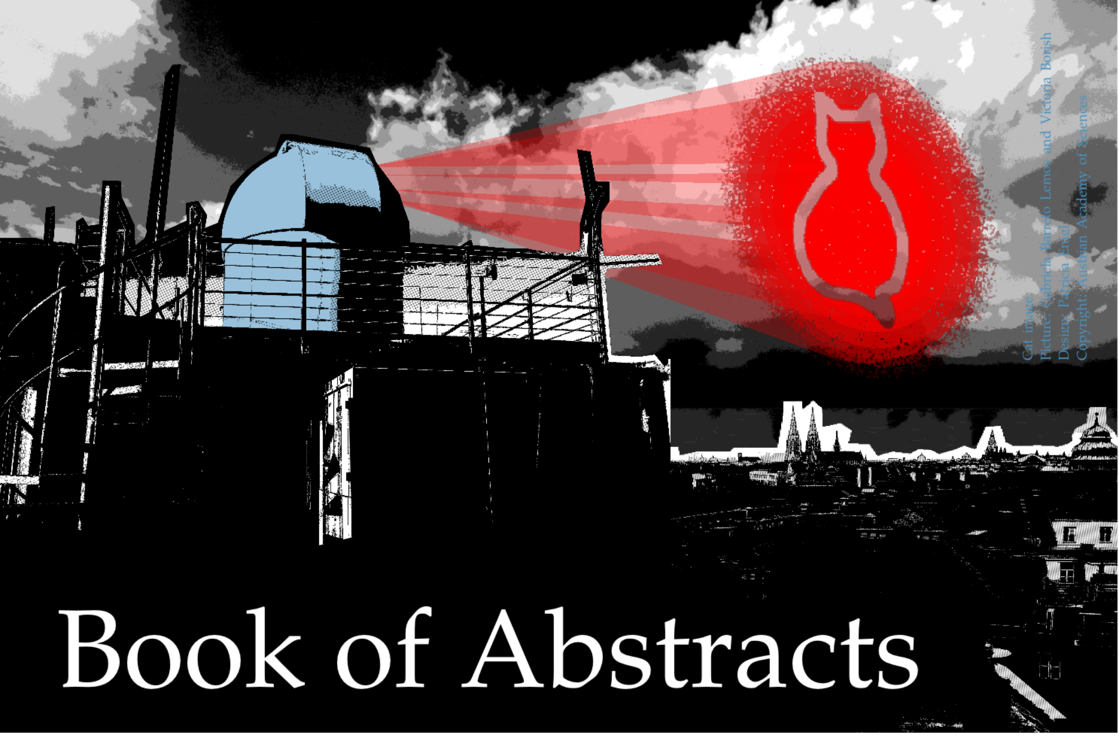

Invited Speakers

International Conference for
Young Quantum Information Scientists (YQIS) and
Summer School of the Vienna Doctoral Program on
Complex Quantum Systems (CoQuS)

University of Vienna, Austria

September 17–21, 2018

Contents

Invited Lecturers

Mohamed Bourennane

Stockholm University
Stockholm, Sweden

Entanglement Detection and Applications

Quantum entanglement leads to the most counterintuitive effects in quantum mechanics. The entanglement quantitative and qualitative characterization for mixed and multipartite systems is still under intense research. An important and crucial question is to know which mixed states can be distilled to maximally entangled states with help of local operations and classical communication. The Horodecki group has made an important discovery by predicting theoretically the existence of quantum entangled states where no entanglement can be distilled. This peculiar entanglement has been called bound entanglement. This new class of states lies between separable and "free" entangled.

In the first part my lectures, I will present the methods and results on experimental demonstrations of "free" two and multipartite entangled states, and three and four qubits bound entangled states, and fully characterize their entanglement properties. I will also show

how one can unlock and activate bound entanglement.

Quantum information science breaks limitations of conventional information transfer, cryptography and computation by using quantum superposition or entanglement as resources for information processing.

In the second part of my lectures, I will present novel multiparty quantum communication protocols: secret sharing, detectable Byzantine agreement, clock synchronization, and reduction of communication complexity, and show that these quantum protocols can outperform any classical one. These protocols use shared multipartite entangled or communication of single quantum systems. I will review how these protocols are realized.

Elham Kashefi

University of Edinburgh
Edinburgh, Scotland, United Kingdom

Verification of Quantum Computation

Quantum computers promise to efficiently solve not only problems believed to be intractable for classical computers, but also problems for which verifying the solution is also considered intractable. This raises the question of how one can check whether quantum computers are indeed producing correct results. This task, known as quantum verification, has been highlighted as a significant challenge on the road to scalable quantum computing technology. We review the most significant approaches to quantum verification and compare them in terms of structure, complexity and required resources. We also comment on the use of cryptographic techniques which, for many of the presented protocols, has proven extremely useful in performing verification. Finally, we discuss issues related to fault tolerance, experimental implementations and the outlook for future protocols.

Referece: https://arxiv.org/abs/1709.06984

Ralph Silva

ETH Zurich
Zurich, Switzerland

Quantum Thermodynamics

In these lectures, we will go over the basic principles of quantum thermodynamics.

In the first lecture, we connect information processing and thermodynamics, by studying the work cost of computations, and heat dissipation in quantum computers. We start with the classic examples of Maxwell's demon and Szilard boxes, and then generalize these to the quantum case. We will study concrete protocols to convert quantum information into work under different operational constraints.

In the second lecture, we will introduce a general framework for quantum thermodynamics: the resource theory of thermal operations. We will explore the ideas behind the resource theory, and justify why thermal operations are a good fit to study thermodynamics. In particular, we will analyse why thermal states can be considered "free". Then we will go over specific results: how majorization characterizes the order between states, and how entropy and free energy measures emerge naturally as monotones under these contraints.

In the third lecture, we explore actual quantum effects within this general framework. First, we will see what happens when there are multiple conserved quantities, in the commuting and non-commuting cases. Then we will look at the role of coherence and asymmetry in applying unitary operations, and how we can quantify them. This will lead us to the study of clocks and control in thermodynamics – why they are needed, how to build them, and how they degrade. Finally, we will introduce the smallest autonomous quantum heat engines.

Invited Speakers

Marissa Giustina

Google, LLC
USA

Hardware challenges to a large-scale quantum computer based on superconducting qubits

A paramount goal across the quantum information field is to build a quantum computer with a large number of high-fidelity qubits. Superconducting qubits, which are operated in a cryogenic environment ($\sim$20 mK) and controlled with microwave electronics, are an interesting platform for this research. We briefly review a few candidate architectures for building a quantum computer with superconducting qubits, and discuss similarities between the physical implementations of each in the Google Quantum-AI lab. We consider what hardware is currently used to build these systems and examine the limits of brute-force scaling. The road to a large-scale quantum computer will include the development of a number of new technologies.

Marcin Pawłowski

University of Gdansk
Gdansk, Poland

Mutually Unbiased Bases, Random Access Codes and Semi-Definite Programming

This talk introduces 3 very different concepts of great importance to quantum information and a link between them. These are Mutually Unbiased Bases (MUBs), Random Access Codes (RACs) and Semi-Definite Programming (SDP). In this talk I will define all of them and present their applications in a wide variety of quantum information problems ranging from foundations of quantum mechanics to pure mathematics, quantum chemistry or cryptography. I will also discuss open problems regarding them focusing on Zauner's conjecture, which states the size of the largest set of MUBs for a given dimension of the Hilbert space. I will finish by presenting the results from one of our latest papers in which we show how to link the number of MUBs to efficiency of RACs and how to upper-bound the latter with SDP and explaining our project to use it to prove Zauner's conjecture.

Gerhard Rempe

Max Planck Institute of Quantum Optics
Garching, Germany

Quantum networking for youngsters

Quantum physics allows for phenomena that are not possible within classical physics. In quantum optics, a prime toolbox for the engineering of quantum effects is cavity quantum electrodynamics due to the giant optical nonlinearities it establishes at the single-photon level. These nonlinearities are subject of fundamental investigations and are central for novel applications in quantum information processing, most notably in quantum networking. This latter research field has recently been propelled forward by a plethora of entanglement, teleportation and quantum-gate experiments with individual atomic and photonic qubits. The talk will discuss these experiments in elementary terms and outline some perspectives.

Stephanie Wehner

QuTech, Delft University of Technology
Delft, The Netherlands

TBA

TBA

Public Talk

Ronald de Wolf

QuSoft, CWI, and University of Amsterdam
Amsterdam, The Netherlands

The Potential Impact of Quantum Computers on Society

This talk considers the potential impact that the nascent technology of quantum computing may have on society. It focuses on three areas: cryptography, optimization, and simulation of quantum systems. We will also discuss some ethical aspects of these developments, and ways to mitigate the risks.