

# GAOPEI PAN

Institute of Physics  $\diamond$  Beijing, China  
(+86) -18813108578  $\diamond$  [gppan@iphy.ac.cn](mailto:gppan@iphy.ac.cn)

## EDUCATION

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**Institute of Physics, Chinese Academy of Sciences, China**

*Sept.2018 - Present*

Ph.D. in Physics

**University of Chinese Academy of Sciences, China**

*Sept.2014- Jul.2018*

B.S. in Physics Major with Computer Science Minor

**National University of Singapore, Singapore**

*Jan.2017 - May.2017*

Exchange student in Department of Physics

## RESEARCHES AND PROJECTS

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### **Investigations for non-Fermi-Liquid(nFL) behaviors**

December 2017 - February 2021

*Advisor:* Prof. Zi Yang Meng

We designed a spin-fermion coupled model, which has an itinerant quantum critical point with fermion pockets and hot spots. Then we unambiguously reveal the nFL fermion selfenergy and the bosonic dynamic susceptibilities.

In addition, since it is very difficult to tune the system to the quantum critical region, we study the self-tuned Yukawa-SYK model. Here self-tuned means the system is critical, independent of the bosonic bare mass  $m_0$ , which gives us a large area of nFL.

### **Sign problem in quantum Monte Carlo methods**

November 2020 - Present

*Advisor:* Prof. Zi Yang Meng

We develop a momentum-space quantum Monte Carlo method for studying twisted systems like twisted bilayer graphene(TBG). At charge-neutrality point(CNP) with the  $C_2P$  and  $C_2T$  symmetries, it's sign-problem-free.

Then we propose Sign Bound Theory, which is helpful to understand the sign problem, especially the behavior of the algebraic decay of signs in the low temperature limit of some systems. It can be seen that the average sign in the low temperature limit is related to the ground state energy and the ground state degeneracy of the system and the reference system.

### **Quantum Monte Carlo simulations for Twisted Systems**

November 2020 - Present

*Advisor:* Prof. Zi Yang Meng

Since we have developed the momentum-space QMC method for twisted system. We study the dynamical properties of collective excitations and thermodynamic behaviors in twisted bilayer graphene(TBG) at charge-neutrality point(CNP). The computational possibilities of other integer fillings also have been discussed. We also detect the superconductivity and bosonic fluid behaviors which emerges from Moiré flat bands system like twisted transition metal dichalcogenides (TMD).

(See research statement for details)

## PUBLICATIONS

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### First Author:

1. Thermodynamic characteristic for correlated flat-band system with quantum anomalous Hall ground state  
**Gaopei Pan**, Hongyu Lu, Heqiu Li, Xu Zhang, Bin-Bin Chen, Kai Sun, Zi Yang Meng  
[arXiv:2207.07133](#)
2. A Sport and a Pastime: Model Design and Computation in Quantum Many-Body Systems  
**Gaopei Pan**, Weilun Jiang, Zi Yang Meng  
[Invited review article on quantum many-body model design and computation.](#)
3. Sign Problem in Quantum Monte Carlo Simulation  
**Gaopei Pan**, Zi Yang Meng  
[Book chapter for Elsevier Encyclopedia of Condensed Matter Physics.](#)
4. Dynamical properties of collective excitations in twisted bilayer Graphene  
**Gaopei Pan**, Xu Zhang, Heqiu Li, Kai Sun, Zi Yang Meng  
[Phys. Rev. B 105, L121110\(2022\)](#)
5. Momentum space quantum Monte Carlo on twisted bilayer Graphene  
Xu Zhang\*, **Gaopei Pan**\*, Yi Zhang, Jian Kang, Zi Yang Meng  
[Chin. Phys. Lett. 38, 077305 \(2021\) Cover story](#)
6. Yukawa-SYK model and Self-tuned Quantum Criticality  
**Gaopei Pan**, Wei Wang, Andrew Davis, Yuxuan Wang, Zi Yang Meng  
[Phys. Rev. Research 3, 013250 \(2021\)](#)
7. Superconductivity near the  $(2 + 1)$ d ferromagnetic quantum critical point  
Yunchao Hao\*, **Gaopei Pan**\*, Kai Sun, Zi Yang Meng, Yang Qi  
[Chin. Phys. Lett. 39 097102\(2022\)](#)

### Non First Author:

1. Quantum Monte Carlo sign bounds, topological Mott insulator and thermodynamic transitions in twisted bilayer graphene model  
Xu Zhang, **Gaopei Pan**, Bin-Bin Chen, Heqiu Li, Kai Sun, Zi Yang Meng  
[arXiv:2210.11733](#)
2. Fermion sign bounds theory in quantum Monte Carlo simulation  
Xu Zhang, **Gaopei Pan**, Xiao Yan Xu, Zi Yang Meng  
[Phys. Rev. B 106, 035121 \(2022\)](#)
3. Superconductivity and bosonic fluid emerging from Moiré flat bands  
Xu Zhang, Kai Sun, Heqiu Li, **Gaopei Pan**, Zi Yang Meng  
[arXiv:2111.10018](#)
4. Solving quantum rotor model with different Monte Carlo techniques  
Weilun Jiang, **Gaopei Pan**, Yuzhi Liu, Zi Yang Meng  
[Chin. Phys. B 31, 040504 \(2022\)](#)
5. Phase diagram of the spin-1/2 Yukawa-SYK model: Non-Fermi liquid, insulator, and superconductor  
Wei Wang, Andrew Davis, **Gaopei Pan**, Yuxuan Wang, Zi Yang Meng  
[Phys. Rev. B 103, 195108\(2021\)](#)
6. Revealing Fermionic Quantum Criticality from New Monte Carlo Techniques  
Xiao Yan Xu, Zi Hong Liu, **Gaopei Pan**, Yang Qi, Kai Sun, Zi Yang Meng  
[TOPICAL REVIEW, J. Phys.: Condens. Matter 31, 463001 \(2019\)](#)

7. Itinerant Quantum Critical Point with Fermion Pockets and Hot Spots  
Zi Hong Liu, **Gaopei Pan**, Xiao Yan Xu, Kai Sun, Zi Yang Meng  
[PNAS August 20, 2019 116 \(34\) 16760-16767](#)

## TECHNICAL STRENGTHS

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<b>Computer Languages</b>	Fortran, C, Matlab, Python, Shell
<b>Tools</b>	Vim, Latex, Adobe Illustrator