Jinguo Liu (刘金国)

Postdoc fellow in Harvard university

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"朝正确的方向努力，而不是去摘下垂的果实。"

Education

Nanjing Institute of Technology — *Nanjing*

B.S. in Software Engineering — *2008–2012*

I was a pioneer of the open-source software movement in my institute. Deeply impressed by the beautiful computation framework in the book "Quantum Computation and Quantum Information" by Michael A. Nielsen, I was eager to learn more about quantum computing.

Nanjing University — *Nanjing*

Ph.D. Theoretical Physics — *2012–2017*

Advised under Prof. Qianghua Wang, I built up my interest in algorithms for solving quantum many-body systems. I mastered tensor networks algorithms and renormalization group theories and became a geek in simulating quantum many-body systems. Most of my works are about designing new algorithms to solve problems in physics, like the multi-channel Kondo problem and fractional topological excitation. In the last year as a doctoral candidate, I won the first prize in the ZTE fantastic algorithm challenge, which reflects my solid algorithmic background in matrix computation and combinatorial optimization.

Skills

Programming	Julia, Python, Fortran
Language	Chinese, English
Knowledge	Tensor Networks, Differential Programming, Quantum computing, Computational complexity, Condensed matter physics, Combinatorial optimization, High performance computing

Experience

Institute of Physics (IOP), Chinese Academy of Sciences (CAS) — *Beijing*

Postdoc — *2017–2019*

I became a postdoc in Lei-Wang's group, one of the smartest people I knew. Besides providing valuable advice about research, Lei also provides opportunities for me to give lectures and talks at international conferences and summer schools. At that time, my research interest is automatic differentiation and quantum algorithms.

QuEra Computing Inc. — *Waterloo*

Consultant — *2020.01-2020.07*

Due to the COVID, I was trapped in Waterloo - a wild place where you can see wild animals on the streets. QuEra kindly offered me a full-time consultant job. I worked on stochastic optimizers for variational quantum algorithms and classical benchmarking quantum approximation optimization algorithm (QAOA).

Harvard university — *Boston*

Postdoc — *2020.08-*

QuEra also sponsored my Postdoc in Mikhail Lukin's group. Working at Harvard is a unique experience for me. While my skills helped experimentalists and theorists in Misha's group, I learned more exciting stuff from people around me every day.

- I developed generic tensor networks (tensor networks with generic element types) to understand the solution space properties of the maximum independent set problem. I learned their approach to analyzing hardness from the solution space geometry: the overlap gap property and adiabatic gap analysis.
- I mapped the maximum independent set problem on a general graph to the one with restricted geometry of diagonal-coupled unit-disk grid graph that Rydberg atom arrays can implement (has been patented). I learned how to reduce many other hard problems to the maximum independent set problem.
- I improved SLM hologram computation for generating arbitrary optical traps (will be patented). I learned how Fourier optics plays a role in the Rydberg atom experiment works in turn.

Honors & Awards

2007	**First prize,** Physics Olympiad	*JiangSu, China*
2016	**Academic Excellence Scholarship,** Nanjing University	*NanJing*
2017	**First prize (out of 8000 teams, 100,000 RMB award),** ZTE Fantastic Algorithm Challenge	*Xi An, China*

Open Source Contributions

Yao.jl

One of the main developers

`Yao.jl` is the most popular quantum circuit simulation framework in the Julia community. The Yao repository has 650+ Github stars, and the paper has 50+ citations. It is fast, generic, GPU accelerated, and differentiable.

OMEinsum.jl and OMEinsumContractionOrders.jl

Mentor of `OMEinsum.jl`, main developer of `OMEinsumContractionOrders.jl`

`OMEinsum.jl` is a generic, differentiable einsum library with GPU support. It was developed by Andreas Peter (mentor under me) on the Google Summer of Code (GSoC) project about differential programming tensor networks. This project is a successful one and now its Github repo has 100+ stars. `OMEinsumContractionOrders.jl` is its extension for contraction order optimization that many state-of-the-art algorithms implemented in it.

GenericTensorNetworks.jl

Main developer

`GenericTensorNetworks.jl` is a package using generic tensor network contraction for solving graph properties. It comes together with the paper: *"Computing solution space properties by generic programming tensor networks"* (see section "Selected Publications").

Presentations

The FOR 1807 Winter School on Numerical Methods for Strongly Correlated Quantum Systems — *Marburg*

Lecturer — *2018*

Lecture: "Deep learning and quantum many body systems"

Deep Learning and Quantum Programming: A Spring School — *Dongguan*

Lecturer — *2019*

Lecture: Quantum computing

SLAC Photon Science Seminar — *Virtual*

Invited Speaker — *2022*

Talk: Computing solution space properties of combinatorial optimization problems via generic tensor networks

March Meeting 2020 — *Cancelled*

Invited Speaker — *2020*

Talk: "Differentiable programming tensor networks and quantum circuits"

March Meeting — *Boston*

Speaker — *2019*

Talk: "Differentiale Quantum Circuits and Generative Modeling"

Juliacon — *Baltimore*

Speaker — *2019*

Talk: "Differential Programming Tensor Networks"

Statistic Physics and Machine Learning — *An Qing*

Speaker — *2018*

Talk: "Machine Learning in frustrated quantum spin system"

Computational Approaches for Quantum Many Body Systems — *Bei Jing*

Speaker — *2016*

Talk: "Local indistinguishability and topological phase of matter"

Beijing 2018 Julia Meetup — *Bei Jing*

Speaker — *2018*

Talk: Tutorial for high performance matrix computations in Julia

Quantum Information for Developers — *Zurich*

Hackathon — *2018*

Hackathon: "Funny Tensor Networks"

23rd Annual Conference on Quantum Information Processing — *Shenzhen*

Poster — *2020*

Poster: "Yao - A differential quantum programming framework"

The 8th Workshop on Quantum Many-Body Computation — *Hang Zhou*

Poster — *2018*

Poster: "Differentiable learning of quantum circuit Born machine"

The 8th Workshop on Quantum Many-Body Computation — *Hang Zhou*

Poster — *2018*

Poster: "Differentiable learning of quantum circuit Born machine"

The First International Conference on Machine Learning and Physics *Bei Jing*

Poster *2018*

Poster: "Differentiable learning of quantum circuit Born machine"

Selected Publications

Maximum independent sets: from unit disk graphs to arbitrary connectivity *Unpublished*

Jinguo Liu, Min-Thi Nguyen, Shengtao Wang et al and Hannes Pichler *2022*

It is a computational complexity paper about reducing the problem of finding maximum independent sets on a general graph to that on a diagonal-coupled unit-disk grid graph. The overhead of the proposed method is only the pathwidth of the source graph, which is much better than the previously known n^8 reduction. We show this mapping scheme is optimal up to a constant factor if the exponential hypothesis is true. With this mapping scheme, a general maximum independent set problem can potentially be solved faster on a quantum device (see arXiv: 2202.09372).

Computing solution space properties by generic programming tensor networks *arXiv: 2205.03718*

Jinguo Liu, Xun Gao, Shengtao Wang, Midelyn Cain and Mikhail Lukin *2022*

Tropical tensor network for ground states of spin glasses *Phys. Rev. Lett. 126, 090506*

Jinguo Liu, Lei Wang and Pan Zhang *2021*

Yao.jl: Extensible, Efficient Framework for Quantum Algorithm Design *Quantum*

Xiuzhe Luo, Jinguo Liu, Pan Zhang and Lei Wang *2020*