# Ziming Liu

School of Physics, Peking University
No. 5 Yiheyuan Road, Beijing 100871, P. R. China
Tel: 86-15011510133 E-mail: liu_zi_ming @pku.edu.cn Web: kindxiaoming.github.io


## EDUCATION

09/2016-06/2020 **PEKING UNIVERSITY** Beijing, China

Bachelor of Science in Physics, School of Physics

- GPA: 3.78/4.0
- Computer Skills: Python (packages: sklearn/scipy/tensorflow/pytorch), Mathematica, LaTeX, Matlab, C/C++/C#, Linux
- English: TOEFL 104, GRE 327 (157/V+170/Q+3.5/AW), GRE Physics Sub 990 (94% Below)

## RESEARCH INTEREST

- Applications of machine learning to engineering and science
- Bayesian learning inspired by physical dynamics
- Online and large-scale tensor decomposition methods
- Quantum computation and quantum information

## RESEARCH

1) *Feb. 2018-July. 2018* **Predicting event-by-event initial fluctuations from emitted particles in Relativistic Heavy-Ion Collisions with Deep Learning**

*Advisor: Huichao Song, Peking University*

**Results:**

- In this project, I read reviews to get familiar with the High energy phenomenology community. Based on GAN(Generative Adversarial Network) construction, which is popular in the deep learning community, I devised an advanced architecture called Hydro-GAN, which is adjusted to predict event-by-event initial fluctuations from spectra of emitted particles. This work can help us recover the initial geometry of the fireball in collisions.

2) *June. 2018-March. 2019* **Principal Component Analysis of Single Particle Distribution in Relativistic Heavy-Ion Collisions**

*Advisor: Huichao Song, Peking University*

**Results:**

- Principal component analysis(PCA) has demonstrated great power in various fields of physics. I applied PCA to study flow in heavy-ion collisions, and revealed fascinating features hidden in large amount of data.
- Unlike traditional methods, we did not use any priori transformation(e.g. Fourier transformation) to define observables. On the contrary, we let PCA automatically determine features in particle distribution, from which we define new observables. New observables show advantages over traditional ones in many aspects, one of which is that observables defined by our method show simpler one-to-one mapping with initial eccentricities.
- ***The paper has been submitted to EPJC (as first author).*** Title: Principal Component Analysis of collective flow in Relativistic Heavy-ion collisions. Author List: Ziming Liu, Wenbin Zhao, and Huichao Song.
- ***The research was presented by me on 4th China LHC Physics Conference (oral, December 2018)*** Title: Why do we use Fourier Transformation to analyze flow?
- ***The research was presented by me on Initial Stages 2019 (oral, June 2019)*** Title: Principal component analysis and its applications to relativistic heavy-ion collisions

# Ziming Liu

School of Physics, Peking University
No. 5 Yiheyuan Road, Beijing 100871, P. R. China
Tel: 86-15011510133 E-mail: liu_zi_ming @pku.edu.cn Web: kindxiaoming.github.io

3) *Jan. 2019- March.2019* **The limitations of Principal Component Analysis(PCA) to analyze experimental data of Relativistic Heavy-Ion Collisions**

*Advisor: Jiangyong Jia, Department of Chemistry, Stony Brook University*

**Results:**

- CMS collaboration had published results of leading modes and sub-leading modes in PbPb and pPb system by applying PCA to two-particle correlation. The results provide a natural way to describe factorization breaking (or 'decorrelation').
- I am using simulated data (Monte Carlo) to test the stability of this method. So far, I have found that different choice of pt bins (Transverse Momentum) can lead to different results. Besides, we found that the sub-leading flow can originate from non-flow effects, except the well-known excited initial states.
- ***The paper will appear on Arxiv soon (as first author).*** Title: Limitations of using Principal Component Analysis to study factorization of collective flow. Author List: Ziming Liu, Arabinda Behera, Huichao Song, and Jiangyong Jia.
- ***The research was presented by me on Initial Stages 2019 (oral, June 2019)*** Title: Principal component analysis and its applications to relativistic heavy-ion collisions

4) *June. 2019- September.2019* **Quantum-Inspired Hamiltonian Monte Carlo**

*Advisor: Zheng Zhang, Department of Electrical and Computer Engineering, University of California, Santa Barbara*

**Results:**

- An efficient and popular sampling algorithm in Bayesian learning is Hamiltonian Monte Carlo (HMC), which is based on the simulation of continuous-time Hamiltonian dynamics.
- Inspired by quantum mechanics, we modify the Hamiltonian dynamics by introducing a time-varying mass term and refer to the proposed algorithm as quantum-inspired Hamiltonian monte carlo (QHMC). In this way we can achieve much better sampling of spiky distributions than the original HMC algorithm. Theories are built based on perspectives from dynamical systems and game theory. Experiments include bayesian bridge regression, image denoising and neural network pruning.
- ***The paper will appear on Arxiv soon (as first author), and will be submitted to International Conference of Machine Learning (ICML) 2020.*** Title: Quantum-inspired Hamiltonian Monte Carlo. Author List: Ziming Liu, Zheng Zhang.

## MATHEMATICAL MODELING AND OTHER EXPERIENCES

- Led a group of eight competing for CUPT (China Undergraduate Physics Tournament) which requires us to solve real-life physics problems and won the second place in Peking University
- Used C# to develop an online Electrical Laboratory software with a group of four
- Worked with three in a data mining competition in Beijing and won the first place. The problem is concerned about key factors of health for citizens in New York City.
- Held a seminar for hydrodynamics, participated in a seminar for numerical analysis, holding a seminar for quantum computation and quantum information.

## AWARDS AND HONORS

- Shenzhen Finance Institute scholarship ($7^{th}$ place out of 220 students) 09/2018
- First place of 'DataOpen Challenge' in Beijing 05/2018

- Scholarship of China National Petroleum Corporation 09/2017
- First Prize for National Mathematics Modeling Contest 09/2017
- First Prize in Mathematics Competition for Undergraduates 12/2017
- 2nd Place in Male Rope Skipping Competition in Peking University 03/2018
- 2nd Place in Latin Dance Competition in Peking University 06/2016

## PUBLICATIONS AND PRESENTATIONS

- Paper: Principal Component Analysis of collective flow in Relativistic Heavy-ion collisions (Ziming Liu, Wenbin Zhao, and Huichao Song). Arxiv: 1903.09833. The paper has been submitted to European Journal of Physics C(EPJC).
- Oral Talk: Why do we use Fourier Transformation to analyze flow? *December 2018, 4th China LHC Physics Conference*.
- Oral Talk: Principal component analysis and its applications to relativistic heavy-ion collisions? June 2019, Columbia University, Initial Stages 2019.
- Oral Talk: Applications of Principal Component Analysis and its Applications to Relativistic Heavy-ion Collisions. May 2019, online conference, 81st HENPIC.
- Paper: Limitations of using Principal Component Analysis to study factorization of collective flow (Ziming Liu, Arabinda Behera, Huichao Song, and Jiangyong Jia). The paper will appear on Arxiv soon and will be submitted to Physics Review C (PRC).
- Paper: Quantum-Inspired Hamiltonian Monte Carlo (Ziming Liu, Zheng Zhang). The paper will be available on Arxiv soon and will be submitted to International Conference of Machine Learning (ICML) 2020.

## SELETED COURSES

| | | | |
|---|---|---|---|
| Solid State Physics | 92 | Seminar for Equilibrium Statistical Physics | 98 |
| Quantum Mechanics | 96 | Atomic physics | 98 |
| Computational Physics | 93 | Group Theory | 91 |
| Classical Mechanics | 100 | Advanced Quantum Mechanics | 100 |
| Equilibrium Statistical Physics | 97 | Seminar for Quantum Mechanics | 99 |
| Probability Theory and Statistics (A) | 88 | Lie Group and Lie Algebras | 98 |
| Applied Stochastic Process | 87 | Solid State Theory | 95 |
| Special Topics of Mathematical Physics | 97 | | |