Computational Condensed Matter Physics group

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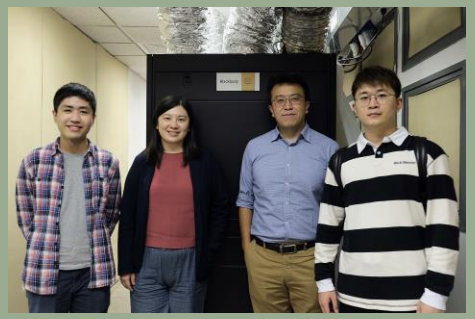
More info: https://quantummc.xyz

Research directions:
Strong correlated electron systems; Computational quantum many-body physics

Group Activities

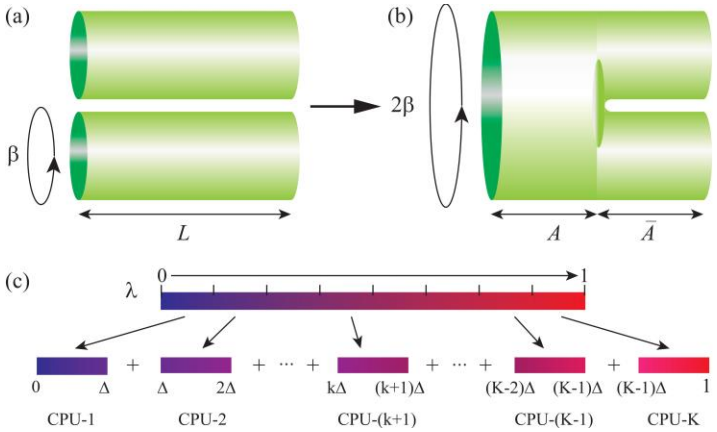
Hong Kong Computational and Theoretical Physics Study Group 2023

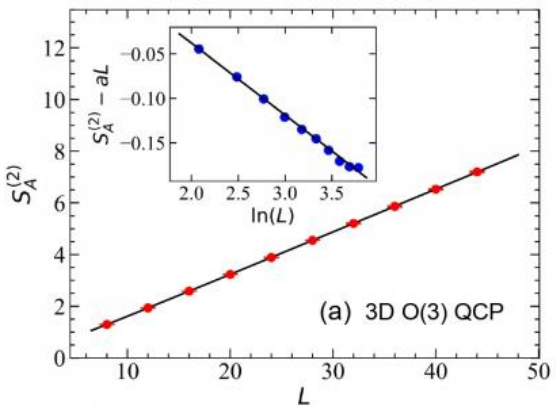
'Blackbody' supercomputer

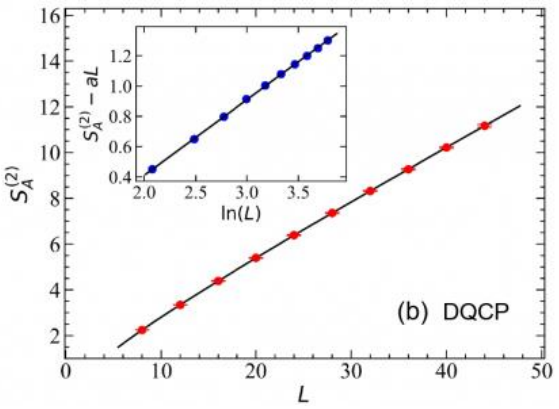


Recent topics:

Quantum Entanglement

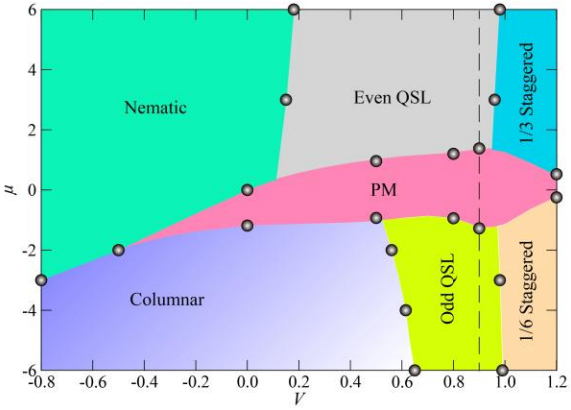


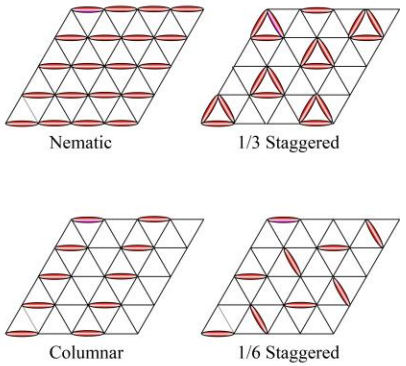




The left-hand side depicts the QMC diagram and the nonequilibrium increment method. On the right-hand side, the scaling of the entanglement entropy indicates the presence of a non-trivial DQCP (Deconfined quantum critical point). **(Read more)**

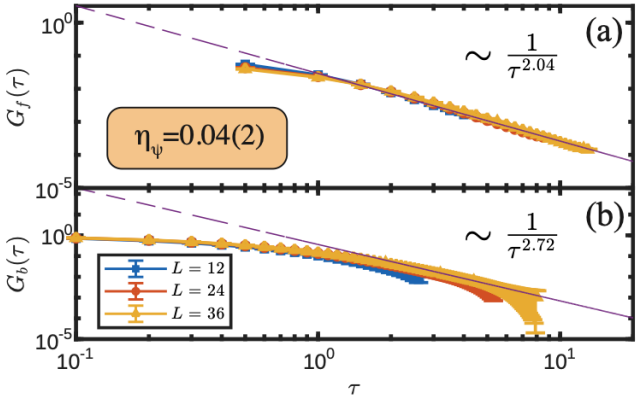
Rydberg Atom and Constrained Lattice Model





The obtained phase diagram of Rydberg Atom on triangle lattice. Within different phases, the even $\mathbb{Z}_2$ quantum spin liquid (QSL) and odd $\mathbb{Z}_2$ QSL are topological ordered novel states of matter that are expected to exist in the Rydberg atom array experiments on Kagome lattices. **(Read more)**

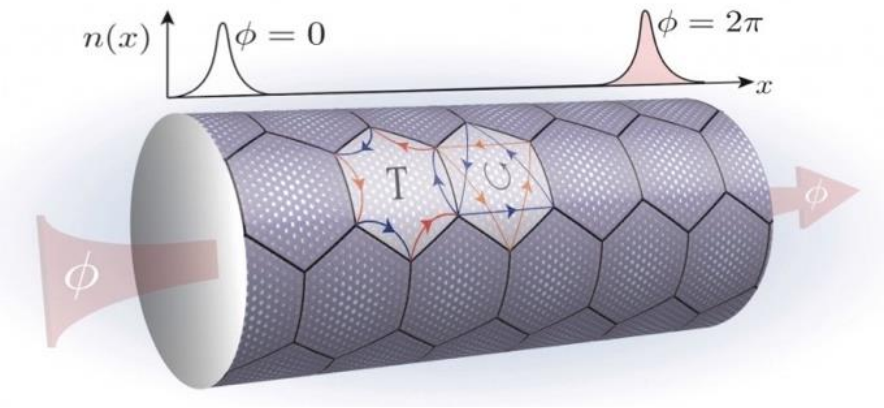
Group Recreations



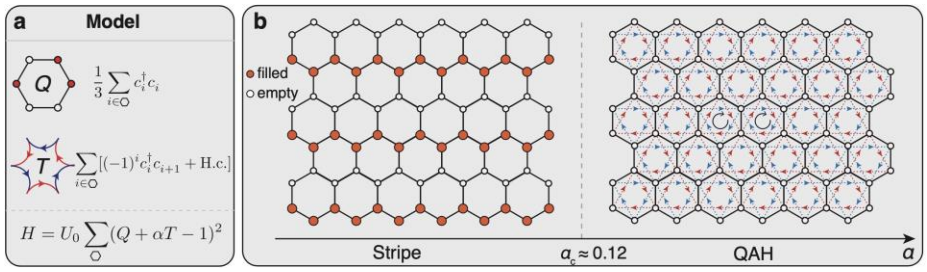
Fermion and Boson Green's functions at the chiral GNY CFT. We fit the imaginary time decays of fermionic (a) and bosonic (b) Green's functions, to extract the anomalous dimension $\eta_\psi = 0.04(2)$ and verify the consistency of $\eta_\varphi = 0.72$. **(Read more)**

Twisted Bilayer Graphene

Quantum anomalous Hall effect

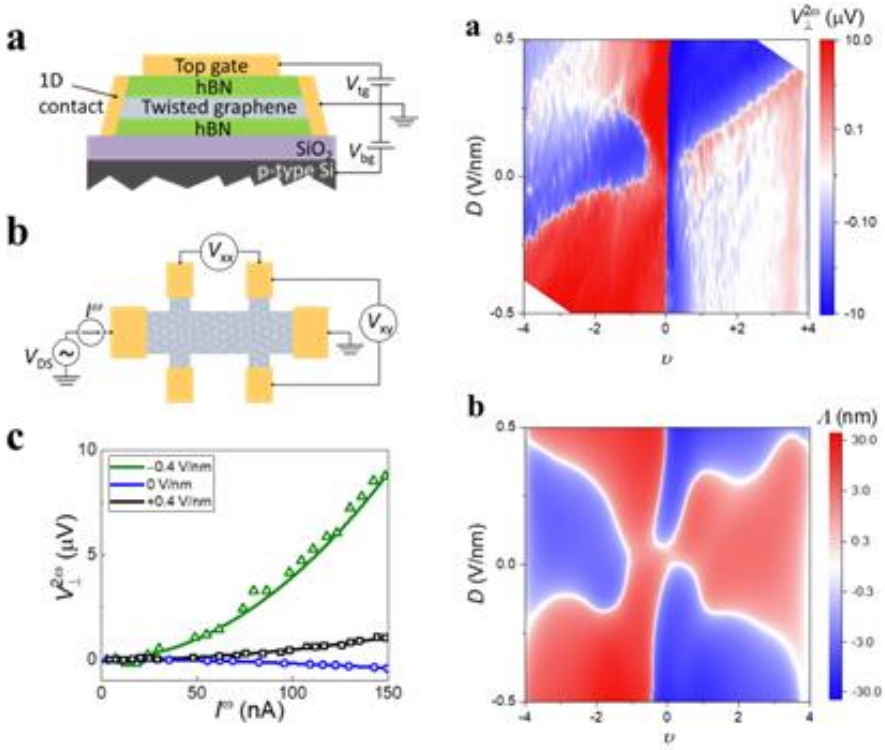


Measurement of Hall conductance via flux insertion in the quantum anomalous Hall phase of the twisted bilayer graphene lattice model.



The honeycomb lattice model and phase diagram. (a) The Hamiltonian consists of two terms: the cluster charge operator Q, and the assisted hopping term T with alternating-sign structure. (b) The phase diagram contains two distinct insulating phases, i.e., the stripe phase for $\alpha < \alpha_c$, and the QAH state for $\alpha > \alpha_c \simeq 0.12$. (Read more). **(Read more)**

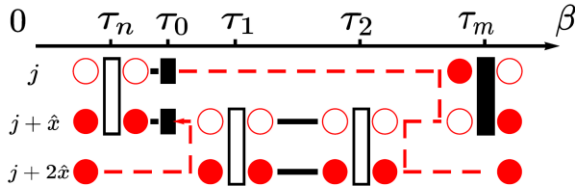
Combination with the experiments



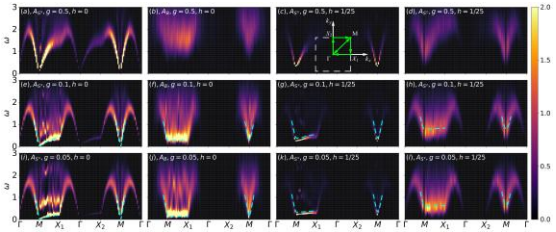
Experimental setup of twisted bilayer graphene (on the left) and perfect comparison between theoretical calculations and experimental results. **(Read more)**

Methods:

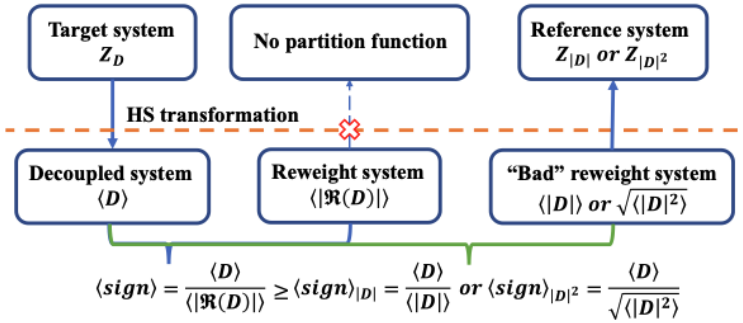
Quantum Monte Carlo



A schema of Sampling space in the Stochastic Series Expansion Quantum Monte Carlo (SSE-QMC) simulation.

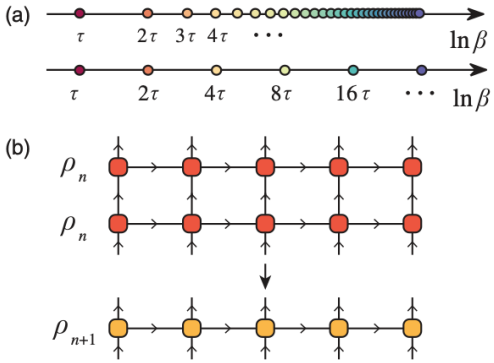


The spectra obtained via the SSE-QMC simulation in the coupled spin chain model. **(Read more)**

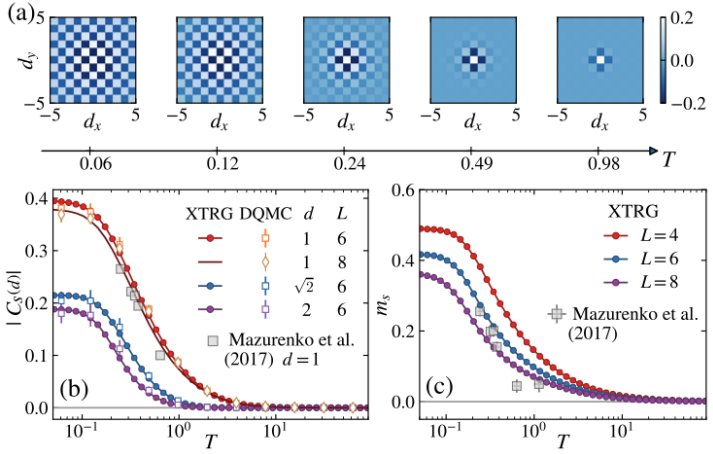


A schema about the sign problem in the QMC simulation. Schematical relationship between target system, reweight system and reference system in fermion quantum Monte Carlo simulations. Average sign is ill-defined observable because reweight system cannot recover to a physical system, while "bad" reweight system corresponds to a physical system so that sign bounds is a well-defined observable. **(Read more)**

Tensor Networks



A schema of a tensor network calculation. (a) Linear versus logarithmic temperature scale employed in thermal simulations. (b) A single step in XTRG (exponential tensor renormalization group) evolution by projecting matrix product operator ρ_n (at $\beta = 2^n\tau$) to itself. **(Read more)**



Half-filled Fermi-Hubbard model with U = 7.2 and L = 4,6,8. (a) The finite-size AF order pattern is determined from the spin correlation $C_S(d)$, which melts gradually as T increases. We show in (b) the spin correlation function $|C_S(d)|$ of various $d = 1, \sqrt{2}, 2$, and in (c) the finite-size spontaneous magnetization m_S. Excellent agreement between the calculated ($L = 8$) data and the experimental data can be observed. **(Read more)**