PHYS8202: Special Topics in Physics
Quantum Many-Body Computation
September – December 2025

Professor Zi Yang Meng, The University of Hong Kong

Purpose of the Course

Computational approaches are playing increasingly important roles in the advances of condensed matter physics and quantum material research, particularly in quantum many-body systems. In recent years, a new trend of research, combining computational methods, such as exact diagonalization, quantum Monte Carlo, tensor network and neural network, and theoretical approaches such as quantum field theory and symmetry analysis, has emerged and enabled scientists to thoroughly, and in an interdisciplinary manner, investigate the highly entangled quantum phases of matter, 2D moiré materials, quantum simulators, etc. Considering these rapid developments and their lack of systematic education to senior undergraduate students, graduate students and researchers in Hong Kong and the GBA area, I have designed this course to cover from basic to advanced topics in quantum many-body computation and theoretical understanding in strongly correlation aspects of quantum materials. I plan to teach the participants basic and live knowledge of modern quantum many-body computation, such that they can apply them into their research works in the corresponding areas.

Lecturer

Zi Yang Meng, physicist and essayist. His research focus on quantum many-body computation and the modelling and understanding of quantum materials. He publishes ~ 150 research articles in Nature, Nature Physics, Science Advances, PNAS, PRX, PRL, etc. He is editorial board member of Reports on Progress in Physics and a Mercator fellow of German Research Foundation. Prior to joining HKU, he was a professor at the Institute of Physics, Chinese Academy of Sciences. He obtained PhD in Germany and was a postdoctoral fellows in USA and Canada. He writes essays (mainly in Chinese) to express opinion on physics research and life and struggle as a scientist in our fractionalized and yet topologically connected cultural and societal landscape, these essays can be found in his **group page**.

Content and Materials

1). Hartree-Fock mean-field theories for Hubbard model and Heisenberg model on different lattices.

2). Exact Diagonalization with symmetry and quantum number implemented for quantum spin systems and field theory with topological term.

3). Density Matrix Renormalization Group methods for ground state and dynamic properties of quantum many-body systems.

4). Quantum Monte Carlo algorithms for interacting fermion (DQMC) and spin/boson lattice models (SSE) and quantum entanglement measurements.

The teaching materials are based on lecture notes and algorithmic codes developed on the cloud computing environment on the **lectures' teaching page**.

Time and Place

Wednesday 1500 -- 1550, 1600 -- 1650, 1700 -- 1750
Room 103, 1/F, Meng Wah Complex, HKU

DEPARTMENT OF PHYSICS
THE UNIVERSITY OF HONG KONG