Symposium Entanglement and Complexity – How "Complex" is Nature? (SYEC)

Julio Magdalena de la Fuente
Freie Universität Berlin
Arnimallee 14
14195 Berlin, Germany
jm@juliomagdalena.de

Entanglement, a key resource in quantum phenomena, was already recognised in the early days of quantum mechanics. In recent decades, the development of quantum information and computing has revealed that carefully engineering quantum dynamics can lead to computational advantages for various classical and quantum problems, as well as secure communication methods. Complexity theory aims to describe and classify different classes of problems based on their "complexity", the resources required to implement the desired task. Surprisingly, these two descriptions reveal a deep connection between how complex and non-classical quantum systems can be. The symposium on entanglement and complexity explores these connections across a wide range of topics. Speakers include M. Heller, who discusses entanglement in quantum field theories; E. Gräfe, exploring entanglement and quantum chaos; N. Callebaut, who delves into entanglement in the AdS/CFT correspondence; and A. Anshu, examining computational complexity and its connection to entanglement. This symposium showcases how these two fields can benefit from mutual exchange.

Overview of Invited Talks and Sessions

(Lecture hall ZHG010)

Invited Talks

SYEC 1.1	Thu	10:45–11:15	ZHG010	**Quantum Information and Spacetime: New Ideas and Results** — •Michal P. Heller
SYEC 1.2	Thu	11:15–11:45	ZHG010	**Entanglement in holography** — •Nele Callebaut
SYEC 1.3	Thu	11:45–12:15	ZHG010	**The theory of learnability of local Hamiltonians from Gibbs states** — •Anurag Anshu
SYEC 1.4	Thu	12:15–12:45	ZHG010	**There's a hole in my quantum bucket – complexified quantum theory and its classical limit** — •Eva-Maria Graefe

Sessions

SYEC 1.1–1.4	Thu	10:45–12:45	ZHG010	**Entanglement and Complexity – How "Complex" is Nature?**

SYEC 1: Entanglement and Complexity – How “Complex” is Nature?

Time: Thursday 10:45–12:45 Location: ZHG010

Invited Talk SYEC 1.1 Thu 10:45 ZHG010
Quantum Information and Spacetime: New Ideas and Results — •Michal P. Heller — Department of Physics and Astronomy, Ghent University

In the course of the past two decades, the main driver of progress at the intersection of quantum information and gravity were, first, the notion of entanglement and, later, also complexity. I will discuss new ideas that build on these developments related, on one hand, to the notion of entanglement in time, and, on the other, to the notion of operator growth. Based on 2408.15752, 2412.17785 and work in progress.

Invited Talk SYEC 1.2 Thu 11:15 ZHG010
Entanglement in holography — •Nele Callebaut — University of Cologne, Germany

In this talk I will review how the quantum information theoretic concept of entanglement acquires a geometric interpretation in holographic dualities, and how this insight has led to breakthroughs in both quantum field theory and gravity.

Invited Talk SYEC 1.3 Thu 11:45 ZHG010
The theory of learnability of local Hamiltonians from Gibbs states — •Anurag Anshu — Harvard University, Cambridge, MA

Learning the Hamiltonian underlying a quantum many-body system in thermal equilibrium is a fundamental task in quantum learning theory and experimental sciences. This talk will provide a general overview of the recent learning algorithms for this problem, and highlight how the progress comes hand-in-hand with new insights into the entanglement structure of quantum Gibbs states. We will explore interesting open questions in this direction, in particular the goal of devising algorithms that are easy to implement in experiments.

Invited Talk SYEC 1.4 Thu 12:15 ZHG010
There’s a hole in my quantum bucket – complexified quantum theory and its classical limit — •Eva-Maria Graefe — Imperial College London

Traditional quantum mechanics focusses on the description of systems that are closed or well-separated from their environment. Take for example the interior of a bucket. If the bucket is in a good condition its contents will remain inside. However, many physical systems exhibit leakage, such as a loss of a leaking buckets contents to the environment. In quantum mechanics the interior of such an open system can effectively be described by non-Hermitian quantum mechanics, where complex-valued energies encode life-times of states. In this talk, I will provide an overview of non-Hermitian quantum theory, focusing on the aspect of quantum-classical correspondence.