Yupan Liu

Curriculum Vitae

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Education

2017.10–2020.03 **M.Sc. in Computer Science**, *Hebrew University*, Jerusalem, Israel.
Advisors: Dorit Aharonov and Itai Arad (Technion)
Overall GPA: 93.22
M.Sc. Thesis: *Towards a quantum-inspired proof for* IP = PSPACE

2013.09–2017.07 **B.Eng. in Computer Science and Technology**, *Zhejiang University*, Hangzhou, China.
Overall GPA: 85.28, Major (last-two-year) GPA: 88.22
Senior Project Advisor: Xin Wan

Research Interests

My research interests lie in theoretical computer science, with a particular focus on quantum computing and complexity theory, such as consequences of derandomization from a quantum perspective (e.g. StoqMA vs. MA), Hamiltonian complexity (e.g., learning local Hamiltonian, stoquastic area law), and delegating quantum computation using interactive proofs. I am also interested in theoretical computer science in general.

Research Experience

2017-2020 **Research Student**, *CS Theory Group*, Hebrew University, Jerusalem, Israel.
Advisors: Dorit Aharonov and Itai Arad

Working on 2D area laws for graphical Hamiltonians, which are some kinds of classical systems, namely its local Hamiltonian problem is inside MA; also using methods from computer science and combinatorics such as random walks.

2018-2019 **Research Student**, *CS Theory Group*, Hebrew University, Jerusalem, Israel.
Advisors: Guy Kindler

Worked on in-class interactive proof for $\mathrm{NP}^{\mathrm{PP}}$ using the celebrated sum-check protocol, while the well-known result is in-class interactive proofs for PSPACE, PP and NL.

Summer 2019 **Research Internship**, National University of Singapore, Singapore.
Advisors: Itai Arad and Miklos Santha

Learning Pauli commuting local Hamiltonians, namely given many copies of the Gibbs state of the Hamiltonian, recovering the Hamiltonian by classical measurements and post-processing.

Summer 2016 **Research Internship**, National University of Singapore, Singapore.
Advisors: Itai Arad and Miklos Santha

Developed new efficient algorithms to calculate the expectation value (and ground state) of physical systems which satisfy $2D$ area law, using tensor-network method and convex optimization with translation-invariant property and commutator gauge property, and also try to give insights for showing that LHP is in NP for $2D$ gapped local systems.

2016–2017 **Research Student**, *Department of Physics*, Zhejiang University, Hangzhou, China.
Advisor: Xin Wan

My senior project is developing new efficient algorithms via convex optimization, to calculate the expectation value of many-body system satisfied area law.

Publications

(In preparation).
Title: StoqMA *meets distribution property testing*
Author: Yupan Liu
Abstract: It is known that MA $\subseteq$ StoqMA $\subseteq$ AM [BBT06], and all complexity classes are supposed to be equal under the derandomization assumption. Also, StoqMA is originally defined in the scenario of stoquastic local Hamiltonians and sign-problem free adiabatic evolution [BBT06,BT09]. Here we make the first step towards proving StoqMA = MA, and provide several strong evidences of this equivalence:

- First, we show that easy-witness StoqMA (i.e. eStoqMA) is in MA, where there is an efficient deterministic algorithm returns the coordinate of the given index of the non-negative witness. The proof essentially comes from the distribution property testing.
- Second, we provide an AND-type repetition procedure of StoqMA, and it implies a direct error reduction of StoqMA_1 (i.e. StoqMA with perfect completeness) which is not known before. It further leads us to an alternating proof of $\text{StoqMA}_1 \subseteq$ MA [BBT06,BT09], since it is implied by $\text{StoqMA}_1 \subseteq$ eStoqMA.
- Third, we prove the classical analog of Non-Identity Check (which is known to be QMA-complete) is StoqMA-complete, when we restrict these two quantum circuits to be reversible circuits with the same number of $|0\rangle$ and $|+\rangle$ ancillas.
- Forth, we prove that StoqMA with perfect soundness is in NP. This property is known for public-coin classical interactive proofs, such as MA and AM [FGMSZ89].

Jan 2020 **QIP 2020 (accepted poster)**, Peng Cheng Laboratory and SUSTech, Shenzhen, China.
Title: *Learning Pauli commuting local Hamiltonians*
Author: Yupan Liu
Abstract: Learning an unknown Hamiltonian from local measurements is an increasingly important task in the NISQ era. Recent work by Bairey, Arad, and Lindner [BAL19] proposed an approach to learn non-commuting local Hamiltonians, however, their approach fails in the commuting Hamiltonians case. In this note, we provide a method to learn Pauli commuting local Hamiltonians, which is a subclass of general commuting local Hamiltonians: Given many copies of the Gibbs state of a Pauli commuting local Hamiltonian on n qubits, one can learn the Hamiltonian by applying an $O(n/\log n)$-depth Clifford circuit and classical post-processing. Our result sheds light on learning general commuting local Hamiltonians using local measurements.

Aug 2019 **AQIS 2019 (accepted poster)**, Korea Institute of Advanced Studies, Seoul, South Korea.
Title: *Towards a quantum-inspired proof for IP = PSPACE*
Author: Ayal Green, Guy Kindler, Yupan Liu (alphabet order)
Abstract: We explore an in-class interactive proof systems where the prover is limited. Namely, we improve on a result by [AG17] showing a quantum-inspired interactive protocol (IP) for PreciseBQP where the prover is only assumed to be a PreciseBQP machine, and show that the result can be strengthened to show an IP for NP^{PP} with a prover which is only assumed to be an NP^{PP} machine which was not known before. Our results shed lights on a quantum-inspired pro of for PSPACE = IP, since PreciseQMA captures the full PSPACE power.

Professional Service

Reviewer ◇ The 61st Annual Symposium on Foundations of Computer Science (FOCS 2020)
◇ The 15th Conference on the Theory of Quantum Computation, Communication and Cryptography (TQC 2020)

Teaching Experience

Fall 2019 **Kazhdan's Lecture: Computation, quantumness, symplectic geometry, information**, Hebrew University, Jerusalem, Israel.
Instructors: Gil Kalai, Leonid Polterovich, Dorit Aharonov, Guy Kindler
Scribed notes for all computer science oriented lectures (half of the course).

Languages

Chinese **Mothertongue**
English **Fluent**