring this underlying latent mediator and using one of or all its surrogates as observable mediators to conduct analysis misinterprets the target mechanism and produces misleading effect estimates. Our proposed method combines the structural equation model and Cox PH model to solve such problem and applies Bayesian approach to jointly estimate the unknown parameters and causal effects, and thereby contributes to the framework of causal mediation analysis especially in medical and psychological research where latent variables are frequently encountered.

Oxidation of Organosulfates at the Aerosol Surface: A Missing Source of Atmospheric Aerosol Sulfate

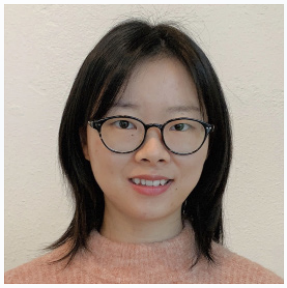
XU Rongshuang
Year 3 PhD Student in Earth & Atmospheric Sciences
Supervisor: Professor CHAN Man Nin

Sulfur is one of the most important constituents of particulate matter (PM). Inorganic sulfate (e.g. HSO_4^- and SO_4^{2-}) is the major form of sulfur in the atmosphere and plays a significant role in determining the health and climatic impacts of PM. Despite its atmospheric abundance, current chemical transport models always underestimate the particle sulfate concentrations in many regions. It is thus highly desirable for us to better understand their sources in the atmosphere. Recently, field studies have revealed in addition to inorganic sulfate, organosulfur compounds (e.g. organosulfates) are abundant in the PM. In this work, we firstly demonstrate that organosulfates (e.g. methylsulfate) can be efficiently oxidized by gas-phase OH radicals at the particle surface. Upon oxidation, inorganic sulfate can be formed through the formation and subsequent reactions of sulfate radical anion ($SO_4^{\bullet-}$). The molar yield of inorganic sulfate, which is defined as the total number of moles of HSO_4^- and SO_4^{2-} formed per mole of methylsulfate consumed, can be as high as 0.62 ± 0.18. These results suggest that a significant portion of organosulfates can be converted from organic form to inorganic form upon oxidation. The finding of this study provides new insights that the transformation of organosulfates and possibly other atmospheric organosulfur compounds through chemical oxidation could be a missing source of particle inorganic sulfate and needs to be considered in the particle sulfur cycle incorporated in chemical transport models.



The Frictional Strength on Faults: A Critical Factor in Controlling Earthquake Occurrence

YAO Suli
Year 4 PhD Student in Earth & Atmospheric Sciences
Supervisor: Professor YANG Hongfeng



Earthquakes have caused significant damage and casualty in human history and accordingly there is a critical need to advance our understanding of earthquake physics so that appropriate societal preparation can be formulated. Earthquakes represent sudden releases of energy accumulated at plate boundaries (termed faults) through fast sliding. Faults slip when shear stress (τ_0) exceeds the frictional strength (τ_s), the static frictional resistance. Therefore, the frictional strength on the fault is a critical factor in controlling earthquake occurrence. However, due to the lack of direct measurements, the frictional strength on faults remains poorly understood.

Here we conduct numerical simulations for the 2012 Nicoya Mw 7.6 megathrust earthquake with a range of values of the frictional strength. Then we select the best-fit earthquake model by comparing the synthetic ground motions with the near-field ground shaking observations. Based on the simulation results, we infer the strength on the megathrust to be less than 7.5 MPa. Such low strength at ~25 km in depth indicates the existence of compacted fluids with a high pore pressure.

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