Seminar on Computation and Physics

Organizer

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This is an seminar about recent connecting between computational complexity and physics, going beyond the fundamental connection established by quantum computing. The seminar is based on the course Scott Aaronson instructed in MIT, Fall 2015. His website is 6.S899 Class Home (mit.edu). Topics will include: topological quantum computing; topological order; quantum computing with bosons and fermions (e.g., BosonSampling and FermionSampling); computational aspects of the black-hole firewall problem and the AdS/CFT correspondence; Hamiltonian complexity and quantum interactive proof; quantum computing with closed timelike curves and quantum algorithm for quantum field theory. The seminar aims to provide a platform for interdisciplinary communication. Note that the goal of this seminar is not to dig into a specific technique of some area, but to understand basic ideas in this interdisciplinary field. And this seminar is not for experimental physics and numerical expeiments.

Suggested Papers

Topological Order and Topological Quantum Field Theory

Dorit Aharonov, Vaughan Jones, Zeph Landau. [quant-ph/0511096v2] A Polynomial Quantum Algorithm for Approximating the Jones Polynomial (arxiv.org)
Michael H. Freedman, Alexei Kitaev, Michael J. Larsen, Zhenghan Wang. [quant-ph/0101025] Topological Quantum Computation (arxiv.org)
Alexei Kitaev, Chris Laumann. [0904.2771] Topological phases and quantum computation (arxiv.org)
Michael H. Freedman, Alexei Kitaev, Zhenghan Wang. [quant-ph/0001071] Simulation of topological field theories by quantum computers (arxiv.org)
Liang Kong, Zhi-Hao Zhang. [2205.05565] An invitation to topological orders and category theory (arxiv.org).
Hong-Chen Jiang, Zhenghan Wang, Leon Balents. [1205.4289] Identifying Topological Order by Entanglement Entropy (arxiv.org).

AdS/CFT Correspondence, Black Hole and Quamtum Information (High Energy)

Ahmed Almheiri, Xi Dong, Daniel Harlow. [1411.7041] Bulk Locality and Quantum Error Correction in AdS/CFT (arxiv.org).
Patrick Hayden, John Preskill. [0708.4025v2] Black holes as mirrors: quantum information in random subsystems (arxiv.org).
Patrick Hayden, Alex May. [1210.0913] Summoning Information in Spacetime, or Where and When Can a Qubit Be? (arxiv.org).
Jonathan Oppenheim, William G. Unruh. [1401.1523] Firewalls and flat mirrors: An alternative to the AMPS experiment which evades the Harlow-Hayden obstacle (arxiv.org).
Fernando Pastawski, Beni Yoshida, Daniel Harlow, John Preskill. [1503.06237] Holographic quantum error-correcting codes: Toy models for the bulk/boundary correspondence (arxiv.org).
Leonard Susskind. [1402.5674] Computational Complexity and Black Hole Horizons (arxiv.org).
Leonard Susskind, Ying Zhao. [1408.2823] Switchbacks and the Bridge to Nowhere (arxiv.org).
P.D. Welch. [gr-qc/0609035] The extent of computation in Malament-Hogarth spacetimes (arxiv.org).
Leonard Susskind. [1507.02287] The Typical-State Paradox: Diagnosing Horizons with Complexity (arxiv.org).
Raphael Bousso, Netta Engelhardt. [1504.07627] A New Area Law in General Relativity (arxiv.org).

Entanglement Complexity and Hamiltonian Complexity

Daniel S. Abrams , Seth Lloyd . [quant-ph/9801041] Nonlinear quantum mechanics implies polynomial-time solution for NP-complete and #P problems (arxiv.org).
Dorit Aharonov, Itai Arad, Thomas Vidick. [1309.7495] The Quantum PCP Conjecture (arxiv.org).
Anand Natarajan, John Wright. [1904.05870] NEEXP in MIP* (arxiv.org).
Dorit Aharonov, Tomer Naveh. [quant-ph/0210077v1] Quantum NP - A Survey (arxiv.org).
Sergey Bravyi, Arvid J. Bessen, Barbara M. Terhal. [quant-ph/0611021] Merlin-Arthur Games and Stoquastic Complexity (arxiv.org).
Scott Aaronson, Salman Beigi, Andrew Drucker, Bill Fefferman, Peter Shor. [0804.0802] The Power of Unentanglement (arxiv.org).
Toby Cubitt, David Perez-Garcia, Michael M. Wolf [1502.04573v2] Undecidability of the Spectral Gap (full version) (arxiv.org).
Toby Cubitt, Ashley Montanaro. [1311.3161] Complexity classification of local Hamiltonian problems (arxiv.org).
Zeph Landau, Umesh Vazirani, Thomas Vidick. [1307.5143] A polynomial-time algorithm for the ground state of 1D gapped local Hamiltonians (arxiv.org).
J. Eisert, M. Cramer, M.B. Plenio. [0808.3773] Area laws for the entanglement entropy - a review (arxiv.org).
Norbert Schuch, Ignacio Cirac, Frank Verstraete. [0802.3351v1] The computational difficulty of finding MPS ground states (arxiv.org).

M. H. Freedman, M. B. Hastings. [1301.1363] Quantum Systems on Non-k-Hyperfinite Complexes: A Generalization of Classical Statistical Mechanics on Expander Graphs (arxiv.org).
Anurag Anshu, Nikolas P. Breuckmann. [2206.02741v1] A construction of Combinatorial NLTS (arxiv.org).

Quamtum Computation Model

Dorit Aharonov, Wim van Dam, Julia Kempe, Zeph Landau, Seth Lloyd, Oded Regev. [quant-ph/0405098] Adiabatic Quantum Computation is Equivalent to Standard Quantum Computation (arxiv.org).
Charles H. Bennett, Debbie Leung, Graeme Smith, John A. Smolin. [0908.3023] Can closed timelike curves or nonlinear quantum mechanics improve quantum state discrimination or help solve hard problems? (arxiv.org).
Sergey Bravyi , Alexei Kitaev . [quant-ph/0003137] Fermionic quantum computation (arxiv.org).
Stephen P. Jordan. [0906.2508] Permutational Quantum Computing (arxiv.org)
Michael H. Freedman, Alexei Kitaev, Michael J. Larsen, Zhenghan Wang. [quant-ph/0101025] Topological Quantum Computation (arxiv.org).
Alexei Kitaev, Chris Laumann. [0904.2771] Topological phases and quantum computation (arxiv.org).
Toby S. Cubitt, Jens Eisert, Michael M. Wolf. [1005.0005] Extracting dynamical equations from experimental data is NP-hard (arxiv.org).
Gil Kalai, Greg Kuperberg. [1412.1907] Contagious error sources would need time travel to prevent quantum computation (arxiv.org).
Lev B. Levitin, Tommaso Toffoli. [quant-ph/0701237v2] Thermodynamic cost of reversible computing (arxiv.org).
Seth Lloyd, Olaf Dreyer. [1302.2850] The universal path integral (arxiv.org).
Seth Lloyd. [quant-ph/0110141] Computational capacity of the universe (arxiv.org).

Quantum Algorithm for Scentific Computation

Dorit Aharonov, Vaughan Jones, Zeph Landau. [quant-ph/0511096v2] A Polynomial Quantum Algorithm for Approximating the Jones Polynomial (arxiv.org).
Michael H. Freedman, Alexei Kitaev, Zhenghan Wang. [quant-ph/0001071] Simulation of topological field theories by quantum computers (arxiv.org).
Stephen P. Jordan, Keith S. M. Lee, John Preskill. [1111.3633] Quantum Algorithms for Quantum Field Theories (arxiv.org).
Stephen P. Jordan, Keith S. M. Lee, John Preskill. [1404.7115v1] Quantum Algorithms for Fermionic Quantum Field Theories (arxiv.org).
Greg Kuperberg. [0908.0512] How hard is it to approximate the Jones polynomial? (arxiv.org).
James Daniel Whitfield, Norbert Schuch, Frank Verstraete. [1306.1259] The computational complexity of density functional theory (arxiv.org).

Quantum Algorithm and Bound for Combinatorial Representation

Dorit Aharonov, Itai Arad, Elad Eban, Zeph Landau. [quant-ph/0702008] Polynomial Quantum Algorithms for Additive approximations of the Potts model and other Points of the Tutte Plane (arxiv.org).
Greg Kuperberg. [0908.0512] How hard is it to approximate the Jones polynomial? (arxiv.org).
Yingfei Gu, Xiao-Liang Qi. [1908.06322] Majorana fermions and the Sensitivity Conjecture (arxiv.org).