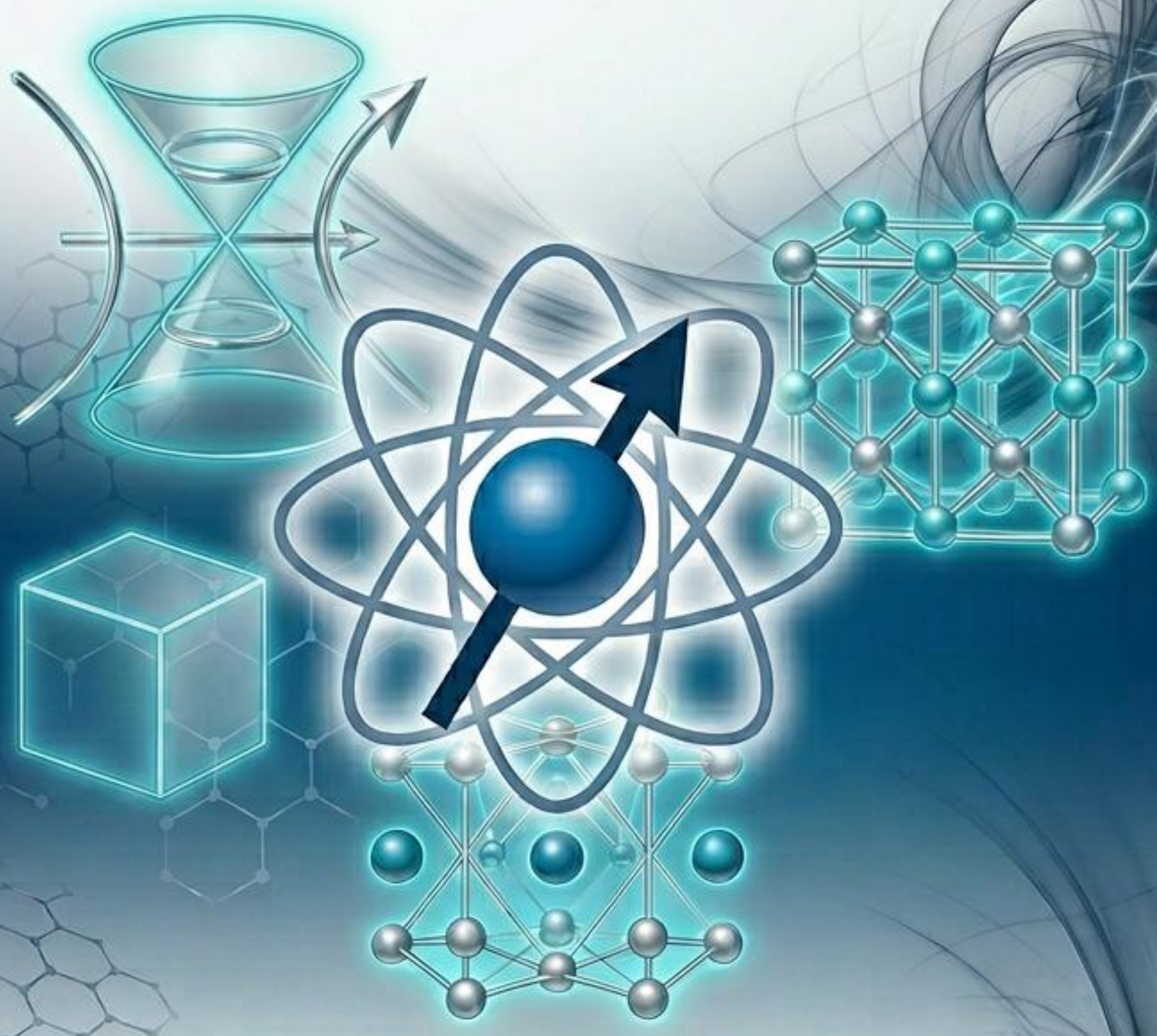
Frontiers of Quantum Magnetism and Correlated Systems

IAS Center for Quantum Matter, HKUST
May 15-16, 2026



Program Book

Advancing the Frontiers of Quantum Materials

IAS 4042, HKUST, Hong Kong

Symposium Program: Frontiers of Quantum Magnetism and Correlated Systems

Date: May 15, 2026 | Venue: IAS 4042, HKUST
Format: 35 min Presentation + 5 min Q&A

🌅 Morning Session I: Plenary Session & Correlated Electron Lattices

Session Chair: Prof. Junwei LIU

Time	Event / Speaker	Institution	Presentation Title
08:40 - 08:50	Opening Remarks	HKUST	Welcome by Prof. Junwei Liu, Director of IAS Center for Quantum Matter
08:50 - 09:35	Haizhou LU **Plenary presentation**	SUSTech	Theories for electrical detection and control of altermagnetism and nonlinear magnetization
09:35 - 10:10	Haoxiang LI	HKUST(GZ)	Anionic electron lattice in layered electrides YCl and LaCl
10:10 - 10:30	☕ Coffee Break		Refreshments and Networking

🌅 Morning Session II: Magnetism & Spintronics

Session Chair: Prof. Haoxiang LI

Time	Event / Speaker	Institution	Presentation Title
10:15 - 10:50	Qiming Shao	HKUST	Topological spintronics: from physics to devices
11:10 - 11:45	Shu Guo	SUSTech	Chemical Engineering of Frustrated Quantum Magnets and Their Physical Properties
11:45-12:20	Berthold JÄCK	HKUST	Multiple wave mixing in a room temperature altermagnet

🌞 Afternoon Session I: Topology & Correlation

Session Chair: Prof. Shiming Lei

Time	Event / Speaker	Institution	Presentation Title
14:00 - 14:35	Junwei Liu	HKUST	A unified understanding of altermagnets based on C-paired spin-momentum locking
14:35 - 15:10	Junzhang Ma	City U	3D dispersive excitonic bound states induced by correlation in AFM $TbNiC_2$
15:10 - 15:45	Tong Zhou	HKUST(GZ)	YCl Electride as a Multi-Orbital Correlated Topological Dice Lattice System
15:45 - 16:10	🍰 Coffee Break		Refreshments and Networking

🌆 Afternoon Session II: Superconductivity

Session Chair: Qiming Shao

Time	Event / Speaker	Institution	Presentation Title
16:10 - 16:45	Qisi Wang	Chinese U	Magnetic and electronic excitations of nickelate superconductors
16:45 - 17:20	Quansheng WU	IOP, CAS	New Paradigm: Magnetotransport + First-Principles --> Electronic-Structure Characterization
17:20 - 17:55	Shiming Lei	HKUST	Unlocking a Quasi-2D Quantum Phase Diagram via Defect Engineering in a Layered Superconductor
18:00 - 18:10			Closing Remarks

Group Dinner: leave at 6:20pm

Theories for electrical detection and control of altermagnetism and nonlinear magnetization

Haizhou LU (Southern University of Science and Technology)

Abstract:

Using only electricity to detect, generate, and control magnetism is of great potentials in applications but remains challenging. In this talk, I will introduce our theories on using only pure electric approaches to detect, switch, and generate unconventional magnetism, including altermagnetism and nonlinear magnetization.

Altermagnetism is an unconventional collinear antiferromagnetism. Its spin-opposite sublattices cannot be related by inversion or translation. This property gives altermagnetism the advantages of both ferromagnetism and antiferromagnetism thus are promising in applications. I will introduce how to use Coulomb drag and nonlinear Hall effect to detect altermagnetism and how to use only electric current to switch the Neel order of altermagnetism deterministically.The Christoffel symbol is an essential quantity in Einstein's general theory of relativity. We discover that an electric field can induce a nonlinear magnetization in quantum materials, described by the quantum Christoffel symbol. We identify many 2D material candidates that host this quantum Christoffel nonlinear magnetization. This nonlinear Christoffel magnetization can be probed by optical techniques such as magneto-optical Kerr spectroscopy. More importantly, this quantum Christoffel nonlinear magnetization gives a paradigm of how geometry dictates physics.

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[3] R. Y. Chu, L. Han, Z. H. Gong, H. Z. Lu, C. Song, et al., "Third-order nonlinear Hall effect in altermagnet RuO2", Phys. Rev. Lett. 135, 216703 (2025).
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[6] Xuan Qian, Xiao-Bin Qiang, W. Z., Hai-Zhou Lu, Yang Ji, Kaiyou Wang, et al., "Probing quantum geometric nonlinear magnetization via second-harmonic magneto-optical Kerr effect", Phys. Rev. B 113, L041407 (2026).

Multiple wave mixing in a room temperature altermagnet

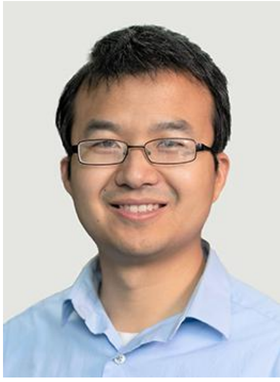
Berthold JÄCK (HKUST)

Abstract:

Altermagnets present a new class of materials with magnetic crystal order and non-relativistic spin-splitting of the electronic bands. It remains an open question whether the presence of an altermagnetic order parameter affects the electrical material properties, leaving their technological potential unexplored. We report the discovery of a third-order nonlinear anomalous Hall effect in altermagnetic CrSb with distinct spatial anisotropy. Theoretical analyses show that this nonlinear Hall response is induced by the nonlinear electric susceptibility of a Berry curvature quadrupole, which is characterized by all symmetries encoded in the altermagnetic g-wave order parameter. We utilize this nonlinear susceptibility to realize a broadband multiple wave mixing device at room temperature. Our study discovers a generalized understanding of the impact of magnetic crystal order on the electric material properties of altermagnets and establishes their technological potential for high-frequency electronics, THz generation, communication networks, and energy harvesting

Unlocking a Quasi-2D Quantum Phase Diagram via Defect Engineering in a Layered Superconductor

Shiming Lei (HKUST)



Abstract:

The rich quantum phenomena predicted to arise in layered van der Waals materials are frequently obscured by native structural defects, which introduce disorder and limit electronic coherence. Overcoming this long-standing challenge requires a materials design strategy that can achieve atomic-scale perfection. Here, we introduce a rational, theory-guided approach that yields a hybrid superlattice with an unprecedented level of crystalline quality. Guided by ab-initio calculations, we employ a co-intercalation and self-assembly process that fundamentally alters the formation energetics of native defect sites, resulting in their effective passivation and a dramatic enhancement of structural order.

To provide a comprehensive and quantitative benchmark of this material's perfection, we perform a powerful multi-modal analysis of its electronic ground state, combining bulk-sensitive quantum oscillation measurements with momentum-resolved angle-resolved photoemission spectroscopy (ARPES). This approach allows for a reconstruction of the multi-band Fermi surface, revealing the topology of its constituent pockets and their respective effective masses. By integrating the Fermi velocities obtained from ARPES, we quantitatively extract the fundamental normal-state and superconducting parameters. Our analysis confirms the system is deep in the 2D clean limit, a regime evidenced by an exceptionally long mean free path (l_{ab}) that significantly exceeds the intrinsic Pippard coherence length (ξ_{0ab}). This pristine electronic environment serves as a window into the material's intrinsic physics. The superconducting state is profoundly anisotropic, with a critical field ratio (γ) exceeding 100, confirming a quasi-2D behavior governed by a lattice of weakly coupled Josephson vortices. Most strikingly, within this ultra-clean limit, we discover a distinct upturn in the in-plane upper critical field at low temperatures—a thermodynamic hallmark of a field-induced reentrant superconducting phase. Our work not only establishes a powerful methodology for creating and quantitatively benchmarking near-perfect quantum materials but also provides a pristine and highly tunable platform to dissect the complex interplay between charge order, extreme anisotropy, and exotic field-induced phenomena in the two-dimensional limit.

Anionic electron lattice in layered electrides YCl and LaCl

Haoxiang Li (HKUST-GZ)

Abstract:

In crystalline solids, electronic structures are usually dictated by the atomic lattice, but layered electrides break this rule by hosting anionic electron lattices (AELs). Using angle-resolved photoemission spectroscopy, we study two isostructural layered electrides, YCl and LaCl. In YCl, excess valence electrons deconfine from the cation framework to form a standalone AEL that realizes a dice lattice. Our measurements unambiguously uncover the long-sought dice-lattice band structure, including a flat band at the Fermi level, establishing YCl as a prototype dice metal. In contrast, isostructural LaCl exhibits a fully reconstructed electronic structure, where direct hopping channels between the AEL and the La cation sites are activated, rewiring the lattice network and reshaping the low-energy band structure compared to YCl. This radical divergence reveals the AEL as a novel tuning knob for electronic structure design.

A unified understanding of altermagnets based on C-paired spin-momentum locking

Junwei LIU (HKUST)

Abstract:

Since proposal in 2022, altermagnetism has become one of most important topics in spintronics, materials science and condensed matter physics, while there are many controversial conclusions. In this talk, I present a unified understanding of unique novel properties of altermagnets and more general unconventional antiferromagnets (AFMs) based on crystal-symmetry-paired spin-valley/momentum locking (CSVL/CSML), which we proposed in 2021[*Nat. Commun. 12, 2846 (2021)*]. CSML is enabled by the intrinsic crystal symmetries exchanging opposite magnetic sublattices of AFMs (e.g., V_2Se_2O, V_2Te_2O, MnTe and RuO_2) [*Nat. Commun. 12, 2846 (2021)*; *Phys. Rev. X 15, 021083 (2025)*], and exists in all unconventional AFMs with spin-splitting band structures but not limited to altermagnets. CSML enables unique properties and feasible controls of AFMs by manipulating the corresponding crystal symmetry. Typically, one can use a strain field to induce net valley polarization/magnetization and use an electric field to generate a noncollinear spin current even without spin-orbit coupling. All the predictions, in particular the existence of altermagnetism in $V_2(Se, Te)_2O$-family materials, have been confirmed in experiments [*Nat. Phys. 21, 760 (2025)*; *Nat. Phys. 21, 754 (2025)*]. These properties have helped us realize the electric readout and 180° deterministic switching of the Néel order in our experimental work [*Sci. Adv. 10, eadn0479 (2024)*; *Nature 638, 645 (2025)*], and motivate us to propose a unified theory of all magnetic deterministic switching [*arXiv:2603.29136*].

3D dispersive excitonic bound states induced by correlation in AFM TbNiC2

Junzhang MA (City University of Hong Kong)

Abstract:

The study of excitonic bound states has traditionally been confined to gapped systems, leaving the potentially transformative realm of mobile excitons in conductor—crucial for efficient information transmission—largely unexplored. While theoretically possible, realizing dispersive excitonic bound states in three-dimensional metals is fundamentally challenging due to electron screening effect. Using ARPES and theoretical modeling, in this talk we report the observation of dispersive excitonic bound states in the topological metallic antiferromagnetic compound TbNiC2. These states manifest as replica valence bands across the 3D Brillouin zone. We demonstrate that their formation is facilitated by a low density of free charges near the Fermi level, induced by electron-phonon coupling, and further enhanced by resonance with topological surface states. Our findings establish a new pathway for generating and stabilizing excitonic bound states in metals.

Topological spintronics: from physics to devices

Qiming Shao (HKUST)

Abstract:
Quantum geometry, characterized by the quantum metric and Berry curvature that encode the local topology of electronic states, gives rise to intriguing physical phenomena and holds promise for novel device applications [1-3]. Here, we first report the observation of quantum metric quadrupole-induced nonlinear transport in a correlated antiferromagnet, enabling effective readout of antiferromagnetic order without external magnetic fields [4]. Subsequently, we demonstrate the generation of spin current via Berry curvature dipole in a low-symmetry Weyl semimetal, which allows efficient and robust perpendicular magnetization switching in the absence of an in-plane magnetic field [5]. Finally, we propose a cryogenic in-memory computing scheme based on magnetic topological insulators exhibiting global topology with quantized Chern numbers [6]. These advances highlight the potential of quantum geometric effects for next-generation electronic and spintronic technologies.

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5. Yiyang Zhang, Xiaolin Ren, Ruizi Liu, Zehan Chen, Xuezhao Wu, Jie Pang, Wei Wang, Guibin Lan, Kenji Watanabe, Takashi Taniguchi, Youguo Shi, Guoqiang Yu, Qiming Shao, Robust Field-Free Switching Using Large Unconventional Spin-Orbit Torque in an All-Van der Waals Heterostructure, Advanced Materials 2406464 (2024).

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Chemical Engineering of Frustrated Quantum Magnets and Their Physical Properties

Shu GUO (Southern University of Science and Technology)

Abstract:

Understanding the origin and evolution of magnetism across different crystal structures and chemical environments is a central scientific challenge in solid-state chemistry and condensed matter physics. The chemical design of novel quantum frustrated magnets with well-defined magnetic-ion topologies not only offers ideal platforms for exploring unconventional quantum ground states but also enables experimental verification of theoretical models. I will present our group's research progress over the past three years on the chemical design, synthesis, and low-temperature magnetic and thermodynamic properties of frustrated quantum magnets, with particular emphasis on their potential applications in magnetocaloric effects. Furthermore, from a unified perspective that combines crystal chemistry and geometric frustration, we systematically analyze the feasibility of geometric frustration in five classes of exotic Archimedean lattices. A series of candidate materials with realistic synthetic accessibility is proposed, thereby establishing a new research framework for quantum frustrated magnets that extends beyond conventional triangular and Kagome lattices.

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[3] Lin W.; Zhao N.; Li Z.; et al. The Innovation, 2026, 7: 101254.
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Magnetic and electronic excitations of nickelate superconductors

Qisi WANG (The Chinese University of Hong Kong)

Abstract:

The discovery of superconducting nickelates has inspired intense efforts to understand their intrinsic properties and to clarify their relationship to the cuprates [1-3]. A comprehensive characterization of their electronic and magnetic structures is therefore essential. In this talk, I will present our recent resonant X-ray scattering and neutron scattering studies of infinite-layer and Ruddlesden-Popper nickelates [4-7]. By analyzing their spin and orbital excitations, we extract key parameters including the strength of magnetic interactions and electron correlations. We further compare these results against established cuprate phenomenology and discuss their implications for the understanding of high-temperature superconductivity.

References

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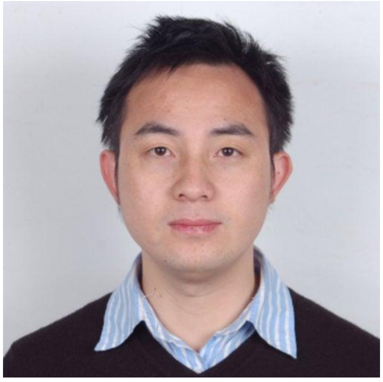
New Paradigm: Magnetotransport + First-Principles-->Electronic-Structure Characterization

Quansheng WU (Institute of Physics, Chinese Academy of Sciences)



Abstract:

This talk presents a workflow-style paradigm for extracting electronic-structure information from magnetotransport by tightly integrating first-principles calculations with a non-perturbative semiclassical Boltzmann framework. Starting from density-functional electronic structures, we construct high-fidelity low-energy Hamiltonians and compute magnetic-field-dependent transport tensors in real materials, where Lorentz-force dynamics, quantum scattering, magnetic-order evolution, and topological band effects intertwine across multiple scales. The key step is to translate band topology and Fermi-surface geometry into quantitative magnetoresistance and Hall responses, enabling a controlled decomposition of contributions from (i) complex Fermi-surface topology, (ii) magnetic order and its field evolution, and (iii) topological features of the bands. The complete pipeline is implemented in the open-source package WannierTools, allowing high-accuracy simulations of magnetotransport directly comparable to experiments. We demonstrate that this first-principles-based approach reproduces, with strong consistency, magnetotransport measurements across a broad set of representative systems, including non-magnetic metals/semimetals/semiconductors and magnetic/topological materials such as the altermagnets RuO_2, CrSb, and KV_2Se_2O, the ferromagnetic Weyl semimetal $Co_3Sn_2S_2$, and antiferromagnetic semiconductors $EuSe_2$ and $Mn_3Si_2Te_6$. Overall, the method moves complex magnetotransport analysis beyond phenomenological fitting: it enables quantitative, material-specific links between electronic structure and transport observables, establishing a practical route to use magnetotransport as a first-principles-resolved probe of electronic structure.

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[5]. Universal Scaling Behavior of Transport Properties in Non-Magnetic RuO2, Q Dong, Y. Wang, Q.Wu et al., Communications Materials 6 (1), 177 (2025)
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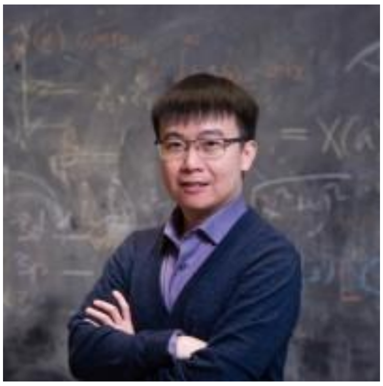
YCl Electride as a Multi-Orbital Correlated Topological Dice Lattice System

Tong Zhou (HKUST-GZ)



Abstract:

The long-sought dice lattice flat band has recently been discovered for the first time in two-dimensional layered electride yttrium monochloride (YCl) [1]. While essential flat band features of YCl were captured by an idealized simple dice lattice model, in this talk, I will reveal that a unique layer-orbital-valley-coupling (LOVC) in YCl puts up a fundamental obstruction against a simple three-band dice lattice description of the flat band, and necessitates a multi-orbital description that faithfully represents the symmetry, topology, and correlation physics in the first-ever dice metal [2]. I will then introduce a faithful multi-orbital Hubbard model with local interactions for YCl and propose that the flat-band system supports robust ferromagnetic order and electrically tunable correlated quantum anomalous Hall phases that are absent in an interacting single-orbital dice lattice. Future outlooks on the novel correlation and topological physics in electride systems will also be discussed.

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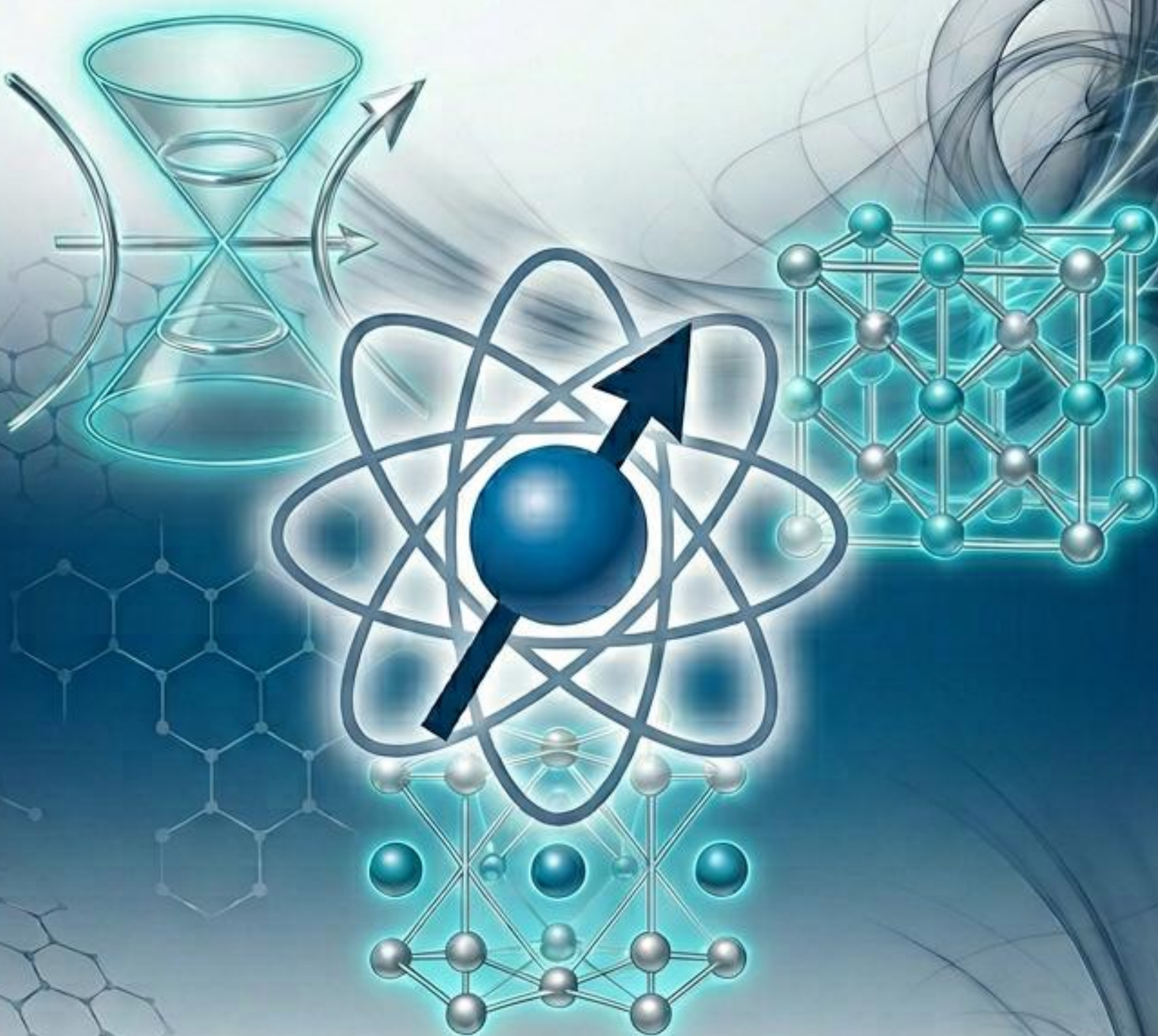
Organizing Committee:

Prof. Shiming Lei (HKUST), and Prof. Junwei Liu (HKUST)



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