

# DURATION

### Sept. – Nov. 2019

# HONG KONG COMPUTATIONAL PHYSICS STUDY GROUP

Computational approaches are playing increasingly important role in the advances of condensed matter physics and quantum material research, in particular, in quantum many-body systems, where strong correlations among multiple degrees of freedom including electronic, spin, lattice and orbital, have rendered conventional analytic and perturbative methods inadequate. On the other hand, modern computational approaches, such as exact diagonalization, quantum Monte Carlo, density matrix renormalization group, tensor network renormalization group and neural network and artificial intelligence, are inherently non-perturbative and unbiased, and could, in principle, tackle quantum many-body systems in controlled manner.

In light of the rapid developments in computational approaches, and

# ORGANIZER

Zi Yang, Meng (HKU) Jun Wei, Liu (HKUST) Jian, Wang (HKU) Fuchun, Zhang (KITS, UCAS)

the lack of their systematically introduction and education to senior undergraduate and graduate students and junior researchers in the Hong Kong area, we would like to organize the Hong Kong Computational Physics Study Group. The form of the study group is flexible, on average, one or two seminar talks during the week and one hands-on tutorial during the weekend per month from September to November 2019.

The purpose of the study group is to provide a full coverage of modern computational techniques to give in-depth understanding and firsthand experience to students and junior researchers, and subsequently boost the research activities and developments of these computational approaches in quantum many-body systems in Hong Kong area. The selected lecturers are active researchers working in the very front of these fields, and the interactions and potential collaborations between the lecturers and participants are strongly encouraged.

### **Invited Speakers and Lecturers**

# INFORMATION

LOCATION The University of Hong Kong

SPONSER HKU-UCAS Joint Institute of Theoretical and Computational Physics at Hong Kong Computational Initiative at Faculty of Science,

HKU

### Exact diagonalization

Prof. Andreas Laeuchli (University of Innsbruck, Austria) Dr. Hanging Wu (Sun Yat-Sen University)

 Quantum Monte Carlo for interacting fermions Prof. Fakher Assaad (University of Wuerzburg, Germany) Dr. Zi Yang Meng (The University of Hong Kong)

 Quantum Monte Carlo for interacting bosons/spins Prof. Stefan Wessel (RWTH Aachen University) Dr. Nisheeta Desai (University of Kentucky) Dr. Hui Shao (Beijing Normal University) Dr. Zheng Yan (Fudan University/The University of Hong Kong)

### MPS and DMRG

Prof. Ying-Jer Kao (National Taiwan University) Dr. Ling Wang (Zhejiang University)

### Tensor-network states and Renormalization Group Prof. Tao Xiang, Academician (Institute of Physics, CAS) Prof. Zhengcheng Gu (Chinese University of Hong Kong) Dr. Rui-Zhen Huang (Kavli Institute of Theoretical Sciences, UCAS)

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# TOPIC IN SEPTEMBER EXACT DIAGONALIZATION

INVITED SPEAKER <u>Prof. Andreas Läuchli</u> <u>University of Innsbruck, Austrilia</u>



### universität innsbruck

Lecture 1: Basics of Exact Diagonalization Time: 14:00 Tuesday (Sep. 10) Venue:CPD-LG.62, LG/F, Central Podium, Centennial Campus, HKU

Lecture 2: Applications of ED in Frontier Physics Time: 14:00 Wednesday (Sep. 11) Venue: CPD-2.14, 2/F, Run Run Shaw Tower, Centennial Campus, HKU

Univ.-Prof. Dr. sc. nat. Andreas Läuchli works at the Institut für Theoretische Physik, Universität Innsbruck. He is interested in the theoretical and computational exploration of correlated quantum matter in condensed matter and AMO systems. His group strives to understand novel phases of matter, quantum critical phenomena and quantum systems out of equilibrium. His research builds on a blend of concepts and ideas from condensed matter theory, statistical mechanics, quantum field theory and quantum information. He also develops and implements innovative computational algorithms in order to perform large-scale computer simulations on high-performance computers. He is currently heading the Institute of Theoretical Physics at Innsbruck University.



### <u>Tutorial and Code Demonstration</u>

Time: 10:00 Friday (Sep.13)

Venue: CPD-G.01, G/F, Cheng Yu Tung Tower,

Centennial Campus, HKU

Dr. Hanging Wu is an associate professor at the School of



Dr. Hanqing Wu Sun Yat-Sen University Physics of Sun Yat-Sen University since 2017. His research interests include topological states under interaction, quantum spin liquids, etc., as well as quantum many-body numerical methods, exact diagonalization, quantum Monte Carlo, etc.

All are welcome. Refreshment will be served.





### HKU-UCAS Joint Institute of Theoretical and **Computational Physics**

# Quantum Monte Carlo for Interacting System 蒙特卡洛的鱗爪



Dr. Zi Yang MENG University of Hong Kong



Abstract: In these three lectures, Mr. Chuhao Li, Gaopei Pan and Dr. Zi Yang Meng will give pedagogical introduction to the quantum Monte Carlo method for interacting fermion systems. Conceptual and technical aspects of the determinantal quantum Monte Carlo will be discussed in detail, also covering the recent methodological developments. Fresh results on quantum critical points and non-Fermi liquid, i.e. the critical phenomena arising from the strong coupling between Fermi surface and bosonic fluctuations will be discussed, as well as the recently realized situation of interaction between topological order and itinerant electrons -- in the form of gauge field couples to matter field -- will be illustrated. For the latter, not only its static but also dynamical properties, are revealed via unbiased large-scale numerical efforts. In the end, possible future directions in combining numerical methods and quantum field theory in the era of big-data and artificial intelligence in pursuing the understanding of correlated electron systems will be introduced.

报告介绍:《巴黎的鱗爪》是徐志摩的散文名篇,行文晦澀,不見其一貫輕快明亮的風格,但文章的內容卻不難理解, 大抵是讚頌豐富寬厚的藝術之都巴黎和其中真誠地追求藝術與生活真諦的人們。對於凝聚態物理學家來說,強關聯電子 系統就是我們眼中的「巴黎」。做為凝聚態物理學研究的主要方向,它的範圍豐富寬厚,涵蓋了自然界中看似光怪陸離、 卻與現代科技息息相關的現象: 量子相變和量子臨界行為, 拓撲相和拓撲序, 阻挫磁體和量子自旋液體等等。這些系統 的性質對理論凝聚態物理學家有着深深的吸引力。但是,就像藝術之都巴黎有着弘闊的文化,強關聯電子系統的性質也 極其繁複,存在着眾多具有強烈關聯相互作用的自由度,展現出量子多體物理學的效應。這些特點使得以微擾論平均場 為代表的解析方法在強關聯電子系統的研究中難以提供定量甚至是定性正確的結果,面對如此困難,大規模數值模擬方 法,隨着計算機性能的突飛猛和大数据与人工智能时代的来临,逐漸成為了研究強關聯電子系統的重要手段。在此次系 列讲座中,報告人將會首先介绍费米在量子蒙特卡洛的算法和程序,进而截取若干實例講述如何運用以大規模量子蒙特 卡洛模擬為代表的數值方法,研究強關聯的電子系統中湧現出的各種奇妙的物質形態,以及形態之間的轉化等有趣的問 題。一如那些在巴黎孜孜追究藝術和生活真諦的人們, 凝聚態物理人的追究也一樣真誠、有趣, 並且, 這《蒙特卡洛 的鱗爪》已經融入到我們的生活和行為之中,改變着我們看待世界的方式。

### Lecture 1: Basics of Quantum Monte Carlo Simulation

Time: 14:00 Wednesday(Oct. 9)

Venue: KKLG111, LG1/F, K.K. Leung Building

Lecture 2: Applications in quantum material research

Time: 14:30 Thursday (Oct. 10)

Venue: Room 522, 5/F, Chong Yuet Ming Physics Building





#### **Tutorial and Code Demonstration**

Time: 10:00 Friday (Oct.11) Venue:CPD-3.16, 3/F, Run Run Shaw Tower, Centennial Campus Gaopei, PAN and Chuhao, LI Institute of Physics Chinese Academy of Science

All are welcome. Refreshment will be served.







### Lecture 1: Numeric and topological order & Quantum Monte Carlo for spin systems Time: 14:00 Monday & 10:00 Tuesday (Nov. 4&5) Venue: MB103, 1/F, Main Building & Room 522, Chong Yuet Ming Physics Building

Prof. Yang Qi is currently working at Fudan University. He is interested in the theoretical physics, mainly studies quantum many body phenomena such as strong correlated electronic system, topological order and quantum



phase transition. His research area also include using numeric simulation methods to study quantum many body systems.



Dr. Zheng Yan is postdoctoral fellow at HKU. His research interests include developing quantum Monte Carlo algorithms to study spin/boson systems with and without constraints. His lecture will focus on explanations of various QMC algorithms for interacting spin/boson systems.

### Lecture 2: From DMRG & MPS to Tensor Network

Time: 14:00 Wednesday & 10:00 Thursday (Nov. 6&7) Venue: CPD-2.16, 2/F, Run Run Shaw Tower & CPD-G.02, G/F, Cheng Yu Tung Tower



Prof. Ying-Jer Kao works at the Department of Physics, National Taiwan University and National Center for Theoretical Sciences. His research interests are employing computational methods combined with analytical tools to study novel phenomena due to strong correlations in many-body systems. In the past few years, he has studied a wide variety of correlated systems to elucidate the underlying physics within. Furthermore, he is also advancing numerical methods to study previously unattainable problems.

Lecture 3: Imaginary time dynamics (Analytic Continuation) Time: 10:00 Friday (Nov. 8) Venue: Room 522, Chong Yuet Ming Physics Building



Zheng Zhou is an outstanding undergraduate student of Fudan University, his research works focus on using quantum Monte Carlo combined with stochastic analysis continuation method to study excitation spectra of quantum many-body systems and the spectral characteristics of various low-energy excitations.

All are welcome. Refreshment will be served.

