Project Abstracts for PhD Student Recruitment AY2025/26

Department of Physics

Project title	**Cortical circuit dynamics**	
Research Clusters	☐Creative Media/Practice **√ Health and Drug Discovery** **√ Data Analytics and Artificial Intelligence in X** ☐ Humanities and Cultures	 ***Prof Thomas KNOPFEL*** *Email address:* *tknopfel@hkbu.edu.hk* *Learn more:* *https://lncd.hkbu.edu.hk/people.html*
Keywords	*Neuronal circuits. AI. Optical imaging. Cerebral cortex.*	
Project abstract	We use genetically encoded voltage indicators to image electrical activity of specific neuronal populations across the entire dorsal cortex of awake (resting or task-performing) mice. We are interested to understand how perception, emotions and cognition emerges from cortical circuit dynamics. In past research we analysed the structure of these ongoing activities while normal mice were at rest. As a next step we characterize cortical circuit dynamics in animal models of human brain diseases. To this end, we will focus on the question of how cortical activity relates to spontaneous, perception-related and (abnormal) task-related behaviour. Tools provided by AI research may be used while our work may also inform AI research.	

Project title	Non-Hermitian topological phenomena	
Research Clusters	☐Creative Media/Practice ☐ Health and Drug Discovery **√ Data Analytics and Artificial Intelligence in X** ☐ Humanities and Cultures	 ***Prof MA Guancong*** *Email address:* *phgcma@hkbu.edu.hk* *Learn more:* *www.acoustmeta.com*
Keywords	*Topology, non-Hermitian systems, photonic crystals, phononic crystals*	
Project abstract	Through the consideration of enriched intrinsic symmetry, we explore the various non-Hermitian system for novel topological phenomena. Special focus will be given to non-Hermitian skin effects and non-Hermitian singularities	

Project title	Novel structures for controlling complex waves	
Research Clusters	☐Creative Media/Practice ☐ Health and Drug Discovery **√ Data Analytics and Artificial Intelligence in X** ☐ Humanities and Cultures	 ***Prof MA Guancong*** *Email address:* *phgcma@hkbu.edu.hk* *Learn more:* *www.acoustmeta.com*
Keywords	*Multiple scattering, random matrix, acoustics, microwaves, optimization*	
Project abstract	By using a combination of physics-informed and optimization-empowered schemes, we seek to desire novel structures to achieve unprecedented control of multiple scattering waves in complex media. Discoveries may lead to revolutionary solutions for control wave propagation in complex scenarios.	

Project title	Elucidating the multiscale system mechanisms underlying tumor-immune interaction in complex 3D tumor microenvironment towards new immuno-oncology drug discovery	
Research Clusters	☐ Creative Media/Practice **√ Health and Drug Discovery** ☐ Data Analytics and Artificial Intelligence in X ☐ Humanities and Cultures	
Keywords	*Single cell dynamics, Quantitative live-cell imaging, Deep learning, 3D patient-derived tumor organoid model, Cancer immunotherapy*	
Project abstract	The most exciting area in current cancer research is immuno-oncology, which aims to develop immunotherapies that activate the immune system to contain and eliminate cancers. To elucidate the intriguing multicellular, multiscale tumor-immune interaction in the complex 3D tumor microenvironment, my lab has established novel patient-derived co-culture models and developed Deep Learning-based 3D live-cell imaging analysis pipeline to quantitatively profile immuno-oncology dynamics in 3D. Based on the large multicellular dynamic datasets that we acquire, our project aims to develop multiscale models using statistical physics principles and data science tools, and ultimately uncover novel immuno-oncology drug targets that can improve cancer immunotherapy.	 ***Prof SHI Jue*** *Email address:* *jshi@hkbu.edu.hk* *Learn more:* *https://physics.hkbu.edu.hk/people/prof-shi-jue-jade*

Project title	High-Throughput Protein Dynamics Prediction Guided by AI Models	
Research Clusters	☐ Creative Media/Practice **√ Health and Drug Discovery** **√ Data Analytics and Artificial Intelligence in X** ☐ Humanities and Cultures	
Keywords	*Protein dynamics; AI; Protein Language Models; Drug discovery; High-throughput methods*	
Project abstract	This research aims to integrate AI techniques with molecular biophysics to explore the relationships between protein folding, dynamics and evolution. By combining Protein Language Models and AlphaFold, the project focuses on developing algorithms that not only predict static protein structures, but also model their dynamics at the molecular level. These advances are expected to improve our understanding of protein behaviour, with significant implications for drug discovery, protein engineering and biomedical applications. Future work will focus on high-throughput methods, refining AI predictions, cross-organism comparison, integration with protein-protein interaction networks and exploring the biological significance of these findings in a broader context.	

Dr TANG Qianyuan

Email address:
tangqy@hkbu.edu.hk

Learn more:
https://physics.hkbu.edu.hk/people/dr-tang-qianyuan
https://sites.google.com/view/tangqy/

Project title	Quantifying Parameter Sensitivities to Guide Neuromodulation for Disease Intervention	
Research Clusters	☐ Creative Media/Practice **√ Health and Drug Discovery** **√ Data Analytics and Artificial Intelligence in X** ☐ Humanities and Cultures	 ***Dr TANG Qianyuan*** *Email address:* *tangqy@hkbu.edu.hk* *Learn more:* *https://physics.hkbu.edu.hk/people/dr-tang-qianyuan* *https://sites.google.com/view/tangqy/*
Keywords	*Parameter sensitivities; Large-scale brain modelling; Biomarkers; Neuromodulation; Brain networks*	
Project abstract	In complex systems, some parameters play a crucial role in determining system behaviours, while others have minimal effect. This project quantifies "parameter sensitivities" to assess how variations in key parameters influence system dynamics, thereby enhancing the prediction and control of dynamics—essential for early disease detection and targeted interventions. Current efforts focus on modelling large-scale brain networks, identifying critical parameters in resting-state task switching, and discovering biomarkers for brain disorders such as autism and Alzheimer's. These initiatives not only validate theoretical models but also create new opportunities for developing neuromodulation strategies and intervening in the progression of neurological diseases.	

Project title	AI for Complex Systems	
Research Clusters	☐ Creative Media/Practice **√ Health and Drug Discovery** **√ Data Analytics and Artificial Intelligence in X** ☐ Humanities and Cultures	
Keywords	*(1) Human Microbiome and its Impact on Health and Disease* *(2) AI for Traditional Chinese Medicine and Drug Discovery* *(3) Complex Multimodal Brain Data and Computational Neuroscience* *(4) Complex network and Nonlinear Systems: Structure and Dynamics* *(5) Biological Big-data, Machine Learning, and Bioinformatics*	
Project abstract	Dr. Tian's group is dedicated to pioneering interdisciplinary research across a range of complex systems, where traditional analytic approaches falter due to a vast number of degrees of freedom with intricate interactions and structure involved. Our approach integrates principles and tools from statistical physics, network science, systems biology, and cutting-edge AI to develop a comprehensive understanding of these systems. At the core of our methodology is the identification and extraction of relevant statistics, dimensions, and features through advanced big-data mining and AI techniques. This allows us to construct statistical physics models and perform simulations that not only describe these systems accurately but also provide interpretative insights that are critical for further analysis and prediction. Our expertise uniquely positions us to reveal and understand the emergent properties and organizational principles of	 ***Dr TIAN Liang*** *Email address:* *liangtian@hkbu.edu.hk* *Learn more:* *https://physics.hkbu.edu.hk/people/tian-liang* *https://scholars.hkbu.edu.hk/en/persons/LIANGTIAN* *https://scholar.google.com/citations?user=0MjiMFAAAAAJ&hl=en*

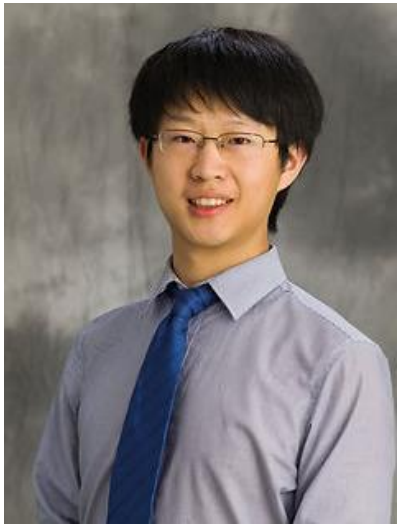
	these systems, as well as the complex interplay between their structures and functions. Through this innovative research framework, Dr. Tian's group aims to generate transformative insights and applications that will advance our understanding of complex systems in nature and technology.	

Project title	Flexible organic electronics for biomedical applications	
Research Clusters	☐ Creative Media/Practice **√ Health and Drug Discovery** ☐ Data Analytics and Artificial Intelligence in X ☐ Humanities and Cultures	 ***Dr WANG Shu-Jen*** *Email address:* *shu-jenwang@hkbu.edu.hk* *Learn more:* *https://physics.hkbu.edu.hk/people/dr-wang-shu-jen*
Keywords	*Organic semiconductors; Flexible electronics; Healthcare sensors; Microelectronics; Organic electronics*	
Project abstract	Organic semiconductors are important optoelectronic material for display applications. Their intrinsic mechanical flexibility, excellent optoelectronic properties and biocompatibility are promising for device applications in the healthcare sector. In this project, we will develop innovative flexible organic electronic sensors with high sensitivity and selectivity using advanced high throughput printing method for monitoring cardiac and metabolic related health conditions.	

Project title	Investigate the 'sequence-ensemble-function' relationship for disordered proteins	
Research Clusters	☐ Creative Media/Practice **√ Health and Drug Discovery** **√ Data Analytics and Artificial Intelligence in X** ☐ Humanities and Cultures	
Keywords	*Intrinsically disordered proteins; Multiscale modeling; Molecular dynamics simulations; Polymer theory; Protein sequence-structure-function relationship*	
Project abstract	Intrinsically disordered proteins (IDPs) or regions (IDRs) lack a stable or ordered three-dimensional structure; instead, they exist as flexible ensembles of conformations. Despite their lack of structured form, IDPs play crucial roles in a variety of biological processes, including cell signalling, transcription regulation, and the formation of biomolecular assemblies. The dynamic nature of IDPs enables them to interact with multiple partners, making them key players in cellular function and regulation. By using multiscale modelling, bioinformatics analysis, polymer theories and close collaboration with experimentalists, this project aims to elucidate the physical principles that govern the functions of these flexible, disordered proteins.	 ***Dr ZENG Xiangze*** *Email address:* *xiangzezeng@hkbu.edu.hk* *Learn more:* *https://sites.google.com/view/xzenglab*

Project title	Design small molecule drugs targeting IDPs/IDRs using machine learning	
Research Clusters	☐ Creative Media/Practice **√ Health and Drug Discovery** **√ Data Analytics and Artificial Intelligence in X** ☐ Humanities and Cultures	 ***Dr ZENG Xiangze*** *Email address:* *xiangzezeng@hkbu.edu.hk* *Learn more:* *https://sites.google.com/view/xzenglab*
Keywords	*Machine learning; Drug discovery; Drug design; Disordered proteins; Protein design*	
Project abstract	Intrinsically Disordered Regions (IDRs) are present in approximately one-third of human proteins. The dysregulation of these IDRs is implicated in numerous diseases, making them crucial targets for therapeutic interventions. However, due to their dynamic nature, conventional drug discovery approaches designed for folded proteins are ineffective for disordered proteins.	

Project title	Uncovering the physical principles governing the formation, material property and function of biomolecular condensates	
Research Clusters	☐ Creative Media/Practice **√ Health and Drug Discovery** **√ Data Analytics and Artificial Intelligence in X** ☐ Humanities and Cultures	
Keywords	*Phase separation*	
Project abstract	Phase separation is a fundamental mechanism by which cells compartmentalize biochemical reactions and processes without the need for membrane-bound organelles. This phenomenon leads to the formation of biomolecular condensates, which can concentrate specific proteins and nucleic acids to facilitate various cellular functions. Understanding the principles of phase separation is critical for elucidating how cells organize their internal environment and regulate biological activities. Moreover, dysregulation of phase separation is implicated in various human diseases, including cancers, neurodegenerative disorders, and infectious diseases. This project seeks to uncover the molecular interactions and physical principles driving phase separation to better understand its role in health and disease.	 ***Dr ZENG Xiangze*** *Email address:* *xiangzezeng@hkbu.edu.hk* *Learn more:* *https://sites.google.com/view/xzenglab*

Project title	Molecular electronics for next-generation of AI and bioelectronics	
Keywords	*Molecular Electronics, AI, Bioelectronics, Charge Transport*	
Project abstract	This project aims to advance the field of artificial intelligence (AI) and bioelectronics through the study of molecular electronics. By gaining a fundamental understanding of molecular charge transport, we intend to create devices that are smaller and significantly more energy-efficient. Our research will focus on two main areas: (1) understanding charge transport at the single-molecule level and (2) applying this knowledge to create advanced molecular electronics for AI computing and bioelectronic applications. These innovations will not only lead to the development of AI systems that are more compact and energy-efficient but will also enhance bioelectronic devices that integrate more seamlessly with biological tissues.	***Dr LI Songsong*** *Email address:* *song2li@hkbu.edu.hk* *Learn more:* *https://lssustc.wixsite.com/songsong*