Forum on Quantum Physics and Complex Systems

December 7 — 9, 2022

Programme Booklet

香港城市大學 City University of Hong Kong
HK TECH FORUM
香港城市大學 City University of Hong Kong
Hong Kong Institute for Advanced Study
Department of Physics
香港城市大學 City University of Hong Kong

Welcome Message

Welcome to HK Tech Forum – “Quantum Physics and Complex Systems.”

Quantum physics is the foundation of the technologies that enrich our daily life. The development of future technology hinges on our fundamental understanding of quantum interactions in increasingly complex materials. This forum brings together leading scholars in the world as well as young and active researchers in a hybrid mode to tackle the challenging issue from the following perspectives: Quantum Materials, Complex Systems, Quantum Information, and Quantum Beam Applications.

Amongst the highlighted speakers are Professor Giorgio Parisi (Nobel Laureate of Physics, 2021), Professor Anton Zeilinger (Nobel Laureate in Physics, 2022), Professor Hesheng Chen (Chinese Academy of Sciences), Professor Jinfeng Jia (Southern University of Science and Technology, China), Professor Sidney Nagel (University of Chicago), Professor Franco Nori (RIKEN, Japan), and Professor Christian Schroer (DESY, Germany).

This forum also serves to mark the five-year anniversary of the Department of Physics at City University of Hong Kong. Our Department was established in 2017, following the split of the Department of Physics and Materials Science. Starting with just 12 faculty members, the department has expanded rapidly by actively recruiting top talent from around the globe. Today the physics faculty comprises 27 outstanding scholars, whose research is recognized by the international scientific community. We are also honored to have Professor Alain Aspect, 2022 Nobel Laureate in Physics, as part of our faculty. Professor Aspect has been a Distinguished Visiting Professor of the department since 2018.

It is indeed a privilege for us to host the Forum on Quantum Physics and Complex Systems, which underscores the strategic directions of our department. We hope that the forum will produce stimulating discussions and perhaps new collaborations will emerge as a result.

Thank you.

Professor Xun-Li Wang
On behalf of the Organizing Committee
HK Tech Forum on Quantum Physics and Complex Systems

Forum Objectives

A central theme of quantum science and technology is the investigation of the properties and the uses of quantum interactions, the characteristic correlations among constituents of a quantum system that have no analogous counterparts in classical systems. Harnessing these fundamentally quantum properties and behaviour has the potential to vastly transform our technological landscape in ground-breaking quantum theories, materials, and devices, and to create entirely new capabilities in computing, sensing, and communications. This forum brings together foremost academic and industry researchers working in the rapidly developing fields of quantum computation, quantum physics, and related areas, leveraging state-of-the-art theories, algorithms, and instrumentations. The forum will also stimulate discussions on complex systems, including spin glasses, neural networks, proteins, and related problems.

The forum aims to provide an exceptional multi-disciplinary, cross-pollination arena for the world-leading scientists to vividly share their critical views on the various aspects of quantum and complex-system physics; in together with the technological implications for the next-generation quantum smart devices and quantum computing architectures, as well as applications for biological and non-biological complex systems.

Forum Objectives:

1. *To establish as a global summit where visionaries, future leaders and youngsters come together to address critical issues in quantum physics and complex systems.*
2. *To serve as an essential linkage platform between blossoming local research community on quantum science & technology and international collaborators.*
3. *To foster the recognition of the public views and policy makers on 'quantum initiatives' as Hong Kong emerges as an international and regional innovation centre.*
4. *To become the conduit of arousing industrial attentiveness and responses on developing future quantum technology.*

Forum Information

Organizer:	HK Tech Forum, CityU Department of Physics, CityU Hong Kong Institute for Advanced Study, CityU
Date:	December 7 – 9, 2022
Venue:	LG/F, Academic Exchange Building, CityU
Format:	Hybrid Mode - On-site at CityU - ZOOM Webinar
Language:	English
Organizing Committee:	Co-Chairs: ▪ Prof Wei Bao, Chair Professor of Physics, CityU ▪ Prof Zheyu Jeff Ou, Chair Professor of Physics, CityU ▪ Prof Yang Ren, Chair Professor of Physics, CityU ▪ Prof Xun-Li Wang, Head of Department & Chair Professor of Physics, CityU Members: ▪ Dr Denver Danfeng Li, Assistant Professor of Physics, CityU ▪ Dr Sunny Xin Wang, Associate Head of Department & Associate Professor of Physics, CityU ▪ Dr Ge Zhang, Assistant Professor of Physics, CityU

Forum Program

Day-1 (December 7, 2022 Wednesday)

Time (in HK)	Activity / Speaker
0900 - 0930	**Opening Ceremony** • Prof Xun-Li Wang, Co-Chair of Forum - Opening remarks • Prof Way Kuo, the President - Welcoming remarks • Prof Anton Zeilinger, Featured speaker - Greeting message • Photo taking • Introduction of the first talk
	Session 1: Quantum Materials **Moderator: Denver Danfeng Li**
0930 - 1030	Keynote talk by **Jinfeng Jia**, Southern University of Science and Technology, China "Topological superconductors by proximity effects"
1030 - 1100	Invited talk by **Tsuyoshi Kimura**, The University of Tokyo, Japan "Symmetry breakings and resulting magnetic, electric, and optical properties in ferroic materials"
1100 - 1115	Break
1115 - 1145	Invited talk by **Guang-Han Cao**, Zhejiang University, China "New Layered Superconductors with Intergrowth Structures"
1145 - 1215	Invited talk by **Wang Yao**, The University of Hong Kong, China "Valley-layertronics in twisted bilayers "
1215 - 1230	Invited talk by **Xiao Li**, City University of Hong Kong, China "Fermionic Many-Body Localization for Random and Quasiperiodic Systems in the Presence of Short- and Long-Range Interactions"
1230 - 1400	Lunch
	Session 2: Soft Matter and Complex Systems I **Moderator: Yu Chai**
1400 - 1430	Invited talk by **Yilong Han**, The Hong Kong University of Science & Technology, China "Mapping the degenerated ground states of spin models to complex networks with novel properties"
1430 - 1500	Invited talk by **Ning Xu**, University of Science and Technology of China, China "Understanding effective temperature of slow-evolving systems from the perspective of inherent structures"
1500 - 1600	Featured talk by **Giorgio Parisi**, Sapienza University of Rome, Italy "Replica Symmetry Breaking and applications"

Forum Program

Day-1 (December 7, 2022 Wednesday)

1600 - 1615	Break
1615 - 1645	Invited talk by **Ludovic Berthier**, Universite de Montpellier, France "Is glass a state of matter?"
1645 - 1715	Invited talk by **Alessio Zaccone**, Universita degli Studi di Milano, Italy "A solution to amorphous elasticity and plasticity based on topological physics"
1715 - 1730	Invited talk by **Ge Zhang**, City University of Hong Kong, China "An entropy perspective on neural networks' loss functions"

Forum Program

Day-2 (December 8, 2022 Thursday)

Time (in HK)	Activity / Speaker
	Session 2: Soft Matter and Complex Systems II **Moderator: Ge Zhang**
0900 - 1000	Keynote talk by **Sidney R. Nagel**, The University of Chicago, USA "Memory in a glassy landscape"
1000 - 1030	Invited talk by **Patrick Charbonneau**, Duke University, USA "Recent Advances on the Glass Problem"
1030 - 1045	Break
1045 – 1115	Invited talk by **Lei Xu**, The Chinese University of Hong Kong, China "Revealing the three-component structure of water with principal component analysis (PCA) of X-ray spectra"
1115 – 1130	Invited talk by **Haixing Li**, City University of Hong Kong, China "Destructive quantum interference in sigma-conjugated silicon molecular wires"
1130 – 1145	Invited talk by **Liang Dai**, City University of Hong Kong, China "Simple Physical Laws for Complex Knotting Phenomena"
1145 - 1200	Invited talk by **Yu Chai**, City University of Hong Kong, China "Using atomic force microscopy to study the self-assembly of colloidal particles at liquid interfaces"
1200 - 1400	Lunch
	Session 3: Quantum Information **Moderator: Jeff Ou**
1400 - 1500	Keynote talk by **Franco Nori**, RIKEN, Japan "Quantum Optics with Giant Atoms: Decoherence-Free Interaction between Giant Atoms in Waveguide Quantum Electrodynamics"
1500 - 1530	Invited talk by **Xue-Hua Wang**, Sun Yat-Sen (Zhongshan) University, China "Highly-efficient on-demand controllable quantum light sources for integration"
1530 - 1600	Invited talk by **Christine Silberhorn**, Paderborn University, Germany "Integrated optics and pulsed light for quantum photonics"
1600 - 1630	Invited talk by **Li You**, Tsinghua University, China "Quantum Science and Technology enabled by Atomic Qubits"
1630 - 1645	Break

Forum Program

Day-2 (December 8, 2022 Thursday)

1645 - 1715	Invited talk by **GyuBoong Jo**, The Hong Kong University of Science & Technology, China "Quantum simulation of topological states with dissipative spin-orbit couplings"
1715 - 1730	Invited talk by **Iochun Hoi**, City University of Hong Kong, China "Deterministic loading of microwaves onto an artificial atom using a time-reversed waveform"
1730 - 1745	Invited talk by **Zhedong Zhang**, City University of Hong Kong, China "Quantum Optical Spectroscopy for Molecular Dynamics"
1745 - 1800	Invited talk by **Sunny Xin Wang**, City University of Hong Kong, China "High-fidelity CPHASE gate in a pair of capacitively coupled few-electron singlet-triplet qubits"

Forum Program

Day-3 (December 9, 2022 Friday)

Time (in HK)	Activity / Speaker
	Session 4: Quantum Beam Application I **Moderator: Wei Bao**
0900 - 1000	Keynote talk by **Hesheng Chen**, Institute of High Energy Physics, CAS, China "China Spallation Neutron Source"
1000 - 1030	Invited talk by **Yuan Li**, Peking University, China "Neutron scattering observation of magnetic molecular orbitals in MnSi"
1030 - 1045	Break
1045 - 1115	Invited talk by **Matthew Stone**, Oak Ridge National Laboratory, USA "A trio of tri-chlorides: magnetic excitations in $FeCl_3$, $YbCl_3$ and $CrCl_3$"
1115 - 1130	Invited talk by **Denver Danfeng Li**, City University of Hong Kong, China "Materials Synthesis Approaches to Infinite-Layer Nickelate Thin Films from a High-Crystallinity Precursor Phase"
1130 - 1145	Invited talk by **Junzhang Ma**, City University of Hong Kong, China "Investigation of quasiparticles in quantum materials with ARPES"
1145 - 1215	Invited talk by **Stefanus Harjo**, J-PARC, Japan "Operando engineering materials characterization using pulsed neutron beam"
1215 - 1400	Lunch
	Session 4: Quantum Beam Application II **Moderator: Yang Ren**
1400 - 1430	Invited talk by **Alfred Baron**, RIKEN, Japan "Frontiers in meV-Resolved Inelastic X-Ray Scattering: Atomic Dynamics Where We Have Not Gone Before"
1430 - 1500	Invited talk by **Yuhui Dong**, Institute of High Energy Physics, CAS, China "High Energy Photon Source (HEPS)"
1500 - 1515	Break
1515 - 1615	Keynote talk by **Christian Schroer**, Deutsches Elektronen-Synchrotron (DESY), Germany "Understanding Quantum Materials and Complex Systems Using Modern and Future Synchrotron Radiation Sources"
1615 - 1630	Break

Forum Program

Day-3 (December 9, 2022 Friday)

1630 - 1700	Invited talk by **Xinhui Lu**, The Chinese University of Hong Kong, China “Grazing Incidence X-ray and Neutron Scattering Based Organic and Perovskite Photovoltaic Studies”
1700 - 1715	Invited talk by **Qi Liu**, City University of Hong Kong, China “Spreading monoclinic boundary network between hexagonal primary grains for high performance Ni-rich cathode materials”
1715 - 1725	Set Up
1725 - 1800	Panel Discussion **Xun-Li Wang** (Moderator) **Wei Bao** **Jeff Ou** **Yang Ren**
1800 - 2030	Banquet

Jinfeng Jia
Southern University of Science and Technology, China

Keynote talk: “Topological superconductors by proximity effects”

Abstract

Topological superconductors attract lots of attentions recently, since they are predicted to host Ma-jorana zero mode (MZM), who behaves like Majorana fermion and can be used in fault-tolerant quantum computation relying on their non-Abelian braiding statistics. Currently, most topological superconductors are artificially engineered based on a normal superconductor and the exotic prop-erties of the electronic surface states of a topological insulator. As predicted, MZM in the vortex of topological superconductor appears as a zero energy mode with a cone like spatial distribution. Al-so, MZM can induce spin selective Andreev reflection (SSAR), a novel magnetic property which can be used to detect the MZMs. Here, I will show you that the Bi2Te3/NbSe2 hetero-structure is an ideal artificial topological su-perconductor and all the three features are observed for the MZMs inside the vortices on the Bi2Te3/NbSe2. Especially, by using spin-polarized scanning tunnel-ing microscopy/spectroscopy (STM/STS), we observed the spin dependent tunneling effect, which is a direct evidence for the SSAR from MZMs, and fully supported by theoretical analyses. More importantly, all evidences are self-consistent. Recently, the segmented Fermi surface induced by the Cooper pair momentum was observed in a Bi2Te3/NbSe2 sys-tem. Finally, the strong proximity effect was found in SnTe-Pb heterostructure. The bulk pairing gap and multiple in-gap states induced by topological surface states can be clearly distinguished. The superconductivity of SnTe is consistent with a new type of topological superconductors under the protection of lattice symmetries. Under lattice-symmetry protection, the superconducting SnTe is predicted to possess multiple MZMs in a single vortex. This system provides a platform to study the coupling of multiple MZMs without the need of real space movement of a vortex.

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Biography

Jinfeng Jia is a chair professor and the vice dean of the school of physics and astronomy, Shanghai Jiao Tong University. He graduated from Peking University in 1987. He received his Ph.D in condensed matter physics from the same university in 1992. From 1995 to 1996, he worked as a JSPS post-doc at Institute for Materials Research, Tohoku University, Japan. From 1996 to 2001, he worked as an associated professor at Department of Physics, Peking University. During the time, he worked as a visiting scientist in USA for 3 years. In 2001, he received the “100 Talents Project” of Chinese Academy of Sciences (CAS) and became a professor at Institute of Physics, CAS. From 2006 to 2009, he worked as a professor at Department of Physics, Tsinghua University. In 2009, he became a Cheung Kong Professor at Dept. of Physics, Shanghai Jiaotong University. He is a condensed matter experimenter. His main research interests include topological supercon-ductors and new quantum materials, quantum phenomenon in low-dimensional nano-structures, thin film growth by molecular beam epitaxy. He authored more than 260 SCI papers, including 4 in Science, 3 in Nature Phys., 2 in Nature Materials, 2 in PNAS, 6 in Adv. Mater., 3 in Nano Let-ters, 23 in Physical Review Letters, with a citation of more than 13000 times. He was selected as a highly cited researcher by Clarivate Analytics in 2018 and 2019. He received a number of recognitions, including the Scientific and Technological Progress Award of Chinese State Educa-tion Commission (first class, 1997), Chinese National Natural Science Funds for Distinguished Young Scholar (2003), Prize for Advancement in Science and Technology of Beijing (first class, 2003), National Prize for Advancement in Natural Science (second class, 2004), Outstanding Science and Technology Achievement Prize of CAS (2005), National Prize for Advancement in Natural Science (second class, 2011), Group Award for Outstanding Science and Technology Achievement from Qiu Shi Science & Technologies Foundation of Hong Kong, 2011 and Achievement in Asia Award (AAA) (Robert T. Poe Prize) by the International Organization of Chinese Physicists and Astronomers (OCPA, 2013), Prize for Advancement in Natural Science of Chinese Ministry of Education (First class, 2016) and the Special Prize for Advancement in Natural Science of Chinese Ministry of Education (2017), National Prize for Advancement in Natural Science (second class, 2019).

Tsuyoshi Kimura
University of Tokyo, Japan

Invited talk: "Symmetry breakings and resulting magnetic, electric, and optical properties in ferroic materials"

Abstract

The symmetry breaking ascribed to the evolution of an order parameter is one of the most important concepts in materials physics. Representative examples are symmetry breakings in "ferroic" materials such as the symmetry breaking of time reversal in ferro-magnets and that of space inversion in ferro-electrics. Thus, one can find that this concept contributes to not only fundamental science but also materials' functionalities available for device applications. Furthermore, recent research developments of "multiferroic" materials with broken time-reversal and space-inversion symmetries have triggered extensive studies on unconventional ferroic materials such as "ferro-toroidic" and "ferro-axial" materials.

In the case of ferro-toroidal order whose order parameter is a toroidal moment, that is, the sum of the cross product of spin and its position vector. Most typically, the toroidal moment is generated by head-to-tail arrangement of magnetic dipoles, which breaks both the time-reversal and space-inversion symmetries. When we replace magnetic dipoles in toroidal moment with electric dipoles, ferro-axial moment is generated. In the ferro-axial order, a rotational electric-dipole arrangement breaking some mirror symmetry, the so-called ferro-axial moment, is an order parameter.

In this presentation, we show symmetry-dependent magnetic, electric, and optical phenomena characteristic of unconventional ferroic orders such ferro-toroidal, ferro-axial, and ferro-quadrupole orders. The phenomena include magnetoelectric effect, nonreciprocal directional dichroism, and electrogyration. Furthermore, in general, ferroic materials bear "domain" structures, that is, spatial distributions of order parameters. However, observations of domain structures in unconventional ferroic materials are not straightforward. Here, we also show ways to spatially visualize domain structures in such unconventional ferroic materials.

Biography

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Tsuyoshi Kimura received his Ph.D degree from University of Tokyo in 1996. From 1996 to 2000, he was at Joint Research Center for Atom Technology at Tsukuba, Japan, as a postdoctoral fellow. Subsequently, he was a lecturer at Department of Applied Physics in University of Tokyo between 2000 and 2003. He worked as a Limited Term Staff Member from 2003 to 2005 in Los Alamos National Laboratory and as a Member of Technical Staff in Bell Laboratories, Lucent Technologies from 2005 to 2007. He became a professor of Graduate School of Engineering Science, Osaka University in 2007, and moved to the present institute (Department of Advanced Materials Science, University of Tokyo) in 2017.

He has extensive research experience in the single-crystal growth of transition-metal oxides (e.g., high- and low-Tc superconductors, magnetoresisitive oxides, magnetoelectric multiferroics, and frustrated spin systems) and in the characterization of structural, magnetic, and electric properties of these materials. So far, he has discovered several fascinating functionalities (e.g., giant tunneling magnetoresisitance, giant magnetoelectric and magnetocapacitive effects) in the research of materials science. Especially, he and his coworker discovered a number of new multiferroic materials.

Guang-Han Cao
Zhejiang University, China

Invited talk: "New Layered Superconductors with Intergrowth Structures"

Abstract

Cuprate and iron-based superconductors are structurally featured with two-dimensional motifs, CuO_2 planes and FeAs/Se layers, which are believed to play the key role for superconductivity. Hence it is rational to explore new superconductors by the "block-layer (BL) design", namely with intercalating various BLs into the superconducting motifs, which actually forms an intergrowth structure. However, it is not easy to evaluate the thermodynamic stability properly because of its complex structure with multiple elements involved.

In this talk, we address this particular issue with a simple BL model, employing the experimental finding of the concepts of lattice match and charge transfer between distinct BLs. We found that the inter-BL charge transfer lowers the internal energy, while lattice match minimizes the elastic energy, both of which together make an intergrowth structure stabilized. This work rationalizes the basic principles of BL design for intergrowth structures, which can be utilized not only for finding new superconducting materials but also for investigating other layered quantum materials.

Biography

Guang-Han Cao is a Qiushi Professor at Zhejiang University. He obtained a PhD in physics from University of Science and Technology of China in 1995. As an STA fellow, He visited National Institute for Materials Science at Tsukuba, Japan, from 1999 to 2001. He works on synthesis, structure, and physical properties of high-temperature superconductors and related materials. Some novel superconductors discovered in recent years in his group include iron-based ferromagnetic superconductors, iron-based superconductors with intergrowth structures and self doping, and quasi-one-dimensional chromium-based superconductors. He has published/coauthored over 300 papers with ~11000 citations in Google Scholar. Currently, he is an associate editor of 'Sci. China Materials' and 'J. Superconductivity and Novel Magnetism', and on the editorial board of 'Phys. Rev. B' and 'Materials'.

Wang Yao
The University of Hong Kong, China

Invited talk: “Valley-layertronics in twisted bilayers”

Abstract

Moiré superlattices arising from twisted van der Waals stacking of 2D materials has provided a powerful tool towards designer quantum materials that can extend the exotic properties of the building blocks. For band edge carriers located at the Brillouin zone corners (valleys), the interlayer hopping features sensitive dependence on the atomic registry between the constituting layers. In twisted TMDs homobilayers, such coupling in the moiré pattern manifests itself as a location-dependent Zeeman field acting on the active layer pseudospin, giving rise to emergent gauge field for spin/valley manipulation [1-3]. In moiré patterns distorted by non-uniform strains, the interplay of moiré interlayer coupling and strain togetherleads to non-Abelian Berry phase effects [4]. I will also show that the interlayer tunnelling across the twisted interface leads to a genuine linear response charge Hall effect in the presence of time reversal symmetry [5].
The work was supported by Research Grant Council of HKSAR (17306819, AoE/P-701/20, HKU SRFS2122-7S05), and the Croucher Foundation.

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Biography

Prof. Wang YAO obtained his BSc from Peking University in 2001, and PhD in physics from University of California, San Diego in 2006. He joined the University of Hong Kong in Sep. 2008, and is currently Chair Professor in the Department of Physics. His research interest lies in the physics of spin and valley in solids, with a current focus on two-dimensional materials and their heterostructures. He has received honours including the OCPA Achievement in Asia Award (Robert T. Poe Prize), Croucher Innovation Award, Nishina Asia Award, XPlorer Prize, and has been named by Clarivate Analytics in the list of "Highly Cited Researchers" in consecutive years since 2018. In 2020, he is elected Fellow of American Physical Society.

Xiao Li
City University of Hong Kong, China

Invited talk: "Fermionic Many-Body Localization for Random and Quasiperiodic Systems in the Presence of Short- and Long-Range Interactions"

Abstract

In this talk, I will discuss our recent work on many-body localization (MBL) for interacting one-dimensional lattice fermions in random (Anderson) and quasiperiodic (Aubry-Andre) models, focusing on the role of interaction range. We obtain the MBL quantum phase diagrams by calculating the experimentally relevant inverse participation ratio (IPR) at half-filling using exact diagonalization methods and extrapolating to the infinite system size. For short-range interactions, our results produce in the phase diagram a qualitative symmetry between weak and strong interaction limits. For long-range interactions, no such symmetry exists as the strongly interacting system is always many-body localized, independent of the effective disorder strength, and the system is analogous to a pinned Wigner crystal. We obtain various scaling exponents for the IPR, suggesting conditions for different MBL regimes arising from interaction effects.

Biography

Dr. Xiao Li joined City University of Hong Kong as an Assistant Professor in January 2019. Previously he worked as a postdoc associate in the Condensed Matter Theory Center, University of Maryland (College Park) from 2015 to 2018. Dr. Li received his BSc degree from Peking University in 2008 and his PhD degree in Physics from The University of Texas at Austin in 2014. Dr. Li is generally interested in exotic quantum phases that arise from the interplay between topology, disorder, and many-body interactions. Recently, his research focus has been on many-body localization and nonergodic phases of matter. Dr. Li has published 27 high-quality papers, including seven in *Physical Review Letters*, one in *Nature Communications*, and one in *Nature*.

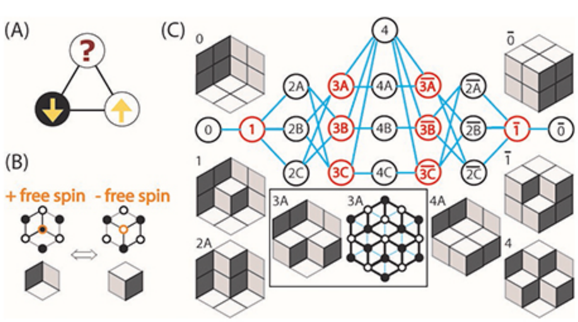
Yilong Han
The Hong Kong University of Science & Technology, China

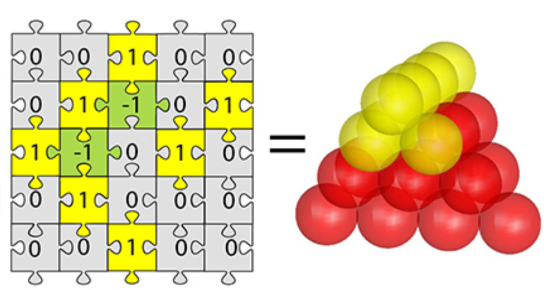
Invited talk: “Mapping the degenerated ground states of spin models to complex networks with novel properties”

Abstract

The phase space or state space of a system with discrete degrees of freedom can be viewed as a network: each node represents a state, and each edge represents a low-energy transition pathway between two states, e.g., a zero-energy mode. We map the exact ground states of various spin models (the antiferromagnet Ising spins on a triangular lattice, the six-vertex model (i.e., square ice), and ±J spin glasses) and phase spaces of 1D and 2D lattice gases to complex networks. Thus, the network analysis can be applied to phase-space studies. The phase spaces, in turn, establish a new class of complex networks (or random matrices) with unique topology characterized by the novel Gaussian spectral density. Although computer can only handle small systems as their phase spaces are huge, we mathematically prove that their spectral densities become exactly Gaussian when systems become infinitely large. The phase spaces of different models under different boundary conditions share some common features. The systems with long- and short-range correlations in real space exhibit fractal and non-fractal phase spaces, respectively, which supports the conjecture in Tsallis statistics. The connectivity distribution, community structures, and fractal structures change drastically at the ferromagnetic-to-glass phase transition. The network community analysis provides a way to describe and simplify the complex entropy landscape.

One by-product in the phase-space construction is a one-to-one mapping between the 2D six-vertex model and 3D sphere stackings. In contrast to cube stackings (i.e., antiferromagnet Ising spins on 2D triangular lattice) which has been intensively studied in combinatorics as plane partition, the sphere stacking has similar combinatorics problems but rarely been explored. We find that some sphere packing follows a mock theta function. We conjecture all models could be mapped to stackings in high dimensions.





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Biography

Prof. Han's is an experimentalist on soft matter physics and is interested in statistical physics. He has published 56 first-author or corresponding-author papers, including 5 on Nature or Science. He received the Achievement in Asia Award by OCPA in 2014 and the 14th Chinese Young Scientist Award in China in 2016.

Currently his group studies crystalline and amorphous solids, their melting and solid-solid transitions using colloids as model systems. His team made the first observations of the following phenomena with the single-particle kinetics: crystal surface premelting, homogeneous 3D crystal melting, homogeneous solid-solid transition, grain boundary roughening, glass transition in non-spherical-particle system. Recently his team discovered of a novel type of surface wetting phenomenon as the precursor of crystal-crystal transition in analogous to premelting and made important contributions on novel topics such as: polycrystal-glass transition, glass surface melting, generalization of the Hall-Petch behaviors form polycrystals to crystal-amorphous composites. Prof. Han also studied topics in statistical physics, including phase-space networks of spin systems, configurational temperatures, and Brownian motion of non-spherical particles.

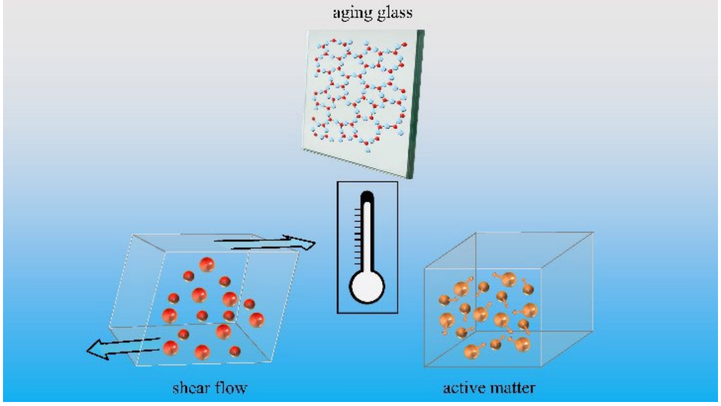
2007 - present, Assistant/Associate/Full Professor, Physics Department, Hong Kong University of Science and Technology
2004 - 2007, Postdoc, University of Pennsylvania, USA
2003, Ph.D. in Physics, University of Chicago, USA
1998, B.S. in Physics, Peking University, China

Ning Xu
University of Science and Technology of China, China

Invited talk: "Understanding effective temperature of slow-evolving systems from the perspective of inherent structures"

Abstract

Borrowing the fluctuation-dissipation theorem of equilibrium systems, we obtain a temperature-like quantity T_{IS} for inherent structures. Interestingly, although it is calculated from nonequilibrium systems, T_{IS} agrees with characteristic temperatures of the equilibrium counterparts, which are crystallization temperature of crystal-formers and onset temperature of glass-formers. We further find that T_{IS} agrees with effective temperatures of slow-evolving systems, such as aging glasses, shear flows, and self-propelled flows. Therefore, previously discussed effective temperatures of slow-evolving systems are actually melting or onset temperatures, which are thus not thermodynamic temperatures. Our work shows the underlying connections between nonequilibrium and equilibrium systems and evidences the equivalence between onset and melting temperatures.



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Biography

Ning Xu received his Ph.D. from Yale University in 2005. After graduation, he worked at University of Pennsylvania and University of Chicago as a postdoc follow till 2009. From July of 2009 to January of 2010 he worked as a research assistant professor at the Chinese University of Hong Kong. He has been a professor at University of Science and Technology of China since January of 2010, the deputy dean of School of Physical Sciences since September of 2014, and the chair professor since September of 2022. His main research interest is the fundamental studies of soft matter physics, including the transition from liquids to noncrystalline solids, the nature of disordered solids, crystallization and melting, nonequilibrium statistical mechanics, and mechanical metamaterials. He has authored about 60 papers.

Giorgio Parisi
Nobel Prize in Physics (2021)
Sapienza University of Rome, Italy

Featured talk: “Replica Symmetry Breaking and applications”

Biography

Giorgio Parisi was born in Rome August 4, 1948, he completed his studies at the University of Rome and he graduated in physics in 1970 under the direction of Nicola Cabibbo.

He carried out his research at the National Laboratories of Frascati, first as a fellow of the CNR (1971-1973) and later as a researcher of the INFN (1973-1981). During this period he made long stays abroad: *Columbia University*, New York (1973-1974), *Institut des Hautes Etudes Scientifiques*, Bures-sur-Yvettes (1976-1977), *Ecole Normale Superieure*, Paris (1977-1978).

He was nominated full professor at the University of Rome in February 1981; from 1981 to 1992 he was professor of Theoretical Physics at the *University of Rome Tor Vergata*. Since 1992 he was Professor of Theoretical Physics at *University of Rome La Sapienza* where he teached *Statistical Mechanics and Critical Phenomena*, and *Probability*. At the present moment, he is emeritus professor of *La Sapienza*.

He wrote more nearly one thousand articles and contributions to scientific conferences; he has also authored four books. In his scientific career, he worked mainly in theoretical physics, addressing topics as diverse as particle physics, statistical mechanics, fluid dynamics, condensed matter, the constructions of scientific computers, optimization theory. He also wrote some papers on neural networks, immune system and the movement of groups of animals.

His works are extremely well known.

In 1992 he was awarded the *Boltzmann Medal* (awarded every three years by I.U.P.A.P. on Thermodynamics and Statistical Mechanics) for his contributions to theory of disordered systems, the *Max Planck Medal* in 2011, from the German Physical Society, the *Wolf Prize* in 2021 and the *Nobel Prize* in 2021.

He also received, the *Dirac Medal* for theoretical physics in 1999, the Enrico Fermi Award in 2003, the *Dannie Heineman Prize* of the APS in 2005, the *Nonino Prize* in 2005, the *Galileo Prize* in 2006, the *Microsoft Prize* in 2007, the *Lagrange Prize* in 2009, the *Vittorio De Sica Prize* in 2011, the *Nature Award for Mentoring in Science* in 2013 and the 2015 *High Energy and Particle Physics Prize* by the EPS HEPP Board 2015, the *Lars Onsager Prize* of the APS in 2016 and the *Pomeranchuk Prize* in 2018, the Wolf Prize and the Nobel prize in 2021.

He is a member of the *Accademia dei Lincei*, the *Accademia dei Quaranta*, the *Académie des Sciences*, the *U.S. National Academy of Sciences*, the *European Academy*, the *Academia Europea*, the *American Philosophical Society* and of the *Academia Pontaniana*.

From 2018 to 2021 he has been president of the *Accademia dei Lincei*.

Ludovic Berthier
Universite de Montpellier, France

Invited talk: "Is glass a state of matter?"

Abstract

Glass is everywhere. We use and are surrounded by glass objects which make tangible the reality of glass as a distinct state of matter. Yet, glass as we know it is usually obtained by cooling a liquid sufficiently rapidly below its melting point to avoid crystallisation. The viscosity of this supercooled liquid increases by many orders of magnitude upon cooling, until the liquid becomes essentially arrested on experimental timescales below the ``glass transition" temperature. From a structural viewpoint, the obtained glass still very much resembles the disordered liquid, but from a mechanical viewpoint, it is as rigid as an ordered crystal. Does glass qualify as a separate state of matter? I will provide a pedagogical perspective on this question using basic statistical mechanical concepts. I will review recent theoretical results suggesting why and how an ``ideal glass" can indeed be defined as a separate equilibrium state of matter and discuss modern computer simulations trying to analyse this glass state. I will close with some experimental perspectives.

Biography

Ludovic Berthier received his Ph. D. in theoretical physics at the Ecole Normale Supérieure in Lyon, France. He was a Marie Curie Postdoctoral Fellow at the Department of Theoretical Physics at Oxford University (UK) until 2003. In 2004 he was appointed as a CNRS researcher at the Laboratoire Charles Coulomb at University of Montpellier (France), where he is now Director of Research. In 2007, he was a visiting scientist at the James Franck Institute of the University of Chicago (US). Since 2019 he is a Visiting Professor at the University of Cambridge (UK) where he is a Fellow of Churchill College.

He works on the statistical mechanics of disordered materials, nonequilibrium systems, and soft matter. He performs theoretical research and computer simulations to develop a fundamental understanding of the structure and dynamics of a broad range of materials that we use on a daily basis, from sandpiles, emulsions, pastes and to window glasses, molecular fluids and active and biological systems.

Alessio Zaccone
Universita degli Studi di Milano, Italy

Invited talk: “A solution to amorphous elasticity and plasticity based on topological physics”

Abstract

I will by reviewing the microscopic theory of linear elasticity in amorphous solids which, from first-principles consideration of non-centrosymmetry in the particle contact environment, leads to mathematical predictions of elastic moduli in quantitative parameter-free agreement with numerical simulations of random jammed packings [1]. This theory fully accounts for the extra non-affine displacements which arise due to the lack of centrosymmetry that leads to force imbalance in the so-called "affine" position, with characteristic negative (softening) contributions to the shear modulus entirely due to non-affine displacements.

I will then show how the theory can be systematically extended to linear viscoelasticity, again in excellent parameter-free agreement with mechanical spectroscopy (oscillatory rheology) in simulations of polymer glass rheology [2]. The same non-affine deformation theory is able to mathematically predict and explain the ubiquitous inverse cubic dependence of low-frequency shear modulus on confinement size for confined liquids and amorphous solids [3]. I will then show that non-affinity of particle motions gives rise to well-defined topological defects (dislocation-like topological defects, DTDs) which have recently been discovered in the displacement field of model amorphous solids [4] and later confirmed in [5]. The norm of the associated Burgers vector of these defects can be used as an accurate predictor of the onset of plastic flow and yielding of the amorphous material, and, in combination with Schmid's law, it can explain the phenomenon of shear banding via self-organization of DTDs in slip systems at 45 degrees with respect to flow direction [4]. Broader implications of a unifying topological field theory of liquids and the liquid-solid transition will also be mentioned [6].

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Biography

Professor Alessio Zaccone received a PhD in Chemical Physics from ETH Zurich in 2010. He served as a faculty member at Technical University Munich, at the University of Cambridge, and, currently, at the University of Milan. His active research interests include jamming and granular packings, the physics of glasses and amorphous solids, elasticity, phonons and continuum mechanics, topological physics, statistical mechanics, colloids, liquids and complex fluids out of equilibrium, and the theory of superconductivity. His awards include the following:

- ERC Consolidator Award of the European Union (2022)
- Fellow of Queens' College, Cambridge (2015)
- Gauss Professor of the Göttingen Academy of Sciences (2020)
- Institute of Physics, Emerging Leader (2020)
- American Chemical Society I&ECR Influential Researcher Award (2017)
- Oppenheimer Research Fellow, Cavendish Laboratory (2011)
- Silver Medal of ETH Zurich (2011)

Ge Zhang
City University of Hong Kong, China

Invited talk: "An entropy perspective on neural networks' loss functions"

Abstract

A neural network contains a large number of parameters that are fitted to the training data. This is done by numerically minimizing the loss function, a function that quantifies the deviation of the fit from the actual training data. A highly desired goal in this field is to design neural networks with good generalization performance, i.e., one that performs well for data points not present in the training data set. The machine learning community generally believed that a flatter minimum of the loss function has better generalization performance than a sharper minimum. Here we show that such a correlation generally exists but is not perfect. We do this by calculating the entropy (logarithm of the volume in the parameter space) versus the accuracy in training and test datasets using the Wang-Landau Monte Carlo algorithm. We show that the test accuracy of the maximum-entropy state is higher than that of a typically-trained state, but is still below the training accuracy. Our current results are obtained from a very small-scale problem (a spiral dataset with about 40 data points and a fully connected neural network with a few hundred parameters), but we will also briefly discuss future plans to study larger-scale problems.

Biography

Dr. ZHANG Ge joined CityU as an assistant professor in physics in September 2021. Before that, he was a postdoc with Prof. Andrea Liu in Department of Physics and Astronomy at the University of Pennsylvania, studying disordered solids using computational models. He earned his Ph. D. from Princeton University working on computational statistical physics, including packing problems and disordered classical ground states.

Sidney R. Nagel
The University of Chicago, USA

Keynote talk: "Memory in a glassy landscape"

Abstract

Out-of-equilibrium systems preserve memories of their formation and training history in a variety of ways allowing for an innovative classification of material and dynamics. I will discuss one case where a cyclically sheared suspension of particles or a charge-density-wave solid (or even a walk in the park!) remembers multiple values from a series of training inputs yet forgets all but two of them at long times despite their continued repetition; however, if noise is added all the memories can be encoded indefinitely! When the packing density is increased, so that the particles become jammed, the evolution takes place in a very rugged energy landscape where scores of local energy minima are visited during each applied oscillation. Nevertheless the jammed solid can readily find the periodic orbits. Memory formation in such a system not only sheds light on how glassy ground states are selected and communicate with one another but also shows a form of memory that allows a new probe of the interactions within a material.

Biography

Professor Sidney R. Nagel received a Ph.D. in Physics from Princeton University in 1974. Currently, he is the Stein-Freiler Distinguished Service Professor (2001–present) at the University of Chicago, where he is affiliated with the Department of Physics, the James Franck Institute, and the Enrico Fermi Institute. His research interests include jamming, granular materials, singularities in free-surface flows, and splashing. Professor Nagel's Honors are listed below:

- Alfred P. Sloan Research Fellowship (1979)
- Fellow, American Physical Society (1988)
- Fellow, American Association for the Advancement of Science (1993)
- Quantrell Award for Excellence in Undergraduate Teaching (1996)
- Fellow, American Academy of Arts and Sciences (1997)
- Klopsteg Memorial Lecture Award, American Association of Physics Teachers (1998)
- Oliver E. Buckley Prize, American Physical Society (1999)
- Member, National Academy of Sciences (2003)
- Member, American Philosophical Society (2020)

Patrick Charbonneau
Duke University, USA

Invited talk: “Recent Advances on the Glass Problem”

Abstract

Over the last decade, theoretical advances have provided an exact solution to the glass problem in the limit of infinite spatial dimension. Interestingly, the dynamical arrest this work predicts is consistent with the mode-coupling theory of glasses, and the ensuing entropy crisis at the Kauzmann transition with the random first-order transition scenario. However, what survives of these features and what other processes contribute to the dynamics of three-dimensional glass formers remain largely open questions. In this talk, I present our recent advances toward a microscopic understanding of the finite-dimensional echo of these infinite-dimensional features, and of some of the activated processes that affect the dynamical slowdown of simple yet realistic glass formers.

Biography

Patrick Charbonneau is professor of chemistry and physics at Duke University. Originally from Montreal, he obtained a Ph.D. in chemical physics from Harvard University in 2006 and was then a Marie-Curie Fellow at the AMOLF Institute, in Amsterdam, before moving to Durham in 2008. Charbonneau’s main research contributions fall within the fields of soft matter and statistical physics. Using analytic theory and numerical simulations, he studies the exotic and intricate structures that colloids and proteins can spontaneously form. He also studies disordered systems, and particularly glasses. This has led him to help establish an international network of close scientific collaborators as the *Simons Collaboration on Cracking the Glass Problem*. He has thus far authored more than 100 peer-reviewed publications, and co-organized a number of international meetings on these topics. A science history enthusiast, he co-curated the exhibit *Seeing the Invisible: 50 Years of Macromolecular Visualization*, and is leading an oral history project *The History of Replica Symmetry Breaking in Physics*. Once in a while, he also gets to teach a course on the science of cooking and on the history of chemistry. Since joining Duke, Charbonneau has earned a National Science Foundation CAREER Award, a Sloan Fellowship, and an Oak Ridge National Lab Ralph E. Powe award, and been granted various visiting scientist positions.

Lei Xu
The Chinese University of Hong Kong, China

Invited talk: "Revealing the three-component structure of water with principal component analysis (PCA) of X-ray spectra"

Abstract

Combining principal component analysis (PCA) of X-ray spectra with MD simulations, we experimentally reveal the existence of three basic components in water. These components exhibit distinct structures, densities, and temperature dependencies. Among the three, the two major components correspond to the low-density liquid (LDL) and the high-density liquid (HDL) predicted by the two-component model, and the third component exhibits a unique 5-hydrogen-bond configuration with ultra-high local density. As the temperature increases, the LDL component decreases and the HDL component increases, while the third component varies non-monotonically with a peak around 20 °C to 30 °C. The 3D structure of the third component is further illustrated as the uniform distribution of five hydrogen-bonded neighbors on a spherical surface. Our study reveals experimental evidence for water's possible three-component structure, which provides a fundamental basis for understanding water's special properties and anomalies.

Biography

8/2018-present - Professor, Physics Department, The Chinese University of Hong Kong
8/2015-8/2018 - Associate Professor, Physics Department, The Chinese University of Hong Kong
8/2009-8/2015 - Assistant Professor, Physics Department, The Chinese University of Hong Kong
2006-2009 - Harvard University, School of Engineering and Applied Sciences, Post-doc Fellow
2000-2006 - The University of Chicago, Department of Physics, Ph.D.
1995-2000 - The University of Science and Technology of China, Department of Physics, B.S.

Haixing Li
City University of Hong Kong, China

Invited talk: "Destructive quantum interference in sigma-conjugated silicon molecular wires"

Abstract

Single molecule techniques have made a profound impact in uncovering the structure-function relationships of molecular materials. Among them, the scanning tunneling microscope break junction (STM-BJ) technique has emerged as a powerful platform for observing quantum mechanical phenomena at nanoscale and for testing electron transport theory at molecule-metal interfaces. In this talk, I will describe single molecule measurements of cyclic silanes performed using a STM-BJ technique and related density functional theory calculations. We demonstrated that we can achieve an ultimate molecular insulator in a functionalized bicyclo[2,2,2]octasilane moiety by the use of complete destructive quantum interference effect in a sigma-conjugated backbone. This work highlights a sigma interference-based approach in creating insulating molecular materials.

Biography

Dr Haixing Li is an Assistant Professor in the Department of Physics at City University of Hong Kong. She obtained her BS in Physics from the University of Science and Technology of China in 2012 where she did her undergraduate thesis with Prof. Xianhui Chen growing oxides in search of superconductors. During her undergraduate studies, she also spent a summer at the University of Oxford learning quantum optics. She then moved to Columbia University and earned her PhD in Applied Physics in 2017 under the guidance of Prof. Latha Venkataraman uncovering the electronic properties of molecular silicon. She worked as a postdoctoral fellow and later a Charles H. Revson Senior Fellow in the laboratory of Prof. Ruben Gonzalez at Columbia University studying mechanisms of ribosomal frameshifting from 2017 to 2021. Her research group examine molecules and bio-inspired architectures at the single molecule level to spark advances in electronics, health, and sustainability.

Liang Dai
City University of Hong Kong, China

Invited talk: "Simple Physical Laws for Complex Knotting Phenomena"

Abstract

Knotting is a common phenomenon in linear objects ranging from macroscopic ropes to DNA, proteins, and other polymers. Physical understanding of knotting phenomena is very limited due to the complexity of knotting. In recent years, we developed a theoretical model to describe the knotting in DNA and other polymers, and revealed many intriguing knot properties. This theoretical model is based on tubes for knots. The tube model assumes that the polymer segments in a knot core are confined within a virtual tube due to topological entanglements and presents a simplified view of knotted polymer conformations that appear irregular and disordered. To materialize the conceptual tube, we generated a large number of knotted polymer conformations by Monte Carlo simulations and superimposed them to obtain the tube. The tube model converts the complicated knotting problem to a tube confinement problem, which can be better tackled by theory and can be used to derive the shape, fluctuations, and free energy of knots.

Biography

Liang DAI is an assistant professor in the Department of Physics at City University of Hong Kong (CityU). Dr. Dai obtained his BSc degree in physics from University of Science and Technology of China in 2004, and his PhD degree in physics from National University of Singapore in 2009. Before joining CityU, he worked as a research scientist in Singapore-MIT Alliance for Research and Technology (SMART). Dr Dai performs research in soft matter physics and biophysics using multi-scale modeling, from atomistic to coarse-grained, and statistical mechanics, with tight collaboration with experimental groups. In addition to addressing fundamental physics problems in soft matter systems, Dr Dai is interested in practical applications such as DNA sequencing technologies based on nanopores or nanochannels, and design of antimicrobial peptides for antibiotic drugs.

Yu Chai
City University of Hong Kong, China

Invited talk: "Using atomic force microscopy to study the self-assembly of colloidal particles at liquid interfaces"

Abstract

Colloidal particles can assemble at liquid interfaces, thereby reducing the interfacial energy. Self-assembly of colloidal particles at liquid interfaces has attracted a lot of attention from academia and industry due to its complex energy landscape and potential application in various emerging fields. However, the small size of colloidal particles and the liquid environment make it challenging to explore the self-assembly of colloidal particles at liquid interfaces, especially for those at the nanoscale. In this talk, I will show our recent research advances in using atomic force microscopy (AFM) to study the self-assembly of nanometer-sized colloidal particles at liquid interfaces. With in situ AFM, we show for the first time real-space imaging of sub-20 nm silica particles assembled at the water-oil interface with the help of oppositely charged polymeric surfactants, and the adsorption events of individual silica particles to the water-oil interface, among others. The local packing and dynamic information of these small particles at liquid interfaces revealed by in situ AFM allow us to develop novel soft devices.

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[2] **Chai, Y.**; Lukito, A.; Jiang, Y.; Ashby, P. D.; Russell, T. P., Fine-Tuning Nanoparticle Packing at Water-Oil Interfaces Using Ionic Strength. ***Nano Letters 2017***, 17 (10), 6453-6457.

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Biography

Dr. Yu Chai is an assistant professor in the physics department at the City University of Hong Kong. He joined CityU in April 2020. Before that, he worked as a postdoctoral researcher at the University of California, Berkeley, and Lawrence Berkeley National Laboratory. He got his Ph.D. in physics at the University of Waterloo, Canada, in 2016. Dr. Chai has a long-term research interest in soft matter with a particular focus on surfaces and interfaces. With the help of state-of-the-art in situ instruments, including atomic force microscopes, he and his group have discovered many interesting behaviors of various soft materials at the surfaces and interfaces. Over the past decade, Dr. Chai has published more than 30 peer-reviewed papers, most of which are in prestigious journals, including *Science*, *Science Advances*, *Nature Communications*, *PNAS*, *Advanced Materials*, *Nano Letters*, *ACS Nano*, etc.

Franco Nori
Theoretical Quantum Physics Laboratory, Center for Quantum Computing, RIKEN, Japan
University of Michigan,USA

Keynote talk: "Quantum Optics with Giant Atoms: Decoherence-Free Interaction between Giant Atoms in Waveguide Quantum Electrodynamics"

Abstract

In quantum optics, atoms are usually approximated as point-like compared to the wavelength of the light they interact with. However, recent advances in experiments with artificial atoms built from superconducting circuits have shown that this assumption can be violated. Instead, these artificial atoms can couple to an electromagnetic field in a waveguide at multiple points, which are spaced wavelength distances apart. Such systems are called giant atoms. They have attracted increasing interest in the past few years (e.g., see the review in [1]), in particular because it turns out that the interference effects due to the multiple coupling points allow giant atoms to interact with each other through the waveguide without losing energy into the waveguide (theory in [2] and experiments in [3]). This talk will review some of these developments. Finally, we will also show how a giant atom coupled to a waveguide with varying impedance can give rise to chiral bound states [4].

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[4] X. Wang, T. Liu, A.F. Kockum, H.R. Li, F. Nori, Phys. Rev. Lett. 126, 043602 (2021). [PDF]

Biography

Prof. Franco Nori is a RIKEN Chief Scientist, heading the "Theoretical Quantum Physics Laboratory". His research is in theoretical condensed matter physics and quantum information processing. He is a Fellow of the American Physical Society, the Optical Society of America, the UK's Institute of Physics, and the American Association for the Advancement of Science. He is an Elected Member of the Latin American Academy of Sciences, and a Foreign Member of the Swedish Royal Society of Arts and Sciences, in Gothenburg, Sweden.

Xue-Hua Wang
Sun Yat-Sen (Zhongshan) University, China

Invited talk: "Highly-efficient on-demand controllable quantum light sources for integration"

Abstract

The generation of high-quality photon sources has been a long-sought goal in modern quantum communication and computation. The semiconductor quantum dot (QD) has been successfully demonstrated as a potentially scalable and on-chip integration technology to generate the triggered photon streams. However, the randomicity of the photon streams emitted from the QD seriously hinders the realization of highly-efficient on-demand controllable quantum light sources. In this talk, I will firstly present the strongly-entangled photon pair sources with high brightness and indistinguishability by combining GaAs QDs with new broadband photonic nanostructures: circular Bragg resonators on highly efficient broadband reflectors (CBR-HBR), which was praised as "an important milestone" in this field. Then, I will talk about the on-demand spin-state manipulation of single-photon emission from quantum dot integrated with metasurface, and the bright solid-state sources for single photons with orbital angular momentum.

Biography

Dr. Xue-Hua Wang is a Professor in Optics, School of Physics and Engineering, Sun Yat-Sen (Zhongshan) University, China. He got his PhD degree in 1995 at Shanghai Jiaotong University, China. He has long conducted researches on nano photonics, quantum optics and solid quantum chips, especially on controlling interaction between light and matter. He has made some significant achievements in these fields, including the universal position-dependent theoretical model for quantum light emission in nano structures, fabrication of highly-efficient on-demand controllable quantum light sources, and realization of the room-temperature quantum strong coupling of a single exciton with a single plasmonic nano particle. He has published more than 130 peer-reviewed papers on famous international journals, such as Nat. Nanotech., Phys. Rev. Lett., Nat. Commun., Sci. Adv., Light: Sci. & Appl., etc.

Christine Silberhorn
Paderborn University, Germany

Invited talk: "Integrated optics and pulsed light for quantum photonics"

Abstract

Quantum technologies promise a change of paradigm for many fields of application, for example in communication systems, in high-performance computing and simulation of quantum systems, as well as in sensor technology. Current efforts in photonic quantum target the implementation of scalable systems, where the realization of controlled quantum network structures is key for many applications.

Here we present the progress for three differing approaches to overcome current limitations for the realization of multi-dimensional photonic systems: non-linear integrated quantum optics, pulsed temporal modes and time-multiplexing..

Biography

Present appointment
(Since 04.2010) Full Professor of Applied Physics/Integrated Quantum Optics, Paderborn University

Previous appointments
(01.2009 – 03.2010) Head of an Independent Max Planck Research Group, Integrated Quantum Optics, Max Planck Institute for the Science of Light, Erlangen, Germany
(05.2005 – 12.2008) Head of an independent Max Planck Junior Research Group, Integrated Quantum Optics, Max Planck Institute for Quantum Optics, Garching/Munich (laboratory at Erlangen), Germany
(01.2005 – 04.2005) Research Assistant, Max Planck Research Group, Erlangen
(01.2003 – 12.2004) Post-doctoral Research Assistant at University of Oxford, Clarendon Laboratory, Head of group: Prof. I. A. Walmsley, UK

Academic qualifications
(05.2005 – 07.2008) Habilitation in Experimental Physics, Faculty of Sciences, Department of Physics, University of Erlangen-Nuremberg, Prof. Dr. G. Leuchs, Germany
(03.1999 - 12.2002) PhD in Physics (summa cum laude), Faculty of Sciences, Department of Physics, University of Erlangen-Nuremberg, Prof. Dr. G. Leuchs, Germany
(11.1993 - 01.1999) Study of physics and mathematics at University of Erlangen-Nuremberg

Research summary

The research activities of Christine Silberhorn cover the exploration of novel optical technologies based on quantum optics, quantum tomography and light-based quantum systems for use in quantum communication and quantum information processing. In particular she is interested in new approaches for scaling photonic quantum systems, which is essential for the implementation of photonic quantum simulator and computers and opens new opportunities in quantum communication and quantum metrology. Her work bridges technological developments, such as the establishment of fabrication methods for nonlinear waveguide structures, with applied science, e.g. with the implementation of integrated quantum devices, and fundamental physics targeting new concepts for ultrafast quantum optics and quantum networks. She has contributed to the development of novel engineered sources of quantum light and quantum circuits using nonlinear integrated optics, and has pioneered timemultiplexed quantum networks for photon counting and quantum simulations. Her fundamental and conceptual work has advanced the realization of quantum communication systems and the exploration of novel quantum metrology application in the temporal-spectral domain.

Li You
Tsinghua University, China

Invited talk: "Quantum Science and Technology enabled by Atomic Qubits"

Abstract

Ensembles of atomic qubits can exhibit quantum advantages in communication, sensing or precision measurement, and quantum simulation or computation. This talk will introduce the basics of such quantum science and technology. We will report recent research efforts on two frontier topics: (1) enhanced sensing precision beyond classical limit in linear interferometry by improved signal-to-noise ratio with entangled atoms with suppressed quantum noise; or in nonlinear interferometry by noiseless signal amplification with interaction-based-readout from coherent disentanglement dynamics; (2) arrays of Rydberg atom qubits can be assembled from bottom up into systems sizes capable of quantum supremacy, demonstrating quantum information processing tasks beyond the capabilities of all current computers.

Biography

Li You, Professor of Tsinghua University, is director of the Institute of atomic, molecular, and optical physics. Dr. You obtained his BS from Nanjing University in 1987 and studied overseas through the US-China CUSPEA program. In 1993, he completed Ph.D. at JILA, University of Colorado. From 1993-1996, he was a postdoc at the Institute of atomic and molecular physics of Harvard-Smithsonian Center for Astrophysics. He was Assistant, Associate, and Full Professor at Georgia Institute of Technology from 1996-2010 and joined Tsinghua University in 2009. Dr. You is a Fellow of American Physical Society (2007). He is a recipient of US NSF Career Award (1997), a ONR Young Investigator (1997). With collaborators, he won the first prize of annual essay award from Gravity Research Foundation (2013). His recent effort "Deterministic entanglement generation from driving through quantum phase transitions," was voted one of the Top Ten major scientific advances in China (2017).

GyuBoong Jo
The Hong Kong University of Science & Technology, China

Invited talk: "Quantum simulation of topological states with dissipative spin-orbit couplings"

Abstract

Given that various synthetic topological matter have been realized with ultracold atoms, the atomic system has become one of most promising platforms for examining topological phases of matter in unprecedented environments, such as those with dissipation. Although such environments are ubiquitous in nature, it is still challenging to exploit them to manipulate the property of the quantum system in which emergent phenomena, such as exceptional points/rings, skin effects, localization, and critical phases, occur. In this talk, I discuss our recent realization of dissipative spin-orbit couplings (SOCs) in bulk and lattices with ultracold fermions.

In bulk, we realize non-Hermitian spin-orbit-coupled quantum gases and observe a parity-time symmetry- breaking transition across the exceptional point (EP) as a result of the competition between SOC and dissipation. The realized EP of the non-Hermitian band structure exhibits chiral response when the quantum state changes near the EP. Recently, we generalize this non-Hermitian SOC scheme to two-dimensional Bloch bands, in which the EP emerges at the end of Fermi arc in the presence of dissipation. By using spin-resolved Rabi spectroscopy in this lattice system, we not only identify the exceptional point but also measure a complex energy-gap spectrum showing the evidence of non-Hermitian skin effect in a two-dimensional lattice system.

Biography

Prof. Gyu-Boong Jo is currently Hari Harilela Associate Professor in the Department of Physics at The Hong Kong University of Science and Technology (HKUST), and leads the Laboratory for Ultracold Quantum Gases. He joined HKUST following his studies at the Massachusetts Institute of Technology (PhD, 2010), where he was awarded the Samsung PhD Fellowship, and postdoctoral work at the University of California, Berkeley (2010-13). He obtained his Bachelor's degrees in physics and mathematics from Seoul National University in 2003. He has received multiple awards including the AKPA Outstanding Young Researcher Award (OYRA) (2013), the Early Career Award from the Research Grant Council of Hong Kong (2014), the Croucher Innovation Award (2016), the HKUST School of Science Research Award (2019) and the RGC Research Fellowship (2021).

Prof. Gyu-Boong Jo's research focuses on the quantum simulation of intractable quantum problems using ultracold atoms, wherein a dilute gas of atoms is routinely cooled down to 100 billionth of 1 Kelvin. He harnesses the long quantum coherence of atoms to engineer atomic systems, and creates synthetic quantum matter for simulating various many-body quantum dynamics, including topological phases, many-body open quantum states, large spin quantum states and dipolar quantum liquids. To do so, he utilizes atomic quantum simulators and explores the interface between atomic molecular optical physics, condensed-matter physics and quantum information science. His research agenda continues to evolve and aims at developing a programmable quantum simulation platform for quantum computation.

Iochun Hoi
City University of Hong Kong, China

Invited talk: "Deterministic loading of microwaves onto an artificial atom using a time-reversed waveform"

Abstract

Loading quantum information deterministically onto a quantum node is an important step towards a quantum network. Here, we demonstrate that coherent-state microwave photons, with an optimal temporal waveform, can be efficiently loaded onto a single superconducting artificial atom in a semi-infinite one-dimensional (1D) transmission-line waveguide. Using a weak coherent state (the number of photons contained in the pulse $N < < 1$) with an exponentially rising waveform, whose time constant matches the decoherence time of the artificial atom, we demonstrate a loading efficiency of 94.2% from 1D semi-free space to the artificial atom. The high loading efficiency is due to time-reversal symmetry: the overlap between the incoming wave and the time-reversed emitted wave is up to 97.1%. We also theoretically show that Fock-state microwave photons can be deterministically loaded with an efficiency of 98.5% due to an overlap of 99.3% between input and time-reversed emission. Our results open up promising applications in realizing quantum networks based on waveguide quantum electrodynamics.

Biography

Io-Chun Hoi received B.S. and Ph.D. in Electro-Physics Department, National Chiao Tung University, Taiwan and Department of Microtechnology and Nanoscience, Chalmers University of Technology, Sweden, respectively. He did his postdoctoral research at University of California, Santa Barbara, U.S.A. He was an assistant professor and associate professor at National Tsing Hua University, Taiwan. He is currently associate professor at Physics department, City University of Hong Kong. He is the author or co-author of 24 publications, including 3 first-authored Physical Review Letters, 1 first-authored Nature Physics and 2 corresponding-authored Physical Review Letters and 1 corresponding-authored Nano Letters.

Zhedong Zhang
City University of Hong Kong, China

Invited talk: "Quantum Optical Spectroscopy for Molecular Dynamics"

Abstract

Quantum states of the light, e.g., single photons, entanglement and squeezing, opens up a new avenue for spectroscopy by utilizing the parameters of quantum optical fields as novel control knobs and through the variation of photon statistics. With the advance of cavity quantum electrodynamics and light source technology, imaging and controlling the electron and vibrational motions of molecules can be achieved, towards unprecedented resolution and precision, not accessible by the classical light pulses. In this talk, I will present our recent works on multidimensional spectroscopy using quantum states of light, including 2D photon-coincidence counting and Raman spectroscopy. Microscopic models for molecular relaxation using reduced density matrix will be incorporated for a unified understanding of the signals.

Biography

Dr. Zhedong Zhang is now an Assistant Professor in Department of Physics at City University of Hong Kong. He obtained his Ph.D. in physics from Stony Brook University in 2016. Since then, he has been working with Shaul Mukamel, Girish Agarwal and Marlan Scully (NAS, FRS & AAAS), as a postdoctoral scholar. He received the Robert A. Welch Postdoctoral Fellowship in 2020. Dr. Zhang is a member of American Physical Society.

Dr. Zhang's research interest is the theoretical quantum physics, with a foci of quantum-light nonlinear spectroscopy and quantum thermodynamics at mesoscopic scale. He has about 30 professional publications, on high-profile journals including *Phys. Rev. Lett., Optica, Light: Sci. & Appl., J. Phys. Chem. Lett., Phys. Rev. A* and *Phys. Rev. B.*

Sunny Xin Wang
City University of Hong Kong, China

Invited talk: “High-fidelity CPHASE gate in a pair of capacitively coupled few-electron singlet-triplet qubits”

Abstract

Due to their limited coupling to charge noises, spin qubits have been the main candidates for robust quantum information processing in semiconductor quantum dot devices. Among the proposed spin qubits, singlet-triplet qubits stand out due to their all electrical control scheme. Although high-fidelity single-qubit operations have been experimentally demonstrated, the fidelities of two-qubit capacitive gates are limited. In contrast to conventional two-electron singlet-triplet qubits, we propose to host the capacitive gates between a pair of four-electron singlet-triplet qubits, each of which is operated in the detuning regime where the electron occupation is asymmetric. Using full configuration interaction calculations, we show that the non-monotonic behavior of the dipole moment of each qubit leads to an optimal operating point where the capacitive coupling is maximal and the effective exchange energies are first-order insensitive to charge noises. Numerical simulations under realistic charge noises and hyperfine noises show that operating CPHASE gates at the optimal point can achieve fidelities above 99%.

[1] G. X. Chan and X. Wang, Phys. Rev. B 106, 075417 (2022)

Biography

Dr. Xin (Sunny) Wang received B.S. from School of Physics, Peking University in 2005, and received his Ph.D. degree from Columbia University in 2010. His Ph.D. study was focused on the theory of strongly correlated materials, in particular the high-Tc superconductors. From 2010-2015, Dr. Wang was a Research Associate in Condensed Matter Theory Center at University of Maryland, College Park. He joined City University of Hong Kong as an Assistant Professor in 2015 and was promoted to Associate Professor in 2020. His current research interests include the theory of quantum computation using electron spins, correlated electron systems, and numerical methods. He has published more than 50 journal papers, including those in *Nature Communications*, *npj Quantum Information*, and *Physical Review Letters*.

Hesheng Chen
Academian, Chinese Academy of Sciences, China
Institute of High Energy Physics, CAS, China

Keynote talk: "China Spallation Neutron Source"

Abstract

The China Spallation Neutron Source (CSNS) is a multidisciplinary research platform with neutron scattering. The site of CSNS is Dongguan, Guangdong Province. The facility comprises an 80-MeV H- Linac, a 1.6 GeV proton rapid cycling synchrotron (RCS), a tungsten target station, and two experimental halls for 20 neutron instruments. The RCS provides a beam power of 100 kW on the target in phase I. There are three initial instruments in the experimental halls. The construction of CSNS was finished on schedule and reached the specifications. The first neuron beam of CSNS was obtained in August 2017. The construction of CSNS went through the acceptance review organized by the Chinese Academy of Sciences in March 2018, and opened to users. CSNS runs stable with high efficiency. The proton beam power on the target reached the design value of 100kW in February 2020, and increased to 140kW Sept. 2022.

Currently, four neutron instruments are running and open to users. Four more user instruments are under commissioning. Another two will be ready next year. There are 4000 registered users in CSNS, and more than 900 experiments were carried out. Many interesting scientific results were obtained. The phase II of CSNS was approved by Chinese funding agency, including increasing the proton beam power of the accelerators and the target station to 500kW, and the construction of 9 neutron instruments as well as the muon beam and a proton test beam.

The construction, scientific results, and upgrade plan of CSNS will be reported.

Biography

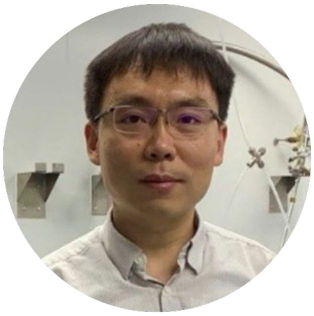
Professor Hesheng Chen is a particle physicist and Academician of Chinese Academy of Sciences. He received his Ph.D. in Physics from the Massachusetts Institute of Technology. He is currently the Head of Command and Engineering Manager of China Spallation Neutron Source (CSNS). He was the Director of the Institute of High Energy Physics, President of the High Energy Physics Association of China, and Vice President of the Chinese Physical Society.

Professor Chen is the co-director of a joint laboratory co-established by City University of Hong Kong (CityU) and the Institute of High Energy Physics under the Chinese Academy of Sciences (CAS). The joint laboratory on Neutron Scattering was launched on 27 February 2019, it is the only laboratory in Hong Kong for research into this discipline.

Professor Chen had made major contributions to the discovery of gluon jet and the systematic study of gluon physics in the Mark-J experiment at DESY. He also made important contribution to the precision measurement of the electro-weak parameters and demonstrating the validity of the Standard Model.

He made very important contributions to the design and construction of the hadron calorimeter, and the physics analysis in the L3 experiment at CERN. His work was the key part in determining of the number of neutrino generations and the precision measurement of the electroweak parameters in L3.

He made major contributions to the study of the strategy of the particle physics and high energy accelerator in China. He led the team of the Beijing Electron-Positron Collider (BEPC) and obtained important physics results in the charm energy region, including the precision measurement of R value between 2 to 5 GeV and the discovery of new resonance X1835, which could be a ppbar bound state. He proposed the BEPC upgrade project (BEPCII), which is a double ring collider in the existing tunnel with the luminosity improving by two orders of magnitude for the study of Charm physics. He is the BEPCII projector manager. Under his leadership, the project was finished on schedule and within the budget. The daily integrated luminosity of BEPCII has been increased by factors of more than 100 respectively. The new resonance of Zc (3900), which could be explained as a 4 quark state was discovered recently. The Daya Bay reactor neutrino experiment was designed and constructed under his leadership. The most precision measurement on the neutrino mixing parameter ⊖13 from the experiment determined the future direction of the neutrino physics experiment.



Yuan Li
Peking University, China

Invited talk: "Neutron scattering observation of magnetic molecular orbitals in MnSi "

Abstract

Physicists are used to describing magnetism with models of interacting spins on lattices of magnetic ions. However, recent developments in topological quantum chemistry reveal the fact that a low-energy description of electrons are not necessarily "ionic", but can instead feature other forms of tight-binding bases. In this talk, I will present an experimental reality of such a kind in the near-ferromagnetic binary compound of MnSi, by showing that the fundamental magnetic units are extended "molecular orbitals" consisting of three Mn atoms each. The key experimental evidence comes from inelastic neutron scattering measurements of the magnetic form factor, and it is further corroborated by first-principles calculation of the magnetic Wannier orbitals. The demonstrated interconnected magnetic molecular orbitals might change our way of looking at magnetism in quantum materials in which structural symmetry, electron itinerancy and correlations act in concert.

Biography

Yuan Li received his B.S. degree from Peking University in 2004, and Ph.D. degree from Stanford University in 2010. He was a Humboldt Research Fellow at the Max Planck Institute for Solid State Research, Germany, from 2010 to 2012. Since 2012, he has been working as an associate professor at the International Center for Quantum Materials, Peking University, where he received tenure in 2018. His research involves the use of state-of-the-art scattering spectroscopic methods, in particular neutron and photon scattering, to study the structure and dynamics of materials with strong electron correlation and novel quasiparticle excitations. He was a recipient of Sir Martin Wood China Prize (2021).

Matthew Stone
Oak Ridge National Laboratory, USA

Invited talk: “A trio of tri-chlorides: magnetic excitations in $FeCl_3$, $YbCl_3$ and $CrCl_3$”

Abstract

The magnetic tri-halide compounds continue to attract great interests has hosts of an array of fascinating quantum phenomena. In this talk, I will focus on three canonical members of this class of materials: $FeCl_3$, $YbCl_3$ and $CrCl_3$. Although all comprise a honeycomb lattice of magnetic ions, details of the exchange coupling and magnetic moment yield striking differences in physical behavior. In the absence of an applied magnetic field $YbCl_3$ has a long range ordered antiferromagnetic phase with a broad continuum of excitations. Inelastic neutron scattering measurements along with a spin wave theory accounting for both longitudinal transverse fluctuations reveal that $YbCl_3$ is perhaps the best realization to date of a nearest neighbor Heisenberg model on the honeycomb lattice and further reveal features in the continua which have long been expected in quantum magnets, but which have previously eluded observation. On the other hand, while $CrCl_3$ is also an example of a 2D honeycomb lattice, each honeycomb lattice plane contains ferromagnetically aligned spins and exhibits an excitation spectrum with well-defined Dirac magnons. This material serves as a test case for determining topological magnons and provides as clear demonstration of how to accurately determine a topological magnetic gap using inelastic neutron scattering. Details of experimental resolution functions must be incorporated in the analysis to accurately understand the energy scale of anisotropy terms in the Hamiltonian. While $FeCl_3$ also has a honeycomb structure, remarkably strong further neighbor interactions drive completely different behavior from the previous examples. We find evidence for the existence of a spiral spin-liquid state in this compound above the ordering temperature.

[A portion of this research used resources at the Spallation Neutron Source, a DOE Office of Science User Facility operated by the Oak Ridge National Laboratory.]

Biography

Matthew Stone received a Ph.D. in physics from Johns Hopkins University in 2002. Matthew is the Quantum Materials Initiative Coordinator for the Neutron Scattering Division at Oak Ridge National Laboratory. He is also the lead instrument scientist for the SEQUOIA instrument at the Spallation Neutron Source. His research interests are quantum materials in one- and two-dimensional systems and development of hardware for improving inelastic neutron scattering measurements.

Denver Danfeng Li
City University of Hong Kong, China

Invited talk: "Materials Synthesis Approaches to Infinite-Layer Nickelate Thin Films from a High-Crystallinity Precursor Phase"

Abstract

The discovery of superconductivity in infinite-layer nickelates has engendered reviving interest in the study of a cuprate-analog system [1,2]. Notably, superconducting nickelates display signatures of intriguing similarities and distinctions to the cuprates in their phase diagrams, antiferromagnetic interactions, rare-earth dependence, and superconducting anisotropy, among others. Partially owing to the non-trivial challenges in materials synthesis and their thin-film nature, experimental demonstration of the intrinsic properties of this family of materials has still been limited [3,4]. In this talk, I will present our latest developments in alternative synthesis approaches for the high-quality Nd-series of the materials system and probing of their electronic structure/properties, in a broader context of the role that chemical and structural environments can play. Our approach may offer new opportunities to overcoming the difficulties in stabilizing this otherwise thermodynamically unstable family of materials.

[1] D. Li *et al., Nature* 572, 624 (2019).
[2] D. Li *et al., Physical Review Letters* 125, 27001 (2020).
[3] K. Lee *et al., APL Materials* 8, 041107 (2020).
[4] K. Lee *et al., arXiv*: 2203.02580 (2022).

Biography

Dr Denver Li is currently an Assistant Professor of Physics at City University of Hong Kong. Dr Li obtained his B.Eng. from Zhejiang University and M.Phil. from The Hong Kong Polytechnic University (advisor: Prof Ji-yan Dai). Shortly after earning his Ph.D. (2016) in the Department of Quantum Matter Physics at University of Geneva (advisor: Prof Jean-Marc Triscone), Dr Li joined Stanford University as a Swiss National Science Foundation postdoctoral fellow, working with Prof Harold Hwang. He started working at CityU since November 2020. Dr Li's main research interests span across condensed-matter physics and materials science, focusing on atomic-scale fabrication of oxide heterostructures and nanomembranes, kinetic based synthesis of unconventional quantum materials, low-dimensional superconductivity, oxide interfaces for emergent states, etc. In 2019, a team led by Dr Li and Prof Hwang discovered the first nickelate superconductor, which had been a target of continuous materials search for over three decades. For his groundbreaking discovery, Dr Li was named to the list of 2021 MIT Technology Review 35 Innovators under 35 (China).

Junzhang Ma
City University of Hong Kong, China

Invited talk: "Investigation of quasiparticles in quantum materials with ARPES"

Abstract

The electronic structure of quantum materials essentially determines the macroscopic electrical, magnetic, and optical properties of materials. The electromagnetic coupling between the charge, spin, lattice, orbital degrees of freedom in materials can lead to the emergence of a variety of important phenomena in condensed matter, which can be utilized in optical sensing, information transmission, imaging, green electronics, and quantum information processing, etc. The related energy excitation between different freedoms usually can be described by quasiparticles such as Dirac fermions, Weyl fermions, phonons, polarons, excitons, etc. Angle-resolved photoemission spectroscopy (ARPES) has proven to be particularly effective for directly measuring the electronic structure of condensed matter in momentum space since it allows direct detection of the single-particle spectral function that dominates the formation of new quasiparticles. In this talk, we will discuss our recent research about investigation of different quasiparticles in quantum materials with ARPES.

Biography

Dr. Junzhang Ma joined the department of physics, City University of Hong Kong as an assistant professor in the January of 2021. He got the degree of Doctor of Philosophy in 2017 from institute of physics (IOP), Chinese Academy of Science after finishing the PhD research in Prof. Hong Ding's group. He furthered his research career as a joint postdoctoral fellow in Swiss Light Source, Paul Scherrer Institute (PSI) and EPFL Switzerland supported by Prof. Ming Shi (Senior Scientist, PSI Director Assistant) and Prof. Jo ël Mesot (current President of ETH, and former Director of PSI). Dr. Ma's research mainly focuses on electronic structure of topological materials, superconductivity, low-dimensional materials, and correlated materials, studying by Angle Resolved Photoemission Spectroscopy (ARPES). Dr. Ma has more than 40 publications in high-impact journals, e.g., 1 in *Nature*, 2 in *Nature Physics*, 1 in *Nature Materials*, 5 in *Science Advance*, 3 in *Nature Communications*, 2 in *Physics Review X*, 6 in *Physics Review Letter*, etc. These works include many breakthrough researches such as the discoveries of Weyl semimetal, three component Fermion, Hourglass Fermion, fluctuated magnetic Weyl Fermion, first unpaired Weyl point, mobile excitons in 1-D metal, etc.

Stefanus Harjo
J-PARC, Japan

Invited talk: "Operando engineering materials characterization using pulsed neutron beam"

Abstract

Neutron beam is one of quantum beams widely known for materials characterization due to its unique properties. Neutrons are used to investigate stresses and crystallographic microstructures inside engineering materials, taking advantage of their large penetrating power and the ability to see the arrangement of atoms by diffraction methods. Pulsed neutron diffraction with the time-of-flight method is suitable for microscopic structural observation as a bulk average behavior because of the simultaneous measurement of multiple Bragg peaks. Careful analysis of the Bragg peaks in a neutron diffraction pattern can reveal important structural details of a sample material such as internal stresses, phase conditions, dislocations, texture etc. Such information is often crucial in engineering applications and the ability to carry out either ex-situ or in-situ measurements makes neutron diffraction particularly useful in this respect. The large penetrating power of neutrons also allows in-situ investigation of crystallographic information on engineering materials under various environments, including operando monitoring during deformation at a wide temperature range from cryogenic to high temperatures, thermo-mechanical processes, and so on.

The pulsed neutron diffraction with the time-of-flight method will be briefly introduced, and a pulsed neutron diffractometer for engineering materials studies in J-PARC with some highlighted researches using operando observations will be introduced.

Biography

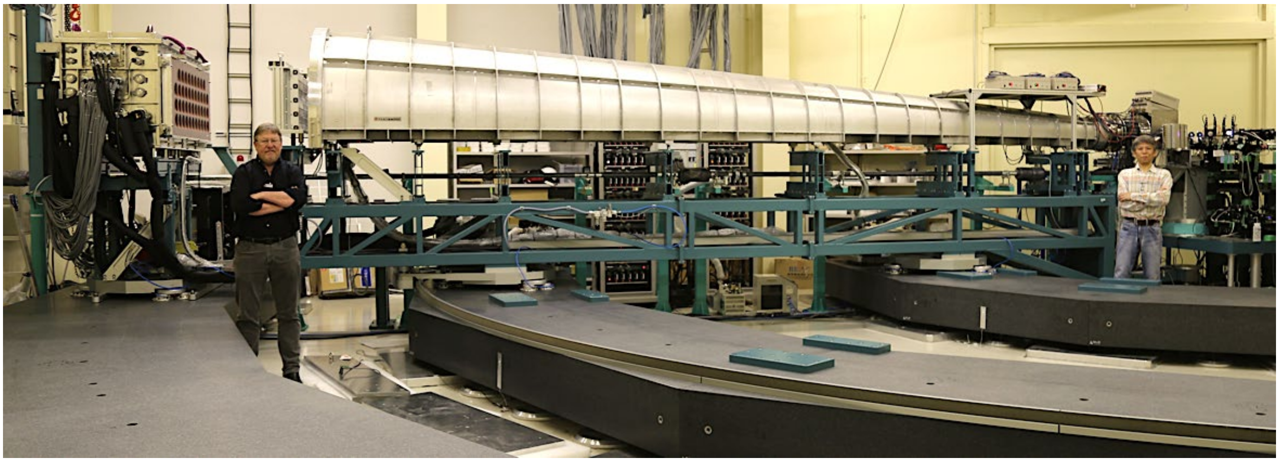
Stefanus Harjo is an instrumental scientist of the Engineering Materials Diffractometer TAKUMI, a pulsed neutron diffractometer at J-PARC, Japan. He received his Ph.D. for his work on the strength of steel using neutron diffraction, and in 2005 joined Japan Atomic Energy Agency to design and build TAKUMI dedicated for engineering materials research related to stress and crystallographic microstructures. His research interests include deformation, phase transformation, and residual stress in steels, light metals, shape memory alloys, concretes, and ceramics.

Alfred Q.R. Baron
RIKEN, Japan

Invited talk: "Frontiers in meV-Resolved Inelastic X-Ray Scattering: Atomic Dynamics Where We Have Not Gone Before"

Abstract

Atomic motions – phonons in crystals and excitations in disordered materials - are critical for many material properties, including superconductivity, thermoelectricity, elasticity, ferro-electricity, magneto-elastic coupling, nematicity, etc. They are also intimately connected to many phase transitions, and to general features of liquid and glass behavior. Inelastic x-ray scattering (IXS) [1], unique advantages for investigating atomic dynamics compared to neutron scattering, This has made IXS especially valuable for investigating disordered materials and small samples, with successful measurements possible even from ng (nanogram) samples. Present work now extends to a large variety of materials and sample geometries (single crystals, thin films, near critical liquids, samples in diamond anvil cells, etc,) in a range of conditions (2<T<3000K, P>100 GPa, H < 7 T, etc.)



The IXS spectrometer at BL43LXU of the RIKEN SPring-8 Center

We will discuss the present state-of-the art in IXS and focus on extension of the method to ***higher resolution and to higher pressures***. Higher resolution studies are needed to probe the mesoscale region (10-100 nm length scales) that is important for understanding the cross-over from continuum to atomistic dynamics in disordered (liquid and glass) materials. This is a region that is now mostly inaccessible by other methods.

Studies at high pressure allow investigation of fundamental geophysical problems such as the composition and evolution of the earth's core. In these areas, BL43LXU of the RIKEN SPring-8 Center is now uniquely capable and is leading world effort. Specific examples will be drawn from recent work on (a) liquid water that resolves a multi-decade controversy [2] and sets the stage for a comprehensive interpretation of mesoscale liquid dynamics and (b) studies to extreme (>300 GPa) pressure that place constraints of the composition of Earths's inner core [3]. These will be presented in the context of the development of specialized instrumentation that has made these very challenging experiments possible [1,4-7]

baron@spring8.or.jp [1] Baron, in Synch. Light Srcs. & FELS, edited by E. Jaeschke, et al, (Springer International Publishing, Cham, n.d.), https://arxiv.org/abs/1504.01098. [2] Ishikawa, Baron, J. Phys. Soc. Japan 90, 83602 (2021) https://doi.org/10.7566/JPSJ.90.083602 [3] Ikuta, Ohtani, Fukui, Sakai, Ishikawa, Baron, To Be Published. [4] Baron, SPring-8 Inf. Newsl. 15, 14 (2010) http://user.spring8.or.jp/sp8info/?p=3138. [5] Baron, Tanaka, Soutome, Takao, Nakamura,Kobayashi, Fujita, Takahashi, Aoyagi, Shimosaki, Seike, Uchiyama, Ishikawa,Chuang, Kimura, Tanaka, Kitamura, Ishikawa, AIP Conf. Proc. 1741, 020033 (2016) http://dx.doi.org/10.1063/1.4952812. [6] Ishikawa, Ellis, Uchiyama, Baron, J. Synch. Rad. 22, 3 (2015) https://doi.org/10.1107/S1600577514021006. [7] Baron, Ishikawa, Fukui, Nakajima, AIP Conf. Proc. 2054, 20002
(2019) https://aip.scitation.org/doi/abs/10.1063/1.5084562

Biography

Alfred Q.R. Baron has been leading development of synchrotron-based hard x-ray techniques for investigation of condensed matter systems for more than 25 years. As a Ph.D. student at Stanford University and post-doc at European Synchrotron Radiation Facility (ESRF), he was instrumental in the development of nuclear resonant scattering (NRS) methods, with specific interest in x-ray coherence and probing neV-scale dynamics, as well as x-ray optics and fast detectors. Moving to SPring-8 in 1998, he accepted responsibility for developing meV-resolved inelastic x-ray scattering (IXS), building Japan's first x-ray spectrometer for measuring phonons at BL35XU. He then took a position in RIKEN where he was given the opportunity to make the Quantum NanoDynamics beamline, BL43LXU, using, arguably, the most powerful SR source of average x-ray intensity in the world. Dr. Baron now directs the Materials Dynamics Group of the RIKEN SPring-8 Center, and is the Precision Spectroscopy Division Director in the CSRR/JASRI. In addition to teaching the next generation of scientists, running BL43LXU, and performing many investigations of phonons, his interests include many areas of condensed matter physics, with, presently, a focus on understanding mesoscale liquid dynamics, as well as continued development of methods for x-ray experiments, especially IXS.

Yuhui Dong
Institute of High Energy Physics, CAS, China

Invited talk: "High Energy Photon Source (HEPS)"

Abstract

The progress of the research in material and other fields evokes higher requirements for synchrotron radiation, especially the high brilliance, coherence and high energy X-ray. This kind of hard X-ray would provide the chance to study the structures of real materials under real conditions, as well as the real-time structures with very high spatial, energy and time resolutions.

One of the important tendencies in the development of synchrotron radiation sources is low emmitance. Low emmitance storage rings could provide higher brilliance, which is very important for all kinds of experiments in synchrotron radiation facilities. For example, the emmitance of NSLS-II, a new facility in Brookhaven National Laboratory, is 1.0nmrad. The emmitance of MAX-IV, another new facility in Sweden, goes down to 0.3nmrad. The light source Sirius in Brazil is also a low emmitance machine. Even the existed machines, such as ESRF, APS and SPring-8, have been or will be upgraded to low emmitance ones.

In the meantime, the successful construction of Shanghai Synchrotron Radiation Facility and the great achievements in the research in this facility, inspire the users to build the new and high-performance light sources in China. In the view point of regional factors, the vast in territory of China requires the reasonable distribution of synchrotron radiation facilities which support the scientific and technological research, in order to farthest satisfy the demands of users from different regions.

Based on the above reasons, we are building a new synchrotron radiation facility in the region around Beijing: High Energy Photon Source (HEPS). The designed electron energy of HEPS is 6GeV and the emmitance is lower than 0.1nmrad. This machine can provide the hard X-ray with brilliance higher than 10^{22}ph/s/mm^2/mrad^2/0.1%BW and photon energy higher than 300keV. Also HEPS keeps the possibility of upgrading to more advanced light source (XERL or diffraction limit storage ring).

One of the main purposes of HEPS is to satisfy the urgent requirements of material sciences, especially the real-time structures of engineering materials under service environment. Certainly, the high brilliance hard X-ray from HEPS can also provide a very good support in other fields of research, such as condensed matter physics, chemistry, environment sciences, life sciences, etc. In Phase I, totally 14 user beamlines will be built for different kinds of research.

The construction of HEPS is going well as planned, even if the outbreak of COVID-19. The civil construction is almost complete, the accelerator and beamlines are in the stage of equipment manufacturing. The whole facility will be in operating at the end of 2025.

Biography

Prof. DONG Yu-Hui is the Deputy Director of Institute of High Energy Physics, Chinese Academy of Sciences. He is the executive member Biophysics Society of China, the director of Photobiology Committee. Now he is in charge of the construction of beamlines and end-stations of High Energy Photon Source (HEPS), a 4^{th} generation synchrotron radiation facility, as Executive Deputy Manager of the project.

In 1990, he obtained B.S. in Physics in Sun Yat-Sen University (Zhongshan University), Guangzhou, China. He obtained Ph.D. in Physics in Beijing Synchrotron Radiation Facility, Institute of High Energy Physics, Chinese Academy of Sciences, Beijing, China, in 1995. During 1995-2000, he was Post-doctoral Research Associate at Institute of Physics, Chinese Academy of Sciences, Beijing, China and University of Trento, Italy.

In 2001 he became Professor of condensed matter physics in Institute of High Energy Physics, Chinese Academy of Sciences.

Teaching activities have included lectures in MSc and PhD courses and supervising of MSc and PhD theses.

His research activities focus on the methodological research in structure determination of proteins and protein complexes based on synchrotron radiation. The main research fields are:

- The structure-function relationship of proteins and protein complexes by synergic method on synchrotron radiation, e.g., protein crystallography, SAXS, X-ray imaging;
- Methods in structure determination of proteins and complexes;

Professor DONG has authored/co-authored: 3 chapters in books written by teams; about 160 scientific papers in journals and conferences.

He is the reviewer for *Nature, Nature Communication, Scientific Report, Nucleic Acid Research Acta Crystallographica Section A: Foundations of Crystallography, Acta Crystallographica Section D: Biological Crystallography, Acta Crystallographica Section F: Structural Biology and Crystallization Communications, Journal of Applied Crystallography, Journal of Physical Chemistry, Journal: Physica B, Solid State Sciences, Chinese Physics Letters*; also for proposals applied to National Natural Science Foundation of China; National Basic Research Program of China (973 Program), Ministry of Science and Technology; ECHO Grants - Chemistry in Relation to Biological and Medical Sciences, Netherland.

Christian Schroer
Leading Scientist, Deutsches Elektronen-Synchrotron (DESY), Germany

Keynote talk: "Understanding Quantum Materials and Complex Systems Using Modern and Future Synchrotron Radiation Sources"

Abstract

The wide range of X-ray analytical techniques available at modern synchrotron radiation sources can reveal information on the composition, the (atomic) structure, and the chemical, magnetic, and electronic states of matter. Their high brightness allows to precisely define the states of the probing light, enabling high-precision measurements in the space and energy domain. This makes synchrotron radiation an ideal tool to understand quantum materials and probe complex systems and study their emergence on a large range of length scales. The new fourth generation of synchrotron radiation sources will enhance the brightness by several orders of magnitude, effectively making them powerful in-situ/operando microscopes for the study of biological, chemical, and physical processes. They can thus help design novel materials solutions for solving the grand challenges of our time.

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Biography

Christian Schroer is leading the science programme of the synchrotron radiation source PETRA III at DESY in Hamburg and is professor for X-ray nanoscience and X-ray optics at the University of Hamburg. His main field of research is X-ray microscopy and X-ray optics that has wide range of applications in physics, chemistry, the life, materials and geosciences, as well as in nanotechnology. He made his doctoral studies in mathematical physics at the Research Centre Jülich (doctoral degree at the University of Cologne in 1995). After a visit as postdoctoral fellow to the University of Maryland, he worked as a research and teaching associate at RWTH Aachen University in the field of X-ray optics and microscopy. Finishing his habilitation in 2004, he joined DESY in Hamburg as a staff scientist. From 2006 to 2014, he was professor for structural physics of condensed matter at Technische Universität Dresden, before he moved back to Hamburg to take on his current position. As lead scientist of PETRA III, he works on the strategic development of the facility. In particular, he lead the development of the science case and the conceptual design of PETRA IV, DESY's ultra-low emittance source. As X-ray microscopist, he is working on DESY's imaging strategy and is cofounder and speaker of Helmholtz Imaging, a platform of the Helmholtz Incubator on Information and Data Science. His scientific group develops X-ray microscopy at synchrotron radiation sources and X-ray free-electron lasers.

Xinhui Lu
The Chinese University of Hong Kong, China

Invited talk: “Grazing Incidence X-ray and Neutron Scattering Based Organic and Perovskite Photovoltaic Studies”

Abstract

Nowadays, solar industry becomes the fastest growing industry due to the rising demands to solve the energy crisis and environmental problems. Third-generation solar cells, such as organic and perovskite solar cells are all relying on a semiconducting thin-film active layer to harvest the solar energy. The bulk morphology of the active layer in terms of crystal structure, orientation, grain size and nanophase separation behaviors is known to be critical to the solar cell device performance. Here, we will present our recent studies on the process-structure-device correlation of organic and perovskite solar cells. In these studies, state-of-art grazing incidence scattering techniques using X-rays and neutrons were employed for various purposes, such as grazing incidence wide-angle/small-angle X-ray scattering (GIWAXS/GISAXS), grazing incidence transmission small-angle X-ray scattering (GTSAXS), grazing incidence neutron scattering (GISANS). These techniques can also be applied in material science, chemistry, biology and condensed matter physics studies. By modifying the wavelength of the probing beam and the experimental geometry, a variety of sample types, such as solutions, powders, surfaces and thin films, can be studied, covering wide length scales as well as versatile dynamic and kinetic behaviors.

Keywords：Organic Photovoltaics, Perovskite Solar Cells, GIWAXS, GTSAXS, GISANS

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Biography

Xinhui Lu is an associate professor in the Department of Physics, the Chinese University of Hong Kong. She received her bachelor's degree from Nanjing University and PhD degree from Yale University. Then, she worked as a postdoctoral research associate at Brookhaven National Laboratory before joining CUHK. Her research interest lies in energy related material science and experimental soft condensed matter physics, including morphology and device performance of organic and perovskite photovoltaic materials, bulk and surface structure of functional thin films and synchrotron x-ray scattering techniques. She is a council member of Physical Society of Hong Kong and Chinese Neutron Scattering Society, and Clarivate Highly Cited Researcher 2020.

Qi Liu
City University of Hong Kong, China

Invited talk: "Spreading monoclinic boundary network between hexagonal primary grains for high performance Ni-rich cathode materials"

Abstract

The capacity degredation in layered Ni-rich LiNixCoyMnzO2 (x ≥ 0.8) cathode largely originated from drastic surface reactions and intergranular cracks in polycrystalline particles. Herein, we report a highly stable single-crystal LiNi0.83Co0.12Mn0.05O2 cathode material, which can deliver a high specific capacity (~209 mAh g–1 at 0.1 C, 2.8–4.3 V) and meanwhile display excellent cycling stability (>96% retention for 100 cycles and >93% for 200 cycles). By a combination of in situ X-ray diffraction and in situ pair distribution function analysis, an intermediate monoclinic distortion and irregular H3 stack are revealed in the single crystals upon charging–discharging processes. These structural changes might be driven by unique Li-intercalation kinetics in single crystals, which enables an additional strain buffer to reduce the cracks and thereby ensure the high cycling stability.

Biography

Qi Liu is currently an assistant professor in the Department of Physics, City University of Hong Kong. He obtained his Ph.D. from Purdue University in 2014. Before joining CityU, he worked as a postdoctoral fellow at Argonne National Laboratory. His current research interests focus on the structure-property studies of functional materials via multiple neutron- and synchrotron-based techniques. His broader research activities include the design and synthesis of novel energy storage materials, phase transition mechanisms and neutron-synchrotron physics.

Thank you!