Talks in theoretical sciences

Friday, 22 November 2019
ETH-ITS, seminar room, CLV B4

Speaker: Sanjay Moudgalya

Time: 09:15 – 09:45

Title: Quantum Many-Body Scars: A New Form of Ergodicity Breaking

Abstract: A cornerstone in the dynamics of isolated quantum systems is the Eigenstate Thermalization Hypothesis (ETH), which provides a sufficient condition for the thermalization of initial states under time-evolution by a quantum Hamiltonian. Eigenstates of non-integrable Hamiltonians were believed to always satisfy ETH in the absence of an extensive number of conserved quantities. However, recent results suggest that this is not always the case. Here we will present the first exact results of a non-integrable quantum system that exhibits some exact eigenstates that violate the Eigenstate Thermalization Hypothesis. These are thus the first examples of quantum many-body scars, a new form of ergodicity breaking in isolated quantum systems also discovered in a recent cold atom experiment. We will further show examples of multiple physically relevant systems that exhibit phenomenology associated with quantum many-body scars and discuss their dynamics.

Speaker: Enrico Herrmann

Time: 10:15 – 10:45

Title: Scattering Amplitudes: from theoretical beauty to practical applications

Abstract: I will give a broad (but somewhat biased) overview of recent progress in scattering amplitudes that highlights several intriguing connections between physics and mathematics, but also relates to practical applications of scattering amplitudes ranging from particle-colliders to gravitational wave physics, as well as understanding cosmology and the large-scale structure of our Universe. I will intersperse some of the ideas that I have been thinking about in the past and mention some possible future work as starting point for discussions.

Speaker: Vatsal Sharan

Time: 11:30 – 12:00

Title: New Problems and Perspectives on Learning and Memory

Abstract: What is the role of memory in continuous optimization and learning? Are there inherent trade-offs between the available memory and the data requirement? Is it possible to achieve the sample complexity of second-order optimization methods with significantly less memory? I will discuss these questions in this talk, and a recent result along these lines. For a basic continuous optimization and learning problem---linear regression---we show that there is a gap between the sample complexity of algorithms with quadratic memory and that

of any algorithm with sub-quadratic memory. I will also discuss several promising future directions to show strong memory/sample tradeoffs for continuous optimization. This is based on joint work with Aaron Sidford and Greg Valiant.

If there is time, I will also briefly discuss a different aspect of the role of memory in learning. The above work studies how much total memory is needed to solve learning problems, but another natural question is to understand which tasks inherently need long-term memory versus only short-term memory. Specifically, for sequential prediction settings where the goal is to predict future observations given past observations: when is it necessary to remember significant information from the distant past to make good predictions? Perhaps surprisingly, we show that for a broad class of sequences, there is an algorithm that predicts well on average, and bases its predictions only on the most recent few observation together with a set of simple summary statistics of the past observations. This is based on joint work with Percy Liang, Sham Kakade and Greg Valiant.

Speaker: Alexander Golovnev

Time: 14:15 – 14:45

Title: Connections between circuits, data structures, and cryptography

Abstract: The goal of complexity theory is to quantify the limits of efficient computation in various computational models. In this talk, we'll see surprising connections between seemingly disparate models: circuits, data structures, and cryptography.

First, we will discuss the current state of the art in circuit lower bounds. Then we will see that the question of proving stronger lower bounds is essentially equivalent to the question of proving new lower bounds for data structures. Finally, we'll prove that data structure lower bounds for a specific class of problems are equivalent to cryptography with preprocessing.

Speaker: Alexandru Gheorghiu

Time: 15:15 – 15:45

Title: Quantum reality and real quantum systems

Abstract: Quantum computers promise to offer an exponential speed-up over classical computers in solving certain problems. Before we are able to exploit this computational advantage, a number of challenges still need to be addressed. Among these are: characterising the computational hardness of problems related to quantum computing; developing applications and protocols specifically targeted at near-term quantum devices; verifying the correctness of quantum computations. In this talk, I will outline my research and how it addresses these challenges. Outside of this computational perspective, quantum mechanics itself presents us with a number of conceptual challenges, such as whether quantum states are fundamental states of reality or merely states of information about reality. In the last part of my talk, I will discuss recent work that addresses this question using the framework of category theory.

Speaker: Nayeli Rodriguez Briones

Time: 16:15 – 16:45

Title: Enhanced Heat-Bath Algorithmic Cooling

Abstract: Quantum information science has shown that energy transport and information processing are two sides of the same coin, inspiring interesting novel methods for cooling physical systems at the quantum scale, such as heat-bath algorithmic cooling. These cooling mechanisms not only provide fundamental insights into quantum thermodynamics, but they are also a practical method to improve the purity of initial states required in implementing algorithms, as well as to provide a reliable low-noise supply of ancilla qubits for quantum error correction. In this talk, I will first review the basic ideas of algorithmic cooling and give analytical results for the achievable cooling limits for the conventional heat-bath version. Then, I will show how the limits can be circumvented by using correlations. In one algorithm I take advantage of correlations that can be created during the rethermalization step with the heat-bath and in another I use correlations present in the initial state induced by the internal interactions of the system. These two algorithms show how correlations can be used to improve cooling.