

# Qi Shi

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## Education

Brookhaven National Laboratory  
Visitor in the Physics Department

Sept. 2022 - present

Central China Normal University  
Ph.D. candidate in Physics

Sept. 2018 - present

- Fields: Lattice Chromodynamics (LQCD), Hadron Structure, QCD Thermodynamics
- Ph.D. degree to be expected in June 2025

Northeast Normal University  
B.S. in Physics

Sept. 2014 - Jun. 2018

## Publications

### Journal Articles

- [1] Heng-Tong Ding, Xiang Gao, Swagato Mukherjee, Peter Petreczky, **Qi Shi\***, Sergey Syritsyn, and Yong Zhao. “Three-dimensional Imaging of Pion using Lattice QCD: Generalized Parton Distributions”. *Under review in JHEP* (July 2024). arXiv: [2407.03516 \[hep-lat\]](#).
- [2] Heng-Tong Ding, Xiang Gao\*, Andrew D. Hanlon, Swagato Mukherjee, Peter Petreczky, **Qi Shi\***, Sergey Syritsyn, Rui Zhang, and Yong Zhao. “QCD Predictions for Meson Electromagnetic Form Factors at High Momenta: Testing Factorization in Exclusive Processes”. *Accepted in Phys. Rev. Lett.* (Apr. 2024). arXiv: [2404.04412 \[hep-lat\]](#).
- [3] Xiang Gao, Andrew D. Hanlon, Swagato Mukherjee, Peter Petreczky, **Qi Shi**, Sergey Syritsyn, and Yong Zhao. “Transversity PDFs of the proton from lattice QCD with physical quark masses”. *Phys. Rev. D* 109.5 (2024), p. 054506. DOI: [10.1103/PhysRevD.109.054506](#). arXiv: [2310.19047 \[hep-lat\]](#).
- [4] Heng-Tong Ding, Sheng-Tai Li, **Qi Shi**, and Xiao-Dan Wang. “Fluctuations and correlations of net baryon number, electric charge and strangeness in a background magnetic field”. *Eur. Phys. J. A* 57.6 (2021), p. 202. DOI: [10.1140/epja/s10050-021-00519-3](#). arXiv: [2104.06843 \[hep-lat\]](#).

### Conference Proceedings

- [1] Heng-Tong Ding, Xiang Gao, Swagato Mukherjee, Peter Petreczky, **Qi Shi\***, Sergey Syritsyn, and Yong Zhao. “Lattice QCD calculation of the pion generalized parton distribution”. *PoS SPIN2023* (2024), p. 024. DOI: [10.22323/1.456.0024](#).
- [2] Heng-Tong Ding, Xiang Gao, Andrew D. Hanlon, Swagato Mukherjee, Peter Petreczky, **Qi Shi\***, Sergey Syritsyn, and Yong Zhao. “Lattice QCD predictions of pion and kaon electromagnetic form factors at large momentum transfer”. *PoS LATTICE2023* (2024), p. 320. DOI: [10.22323/1.453.0320](#).
- [3] Heng-Tong Ding, Sheng-Tai Li, **Qi Shi**, Akio Tomiya, Xiao-Dan Wang, and Yu Zhang. “QCD phase structure in strong magnetic fields”. *Acta Phys. Polon. Supp.* 14 (2021), p. 403. DOI: [10.5506/APHYSPOLBSUPP.14.403](#). arXiv: [2011.04870 \[hep-lat\]](#).

## Skills

**LQCD software** Qlua (Qlu+CUDA)  
**Supercomputing** NERSC, DELTA, SDCC, NSC3  
**Cluster** Slurm, Vim, Bash

**Programming** Python  
**Languages** Chinese (Native), English (Fluent)  
**Other Tools** Latex, Jupyter Notebooks

## Oral Presentations

1. “Exploring Meson Structures from Lattice QCD”, From Quarks and Gluons to the Internal Dynamics of Hadrons, May 15 - 17, 2024, Stony Brook University, USA

2. “Lattice QCD calculation of the pion generalized parton distributions (GPDs)”, Workshop on Generalized Parton Distributions for Nucleon Tomography in the EIC Era (**RBRC workshop**), January 17 – 19, 2024, Brookhaven National Laboratory, USA.
3. “Lattice QCD calculation of the pion generalized parton distributions (GPDs)”, 25th International Spin Symposium (**SPIN 2023**), September 24 - 29, 2023, Durham Convention Center, USA.
4. “Lattice QCD prediction of pion and kaon form factor at large momentum transfer  $Q^2$ ”, **Invited seminar talk**, August 29, 2023, Argonne National Laboratory, USA.
5. “Transversity PDFs of the proton from lattice QCD with physical quark masses” (online talk), 2023 Meeting on Lattice Parton Physics from Large Momentum Effective Theory (**LaMET 2023**), July 24 - 26, 2023, University of Regensburg, Germany.
6. “Lattice QCD prediction of pion and kaon form factor at large momentum transfer  $Q^2$ ”, The 40th International Symposium on Lattice Field Theory (**Lattice 2023**), July 31 - August 4, 2023, Fermi National Accelerator Laboratory, USA.
7. “Lattice QCD prediction of pion and kaon form factor at large momentum transfer  $Q^2$ ”, 2022 Meeting on Lattice Parton Physics from Large-Momentum Effective Theory (**LaMET 2022**), December 1 – 3, 2022, Argonne National Laboratory, USA.
8. “Lattice QCD prediction of kaon form factor at large momentum transfer up to 10 GeV<sup>2</sup>”, American Physical Society April Meeting 2022 (**APS 2022**), April 9 - 12, 2022, online meeting, USA.

## Research Experience

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### The Internal Structure of Hadron

Sept. 2021 – present

#### LQCD Calculation of Pion Generalized Parton Distributions (GPDs)

Jun. 2023 - present

- Pre-processed raw data from two-point and three-point correlation functions, utilizing the symmetry of quantities such as transverse momentum and transverse momentum transfer in the  $\gamma_t$  component.
- Applied a frame-independent method to lattice results of the matrix element to extract the Lorentz-invariant amplitude, confirming the method’s effectiveness by obtaining comparable amplitude results from two different frames.
- Implemented a hybrid renormalization scheme to remove ultraviolet divergences and developed improved perturbative matching techniques, incorporating leading-renormalon resummation (LRR) and renormalization group resummation (RGR), ultimately obtaining the light-cone GPDs within the LaMET framework.
- Explored the pion impact-parameter space parton distributions (IPDs) through the Fourier transform of the light-cone GPDs with respect to the transverse components of the momentum transfer.

#### LQCD Calculation of Pion and Kaon Electromagnetic Form Factors (EMFFs)

Jun. 2022 - Jun. 2023

- Generated two-point and three-point correlation functions for the pion and kaon. Performed  $N$ -state fit on two-point functions to extract energy levels and corresponding amplitudes, validating the data by comparing energy results with those obtained from the dispersion relation.
- Extracted bare matrix elements from the ratio of two-point and three-point functions using the previously obtained energy levels and amplitudes, applying various fit methods such as  $N$ -state fit, Summation fit and Exponential Summation fit to ensure robustness of the results.
- Obtained physical EMFF results at large momentum transfers after applying the renormalization factor to bare matrix elements. Provided predictions and guidance for future experiments such as JLab, EIC, and EicC, comparing the lattice results with perturbative QCD results to test factorization in specific exclusive process, and offering benchmarks for effective theories.

#### LQCD Calculation of Proton Transversity Parton Distribution Functions (PDFs)

Sept. 2021 - Jun. 2022

- Set up the computing environment by installing CUDA, CMake, OpenMPI, and GCC to enable efficient lattice QCD simulations.

- Built Qlua based on above software stack, following the [guidance](#) provided by the USQCD collaboration.
- Computed two-point and three-point correlation functions using Qlua with carefully tuned parameters to ensure accurate results for the extraction of the transversity PDFs.

## **QCD Thermodynamics**

**Sept. 2020 – Sept. 2021**

### Fluctuations and Correlations of Conserved Charges in Lattice QCD

- Derived the partition function in the HRG model and ideal gas limit under the influence of background magnetic fields.
- Calculated thermodynamic observables, including fluctuations and correlations among the conserved charges (baryon number, electric charge, and strangeness)
- Generated and analyzed the lattice data and compared them with predictions from the HRG model and the ideal gas limit.